Lower Sprague-Lower Williamson Watershed Assessment

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List of Acronyms and Abbreviations

AT	Assessment Team
AUM	Animal unit month
BLM	Bureau of Land Management
BMP	Best Management Practice
CCC	Commodity Credit Corporation
CRP	Conservation Reserve Program
CFS	Cubic feet per second
CHT	Channel habitat type
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWD	Chronic wasting disease
DEM	Digital elevation model
DLG	Digital Line Graph
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ERO	Ecosystem Restoration Office (of the U.S. Fish and Wildlife Service)
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
ET	Evapotranspiration
FLIR	Forward Forward-Looking Infrared Radiometry
FSA	Farm Service Agency
GAP	Gap Analysis Project
GIS	Global (Geographic) Information System
HUC	Hydrologic unit code
HWG	Hatfield Working Group
INR	Institute for Natural Resources
IPCC	International Panel on Climate Change
KBEF	Klamath Basin Ecosystem Foundation
KNRD	Klamath Tribes Natural Resources Department
KSWCD	Klamath Soil and Water Conservation District
KWC	Klamath Watershed Council
LASAR	Laboratory Analytical Storage and Retrieval Database
LiDAR	Light Detection and Ranging
LWD	Large woody debris
LWG	Local working group
MPID	Modoc Point Irrigation District
NAIP	National Agriculture Imagery Program
NAS	National Academy of Science
NCDC	National Climatic Data Center
NF	National Forest
NHD	National Hydrography Dataset
NHI	Northwest Habitat Institute
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRST	National Riparian Service Team

NTU	Nephelometric turbidity unit
NWI	National Wetlands Inventory
OAR	Oregon Administrative Rules
OC&E	Oregon, California, and & Eastern
OCMRC	Oregon Central Military Road Company
OCS	Oregon Climate Service
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
OGAP	Oregon Gap Analysis Program
OGEO	Oregon Geospatial Enterprise Office
ORNHIC	Oregon Natural Heritage Information Center
ONHP	Oregon Natural Heritage Program
ORS	Oregon Revised Statute
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWQI	Oregon Water Quality Index
OWRD	Oregon Water Resources Department
PFC	Proper Functioning Condition
PNC	Potential natural community
PNW	Pacific Northwest
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RM	River Mile
RUSLE	Revised Universal Soil Loss Equation
SNOTEL	Snowpack Telemetry
SP	Southern Pacific
SRI	Soil Resource Inventory
SSURGO	(NRCS) Soil Survey Geographic
STATSGO	(NRCS) State Soil Geographic
TAG	Technical Advisory Group
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TP	Total Phosphorus
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish & and Wildlife Service
USGS	U.S. Geological Survey
WARS	Water Availability Reporting System
WLA	Working Landscapes Alliance
WMU	Wildlife Management Unit
WPCF	Water Pollution Control Facility
WPN	Watershed Professionals Network
WQMP	Water Quality Management Plan
WRCC	Western Regional Climate Center
WRIS	Water Rights Information System
WRP	Wetlands Reserve Program

Disclaimer

This Watershed Assessment is based almost entirely on the work of others. The authors of this document have attempted to organize relevant data and associated interpretations into a format that will be most useful to Lower Sprague-Lower Williamson River Watershed stakeholders and funders. Citations are provided to key databases and existing reports that provided the foundation for this Assessment. Note, however, that data interpretations provided in these reference reports are relied on heavily, as is standard practice for watershed assessments. Borrowed works have been cited for this document and fair use doctrine has been maintained. Under the fair use doctrine of the U.S. copyright statute, it is permissible to use limited portions of a work for purposes such as scholarly reports and documents.

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CHAPTER 1. INTRODUCTION

A WATERSHED

A watershed is an area of land that contributes to the flow of water at a given point. A watershed reaches from one mountain ridge to the next, and includes all of the area in between. Watersheds are nested within one another. Tiny watersheds are grouped in small watersheds, which are grouped in larger watersheds.

The Lower Sprague-Lower Williamson Watershed Assessment area includes the lands that cover all the territory downstream of Beatty Gap on the Sprague River and downstream of Kirk Reef on the Williamson River in Klamath County, Oregon (see Maps 3-1 and 3-2). These rivers are the reflection of geology, soils and vegetation, farms and ranches, cities and towns, and attitudes and economies that fill their basins and watersheds. With respect to this Watershed Assessment, only the lower portion of the Sprague River and Williamson River watersheds are included. The Upper Sprague and Sycan Watershed Assessment and Upper Williamson Watershed Assessment were already conducted. The next portion of the watershed to be assessed, moving downstream, is the Upper Klamath Lake Basin.

A watershed consists of three basic physical components: the uplands, riparian/wetland areas and the aquatic zone. The uplands generally comprise up to 95 to 98 percent of a watershed's surface area, receiving and processing a corresponding percentage of the precipitation (rain and snow) that falls in the watershed. Uplands are commonly represented by toe slopes, alluvial fans, side slopes, and shoulders and ridges of mountains and hills, and include plains and terraces in valley bottoms not influenced by groundwater or by occasional flooding.

Riparian areas are transitional areas positioned between permanently saturated water bodies and uplands. They exhibit vegetation and physical characteristics reflective of permanent subsurface water or seasonal surface water. Lands along, adjacent to, or contiguous with perennial and intermittently flowing rivers and streams are referred to as lotic (flowing water) riparian areas, while those associated with potholes, lakes and reservoirs with stable water levels are referred to as lentic (standing water) systems. When functioning properly, lotic riparian areas trap sediment during high flows, help maintain appropriate stream channel width-to-depth ratios, attenuate flood flows and store water. Lentic riparian areas protect banks from the erosive effects of wave action and support water quality by filtering water and trapping sediments.

Wetlands are areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to life in saturated soil conditions. The aquatic zone is an area of open water including streams, rivers, ponds and lakes (Prichard 1998).

WATERSHED FUNCTION

When functioning properly, each of the physical components of a watershed (uplands, riparian/wetland areas and the aquatic zone), working in concert, optimize the watershed's ability to capture, store and safely release the precipitation it receives.

<u>Capture</u> of moisture is directly related to the proportion of the precipitation that is not lost through interception in the uplands. Once water strikes the earth's surface, it may take one of many

pathways depending on temperature, slope of the land, geology, soils or vegetation cover. The process in which water moves into the soil profile is called infiltration. The factors that affect infiltration are the passage of moisture from the atmosphere, through the soil surface and into the soil profile. Riparian/wetland areas serve many important roles: storing moisture, trapping sediment, and attenuating flood flows during high flow and flood events.

Storage relates to the retention/detention of moisture in the soil profile once that moisture has entered the soil following infiltration. This moisture, once surpluses have percolated past the root zone, is available for plant growth and the maintenance of soil organisms. Once at field capacity, loss of soil moisture in this process is through evapotranspiration.

Safe release includes the processes of the percolation of excess moisture deep into the soil profile or to fractured bedrock and eventual groundwater recharge; lateral flow down-slope to the riparian area, wetland or stream; and the use of moisture by plants and soil organisms. Safe release brings the eventual yield of long duration flows of quality water to support the needs of fish, wildlife and humans.

HISTORY OF LOWER SPRAGUE-LOWER WILLIAMSON WATERSHED ASSESSMENT

Watershed assessments are based on science, which also includes landowner knowledge. The watershed assessment process was developed by coalitions of farmers, ranchers, environmentalists, scientists, foresters, agency personnel, tribes, business people and many others. Assessments were intended to give local communities and resource managers the information and tools they need to document their understanding of the various factors that affect watershed function, and the associated social, cultural, historical and economic context. With this information, individuals may be empowered to take actions that will increase the capacity of the natural environment and provide a sustainable livelihood. This process, which was pioneered here in the state of Oregon, grew out of the recognition that it takes input from all stakeholders to successfully manage natural resources to the best extent possible for multiple uses.

Starting in 2003, three different organizations—the Hatfield Working Group, Klamath Watershed Council (KWC), and Klamath Basin Ecosystem Foundation (KBEF)—started collaborating on watershed assessments in the Upper Klamath Basin. The diverse interest groups represented by these three organizations worked together to secure grants for the development of a watershed assessment from the Oregon Watershed Enhancement Board (OWEB) and the Klamath Falls field office of the U.S. Fish and Wildlife Service.

The first step was to develop a strategy for conducting the assessments across the entire Upper Klamath Basin. Since the Upper Klamath Basin is a very large area, doing the assessments at the scale and pace that they have been done in other parts of the state would take around 60 years and cost somewhere between six and seven million dollars. No one was interested in this timeframe and cost, so the partnership devised a strategy that balanced the need for detailed analysis with the need to be expedient and responsible with taxpayer dollars.

The Upper Klamath Basin was divided into seven "Assessment Units," or subbasins: the Upper Williamson, the Upper Sprague/Sycan, the Lower Sprague-Lower Williamson, Upper Klamath Lake, Upper Lost River, Lower Lost River/Klamath Project and the Klamath River Canyon (DEA 2004).

The plan was to work systematically through the subbasins, conducting watershed assessments in a reasonable timeframe, for a reasonable cost. Stakeholders acknowledged the importance of including local knowledge with the science from published studies and reports in the assessment document.

To accomplish the watershed assessment, guidance was provided by the OWEB and its Watershed Assessment Manual (WPN 1999). This manual is geared toward incorporating community involvement in the assessment process. This process was used in the Upper Williamson assessment (DEA 2005), and then refined and improved upon for the Upper Sprague/Sycan River assessment (KBEF and OSU KBREC 2007) and subsequently this Lower Sprague-Lower Williamson Watershed Assessment, by incorporating a series of public field days covering various parts of the watershed. Field days were held on private and public property, usually with private landowners interested in improving management practices and land conditions. Some of the discussions included sharing progress and best management practices that have already been implemented.

Technical support during the field days was provided by the Working Landscapes Alliance (WLA). The WLA is a group of natural resource specialists with decades of experience in the management of natural resources in the western United States. Their approach to stream assessment and enhancement is called "Proper Functioning Condition" or "PFC" (Prichard 1998). PFC assessment refers to a methodology for assessing the physical functioning of riparian-wetland areas including hydrology, vegetation, and erosion/deposition (soils) attributes and processes. Whereas PFC is one of numerous methods used to assess the riparian area and stream conditions, it is the preferred method for purposes of this Watershed Assessment. WLA also has a collaborative, adaptive management philosophy and works to create a common vocabulary about riparian-wetland function within communities.

As early as 1995, local producer groups, in cooperation with the Oregon Cattlemen's Association, Oregon State University (OSU) and the Klamath Watershed Council (KWC), had been sponsoring workshops teaching the principles of PFC. The PFC methodology became popular among professionals because it focused on actual conditions of specific stream reaches, describing in detail how soil, vegetation and water interact to dissipate the stream energies that cause erosion. This dissipation results in more stable stream channels, improved fish habitat, cleaner water and even improved forage production. The information gathered through this approach is documented in a way that can contribute to the overall watershed assessment by serving as a "cross-reference" for the published studies.

One criticism of PFC is that it does not place enough focus on the majority of the watershed that is not in the riparian zone—the uplands. WLA met this need by including in its group a specialist in range management and upland function who focuses on the ability of upland landscapes to "capture, store, and safely release" precipitation.

> **Action plans and assessments are a no-brainer really, to have a long-term plan. It's kind of scary, though, to think about who will control things over the long-term because landowners don't have control over the whole watershed.**
>
> **Agriculture as a whole in the Klamath Basin—the AG community— has really stepped up. When there is a challenge, the community bonds together quite well.**
>
> ***--Tom Mallams, Rancher***

This Watershed Assessment was compiled using the process described in the OWEB Watershed Assessment Manual for reviewing existing data and published studies, and using PFC to look more closely at specific riparian sites. For this Watershed Assessment, a combination of contractors was used to compile and present existing data. E&S Environmental Chemistry gathered data and prepared figures, tables and maps, and Rabe Consulting provided text and included landowner perspectives. A technical advisory group (TAG) was developed to oversee the technical content of the Assessment. The TAG was composed of professionals from different focus areas, including hydrology, fish, wildlife, soils, botany, wetlands, riparian, vegetation and water quality. Another layer of review included the Assessment Team (AT), which included the TAG members as well as other resource specialists, Tribal members, and landowners living in the assessment area. In addition to the technical review and input, landowners were interviewed and public meetings were held to gather landowner perspectives. Landowners' viewpoints are included as much as possible, because often landowners can impart valuable first-hand knowledge of the watershed.

In July of 2007, the Klamath Watershed Council and the Klamath Basin Ecosystem Foundation combined to form one organization, the Klamath Watershed Partnership. The partnership has coordinated the various contractors, technical advisors and team members, and completed this process and document.

THE OWEB PROCESS AND ISSUE IDENTIFICATION

In short, the OWEB watershed assessment process is as follows:

1. Define the area and items to be assessed.
2. Assess this area based on available data and knowledge.
3. Plan actions based on data gaps or issues identified in the assessment.
4. Implement the action plan.

For many, the item of most interest is the action planning, with a focus on implementing projects on the ground, while there is little interest in assessment alone. However, this assessment document covers only steps 1 and 2 in the list above. Steps 3 and 4 will come later, as the community works together to develop and implement the action plan. Although it may be frustrating to take the time to complete the assessment, it is essential to providing sound direction for the action plan.

Action planning uses information from the assessment document to make a prioritized list of the practical actions necessary to meet the identified needs in the watershed. Projects could include fencing the riparian areas, setting up off-stream watering, planting trees or gathering more information on topics or in areas where the existing information was not complete.

To complete Steps 1 and 2 for the Lower Sprague-Lower Williamson Watershed Assessment, which covers all the territory downstream of Beatty Gap on the Sprague River and downstream of Kirk Reef on the Williamson River, kick-off field days were held May 25 to 26, 2006, and July 25 to 26, 2006. During these field days, the WLA discussed riparian and upland systems and issues with landowners and other stakeholders. The field days included one day of indoor discussion, followed by a day in the field assessing a landowner's property.

Subsequently, an "Issue Identification" workshop was held on September 18, 2007, at the Community Center in Chiloquin. People attending the workshop included landowners, Klamath Tribe representatives, agency personnel and private industry representatives.

At the workshop, participants assembled into small groups to generate and rank lists of as many potential issues for the watershed as possible. Participants spent part of the time developing issues from viewpoints different from their own, and part of the time identifying issues that affected them directly.

The ranking process allowed each participant to indicate the top three issues within the watershed area, and then identify a group of the next seven most important. Issues were ranked according to the total number of votes received. In the case of ties, issues were ranked equally.

There were 94 issues raised, and these issues were classified into 12 categories. The issues were ranked based on the number of votes within categories and also ranked regardless of category. Of the 94 issues identified during the workshop, 38 (nearly 40 percent) received only one vote. These 37 are numbered (57-94) in Table 1-2, but they have equivalent rankings. The top issues reflected concerns about noxious weeds, sustaining rural communities, impacts of wells on artesian flow and groundwater, and government regulations.

The following tables summarize the input received. Table 1-1 lists all the issues raised ranked within their categories by number of votes. Table 1-2 lists the issues ranked by the total number of votes.

Table 1-1 Issues raised during the Issues Identification Workshop ranked by votes within categories.

Category	Issue	Tally
WATER QUANTITY		
	What impact are wells having on artesian flow and groundwater	10
	Having enough water to grow hay and water cattle	7
	A true balance of water delivery	6
	Irrigation water supply	5
	Who owns the water can affect my lifestyle and maybe even livelihood	4
	In-stream flow needs for channel maintenance, biotic support, refugia and migration for healthy riparian function	4
	Are the water rights such that there is enough water left in channel for physical ecological processes and biology to flourish	3
	Weeds and invasive species consume more water and are outcompeting native species	3
	Tribal rights are reduced by over-allocated water resources	2

Category	**I**ssue	**T**ally
	Mid-elevation uplands are in fair to poor hydrologic condition (sagebrush/grass, sagebrush/grass/juniper, juniper/grass/shrub)	2
	Water rights adjudication creates uncertainty about water for irrigation and fish and wildlife	1
	Need to settle adjudication ASAP	1
	Not addressing groundwater in upper basin. Future impacts on domestic and overall supply, impacts to surface water. Lack of information on groundwater and groundwater pumping.	1
	Juniper encroachment may affect water availability for Sprague system	1
	Irrigation water and Tribal rights	1
	How do we manage annual fluctuations in water amount	1
	How much water can be saved through irrigation water management, and also what is impact on forage production and water quality	1
RANCH		
	Rising land values affect opportunities for agricultural landowners to own and retain land	5
	Presence of endangered species on my land may retard use and profit	5
	How will this info increase my bottom line	3
	Forage production	3
	Conservation of open space	3
	River and riparian restoration may affect economic viability of ranching and farming operations	2
	Grazing allotment reform	2
	Increase public land grazing	1
	Access to public lands for grazing	1
WATER QUALITY		
	Poor water quality issues including temperature, sediment, dissolved oxygen, pH, nutrients	6
	Water quality, including temperature and chemistry, is a problem for fish recovery	2
	Streambank erosion affecting water quality	2
	Need improved water quality by reducing impacts of livestock, roads, forest practices	2
	How do land management activities affect water quality	1
	Need to preserve wild and scenic qualities of the waters	1
RIPARIAN		
	Functional soil, water and vegetation to sustain creation of what we value	6
	Stream and riparian degradation can be caused or influenced by	4

Category	Issue	Tally
	on-site management, and upland or upstream management; it takes critical thinking to determine cause and effect	
	Restoration of previous wetland and riparian areas	4
	Geomorphology issues including lack of floodplain connectivity, lateral and vertical stability, sediment loads, channel geometry	3
	Bank stability	2
	What limitations does the agriculture water quality management plan impose	1
	Current conditions of riparian area is very poor	1
	Floodplain connectivity	1
	What regulations control managing riparian areas on private lands	1
CULTURE		
	How will the information influence the way we make management decisions	6
	Tribal culture and heritage is not respected by nontribal groups	3
	Truthful representation of biology	3
	Local participation	3
	Dignity, economy and biology go hand in hand	2
	Communicate to general public	1
	Educate land user	1
	Lack of knowledge: Landowners do not know what water law means, need an overview of federal law, how are Tribes still separate governments	1
	Agency people do not understand community connection to land, have bad reputation with landowners	1
	Too much agency and lawyer involvement, not enough community decision-making	1
	Private property rights	1
	Community trust	1
	Want to sustain our Tribal culture by getting lands back	1
	Lack of understanding: What's the big deal	1
RECREATION		
	Preserve open lands for public use	4
	Eco-tourism	1
FISH HABITAT		
	Relationships with landowners and agencies who are managing the fish habitat so that we all get what we need and want for the watershed	5
	Fish habitat	4
	Maintaining traditional hunting and fishing areas under ESA	2

Category	Issue	Tally
	requirements	
	Suckers live in the mud, who cares	2
	Fish populations are too low: (1) redband, (2) bull trout, (3) sucker	1
BIOLOGICAL DIVERSITY		
	Noxious weeds	11
	Maintain plant and animal diversity and viability	4
WETLAND		
	What federal and other programs assist people who want to improve streams	4
	Does the Sycan Marsh reduce water flows to downstream areas	2
REGULATORY		
	Government regulations on water and land usage and how they are affecting the next generation of agriculturalists	9
	Is there a way to recover the watershed while providing protection of private landowners	9
	Government agency intrusion	4
	Landowner is responsible for land, not government, but need freedom to take care of their property	1
	Policy and regulations (state and federal) conflict with watershed recovery (e.g., diking)	1
ECONOMICS		
	Sustaining rural communities	11
	Loss of private lands and rapid sale to developers	4
	Land values/forcing out future generations	1
	Economic viability/diversity of restoration projects	1
	Sustaining Tribal economies	1
	No time to work on these things and make a living	1
FOREST AND UPLANDS		
	Make the forest healthy, sustainable and resistant to fire	9
	Keep forests healthy and productive	7
	Need to cover uplands, the other 98% of the watershed	5
	The mismanagement of timber resources yielding less production and unhealthy forest stands	4
	Need to increase timber harvest to reduce fuel loads and release suppressed stands	3
	Timber harvest	3
	Insect degradation leads to stand degradation	3

Category	Issue	Tally
	Does cutting juniper and pine forest increase stream flow	2
	What are primary barriers to forest health thinning	2
	High danger of catastrophic fire (especially near USFS and BLM)	2
	Timber: juniper encroachment into historically nonjuniper areas	2
	Regulatory issues—Oregon Forest Practices Act	1
	Lack of prescribed fire	1
	Need to preserve late and old succession forest	1
	Preserve all unroaded areas	1
	Roads can act like stream channels if not designed, constructed, maintained	1
	Timber thinning to release suppressed stands and provide biomass for electricity generation	1

Table 1-2 Watershed issues ranked by total votes cast by workshop participants.

Rank	Issue	Votes
1.	Noxious weeds	11
2.	Sustaining rural communities	11
3.	What impact are wells having on artesian flow and groundwater	10
4.	Government regulations on water and land usage and how they are affecting the next generation of agriculturalists	
5.	Is there a way to recover the watershed while providing protection of private landowners	9
6.	Make the forest healthy, sustainable and resistant to fire	9
7.	Having enough water to grow hay and water cattle	7
8.	Keep forests healthy and productive	7
9.	A true balance of water delivery	6
10.	Poor water quality issues including temperature, sediment, dissolved oxygen, pH, nutrients	6
11.	Functional soil, water and vegetation to sustain creation of what we value	6
12.	How will the information influence the way we make management decisions	6
13.	Irrigation water supply	5
14.	Rising land values affect opportunities for agricultural landowners to own and retain land	5
15.	Presence of endangered species on my land may retard use and profit	5
16.	Relationships with landowners and agencies who are managing the fish habitat so that we all get what we need and want for the watershed	5
17.	Need to cover uplands, the other 98% of the watershed	5
18.	Who owns the water can affect my lifestyle and maybe even livelihood	4

Rank	Issue	Votes
19.	In-stream flow needs for channel maintenance, biotic support, refugia and migration for healthy riparian function	4
20.	Stream and riparian degradation can be caused or influenced by on-site management, and upland or upstream management; it takes critical thinking to determine cause and effect	4
21.	Restoration of previous wetland and riparian areas	4
22.	Preserve open lands for public use	4
23.	Fish habitat	4
24.	Maintain plant and animal diversity and viability	4
25.	What federal and other programs assist people who want to improve streams	4
26.	Government agency intrusion	4
27.	Loss of private lands and rapid sale to developers	4
28.	The mismanagement of timber resources yielding less production and unhealthy forest stands	4
29.	Are the water rights such that there is enough water left in channel for physical ecological processes and biology to flourish	3
30.	Weeds and invasive species consume more water and are outcompeting native species	3
31.	How will this info increase my bottom line	3
32.	Forage production	3
33.	Conservation of open space	3
34.	Geomorphology issues including lack of floodplain connectivity, lateral and vertical stability, sediment loads, channel geometry	3
35.	Tribal culture and heritage is not respected by nontribal groups	3
36.	Truthful representation of biology	3
37.	Local participation	3
38.	Need to increase timber harvest to reduce fuel loads and release suppressed stands	3
39.	Timber harvest	3
40.	Insect degradation leads to stand degradation	3
41.	Tribal rights are reduced by over-allocated water resources	2
42.	Mid-elevation uplands are in fair to poor hydrologic condition (sagebrush/grass, sagebrush/grass/juniper, juniper/grass/shrub)	2
43.	River and riparian restoration may affect economic viability of ranching and farming operations	2
44.	Grazing allotment reform	2
45.	Water quality, including temperature and chemistry, is a problem for fish recovery	2
46.	Streambank erosion affecting water quality	2
47.	Need improved water quality by reducing impacts of livestock, roads, forest practices	2
48.	Bank stability	2

Rank	Issue	Votes
49.	Dignity, economy and biology go hand in hand	2
50.	Maintaining traditional hunting and fishing areas under ESA requirements	2
51.	Suckers live in the mud, who cares	2
52.	Does the Sycan Marsh reduce water flows to downstream areas	2
53.	Does cutting juniper and pine forest increase stream flow	2
54.	What are primary barriers to forest health thinning	2
55.	High danger of catastrophic fire (especially near USFS and BLM)	2
56.	Timber: juniper encroachment into historically nonjuniper areas	2
57.	Water rights adjudication creates uncertainty about water for irrigation and fish and wildlife*	1
58.	Need to settle adjudication ASAP	1
59.	Not addressing groundwater in Upper Basin. Future impacts on domestic and overall supply, impacts to surface water. Lack of information on groundwater and groundwater pumping.	1
60.	Juniper encroachment may affect water availability for Sprague system	1
61.	Irrigation water and Tribal rights	1
62.	How do we manage annual fluctuations in water amount	1
63.	How much water can be saved through irrigation water management, and also what is impact on forage production and water quality	1
64.	Increase public land grazing	1
65.	Access to public lands for grazing	1
66.	How do land management activities affect water quality	1
67.	Need to preserve wild and scenic qualities of the waters	1
68.	What limitations does the agriculture water quality management plan impose?	1
69.	Current conditions of riparian area are very poor	1
70.	Floodplain connectivity	1
71.	What regulations control managing riparian areas on private lands	1
72.	Communicate to general public	1
73.	Educate land user	1
74.	Lack of knowledge: Landowners do not know what water law means, need an overview of federal law, how are Tribes still separate governments	1
75.	Agency people do not understand community connection to land, have bad reputation with landowners	1
76.	Too much agency and lawyer involvement, not enough community decision-making	1
77.	Private property rights	1
78.	Community trust	1
79.	Want to sustain our Tribal culture by getting lands back	1

Rank	Issue	Votes
80.	Lack of understanding: What's the big deal	1
81.	Eco-tourism	1
82.	Fish populations are too low: (1) redband, (2) bull trout, (3) sucker	1
83.	Landowner is responsible for land, not government, but need freedom to take care of their property	1
84.	Policy and regulations (state and federal) conflict with watershed recovery (e.g., diking)	1
85.	Land values/forcing out future generations	1
86.	Economic viability/diversity of restoration projects	1
87.	Sustaining Tribal economies	1
88.	No time to work on these things and make a living	1
89.	Regulatory issues—Oregon Forest Practices Act	1
90.	Lack of prescribed fire	1
91.	Need to preserve late and old succession forest	1
92.	Preserve all unroaded areas	1
93.	Roads can act like stream channels if not designed, constructed, maintained	1
94.	Timber thinning to release suppressed stands and provide biomass for electricity generation	1

* NOTE: Number 57 to Number 94 only received one vote each (should all be ranked as Number 57).

These prioritized lists of issues were used to guide the assessment work, although in some cases, such as for the "Culture" or "Economics" categories, it was difficult to address certain unrelated issues. It also should be acknowledged that the issue identification process may not have resulted in the best possible representation of community concerns in the assessment area, because it did not gather input from everyone, and because it was limited to a brief period of time during the fall of 2007.

Restore health, structure and function of the watershed. This will help us more effectively address the array of issues raised.

--Don Gentry, Klamath Tribes

THE WORKING LANDSCAPES ALLIANCE

Proper Functioning Condition Assessment Process

The Working Landscapes Alliance (WLA) is an interdisciplinary team of scientists partnering together, from the National Riparian Service Team, private sector specialists, and Sustainable Northwest, with expertise in hydrology, riparian-wetland vegetation, soils and biology. As part of both the Upper and Lower Sprague Watershed Assessment processes in 2005 and 2006, WLA conducted community workshops on assessing riparian-wetland health using Proper Functioning Condition (PFC) Assessment, and facilitated public field days. WLA has a collaborative adaptive management philosophy and works to create a common vocabulary about riparian-wetland function within local communities. The WLA was also requested to walk stream reaches during private ranch visits, and provided their perspectives on riparian-wetland condition and possible management practices to landowners.

The public field days were hosted by several private landowners, The Nature Conservancy, and the U.S. Department of Agriculture (USDA) Forest Service. The community was invited to participate with WLA in an assessment and discussion of riparian-wetland condition and management on a reach of stream, in the context of where that property was located in the watershed. This led to an on-the-ground understanding of site conditions and potential.

The PFC Assessment refers to a methodology for assessing the physical functioning of riparian-wetland areas, including hydrology, vegetation, and erosion/deposition attributes and processes. Discussions about which attributes and processes are in a working order, and which ones are not, helps clarify what a landowner can do—or cannot do for that matter—about the conditions of the stream. In some cases, site assessments led to a recommendation that management practices be changed or modified, in others monitoring was recommended, and in others the recommendation was that landowners just keep doing what they are doing.

The WLA reviewed a broad range of stream conditions, from functional conditions on a few reaches to some that very much needed a change in management to allow for recovery of riparian-wetland vegetation. Management of riparian vegetation should be considered the highest need overall, but there were some places noted where active restoration along with vegetation management was important to reduce meander cut-offs in the main-stem Sprague River. On the tributaries reviewed by the WLA, a change in livestock management to reduce growing season pressure was the priority need, where streams were assessed as "functioning-at risk" with no apparent trend or a downward trend. Some tributary reaches, including ones deemed highly important for recovery of the ESA-listed suckers, were in excellent condition.

Several things were particularly striking about what we learned on these field days, at almost every site visited:

- People in the watershed are seeing that stream restoration can occur through natural recovery processes, and there is a desire by landowners to receive assistance on management practices that will lead to natural recovery where possible. These landscapes and streams are truly resilient and responsive. So often we approach environmental issues feeling that they are enormously complicated and difficult. But we saw over and over again how with a little better understanding of how these systems function, and some relatively minor adjustments in management, these riparian sites will bounce back both quickly and dramatically.

- There are reaches of the Sprague river system that were channelized for flood control to protect housing developments, and protection from floods is still a need for those areas. There are other diked areas that are associated with controlling flooding on pasture land that can be looked at on a site-by-site basis to determine whether reconnecting to the floodplain would be beneficial or not.

- Legacy effects from many different kinds of past management degraded riparian-wetland areas in the watershed. Once a riparian-wetland area is degraded, it is easier to keep it in poor condition with just a few head of livestock, than it is to take a good condition riparian-wetland area and degrade it. Some landowners changed grazing management many years ago, and it led to the natural recovery of physical function, which was a good test of our hypothesis. We found other riparian-wetland areas that will respond to improved management.

- In some cases, improved management leads to the establishment of reed canarygrass (*Phalaris arundinacea*). Most people consider it non-native to eastern Oregon. While possibly native to North America, European cultivars have been widely introduced for use as hay and forage on the continent; there are no easy traits known for differentiating between the native plants and European cultivars. The species grows so vigorously that it is able to inhibit and eliminate competing species. Since it often forms persistent monocultures, it does pose a challenge to establishing native sedges and rushes.

One general recommendation for all the areas the WLA viewed was to first focus on regaining or maintaining the health of the riparian vegetation communities, and to establish benchmark conditions through a process such as Greenline Composition sampling (Winward 2000), accompanied by photo-point documentation. Riparian vegetation is critical to the long-term health of the alluvial systems in the Sprague, and increasing the vigor and quantity of diverse species should be paramount in recovery actions.

Another interesting thing learned was how often a recommended action benefited both the natural system and the landowner. Often it is presumed that, in order to improve the natural systems, there must be a long-term negative impact on agricultural operations (or vice-versa). But the field visits showed that sites where the stream was not working well were often also the sites where forage production had gone down. Since stream stability is invariably linked to the amount and vigor of the vegetation on the site, the solution to the stream problem often results in more forage as well.

CONCLUSION

Although this document is printed and bound, the Lower Sprague-Lower Williamson Watershed Assessment will continue to be a work in progress. The landscapes are always changing, and so are the human interactions with the natural resources. As new information and management practices surface, they can be included in this document to keep the document up to date and usable for the landowners and land managers within the Lower Sprague-Lower Williamson River subbasin. It is just as important to include failures in land management methods as it is to include successes, because they can often provide even more significant learning opportunities.

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CHAPTER 2. HISTORICAL CONDITIONS

The history of the Lower Sprague-Lower Williamson subbasin encompasses the pre-settlement era, the Yainax Sub-agency, the towns of Chiloquin, Sprague River, and Beatty, the timber industry with its logging and sawmills, the Oregon, California and Eastern (OC&E) Railroad, the livestock industry from sheep to cattle, and the Chiloquin Dam. Each of these in some way has influenced and defined the landscape and watershed conditions seen today. Following are brief summaries of these topics.

PRE-SETTLEMENT

Ed Chiloquin, grandson of the renowned Klamath Chief Chal-o-quin [Chiloquin], talks of a time when "…people lived in earth lodges, particularly during the winter months. At other times some lived in tepees, grass lodges, and bark lodges. Their main source of food was fish, wild animals, and native plants and berries, including wocis [waterlily], ipos, chokecherries, serviceberries, etc."

The first white men to arrive in the lower Sprague and Williamson rivers were envoys of the Hudson's Bay Fur Company, who reached the confluence of the rivers for the first time in the fall of 1826. Led by Finan McDonald and Thomas McKay, the group penetrated south from the Columbia River in search of fur trapping locales. Later that fall, on December 5, 1826, Peter Skene Ogden arrived near Chiloquin (Helfrich 1974). Peter Skene Ogden and his party of trappers traded with the Indians, securing foodstuffs to keep them alive until spring. They camped near the present site of Collier Memorial State Park.

Most of the information in this section was taken from the [Chief Chiloquin Interview], Lindsay Applegate Papers, Ax 4, Division of Special Collections and University Archives, University of Oregon, Eugene, Oregon 97403-1299.

YAINAX SUB-AGENCY

In 1865, after the establishment of the Klamath Indian Reservation, the Yainax Sub-agency was established (Helfrich 1974). The site of the Sub-agency is currently a private ranch owned by the Bartel family. It was located on the southern edge of the Sprague River valley to the south of Council Butte.

Yainax Sub-agency provided reservation management, a doctor, a school, and a jail. There was also a post office at this location for a short period of time in the late 1800s (Helfrich 1974).

CHILOQUIN

Picture of Downtown Chiloquin circa 1940 (Chiloquin 2007).

Many years before Chiloquin became a town, it was a campsite for a group of Klamath Indians. The name of the town came from the renowned Chief, Chal-o-quin, but became known as Chiloquin since some people found the original name difficult to pronounce.

In 1910, when the railroad was extended north from Klamath Falls to the terminal point in Kirk, Chiloquin was nothing more than a few shacks and tents scattered over a wide field at the confluence of the Sprague and Williamson rivers. The Chiloquin Mercantile and the Chiloquin Warehouse were the pioneer businesses in the town. The first movies were shown in the warehouse, where the audience sat on bales of hay and the picture machine was powered by the automobile engine of the itinerant movie operator. The first post office was established in 1912, with Mary A. Whittemore as postmistress.

Newspaper accounts of those times include the following descriptions: *Klamath Echoes*, August 20, 1912: "Chiloquin's new $5,000 depot was opened. Twice daily trains will run between Chiloquin and Klamath Falls."

Klamath Echoes, August 5, 1915: "Forty trains per day pass through Kirk (North of Chiloquin). Six railroad companies are operating out of Kirk. Daily shipments of around a million and a half board feet of logs are made over Southern Pacific Railroad to Klamath Falls and its mills."

During the daily round trip of the train from Klamath to Kirk through Chiloquin, the engineer stopped the train along Klamath Lake to pick up fishermen. One day, the train waited while a fisherman continued to net the last fish for his bag limit.

Because Chiloquin was located in the center of the Klamath Indian Reservation, white men had to purchase Indian allotments to obtain land. The first allotments on the site were sold in 1918. In the early 1920s, Henry Stowbridge, L. B. Robinson and Mary C. Jackson plotted the part of the town east of the Williamson River, on land that was known as the "Juda Jim Allotment." The west side was developed by R. C. and Alice Spink. Chiloquin was a boomtown known as the "Little Chicago of the West," where the keeping of law and order was one of the main problems.

A one-room school took care of the educational needs of the Chiloquin youngsters until the school year of 1918/1919, when two teachers were used rather than one. In the 1920s, Chiloquin's elementary and high school districts were formed. In the mid-1920s, construction began on a brick and stucco structure, which was finished in 1926 and housed the elementary and high school students. The last two years of high school were offered locally for the first time!

Between May of 1923 and the summer of 1929, a building boom hit Chiloquin. A. C. Gienger and his son Roy constructed the first brick business, a two-story building located on the site of their earlier wooden building, which they moved a block south. The brick building housed three or four stores on the first floor and apartments on the second floor. Henry Wolff, who, with his wife Josephine, had begun a successful bakery in the town the year before, built a brick building on the opposite side of the street from Gienger and moved in during the July 4th celebration in 1926. Three more blocks of brick buildings were completed during this era and ended with the Markwardt Bros. Garage, which opened in the summer of 1929. Gienger had begun a water works company early in 1924, which was later sold to the City of Chiloquin after incorporation on March 9, 1926. Gienger, who had worked hard for the city government, was elected the city's first mayor. None of the members of the council or of the city administration, who were responsible for drafting the laws of the new city, had ever been connected with municipal work before.

At that time in the area, there were 2,000 inhabitants, three big lumber mills, box factories, restaurants, barber shops, grocery stores, drug stores, doctors, dentists, lawyers, pool halls, dance halls and card rooms. Chiloquin was the trade area for the entire northern part of Klamath County and served Fort Klamath and the Klamath Agency as a mail and freight distribution point. Chiloquin was also the shipping point for the vast Klamath Indian Reservation and for a great expanse of country east of town along the Sprague River. Few small towns in any state could boast of handling the volume of business that daily went on in this bustling little community of so rich a land!

Edward M. Miller, Automobile Editor of the Portland *Oregonian*, said, on May 3, 1931:

> Having completed my pleasant duties at Crater Lake, I stepped on the throttle of J. K. Leander's free-wheeling Studebaker sedan and in less than an hour, found myself on the Williamson River Bridge in Chiloquin. The Williamson River bisects the city and joins the Sprague River a quarter mile below the city. Into this valley, provided by the two rivers, the town of Chiloquin has arisen in the last five years. A brand new city, nurtured by sawmills, lumber camps, railroads, Indians, sheep and cattle. Surroundings are handsome. Creeping into the city from the east and the west is a pine forest. The trees on the east rise high on a range of brown hills. On the western horizon are the peaks of the Cascade Range, snow-capped in winter and spring.
>
> As reported in the Portland *Oregonian* on May 3, 1931: "Chiloquin stands as one of the few communities in the United States without a luncheon club. The town makes no apologies and explains that businessmen can't afford to take off for lunch." In addition,

"Chiloquin is the largest livestock shipping point on the Southern Pacific lines in Oregon; 6,000 head of cattle going out every fall and coming in every spring."

Beginning around 1910, the lumber industry in Klamath County experienced rapid growth, and lumber products became the lifeline of the Chiloquin area. In 1916, Wilbur Knapp built a small circular sawmill on the Williamson River, one mile north of Chiloquin. In 1924, the mill was sold to the Forest Lumber Company from Kansas City, Missouri, who changed the name to Pine Ridge Klamath County Oregon Division. In 1939, a fire burned the entire plant, and it was not rebuilt.

John Bedford and Harold Crane built the Sprague River Lumber Company on the Sprague River, three miles east of Chiloquin in 1919. The mill was sold to William Bray in 1921 and became the Braymill White Pine Company before closing in 1928 after the stock market collapse. Bray let some of the crew that had worked in the mill at the time of the shutdown live in the company houses during the Depression.

In 1918, E. A. Blocklinger and his son, Arthur, organized the Chiloquin Lumber Company and Box Company on the Sprague River at Chiloquin. The box factory burned in 1947. The mill subsequently became The Chiloquin Mill, owned by the Salvage Brothers of Cave Junction, Oregon. It was purchased by Ernest DeVoe and J. R. Simplot in 1955. In 1962, DeVoe sold his interest to Simplot, who operated the mill under the name of the Simplot Lumber Company until it was sold to the DiGorgio Corporation in June of 1969. The plant then operated under the name of Klamath Lumber Company, a subsidiary of the Klamath Lumber Mill in Klamath Falls, until the name was changed to D. G. Shelter Products. In June of 1977, the plant was sold to a group in Bend, Oregon, and was renamed Chiloquin Forest Products. The plant was closed in 1988.

The closures of the lumber mills in Chiloquin, the Depression and a series of disastrous fires had a major effect on the town. The population of the incorporated portion of Chiloquin is now approximately 750 people; this does not, of course, include the many residents who live within the Chiloquin mailing area but outside of the city limits, which is where the greatest growth is now being experienced.

The above section was adapted from the webpage of the City of Chiloquin, which states that this information was compiled by Darlene Lightner (Chiloquin 2007).

TOWN OF SPRAGUE RIVER

The youngest town in the Sprague River valley is Sprague River, begun as a direct result of the construction of the OC&E Railroad. At approximately the same time, anticipating the arrival of the railroad, several logging camp operations were also set in motion, at least two sawmills were planned, and construction on them began (Helfrich 1974).

The post office was opened in Sprague River on September 14, 1923. Today, the post office is located in the café. The Sprague River School, which included elementary and high schools, was started in 1921. This school was later (about 1964) combined with the Chiloquin School (Helfrich 1974). In the mid-1980s the Sprague River school building burned down.

BEATTY

The town of Beatty was originally established by Mr. and Mrs. Peffley, Methodist missionaries, who built a parsonage on this southeast corner of the Klamath Indian Reservation. In 1915, the first store was built in Beatty and called "The Beatty Store." A new store and motel were built in 1938, on the site of which the Beatty Store and Motel still stand (Helfrich 1974).

Beatty had a school from around 1913 through 1940. At that time, the Beatty school was consolidated with the Bly school, because of the shortage of teachers during World War II (Helfrich 1974).

Beatty never had a mill, though one was established a few miles away on Whiskey Creek. During the 1950s, an active rodeo ground was located on the north side of Beatty. Local crowds attended regular rodeos at this location (Helfrich 1974).

TIMBER INDUSTRY

A number of mills were operated in the areas of Chiloquin and the town of Sprague River. These mills changed ownership regularly, and most were closed after World War II. The history of the individual mills is included in the timeline below. The towns of Chiloquin and Sprague River boomed during the height of the sawmill and logging industries. The towns have declined in services and population since the close of the mills (particularly the town of Sprague River).

The OC&E Railroad used water to move logs to the mill sites and lumber out of the mills. The Sprague River and Williamson River provided much-needed water sources for the mills.

RAILROAD

The city of Klamath Falls (originally known as Linkville) had long desired a railroad, and when the Southern Pacific (SP) Railroad completed its line into town from Weed, California, in 1909, the citizens went wild with celebration. The city had its link to the outside world, and better yet, that link was looking like it might turn into a major mainline railroad running between Oregon and California. However, by 1911 the railhead stopped at Kirk, 40 miles north of Klamath Falls, leaving the city part way up a dead-end branch line.

Business on the new railroad boomed from the start, but the plentiful business very quickly exceeded the capacity of the single-track railroad to the south to transport it. The citizens also felt that SP was charging too much, and many who celebrated the arrival of the railroad a few years before quickly grew to resent being at the mercy of only one railroad. It was not long before cries for some form of competition to SP were being heard.

Into this scene stepped Robert Strahorn, a railroad builder who had big plans to provide competition to SP. Strahorn's plans called for a 400-mile-long system based out of a central hub at Silver Lake, Oregon. The proposed system would have connected several dead-end railroads in the central part of the state with each other and would have provided the citizens and businesses of Klamath Falls with alternatives to the SP. Strahorn then formed the Oregon, California & Eastern Railroad on October 6, 1915,. After a series of complications and slow construction, the railroad to Sprague River was finally completed and a "golden spike" to mark the completion of the first 40 miles was held on October 12, 1923.

The completion of the OC&E to Sprague River did open up vast new stands of timber to harvesting, and in many cases loggers had already accumulated huge decks of logs adjacent to the grade before any rails had been laid. In the summer of 1923, the railroad was already delivering 40 carloads of logs per day to the SP for shipment to sawmills around the Klamath Basin, and new requests for sidings to load log cars on were being received on a regular basis. By the following summer, Strahorn was boasting that his railroad was handling around a billion board feet of lumber each month.

Today much of this railroad line from Klamath Falls to Sprague River and beyond to Bly has been removed. The remaining railroad bed has been converted to the OC&E Trail, which is an Oregon State Park operated by the Oregon Department of Recreation.

This section was adapted from information in the TrainWeb webpage, which was accessed in November 2007 (TrainWeb 2007).

LIVESTOCK INDUSTRY

In the late nineteenth century, as a result of the passing of a federal law known as the Dawes Act, many of the restrictions on non-Indian use of reservation grazing lands were relaxed or eliminated. When the Klamath Indian Reservation was first created, only Indians could graze on the Indian land, but as the nineteenth century ended, more and more non-Indians were leasing allotments on the reservation. Most of the reservation was unfenced, providing little control of livestock numbers in different areas. This situation resulted in an increase in livestock numbers (sheep and cattle) in the late nineteenth and early twentieth centuries, which meant that the range immediately adjacent to the reservation, including almost all of the territory covered by this Watershed Assessment, experienced very heavy grazing pressure nearly year-round.

During the time of early agricultural development in the area, a number of weirs were built across the Sprague River in the valley reaches (National Archive photographs). These photographs showed brush and logs stacked across the river. The dams created diversions to flood irrigate the pastures and hay ground later in the season. All of these weirs were washed out over time with heavy flood waters. The loss of these dams may have reshaped the channel cross-section, creating the entrenched system that exists to this day.

CHILOQUIN DAM AND RIVER CHANNELIZATION

The Chiloquin Dam is located just south of the town of Chiloquin on the Sprague River, about a mile above the Sprague confluence with the Williamson River, and about 15 miles above Upper Klamath Lake. The Chiloquin Dam was constructed in 1917 as a control structure for the point of diversion of the United States Indian Irrigation Service project for Modoc Point. When the Klamath Indian Reservation was terminated in 1954, the dam, its canal, and the Modoc Point irrigation project were transferred to the Modoc Point Irrigation District.

During the 1950s, the U.S. Army Corps of Engineers (Corps of Engineers) initiated a program of channelization of flows within portions of the Sprague River and West Sprague River watersheds. It has been difficult to obtain details regarding this channelization, but sections through the Sprague River valley west of Council Butte and the valley reach to the west of the Sprague River valley have been channelized and diked.

There are local citizens who were involved with the construction, who have indicated that the activities occurred at a time when flood control modifications were taking place throughout the western states. This wave of flood control construction stemmed from passage of a National Flood Control Act in 1936, which authorized and funded the Corps of Engineers to implement such projects. Actual implementation was delayed due to World War II, but after the war was over, there were two major flood events in the southern Oregon region, one in 1950 and the other in 1964. With funding, personnel and equipment, as well as a strong interest in preventing further flood damage, the Corps of Engineers made major modifications in a relatively short time. Officials at the Corps of Engineers have indicated that the structures were likely built under an "emergency authorization," which would mean that little or no planning or documentation of construction activities would have been required (Jennifer Sowell, Corps of Engineers, pers. comm.).

A long-time resident in Bly, Butch Hadley, worked on the dredging and diking of the Sprague River. He explained that the Corps of Engineers was also advocating and conducting willow removal, in order to "conserve" water for agriculture, without realizing the impacts on the streambanks and eventual erosion (need reference here as well).

TIMELINE OF SIGNIFICANT EVENTS

- 1826 (fall): Hudson's Bay Company party led by Finan McDonald and Thomas McKay penetrated south from the Columbia River as far as the neighborhood of present day Chiloquin on the confluence of the Sprague and Williamson rivers (Helfrich 1974).

- 1826 (December or winter): Hudson's Bay Company Fur Brigade of Peter Skene Ogden arrived near Chiloquin on December 5 (Helfrich 1974).

- 1846 (early May): Captain John C. Fremont, with Kit Carson as guide, entered Klamath Country to circle Upper Klamath Lake. During this stay he had a battle with Indians on the Williamson River, near the present-day Highway 97 crossing (Helfrich 1974).

- 1855: Lt. R .S. Williamson, who was attached to the Pacific Railroad Party, traveled through the Klamath Country from south to north by a route approximating the present-day Highway 97 (Helfrich 1974).

- 1863 (spring): Sprague River was known as Martin's River as a group of miners led by John W. King passed through the area en route from the Shasta Valley to Canyon City. One wonders if the river was named after General R. M. Martin, who trailed 300 head of cattle on this route during the spring (Helfrich 1974).

- 1864 (June 28): Col. C. S. Drew started on an expedition that resulted in the opening of a trail from Fort Klamath, via Sprague River, Drew's Valley and Goose Lake to the Applegate Trail, which crossed the Warner Mountains over Fandango Pass (Helfrich 1974).

- 1865 (July 17): The Oregon Central Military Road Company (OCMRC), under B. J. Pengra, left Eugene looking to build a road over the Cascade Mountains to the eastern boundary of Oregon (Helfrich 1974).

- 1865 (August 8): The OCMRC, under the military escort of Lt. John McCall, arrived at Sprague River and set up camp at Council Butte. Pengra signed a treaty with Paulina on the August 13 (Helfrich 1974).

- 1866: Captain F. B. Sprague was in command at Fort Klamath. It is said that his name was applied to the river as early as 1864.

- 1869: Yainax Sub-agency, with Ivan D. Applegate as superintendent, was established at Yainax for the administration of the reservation. Here he conducted the affairs of the Sprague River Klamaths, Paiutes, and a large division of the Modoc tribe under Chief Schonchin. The sub-agency was located at the foot of Yainax Butte, now known as Council Butte (Helfrich 1974).

- 1882: First school opened at Yainax (Helfrich 1974).

- 1909 (May 20): The Klamath Lake Railroad, operated by SP, reached Klamath Falls. The line eventually reached Chiloquin and Kirk in 1911 (Helfrich 1974).

- 1912: First post office at Chiloquin was established, with Mary A. Whittemore as postmistress (Chiloquin 2007).

- 1913 (Nov. 10): Reverend J. L. Beatty, second pastor of the Yainax Church, secured a post office called Beatty. The Beatty Store was opened in the spring of 1915 by J. L. Sparretorn (Helfirch 1974).

- 1914: Chiloquin Dam was built by the U.S. Indian Service as part of the Klamath Indian Irrigation Project. The purpose of the dam was to encourage farming by Indians (Battelle Memorial Institute 2005).

- 1915 (August 5): By this time, 1.5 million board feet of logs were being sent on the SP Railroad through Chiloquin to Klamath Falls (Chiloquin 2007).

- 1915 (October 6): Robert Strahorn formed the OC&E Railroad (TrainWeb 2007).

- 1916 (November): Issuing of bonds was approved by the Klamath Falls city electorate to raise $300,000 to begin construction of the railroad. Prominent citizens raised $50,000 to purchase a lot for a train terminal in Klamath Falls (TrainWeb 2007).

- 1916: Wilbur Knapp built a small circular saw on the Williamson River, one mile north of Chiloquin. The mill was sold to the Forest Lumber Company of Kansas City in 1924 and burned down in 1939. The mill is not rebuilt (TrainWeb 2007).
- 1917 (July 4): First ground was broken in the construction of a 20-mile railroad to Dairy, and the line was completed in early 1919 (TrainWeb 2007).
- 1918: First allotments in Chiloquin, located in the center of the Klamath Indian Reservation, were sold to white men. This is the beginning of the boom, when Chiloquin was known as the "Little Chicago of the West" (Chiloquin 2007).
- 1918: Chiloquin Lumber and Box Company was organized in Chiloquin. The mill changed hands and names various times until its closure in 1988 (Chiloquin 2007).
- 1919 (May): Elections approved Strahorn's offer to buy the railroad for $300,000 worth of income bonds and his promise to complete the line to Sprague River. Klamath Falls deeded the first 20 miles of completed railroad to the OC&E Railroad (Chiloquin 2007).
- 1919: The Sprague River Lumber Company was built three miles east of Chiloquin. The mill was sold to William Bray in 1921 and became the Braymill White Pine Company. The mill closed in 1928 after the stock market collapse (Chiloquin 2007).
- 1920 (March 20): Saddle Mountain sawmill (in Sprague River) was first mentioned in newspapers. The mill never opened, because the necessary machinery could not be purchased, and it was sold to Campbell-Towle Lumber Company (Helfrich 1974).
- 1923 (September 16): Line from Klamath Falls to Sprague River was completed, opening vast new stands of timber for harvesting (TrainWeb 2007).
- 1923 (May): A building boom that lasted until 1929 hit Chiloquin. (Chiloquin 2007).
- 1923 (May 11): Frank Mutto, superintendent of Yainax Sub-agency, laid out a townsite of 300 acres that eventually becomes Sprague River (Helfrich 1974).
- 1923 (June 26): Sprague River White Pine Lumber Company sawmill neared completion (Helfrich 1974).
- 1923 (September 14): The post office at Sprague River officially opened, with Benjamin E. Wolford as its first postmaster (Helfrich 1974).
- 1926 (March 9): Town of Chiloquin was incorporated and A. C. Gienger became its first mayor. At this point, the town had a population of 2,000, three big lumber mills and a plethora of businesses. It became a mail and freight distribution point for the Sprague River valley (Chiloquin 2007).
- 1928 (May 10): By this date, the Sprague River White Pine Lumber Company was owned by Edgerton and Adams and had a capacity of 75,000 board feet per day (Helfrich 1974).
- 1928 (June 2): First ground was broken for the construction of the railroad from Sprague River to Bly. It was completed on November 24, 1928 (Helfrich 1974).

- 1928: Sprague River White Pine Lumber Company was bought by G. C. Lorenz and completely rebuilt. It operated under the name of Lorenz Lumber Company until 1930, when it was bought by the Crater Lake Lumber Company (Oregon Historical Society 2007).

- 1929 (May or June): Lorenz Lumber Company began construction of a five-mile-long railroad from the OC&E line near Sprague River to the Whiskey Creek watershed. Also, the Ewauna Box Company began construction of a railroad to extend 15 miles northwest of Sprague River (Helfrich 1974).

- 1931 (May): By this time, Chiloquin is the largest livestock shipping point on the SP Railroad, with 6,000 head of cattle going out every fall (Chiloquin 2007).

- 1937: The sawmill at Sprague River was operated by Crater Lake Box and Lumber Company (Helfrich 1974).

- 1943: The sawmill at Sprague River was shut down and dismantled (Helfrich 1974).

- 1954: The Klamath Tribes were terminated by an Act of Congress. Chiloquin Dam was then transferred from federal to Modoc Point Irrigation District ownership (OWRD 2004).

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CHAPTER 3. GENERAL GEOGRAPHIC CHARACTERISTICS

This Watershed Assessment covers the portion of the Sprague River basin (4th-field U.S. Geologic Society [USGS] Hydrologic Unit Code [HUC] number 18010202) from Beatty Gap on the Sprague River downstream to its confluence with the Williamson River and from Kirk Reef on the Williamson River to its delta at Agency Lake and Upper Klamath Lake. Previous watershed assessments or watershed analyses have been conducted for the South of Sprague Watershed Area (south side of the Sprague River between Sycan River confluence and Williamson River confluence). Information from this assessment has been incorporated into this report.

PHYSICAL CHARACTERISTICS

Size and Setting

The Lower Sprague-Lower Williamson subbasin is located in the Upper Klamath Lake Basin in Klamath County in south-central Oregon, east of the southern Cascade Mountains. The Lower Sprague-Lower Williamson rivers drain a varied landscape, from sloped hillsides to low-gradient floodplains and river deltas (Map 3-1). More than half of the watershed area lies within the Fremont-Winema National Forest. Notable geographic features in the watershed include Williamson River Delta, Chiloquin Dam, and the communities of Sprague River, Chiloquin and Beatty.

The Lower Sprague-Lower Williamson subbasin is characterized by three distinct regions: (1)the privately owned lowland valleys of the Lower Sprague and Lower Williamson rivers, which are used mostly for livestock and some hay production; (2)the Williamson River Delta, which is owned by a single private landowner and is used for natural ecosystem preservation and restoration; and (3)the forested upland region, the majority of which is publicly owned and managed by the U.S. Forest Service, and which also includes forest lands owned by private timber companies. Natural resource issues, problems and concerns often differ among these regions because of variations in climate and environmental conditions, as well as different land uses.

The area covered by this assessment is approximately 600 square miles, as determined by Geographic Information System (GIS) analysis. Within that area are a variety of aquatic features including perennial and intermittent streams, rivers and canals (Table 3-1). For the purposes of this analysis, the subbasin has been divided into several watersheds (5th-field hydrologic units) that comprise the basic units for many of the analyses presented in this report (Table 3-2). These four units are the North Sprague River, Sprague River, West Sprague River and Williamson River.

Most streams in the subbasin are intermittent with fewer streams being perennial or canal-type streams (Table 3-1). The canal miles do not include small irrigation supply, spreader, and drain ditches located on private irrigated lands. The canal miles refer to a large supply diversion owned by the Modoc Point Irrigation District.

The major streams within the watershed flow generally from east to west and north to south. The Lower Sprague River continues from Beatty Gap west to its confluence with the Williamson River. The Lower Williamson River continues south from Kirk Reef and then southwest from the Sprague River confluence until it reaches its delta at Upper Klamath Lake.

Elevation ranges from 4,143 feet at the Williamson River Delta to 7,268 feet at the summit of Swan Lake Point. Bly Mountain (5,684 feet), Round Mountain (5,409 feet), Bug Butte (4,907 feet), Council Butte (4,622 feet), Horse Butte (4,904 feet), Cooks Mountain (6,822 feet), Fuego Mountain (6,822 feet), Calimus Butte (6,599 feet), Saddle Mountain (6,845 feet), Swan Lake Point (7,268 feet), Crawford Butte (5,340 feet), Little Applegate Butte (5,792 feet), Applegate Butte (6,011 feet) and Solomon Butte (5,760 feet) are prominent high points in the watershed (OGEO 2005). See Map 3-1.

Table 3-1 Stream length (miles) by stream type in the Lower Sprague-Lower Williamson subbasin. [1]
(Data Source: USFS 2005)

Stream Type	Watershed				
	North Sprague River	Sprague River	West Sprague River	Williamson River	Total
Canal	0.0	0.0	0.8	5.7	6.5
Intermittent	113.0	218.8	151.6	117.6	600.9
Perennial	4.7	89.8	53.4	36.8	184.7
Total[2]	117.7	308.7	205.7	160.0	792.0

[1] The length of stream quantified on a map is a function of the scale and resolution of the map; larger scale maps will show more streams. The stream length used for the Assessment is the length of canal, perennial and intermittent streams that were resolved at the map scale of the GIS data used for the Assessment (approximately 1:24,000).
[2] Totals may not reflect numbers in this table due to rounding.

Table 3-2 Watersheds and key streams of the Lower Sprague-Lower Williamson subbasin.
(Data Sources: USFS 2005, NRCS 2005[1])

Watershed	Area (mi^2)	Major Streams	Total (mi)
North Sprague River	123.0	Sprague River	0.4
		Unnamed	117.3
Sprague River	183.9	Cherry Creek	1.3
		East Branch Whiskey Creek	7.7
		Middle Fork Trout Creek	1.7
		North Fork Trout Creek	3.7
		Rock Creek	10.9
		South Fork Trout Creek	6.4
		Sprague River	46.9
		Sycan River	0.0
		Trout Creek	1.6
		Unnamed	214.1
		Whiskey Creek	14.3

Watershed	Area (mi^2)	Major Streams	Total (mi)
West Sprague River	176.0	Modoc Point Main Canal	0.8
		Sprague River	43.8
		Unnamed	161.1
Williamson River	116.7	Larkin Creek	3.5
		Modoc Point Main Canal	5.7
		Sprague River	0.1
		Spring Creek	3.5
		Unnamed	119.2
		Williamson River	28.0
Total	599.6		792.0

[1] 6th-field hydrologic unit codes (HUCs) were aggregated to form the four watersheds listed in the table. These HUC aggregations are listed below:

North Fork Sprague River = Cooks Creek, Knot Tableland, and Macs
Sprague River = Sprague above Williamson, Whiskey Creek, and Dockney Flat
East Sprague River = Applegate, Long Prairie, Lower Sprague River, and Copperfield Draw
Williamson River = Williamson River-Spring Creek, Williamson at Kirk, Williamson-Sprague Rivers

The "Williamson River" watershed was modified to include the land area (4.6 square miles) known as Modoc Point.

The boundaries of Modoc Point were defined as:
Western boundary = Klamath Lake
Northern and eastern boundary = Williamson River below Klamath Marsh watershed
Southern boundary = the apparent watershed divide as derived from a digital elevation model (DEM) hillshade

The growing season varies considerably across the subbasin. The Sprague River valley has a growing season of about 50 to 70 days (WRCC 2007. The majority of irrigation is for pasture and alfalfa. Mountainous areas are mostly used for timber, range and wildlife habitat. Where annual precipitation is between 10 and 16 inches, plant cover consists mostly of big sagebrush, antelope bitterbrush, western juniper, other shrubs and bunchgrasses. Where annual precipitation averages between 16 and 35 inches, forests of ponderosa pine, Douglas-fir, white fir, lodgepole pine and other tree species are predominant.

Land Ownership

More than half of the land in the assessment area is national forest (U.S. Forest Service, USFS). Other major land holders are private timber companies, other private landowners, and The Nature Conservancy (TNC). The Bureau of Land Management (BLM) and the State of Oregon have small holdings in the subbasin (Table 3-3, Map 3-2). The major land uses in the subbasin are industrial forestry and agriculture, and the major vegetation type is coniferous forest.

Table 3-3 Land ownership in the Lower Sprague-Lower Williamson subbasin (square miles).
(Data Source: USFS 2005)

Owner	North Sprague River	Sprague River	West Sprague River	Williamson River	Total
Bureau of Land Management	0.0	0.1	0.0	0.0	0.1
Private	53.5	97.2	24.0	45.1	219.7
Private Commercial Timber	0.6	0.3	3.0	12.2	16.1
State	0.0	0.5	0.2	5.7	6.4
U.S. Forest Service	68.9	85.9	148.7	53.7	357.2
Total[1]	123.0	183.9	176.0	116.7	599.6

[1]Totals may not reflect numbers in this table due to rounding.

Climate

The climate of the Lower Sprague-Lower Williamson subbasin is largely determined by the prevailing air masses that move in from the Pacific Ocean but are greatly modified when crossing the Coast Range and Cascade Mountains. Continental air masses that move down from the interior of western Canada are also a major weather factor. The resulting climate is much drier than that of western Oregon, and has more extreme temperatures, particularly in winter months. Seasonal characteristics are well defined, and changes between seasons are generally gradual.

Average annual precipitation ranges from 12 to 16 inches in the valleys, 16 to 25 inches in nearby hills, and 30 to 40 inches at higher elevations. In Chiloquin, about 46 percent of the moisture occurs in winter, 23 percent in spring, 8 percent in summer and 23 percent in fall. In the town of Sprague River, approximately 41 percent of the moisture occurs in winter, 23 percent in spring, 11 percent in summer and 25 percent in fall. The precipitation in the area is characterized by a secondary peak in May just before the beginning of the dry summer (WRCC 2007).

Snowfall accounts for about 30 percent of the annual precipitation in the valleys and as much as 50 percent in the mountains. Annual snowfall averages 15 to 45 inches in the valleys, 60 to 125 inches in the foothills and over 160 inches in some places above 4,500 feet elevation. Maximum snow depths have varied typically from two to three feet in the valleys and from five to six feet in the hills and mountains. Despite being at a lower elevation, Chiloquin has significantly more snowfall than Sprague River and Beatty, probably because it is closer to Crater Lake and the southern Cascade Mountains, where snowfall amounts are high (WRCC 2007).

Warm days (of 90° Fahrenheit (F) or above) average 15 days per year in the valleys and 5 days per year in the mountains. The average daily maximum temperatures for Klamath Falls and Chiloquin are similar, but the average daily minimum temperatures at Chiloquin are about 6° F cooler in winter and 12° F cooler in summer. At the 6,500-foot level in the mountains, maximum temperatures average from 5° F cooler in winter to 14° F cooler in summer as compared to Klamath Falls and

Chiloquin. Record temperatures in the area have ranged from –28° F at Chiloquin in 1937 to 105° F at Klamath Falls in 1911 (WRCC 2007).

At Klamath Falls, prevailing winds are southerly for November through February; westerly from March through July; and northerly during August, September and October. Monthly wind speeds average from 4.4 miles per hour in September to 7.3 miles per hour in March. Wind conditions are calm 17 to 33 percent of the time. Conditions differ throughout the assessment area, in part due to elevation and topographic variation (WRCC 2007).

Thunderstorms average about 12 per year, with an occasional severe hailstorm. Hailstorm damage, however, is rarely severe or widespread. Average yearly cloudiness is about 50 percent at Klamath Falls; 130 days are clear, 90 are partly cloudy, and 145 are cloudy. Early morning values of relative humidity average 74 to 83 percent year-round, and the afternoon low values range from 26 to 33 percent in summer and from 62 to 74 percent in winter (WRCC 2007).

CULTURAL CHARACTERISTICS

Population and Early History

The Lower Sprague-Lower Williamson subbasin has been the home of Native Americans for centuries. The area was a seasonal home to the Yahooskin band of the Northern Paiute Tribe, who traveled into the eastern end of the Lower Sprague each year to harvest and hunt the native flora and fauna. The tribes lower down the river— the Klamaths and Modocs—also use the Lower Sprague River and Lower Williamson River systems on a seasonal basis. Nevertheless, the area east of Trout Creek was primarily Yahooskin territory, at least at the time of European settlement, whereas the area from Upper Klamath Lake to west of Trout Creek was primarily Klamath territory.

Europeans came to Klamath County in the early nineteenth century. About 1820, Peter Skene Ogden led a party of Hudson Bay Company trappers into the area to trap and explore. Two military expeditions organized by John C. Fremont explored the area in the 1840s. A military party, surveying a railroad route from the Sacramento Valley to the Columbia River, came through the area in 1855.

The Klamath Indian Reservation was established by treaty on October 14, 1864. The Sprague River valley west of the Beatty Gap, the Wood River valley east of the Wood River, and part of the Winema Forest was included in the Klamath Indian Reservation. In 1954, the Klamath Tribes were terminated. The Federal Government ended its supervision over Klamath Indian affairs in 1960, and at that time most of the land on the reservation became privately owned. The Tribes regained federal recognition by an act of Congress in 1986.

The population of Klamath County was 66,438 in 2006 as estimated by the U.S. Census Bureau, an increase of 2,663 since 2000, and a 16-fold increase from 3,970 in 1900. Most of the growth in Klamath County has been in and around Klamath Falls; therefore, the rate of population change in the assessment area is likely slower. In 2000, the population of ZIP code 97621, which includes Beatty, was 363 and the population of Chiloquin was 716 (U.S. Census Bureau 2006).

Agriculture

Range and forest land dominate the landscape in the Lower Sprague-Lower Williamson subbasin. Irrigated agriculture is found primarily in the Sprague River valley reaches between the towns of

Beatty and Sprague River and further downstream. The irrigated land is almost all pasture and hay fields. Timber management is an important land use in much of the upper assessment area. The Lower Sprague-Lower Williamson subbasin presents numerous challenges as well as opportunities for agriculture. The cool climate, limited rainfall and short growing season limit the number of crops that can be grown successfully. Farmers currently grow only a few crops in the area, including barley, oats, alfalfa, potatoes and grass.

The Lower Sprague-Lower Williamson subbasin is well suited to raising livestock and has been intensively used for that purpose for many decades. Some of the most intense grazing pressure within the Lower Sprague-Lower Williamson subbasin occurred between 80 and 120 years ago (National Archive photographs). During that time, there was heavy grazing of sheep and some cattle. Since then, much of the original riverside woodlands, riparian zones and wetlands have been modified by diking, draining, spraying herbicides, land clearing and grazing.

In recent years, management methods in both the public and private sectors have been changing in response to shifting economic, social and regulatory developments. Private landowners throughout the assessment area have been pursuing cooperative projects that have resulted in measurable improvements in habitat conditions and ecosystem function. Federal programs, such as the National Resources Conservation Service (NRCS) Wetland Reserve Program and the Conservation Reserve Enhancement Program, as well as various state programs, provide financial assistance to ranchers who place environmentally sensitive acreage under conservation easements.

Forestry

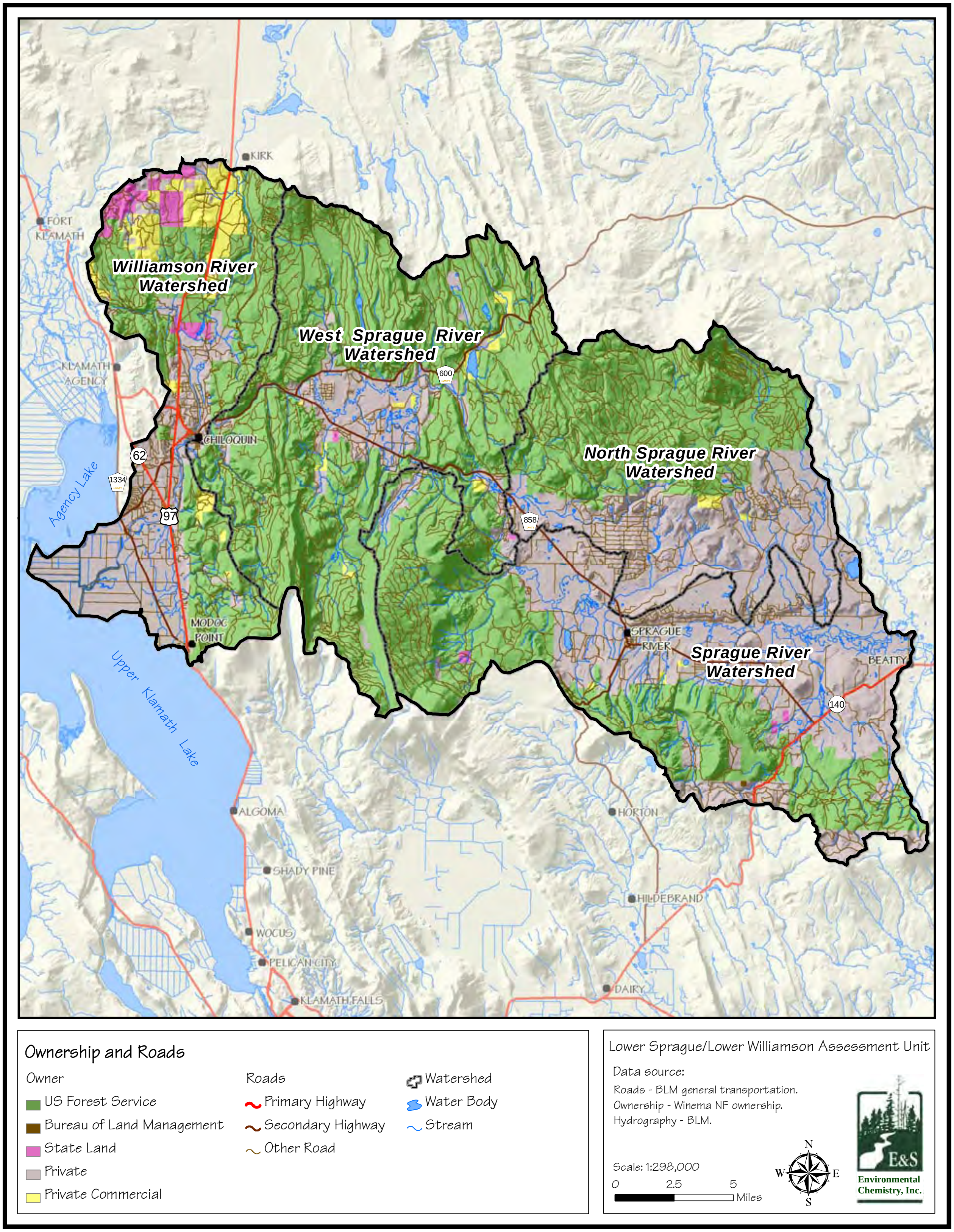
The logging industry has operated in the Upper Klamath Basin since the railroad first arrived in Klamath Falls in 1909. Timber interests were aware of the massive ponderosa pine stands in the Sprague and Williamson Rivers region since the 1850s, but had been prevented from exploiting the stands because there was no way to get the lumber to market. The OC&E railroad was constructed through the Sprague River valley in the early 1920s. A number of mills were located within the Lower Sprague-Lower Williamson subbasin in and around Chiloquin and the town of Sprague River. Additional mills were located three miles east of Chiloquin (Bray's Mill) and a mill on Whiskey Creek. Mills changed ownership regularly, and some were in operation through the 1950s.

Forestry activities today are more focused on improvement of forest health conditions, thinning to help achieve properly functioning forest conditions, and management of fire risk and fuel loads. Extractive logging is not as important to the local economy as it was in earlier decades.

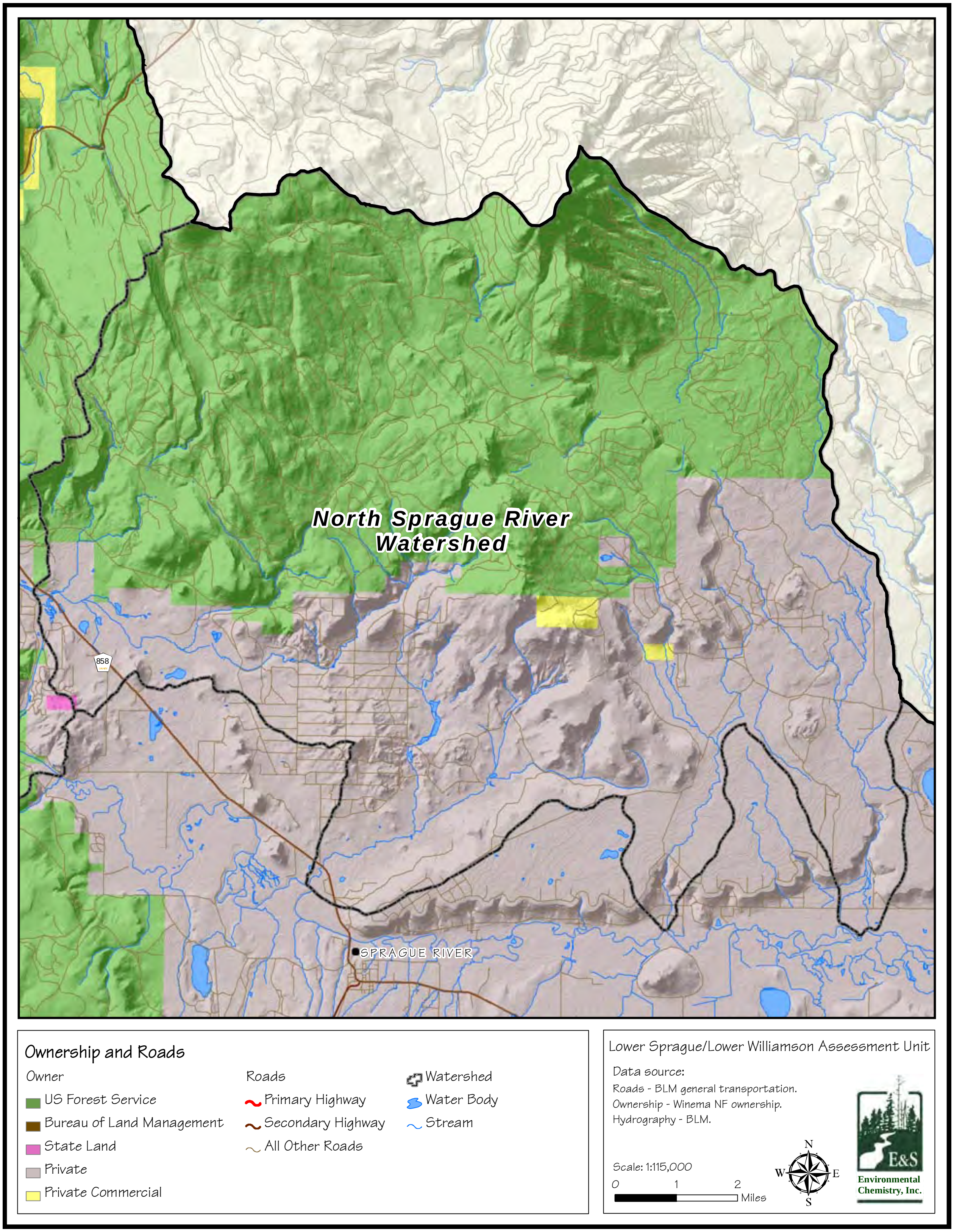
Recreation

Recreational opportunities are plentiful in the assessment area. Popular activities include fishing, hunting, horseback riding, backpacking, hiking, cross-country skiing, camping, bird-watching, rock climbing and leisure driving. Several varieties of trout inhabit the lakes and streams of the subbasin, and the marshes of the subbasin provide habitat for a variety of waterfowl. Small populations of large predators (cougar and bobcat) are present, as well as grazing game species including elk, pronghorn antelope and mule deer. In addition, there is a variety of nongame species.

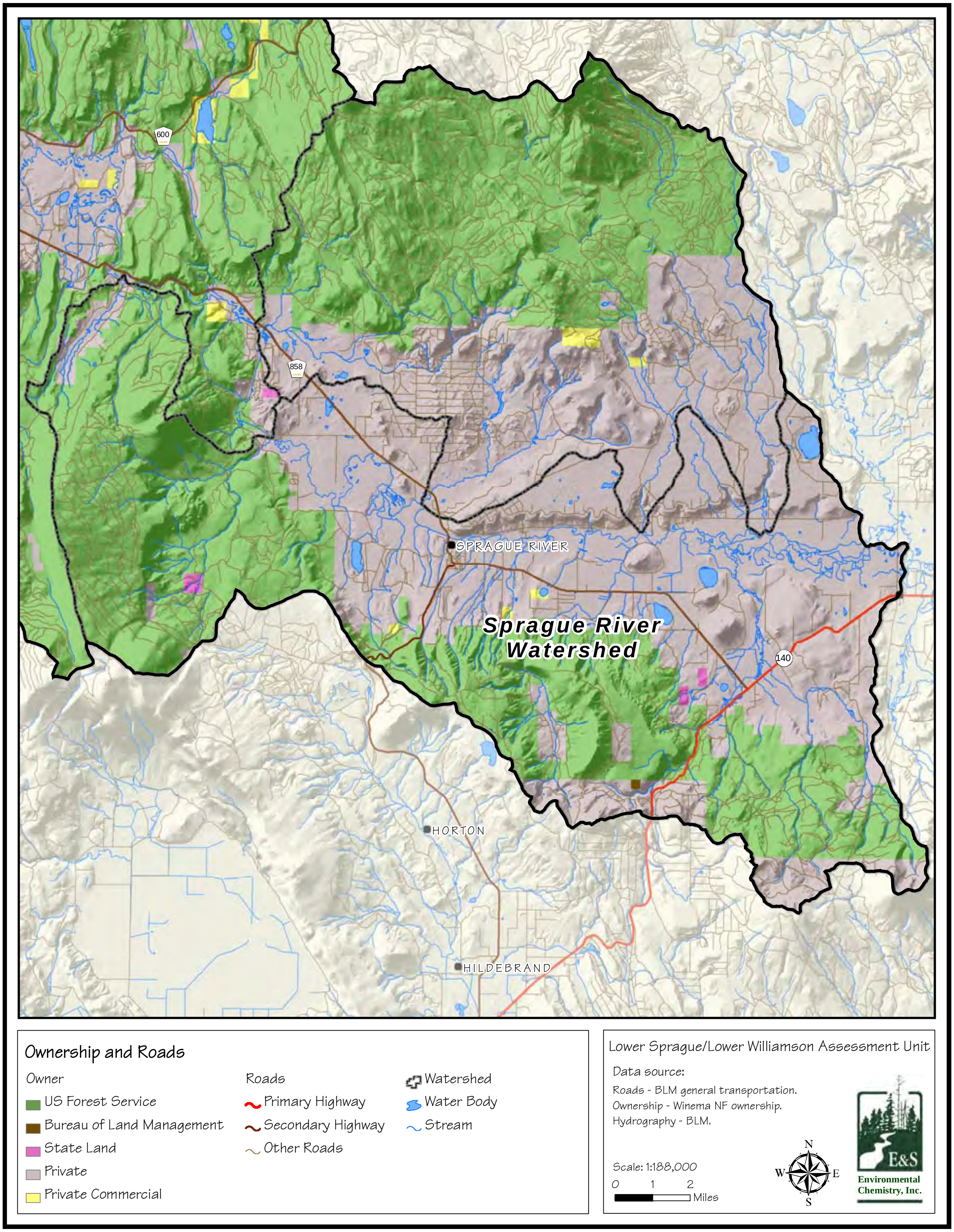
Map 3-1 Geographic features of the Lower Sprague-Lower Williamson subbasin. (Data Sources: USFS 2000, BLM 2005)



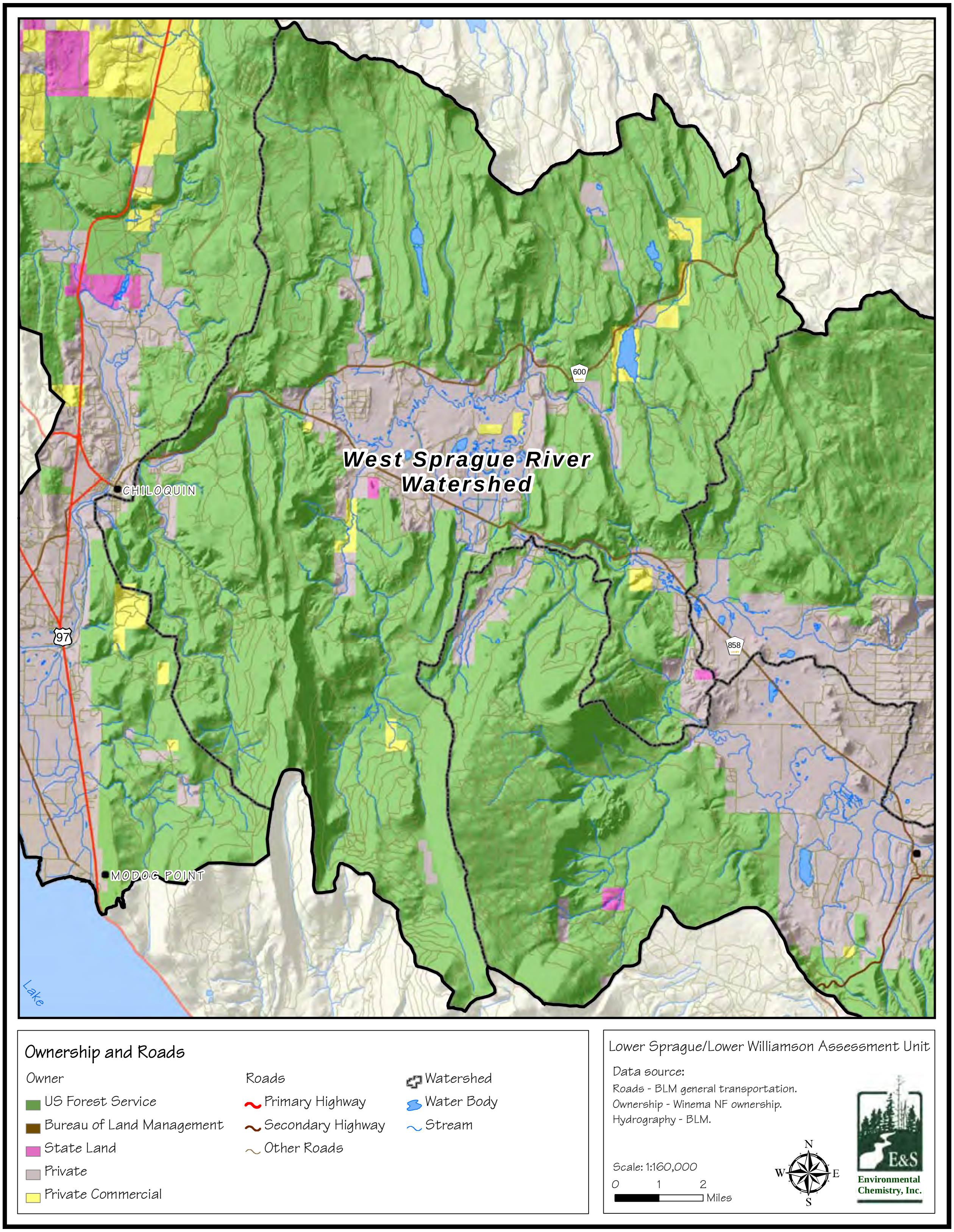
Map 3-2 Land ownership in the Lower Sprague-Lower Williamson subbasin. (Data Source: USFS 2005)



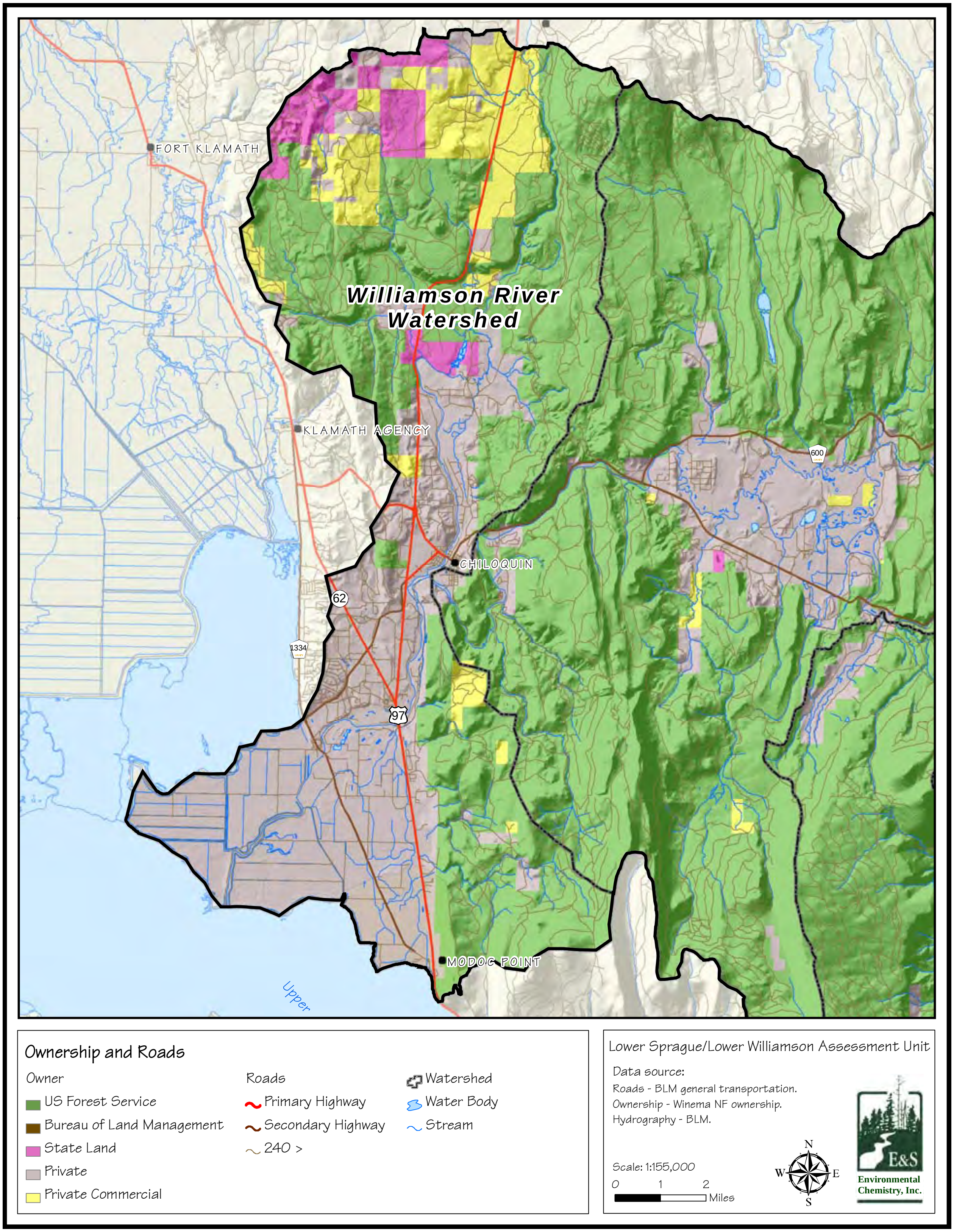
Map 3-2a Land ownership in the North Sprague River watershed. (Data Source: USFS 2005)



Map 3-2b Land ownership in the Sprague River watershed.
(Data Source: USFS 2005)



Map 3-2c Land ownership in the West Sprague River watershed. (Data Source: USFS 2005)



Map 3-2d Land ownership in the Williamson River watershed. (Data Source: USFS 2005)

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CHAPTER 4. GEOLOGIC PROCESSES

CHARACTERIZATION

This section summarizes the geology, geomorphology and soils of the Lower Sprague-Lower Williamson subbasin. It also summarizes available information regarding the potential for soil erosion, mass movement and streambank erosion. Information presented is based on existing studies, especially by NRCS (2006a, 2006b), USFS (2005), and Oregon Department of Fish and Wildlife (ODFW 2006). Discussion of erosion impacts is based on assessment summary information provided by Biosystems (2003) and WPN (1999).

The geologic history and current geological setting of the watershed are important to understanding natural resource issues within it. In particular, geologic variation throughout the watershed can influence erosion and the delivery of sediment to the stream system. Excessive sediment can cause problems, but appropriate sediment is critical to maintaining both channel function and suitable fish spawning habitat. A geology map is available covering the entire Lower Sprague-Lower Williamson subbasin (Walker and MacLeod 1991).

The Klamath Basin has a complex geologic history that has resulted in a unique assemblage of fish species. In the Pleistocene Epoch the modern Klamath Basin was dominated by pluvial Lake Modoc, which began to recede approximately 10,000 years ago (Dicken 1980). Presently the Klamath River flows into the Pacific Ocean; however, it is believed that at one time there was a connection between the upper Klamath and the Snake River system (Minckley et al. 1986).

Volcanic activity has also been a significant factor influencing the Klamath Basin. The Klamath Basin is somewhat unique in that it represents one of the few areas that was not glaciated during the Wisconsin Ice Age (Haas and McPhail 2001). Many of the soils and rocks exhibited today in the Klamath Basin are of volcanic origin. The entire Sprague River valley is highly faulted in the northwesterly direction, with secondary fault lines in the northerly direction. These fault lines make determining groundwater hydrology, including flow direction and location of aquifers, complex and difficult to characterize. Bly Mountain is an example of a mountain that was formed by uplifting along a fault line (Bruce Topham, pers. comm. 2008).

The geological history of the Lower Sprague-Lower Williamson subbasin has included periods of extensive volcanic activity. Basalt flows caused by volcanic extrusions blocked rivers that drained the region, creating large, shallow lakes. Large quantities of volcanic material were deposited into the shallow waters from the Cascade Mountains and other nearby volcanic sites (Carson 1979).

Erosion and the subsequent transport and deposition of sediment within the stream system are natural processes. The timing and magnitude of erosion varies from watershed to watershed and among stream reaches within a given topography. Many aquatic organisms are adapted to deal with a range of conditions, including episodes of intense erosion and sediment movement during large storm events, snowmelt and landslides, and following high-intensity fire seasons. Additional significant sources of sediment are rill and gully erosion.

Data that reflect erosion potential are available from the USFS Fremont-Winema National Forests and the NRCS. The Fremont-Winema National Forest (NF) soil surveys provide data on soil type and surface erosion potential on the national forest lands. The NRCS Soil Survey Geographic (SSURGO) data are available for some of the private land areas bordering the Sprague and Williamson rivers. The NRCS State Soil Geographic (STATSGO) map provides a general soil map covering the entire Lower Sprague-Lower Williamson subbasin.

CURRENT CONDITIONS

Geology

Geologic processes have created many different physiographic provinces, or areas of similar geomorphology, within Oregon. The Lower Sprague-Lower Williamson subbasin is located within the Basin and Range physiographic province. The subbasin lies in a transitional zone with the adjacent Cascade-Sierra Mountains physiographic province.

Approximately 42.0 percent of the Lower Sprague-Lower Williamson subbasin is underlain by geologic material that formed during the Tertiary period. This period began 65 million years ago and ended 1.7 million years ago with the beginning of the Quarternary period. Of the remaining area of the Lower Sprague-Lower Williamson subbasin, 57.7 percent is composed of rocks formed during the transition from the Tertiary period to the Quarternary period and within the Quarternary period. The additional 0.2 percent is open water. This information is displayed in Table 4-1 and Map 4-1.

Volcanic activity has generated much of the present day bedrock material in the subbasin. Volcanic eruptions, such as the eruption of Mt. Mazama approximately 7,000 years ago that formed the Crater Lake caldera (USGS 2006a), resulted in lava flows and ash deposits that followed the local topography, spreading down the mountain slopes and across the lower elevations. Sedimentary rocks are also present in the subbasin, particularly in the area north of the Williamson River Delta on the eastern side of Agency Lake and in the valley floors along the Lower Sprague River (Map 4-1).

Quartenary Basalt (geologic type symbol - QTb) is the most common rock in the Lower Sprague-Lower Williamson subbasin, covering 217.8 square miles (36.3 percent). Basalt is low-viscosity volcanic rock with less than about 52 percent silica. Eruptions occur at temperatures between 2,000º F and 2,300º F, and may release volcanic gases without creating large eruption columns or may form lava fountains hundreds of feet tall. In addition to silica, olivine, pyroxene and plagioclase are commonly found in basalt (USGS 2006b). Quartenary Basalt is located in the mountains surrounding the Sprague and Williamson rivers.

Tertiary Tuffaceous Sedimentary Rocks and Tuff (geologic type symbol - Ts) is the second most prevalent rock within this subbasin. This rock encompasses 109.6 acres (18.7 percent) and is located on the valley floors and along the valley slopes.

Over time, physical as well as chemical processes have weathered the bedrock and produced the variety of soil types that exists within the Lower Sprague-Lower Williamson subbasin. Five major types of bedrock parent material are responsible for the derivation of the various groups of soils within the subbasin (Wenzel 1979):

Rocks of alluvial or lacustrine origin—these materials were once moved by water or developed within a lake bottom;

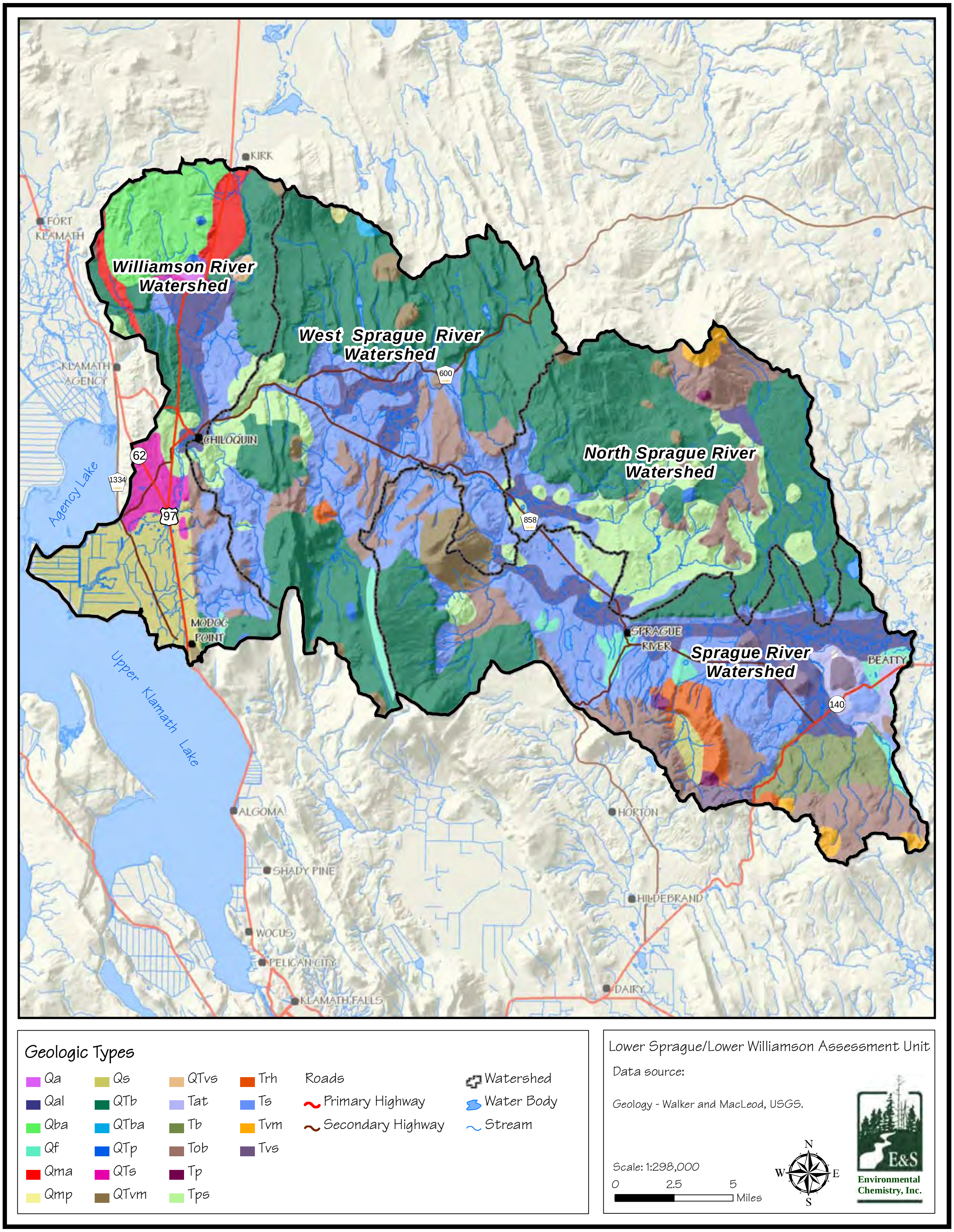
Interbedded basalt, andesite and tuff—these rock types are found on rolling lava tablelands, block faults and shield volcanoes;

Rhyolite—a fine-grained, light-colored extrusive rock that is highly fractured, moderately hard and high in silica content;

Pyroclastic and sedimentary rocks—these are highly variable rocks including tuff, breccia, mudflows, lacustrine tuffaceous sandstone and ashy diatomite; and

Eolian Mazama ash and pumice deposits—these volcanic materials were deposited by wind.

Rhyolite, pyroclastic and sedimentary rocks are all typically highly fractured. Knowing the locations where the bedrock has a high potential for fracturing is important to understanding the hydrogeology of the subbasin. Fault lines make determining groundwater hydrology, including flow direction and location of aquifers, complex and difficult to characterize. The U.S. Geological Survey (USGS) just finished conducting a groundwater survey and modeling project in order to better understand the hydrogeologic nature of the Lower Sprague-Lower Williamson subbasin (USGS 2006c).



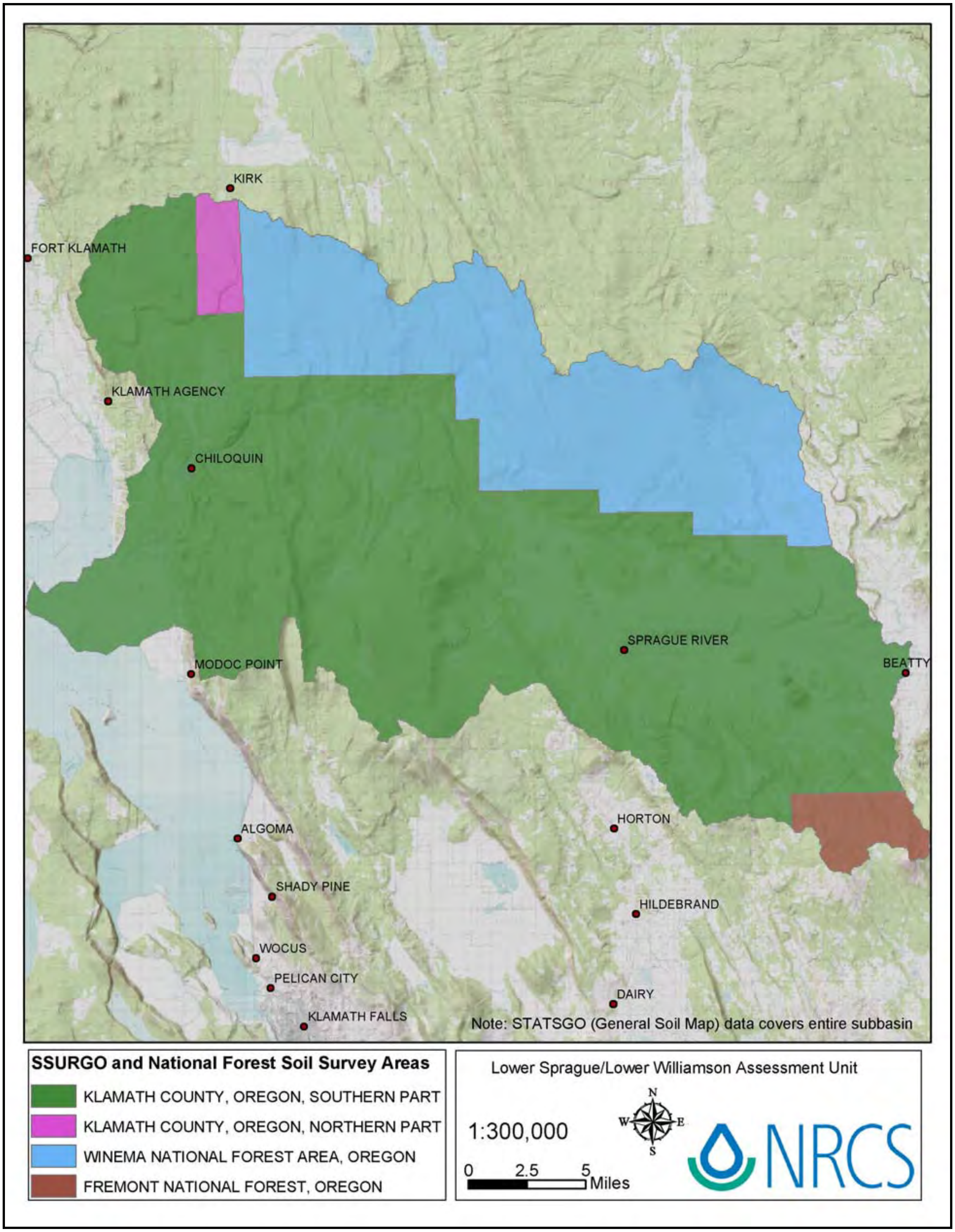
Map 4-1 Map of geologic types within the Lower Sprague-Lower Williamson subbasin (Data Source: Walker and MacLeod 1991)

Table 4-1 Geologic parent material of the Lower Sprague-Lower Williamson subbasin (Data Source: Walker and MacLeod 1991)

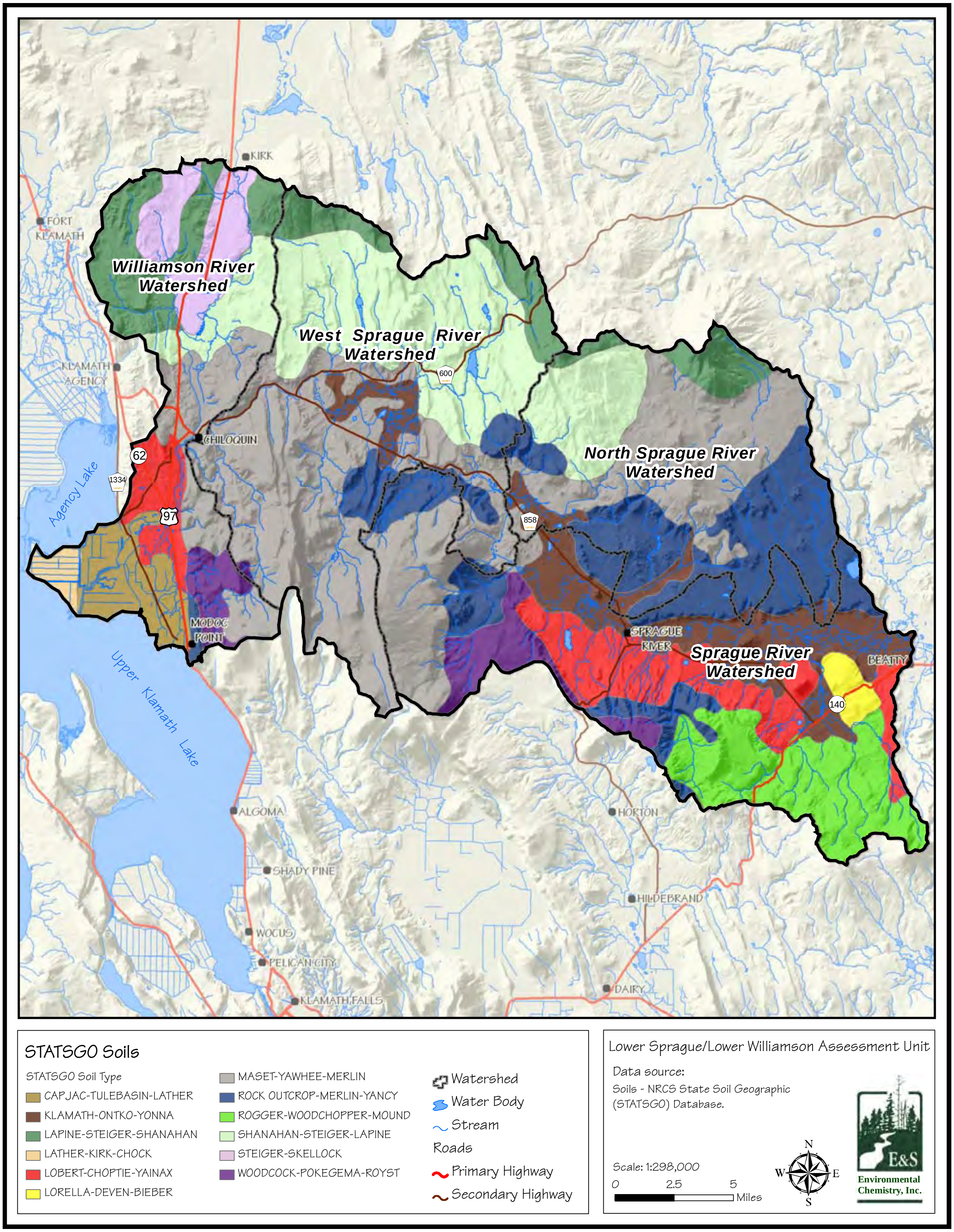
Map Code	Parent Material	Area (sq. miles)
Qa	Quaternary Andesite (Holocene and Pleistocene)	0.9
Qal	Quaternary Alluvial Deposits	42.5
Qba	Quaternary Basaltic Andesite and Basalt (Holocene)	18.8
Qf	Quaternary Fanglomerate (Holocene and Pleistocene)	8.4
Qma	Quaternary Mazama Ash Deposits (Holocene)	7.4
Qmp	Quaternary Mazama Pumice Deposits (Holocene)	0.4
Qs	Quaternary Lacustrian and Fluvial Sedimentary Rocks (Pleistocene)	27.0
QTb	Quaternary Basalt (Pleistocene and Pliocene)	217.8
QTba	Quaternary Basalt and Basaltic Andesite (Pleistocene and Pliocene)	0.6
QTp	Quaternary Pyroclastic Rocks of Basaltic and Andesitic Cinder Cones: Basaltic and Andesitic Ejecta	1.1
QTs	Quaternary Sedimentary Rocks (Pleistocene and Pliocene)	7.5
QTvm	Quaternary Mafic Vent Deposits (Pleistocene, Pliocene and Miocene)	13.3
QTvs	Quaternary Silicic Vent Deposits (Pleistocene and Pliocene)	0.9
Tat	Tertiary Silicic Ash-Flow Tuff (Lower Pliocene and Upper Miocene)	4.9
Tb	Tertiary Basalt (Upper and Middle Miocene)	11.6
Tob	Tertiary Olivine Basalt (Pliocene and Miocene)	60.3
Tp	Tertiary Pyroclastic Rocks of Basaltic Cinder Cones (Lower Pliocene and Miocene) - Basaltic and Andesitic Ejecta	1.1
Tps	Tertiary Pyroclastic Rocks of Basaltic Cinder Cones (Lower Pliocene and Miocene) - Subaqueous Pyroclastic Rocks	48.1
Trh	Tertiary Rhyolite and Dacite (Pliocene and Miocene)	7.2
Ts	Tertiary Tuffaceous Sedimentary Rocks and Tuff (Pliocene and Miocene)	109.6
Tvm	Tertiary Mafic and Intermediate Vent Rocks (Pliocene and Miocene)	3.6
Tvs	Tertiary Silicic Vent Rocks (Pliocene; Miocene; Oligocene and Eocene)	5.2
Water	Water	1.3
Total		**599.6**

Soils

Although detailed soil maps are available for most areas in the Lower Sprague-Lower Williamson subbasin, except for the Klamath County Northern Part (Map 4-2), the only map that covers the entire subbasin is the NRCS STATSGO map (NRCS 2006b). STATSGO provides a description of very general soil types at a coarse scale throughout the subbasin (Map 4-3 and Table 4-2).



Map 4-2 Soil survey areas within the Watershed Assessment area
(Data Sources: Map provided by J. Outlaw; NRCS 2007)



Map 4-3 General soil types from the STATSGO database (Data Source: NRCS 2006b)

Table 4-2 STATSGO general soil types found in the Lower Sprague-Lower Williamson subbasin
(Data Source: NRCS 2006b)

Map Unit Name	Area (mi²)	%
Capjac-Tulebasin-Lather	16.5	2.8
Klamath-Ontko-Yonna	51.2	8.5
Lapine-Steiger-Shanahan	45.9	7.7
Lather-Kirk-Chock	3.5	0.6
Lobert-Choptie-Yainax	42.0	7.0
Lorella-Deven-Bieber	4.6	0.8
Maset-Yawhee-Merlin	176.8	29.5
Rock Outcrop-Merlin-Yancy	85.4	14.2
Rogger-Woodchopper-Mound	38.6	6.4
Shanahan-Steiger-Lapine	94.8	15.8
Steiger-Skellock	18.9	3.2
Woodcock-Pokegema-Royst	21.2	3.5
(Blank)	0.2	0.0
Total	**599.6**	**100.0**

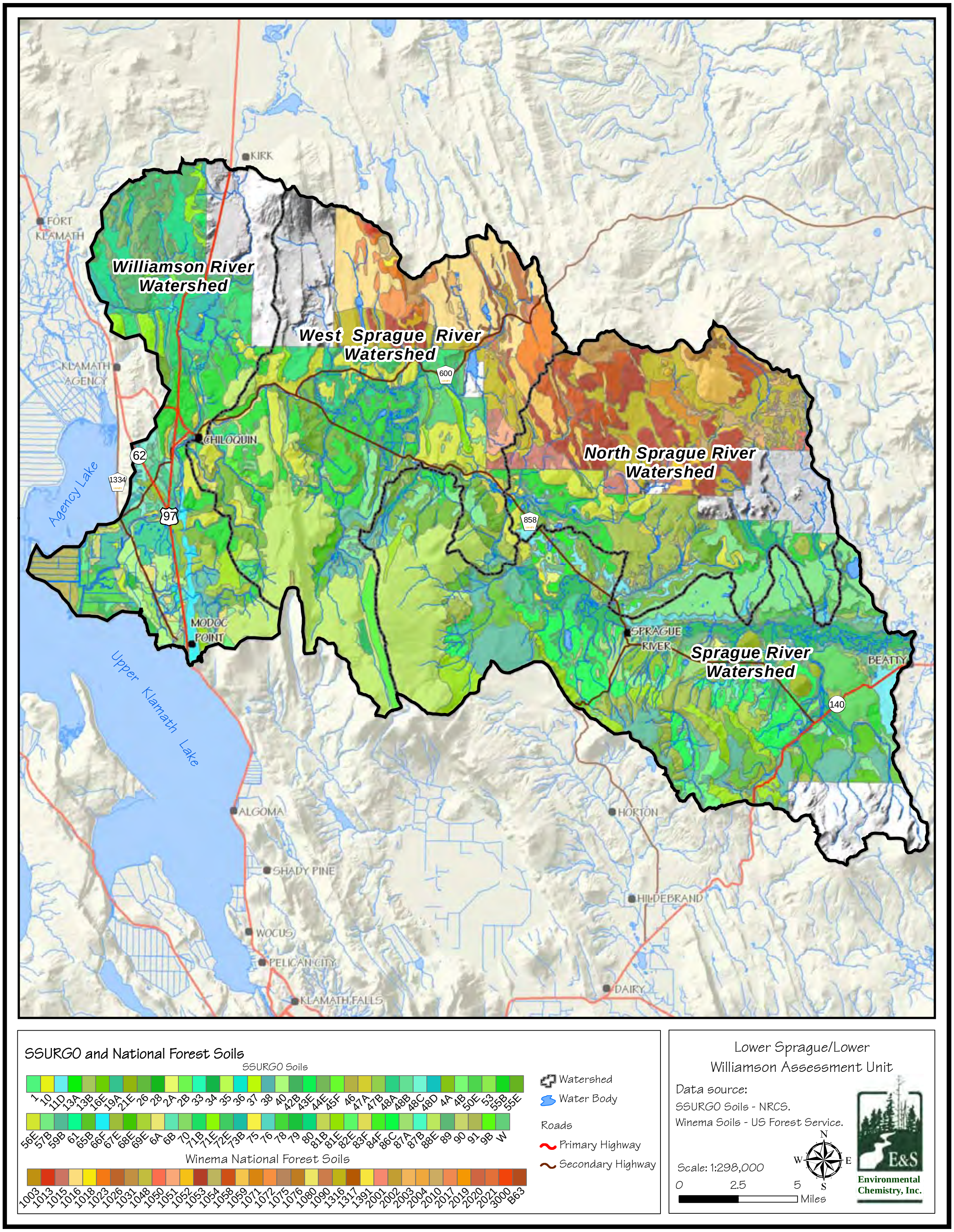
There are three general soil types that predominate within the Lower Sprague-Lower Williamson subbasin (Map 4-3). The most common soil type is Maset-Yawhee-Merlin encompassing 176.8 square miles (29.5 percent) within the subbasin. It covers the central portion of the North Sprague River watershed, the southern half of the West Sprague River watershed and the western portion of the Sprague River watershed. The next two most common are the Shanahan-Steiger-Lapine (94.8 square miles; 15.8 percent) and Rock Outcrop-Merlin-Yancy (85.4 square miles; 14.2 percent). The Rock Outcrop-Merlin-Yancy encompasses the table land area of the southern portion of North Sprague River watershed and the northwestern portion of the Sprague River watershed. The remainder of this soil type is scattered throughout the central portion of the subbasin. The Shanahan-Steiger-Lapine soil type dominates the northern portion of the subbasin.

The USFS conducted Soil Resource Inventories (SRIs) for the Winema National Forest in 1979 (Carson 1979). An SRI provides more detail and higher resolution soil information than does the STATSGO database. The purpose of an SRI is to provide soil, geology, vegetation and landform information to assist forest land managers in applying multiple-use principles to forest management. The SRIs are based on field surveys conducted between 1973 and 1976. Maps are produced at a scale of 1:63,360 (Carson 1979). Although the Fremont National Forest and the Winema National Forest are now managed as a single national forest, the SRIs were completed before the two forests were merged (Map 4-4).

The most detailed soil map available is the NRCS SSURGO map (NRCS 2006b), which is based on the Soil Survey of Klamath County, Southern Part (Cahoon 1985). The SSURGO soils are mapped at a scale of 1:20,000, based on aerial photos and field surveys completed between 1963 and 1976. However, the extent of this map is limited to the agricultural regions along the Sprague and Williamson rivers. For these detailed maps, only the soil types that are most common and spatially extensive are shown. The map scale would not allow depiction of all of the less common soil types (Map 4-4).

Table 4-3 displays soil map unit characteristics for the SSURGO and Winema Soil maps. It is important to note that these studies were not conducted in precisely the same manner, and map unit definitions, while similar for the two maps, are not exactly the same. In addition, in some cases only a portion of each watershed was mapped. Nonetheless, this information may be useful for the purpose of prioritizing projects.

Soils derived from rhyolite, eolian Mazama ash, and pumice deposits are common, particularly in the northern portion of the subbasin. These soil deposits are poor conductors of heat and can therefore become very hot and very cold in a short period of time. This feature of the soil largely controls the plant community that is associated with these soil types. The pumice soils are highly permeable and do not have runoff due to precipitation, because almost all of the water infiltrates. This characteristic is important, because it makes the areas with these soil types a good place for recharge of aquifers and springs. In some areas, deposits of pumice are up to 300 feet deep (Bruce Topham, pers. comm. 2008).



Map 4-4 Detailed soil types from Forest Service and SSURGO data (Data Sources: USFS 2005, NRCS 2006a)

Table 4-3 Soil characteristics associated with the SSURGO and Winema soil maps (Data Sources: NRCS 2006a, USFS 2005)

SSURGO Soils Description

Map unit: 1 - Algoma silt loam
The Algoma soil is over 60 inches deep to bedrock. It is silty over sandy, high in ash, poorly drained, and occurs in basins and on floodplains. Permeability is slow. The soil is alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall. This is a hydric soil.

Map unit: 2A - Barkley loam, 0% to 2% slopes
The Barkley soil is over 60 inches deep to bedrock, a hardpan is at 20 to 35 inches. It is loamy, well drained and occurs on fans and terraces. Water erosion is a potential hazard.

Map unit: 2B - Barkley loam, 2% to 8% slopes
The Barkley soil is over 60 inches deep to bedrock, and a hardpan is at 20 to 35 inches. It is loamy, well drained, and occurs on fans and terraces. Water erosion is a potential hazard.

Map unit: 4A - Bly loam, 0% to 2% slopes
The Bly soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 4B - Bly loam, 2% to 8% slopes
The Bly soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 6A - Calimus fine sandy loam, 0% to 2% slopes
The Calimus soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on fans. Water erosion is a potential hazard.

Map unit: 6B - Calimus fine sandy loam, 2% to 5% slopes
The Calimus soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on fans. Water erosion is a potential hazard.

Map unit: 6C - Calimus fine sandy loam, 5% to 15% slopes
The Calimus soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on fans. Water erosion is a potential hazard.

Map unit: 9A - Capona loam, 0% to 2% slopes
The Capona soil is 20 to 40 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water and wind erosion are potential hazards.

Map unit: 9B - Capona loam, 2% to 5% slopes
The Capona soil is 20 to 40 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water and wind erosion are potential hazards.

Map unit: 9C - Capona loam, 5% to 15% slopes
The Capona soil is 20 to 40 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water and wind erosion are potential hazards.

Map unit: 10 - Chiloquin loam
The Chiloquin soil is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on floodplains. This soil is subject to flooding. A water table is present during spring and early summer.

Map unit: 11D - Choptie loam, 2% to 25% slopes
The Choptie soil is 10 to 20 inches deep to bedrock. It is loamy, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 13A - Crume loam, 0% to 2% slopes
The Crume soil, wet phase, is 40 to 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. A water table is present during spring and early summer.

Map unit: 13B - Crume loam, 2% to 8% slopes
The Crume soil is 40 to 60 inches deep to bedrock. It is loamy, well drained, and occurs on fans and terraces. Water erosion is a potential hazard.

Map unit: 16E - Dehlinger very stony loam, 15% to 65% south slopes
The Dehlinger soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on terraces. The subsoil is high in rock fragments. Water erosion is a potential hazard.

Map unit: 19A - Fordney loamy fine sand, 0% to 2% slopes
The Fordney soil, wet phase, is over 60 inches deep to bedrock. It is sandy, excessively drained and occurs on terraces. Permeability is very rapid. A water table is present during spring, summer and early fall. Wind erosion is a potential hazard.

Map unit: 19C - Fordney loamy fine sand, 2% to 20% slopes
The Fordney soil is over 60 inches deep to bedrock. It is sandy, excessively drained and occurs on terraces. Permeability is very rapid. Water and wind erosion are potential hazards.

Map unit: 21E - Fuego-Rock outcrop complex, 5% to 40% slopes
The Fuego soil is 20 to 40 inches deep to bedrock. It is loamy, high in rock fragments, somewhat excessively drained and occurs on mountains. Water erosion is a potential hazard. Rock outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation.

Map unit: 26 - Henley loam
The Henley soil is over 60 inches to bedrock,; a hardpan is at 20 to 40 inches. It is loamy, somewhat poorly drained and occurs on terraces. The soil is alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall. Wind erosion is a potential hazard.

Map unit: 28 - Henley-Laki loams
The Henley soil is over 60 inches deep to bedrock; a hardpan is at 20 to 40 inches. It is loamy, somewhat poorly drained and occurs on terraces. This soil is alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall. Wind erosion is a potential hazard. The Laki soil is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on terraces. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 33 - Kirk-Chock association
The Kirk soil is over 60 inches deep to bedrock. It is loamy, the surface layer is high in ash, and the subsoil is high in pumice. It is poorly drained and occurs on floodplains. Permeability is rapid. This soil is subject to flooding. A water table is present during spring, summer and early fall. The Kirk soil is a hydric soil. The Chock soil is over 60 inches deep to bedrock. It is loamy, high in ash, poorly drained and occurs on floodplains. This soil is subject to flooding. A water table is present throughout the year. The Chock soil is a hydric soil.

Map unit: 34 - Klamath-Ontko-Dilman association
The Klamath soil is over 60 inches deep to bedrock. It is claylike, poorly drained and occurs on floodplains. Permeability is slow. This soil is subject to flooding. A water table is present during spring and early summer. The Klamath soil is a hydric soil. The Ontko soil is over 60 inches deep to bedrock. It is silty over loamy, and the surface layer is high in ash. It is poorly drained and occurs on floodplains. Permeability is slow. This soil is subject to flooding. A water table is present during spring and early summer. The Ontko soil is a hydric soil. The Dilman soil is over 60 inches deep to bedrock. It is loamy over sandy and the subsoil is high in ash. It is poorly drained and occurs on floodplains. Permeability is slow. This soil is subject to flooding. A water table is present during spring and early summer. The Dilamn soil is a hydric soil.

Map unit: 35 - Klamath variant clay loam
The Klamath variant soil is over 60 inches deep to bedrock. It is loamy, and the surface layer is high in ash. It is poorly drained and occurs on floodplains. Permeability is slow. This soil is alkaline. This soil is subject to flooding. A water table is present during spring and early summer. This is a hydric soil.

Map unit: 36 - Lakeview silty clay loam
The Lakeview soil is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on floodplains. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 37 - Laki fine sandy loam
The Laki soil, wet phase, is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on terraces. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 38 - Laki loam
The Laki soil, wet phase, is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on terraces. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 40 - Laki-Henley loams
The Henley soil is over 60 inches deep to bedrock; a hardpan is at 20 to 40 inches. It is loamy, somewhat poorly drained and occurs on terraces. This soil is alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall. Wind erosion is a potential hazard. The Laki soil is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on terraces. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 42B - Lapine gravelly loamy coarse sand, 1% to 10% slopes
The Lapine soil is over 60 inches deep to bedrock. It is sandy, high in pumice, excessively drained and occurs on plateaus. Permeability is very rapid.

Map unit: 43E - Lapine gravelly loamy coarse sand, 10% to 40% north slopes
The Lapine soil is over 60 inches deep to bedrock. It is sandy, high in pumice, excessively drained and occurs on plateaus. Permeability is very rapid.

Map unit: 44E - Lapine gravelly loamy coarse sand, 10% to 35% south slopes
The Lapine soil is over 60 inches deep to bedrock. It is sandy, high in pumice, excessively drained and occurs on plateaus. Permeability is very rapid.

Map unit: 45F - Lapine gravelly loamy coarse sand, 35% to 55% south slopes
The Lapine soil is over 60 inches deep to bedrock. It is sandy, high in pumice, excessively drained and occurs on plateaus. Permeability is very rapid.

Map unit: 46 - Lather muck
The Lather soil is over 60 inches deep to bedrock. It is an organic soil, is very poorly drained and occurs in basins. This soil is subject to flooding. A water table is present throughout the year. This is a hydric soil. Wind erosion is a potential hazard when the soil is drained.

Map unit: 47A - Lobert sandy loam, 0% to 2% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 47B - Lobert sandy loam, 2% to 12% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 48A - Lobert loam, 0% to 2% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 48B - Lobert loam, 2% to 5% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 48C - Lobert loam, 5% to 15% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 48D - Lobert loam, 15% to 25% slopes
The Lobert soil is over 60 inches deep to bedrock. It is loamy, well drained and occurs on terraces. Water erosion is a potential hazard.

Map unit: 50E - Lorella very stony loam, 2% to 35% south slopes
The Lorella soil, stony phase, is 10 to 20 inches deep to bedrock. It is claylike, high in rock fragments, well drained and occurs on mountains. Permeability is slow. Water erosion is a potential hazard.

Map unit: 53 - Malin clay loam
The Malin soil is over 60 inches deep to bedrock. It is claylike, somewhat poorly drained and occurs on floodplains. The soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 55B - Maset coarse sandy loam, 1% to 12% slopes
The Maset soil is 20 to 40 inches deep to bedrock. It is loamy, high in ash and the subsoil is high in rock fragments. It is well drained and occurs on terraces and plateaus. Water erosion is a potential hazard.

Map unit: 55E - Maset coarse sandy loam, 12% to 45% north slopes
The Maset soil is 20 to 40 inches deep to bedrock. It is loamy, high in ash and the subsoil is high in rock fragments. It is well drained and occurs on terraces and plateaus. Water erosion is a potential hazard.

Map unit: 56E - Maset coarse sandy loam, 12% to 35% south slopes
The Maset soil is 20 to 40 inches deep to bedrock. It is loamy, high in ash and the subsoil is high in rock fragments. It is well drained and occurs on terraces and plateaus. Water erosion is a potential hazard.

Map unit: 57B - Merlin-Yancy association, gently sloping
The Merlin soil is 10 to 20 inches deep to bedrock. It is claylike, well drained and occurs on plateaus. Permeability is very slow. Water erosion is a potential hazard. The Yancy soil is over 60 inches deep to bedrock; a hardpan is at 12 to 20 inches. It is claylike, well drained and occurs on terraces. Permeability is slow. Water erosion is a potential hazard.

Map unit: 59B - Nuss-Royst association, gently sloping
The Nuss soil is 12 to 20 inches deep to bedrock. It is loamy, well drained, and occurs on plateaus and mountains. Water erosion is a potential hazard. The Royst soil is 20 to 40 inches deep to bedrock. It is claylike, high in rock fragments, well drained and occurs on mountains. Permeability is slow. Water erosion is a potential hazard.

Map unit: 61 - Pit silty clay
The Pit soil is over 60 inches deep to bedrock. It is claylike, poorly drained and occurs on floodplains. Permeability is slow. Shrink-swell is a hazard. This soil is subject to flooding. A water table is present during late spring, summer and early fall. This is a hydric soil.

Map unit: 65B - Ponina-Rock outcrop complex, 1% to 8% slopes
The Ponina soil is over 60 inches deep to bedrock; a hardpan is at 12 to 20 inches. It is claylike, well drained and occurs on plateaus. Permeability is very slow. Water erosion is a potential hazard. Rock

outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation.

Map unit: 66F - Rock outcrop-Dehlinger complex, 35% to 65% slopes
Rock outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation. The Dehlinger soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on terraces. The subsoil is high in rock fragments. Water erosion is a potential hazard.

Map unit: 67E - Rock outcrop-Nuss complex, 5% to 40% slopes
Rock outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation. The Nuss soil is 12 to 20 inches deep to bedrock. It is loamy, well drained, and occurs on plateaus and mountains. Water erosion is a potential hazard.

Map unit: 68E - Royst stony loam, 5% to 40% north slopes
The Royst soil is 20 to 40 inches deep to bedrock. It is claylike, high in rock fragments, well drained and occurs on mountains. Permeability is slow. Water erosion is a potential hazard.

Map unit: 69E - Royst stony loam, 5% to 40% south slopes
The Royst soil is 20 to 40 inches deep to bedrock. It is claylike, high in rock fragments, well drained and occurs on mountains. Permeability is slow. Water erosion is a potential hazard.

Map unit: 70 - Scherrard clay loam
The Scherrard soil is over 60 inches deep to bedrock; a hardpan is at 20 to 40 inches. It is claylike, somewhat poorly drained and occurs on terraces. Permeability is slow. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during spring, summer and fall. This is a hydric soil. Wind erosion is a potential hazard.

Map unit: 71B - Shanahan gravelly loamy coarse sand, 1% to 12% slopes
The Shanahan soil is over 60 inches deep to bedrock. It is loamy, and the surface layer is high in ash. It is somewhat excessively drained and occurs on terraces and plateaus.

Map unit: 71E - Shanahan gravelly loamy coarse sand, 12% to 45% north slopes
The Shanahan soil is over 60 inches deep to bedrock. It is loamy, and the surface layer is high in ash. It is somewhat excessively drained and occurs on terraces and plateaus.

Map unit: 72E - Shanahan gravelly loamy coarse sand, 12% to 45% south slopes
The Shanahan soil is over 60 inches deep to bedrock. It is loamy, and the surface layer is high in ash. It is somewhat excessively drained and occurs on terraces and plateaus.

Map unit: 73B - Steiger loamy coarse sand, 1% to 15% slopes
The Steiger soil is over 60 inches deep to bedrock. It is sandy, high in ash, somewhat excessively drained and occurs on plateaus and terraces. Permeability is rapid.

Map unit: 75 - Sycan loamy sand
The Sycan soil is over 60 inches deep to bedrock. It is sandy, high in ash, excessively drained and occurs on terraces. Permeability is rapid. This soil is subject to flooding.

Map unit: 76 - Sycan variant loamy coarse sand
The Sycan variant soil is over 60 inches deep to bedrock. It is sandy, high in ash, somewhat poorly drained and occurs on terraces. Permeability is rapid. This soil is alkaline. This soil is subject to flooding. A water table is present during spring, summer and early fall.

Map unit: 78 - Tulana silt loam
The Tulana soil, moderately drained phase, is over 60 inches deep to bedrock. It is silty over loamy and high in ash. The surface layer may be high in organic matter. It is poorly drained and occurs in basins. A water table is present during spring, summer and early fall.

Map unit: 79 - Tulana silt loam, sandy substratum
The Tulana soil, moderately drained phase, is over 60 inches deep to bedrock. It is silty over loamy and high in ash. The surface layer may be high in organic matter. It is poorly drained and occurs in basins. A water table is present during spring, summer and early fall.

Map unit: 80 - Tutni coarse sandy loam
The Tutni soil is over 60 inches deep to bedrock. It is sandy, high in ash, moderately well drained and occurs in basins. Permeability is rapid. A water table is present during spring.

Map unit: 81B - Woodcock gravelly loam, 1% to 5% slopes
The Woodcock soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 81E - Woodcock association, north
The Woodcock soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 82E - Woodcock association, south
The Woodcock soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 83F - Woodcock-Rock outcrop complex, 40% to 60% north slopes
The Woodcock soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on mountains. Water erosion is a potential hazard. Rock outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation.

Map unit: 84F - Woodcock-Rock outcrop complex, 40% to 60% south slopes
The Woodcock soil is over 60 inches deep to bedrock. It is loamy, high in rock fragments, well drained and occurs on mountains. Water erosion is a potential hazard. Rock outcrop consists of exposures of bare, hard bedrock other than lava flows and rock-lined pits. It consists mainly of unweathered volcanic, metamorphic or sedimentary rock. Rock outcrop has little or no vegetation.

Map unit: 86C - Yainax loam, 1% to 15% slopes
The Yainax soil is 20 to 40 inches deep to bedrock. It is loamy, well drained and occurs on plateaus. Water erosion is a potential hazard.

Map unit: 87A - Yancy clay loam, 0 to 2% slopes
The Yancy soil is over 60 inches deep to bedrock; a hardpan is at 12 to 20 inches. It is claylike, well drained and occurs on terraces. Permeability is slow. Water erosion is a potential hazard.

Map unit: 87B - Yancy clay loam, 2% to 8% slopes
The Yancy soil is over 60 inches deep to bedrock; a hardpan is at 12 to 20 inches. It is claylike, well drained and occurs on terraces. Permeability is slow. Water erosion is a potential hazard.

Map unit: 88E - Yawhee stony coarse sandy loam, 3% to 45% slopes
The Yawhee soil is over 60 inches deep to bedrock. It is sandy over loamy, high in ash and high in rock fragments. It is well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 89 - Yonna loam
The Yonna soil is over 60 inches deep to bedrock. It is loamy, and the surface layer is high in ash. It is poorly drained and occurs on floodplains. This soil is alkaline. This soil is subject to flooding. A water table is present during spring and early summer.

Map unit: 90 - Zuman loamy fine sand
The Zuman soil is over 60 inches deep to bedrock. It is loamy over sandy, poorly drained and occurs in basins. Permeability is rapid. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during the spring, summer and early fall. This is a hydric soil.

Map unit: 91 - Zuman silt loam
The Zuman soil is over 60 inches deep to bedrock. It is loamy over sandy, poorly drained and occurs in basins. Permeability is rapid. This soil is saline and alkaline. This soil is subject to flooding. A water table is present during the spring, summer and early fall. This is a hydric soil.

Winema Soils Description

1003 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: ashy coarse sandy loam
Slope: 1% to 6%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1013 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: coarse sandy loam
Slope: 35% to 70%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively

Parent material: volcanic ash and pumice derived from dacite over colluvium or residuum weathered from volcanic rock or tephra

1015 - Name: Maset taxadjunct
Taxonomic class: Ashy over loamy, glassy over isotic, frigid Alfic Humic Vitrixerands
Texture: ashy over loamy soils
Slope: 4% to 12%
Depth class: moderately deep (50 to 100 cm) to bedrock (paralithic)
Drainage class: well
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic sandstone or siltstone

1016 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: ashy soils with greater than 35% pumice paragravel
Slope: 2% to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1018 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: paragravelly ashy coarse sandy loam
Slope: 12% to 35%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1023 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: paragravelly ashy coarse sandy loam
Slope: 12% to 35%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1026 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: paragravelly ashy coarse sandy loam
Slope: 12 to 35%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1031 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: paragravelly ashy coarse sandy loam
Slope: 2% to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1048 - Name: Humic Vitrixerands family
Taxonomic class: Ashy, glassy, frigid Humic Vitrixerands
Texture: ashy soils
Slope: 20% to 40%
Depth class: moderately deep to very deep (20 cm to greater than 150 cm) bedrock (lithic)
Drainage class: somewhat excessively
Parent material: eolian deposits derived from pumice

1050 - Name: Yancy series
Taxonomic class: Claylike, smectitic, frigid, shallow Vitrandic Durixerolls
Texture: soils with a layer of loamy material and greater than 35% gravel over a claylike layer
Slope: 1% to 4%
Depth class: shallow (25 cm to 50 cm) to duripan
Drainage class: well
Parent material: alluvium

1051 - Name: Alfic Humic Vitrixerands family
Taxonomic class: Ashy over claylike, glassy over smectitic, frigid Alfic Humic Vitrixerands
Texture: ashy over claylike soils
Slope: 2% to 12%
Depth class: moderately deep (50 cm to 100 cm) to duripan
Drainage class: well
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1052 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: very paragravelly ashy loamy coarse sand
Slope: 12% to 35%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1053 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: very paragravelly ashy loamy coarse sand
Slope: 2% to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively

Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1054 - Name: Bottlespring series
Taxonomic class: Fine, smectitic, frigid Vitrandic Durixerolls
Texture: stony ashy loam
Slope: 1% to 4%
Depth class: moderately deep (50 cm to 100 cm) to duripan
Drainage class: well drained
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra
Rock fragments on surface: 3% to 50%, dominantly cobbles or stones

1058 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic, Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 2 to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1059 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 12% to 35%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1071 - Name: Shanahan series
Taxonomic class: Ashy over loamy, glassy over isotic Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 0% to 2%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over alluvium derived from volcanic rock or tephra

1072 - Name: Lapine series
Taxonomic class: Ashy-pumiceous, glassy Xeric Vitricryands
Texture: paragravelly ashy coarse sandy loam
Slope: 2% to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1075 - Name: loamy-skeletal soils
Taxonomic class: none
Texture: loamy soils with greater than 35% gravel or cobbles
Slope: 35% to 60%
Depth class: very deep (greater than 150 cm)
Drainage class: well
Parent material: residuum or colluvium weathered from volcanic rock or tephra

1076 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 35% to 60%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over residuum or colluvium weathered from volcanic rock or tephra

1080 - Name: Bly series, ashy sandy loam phase
Taxonomic class: Fine-loamy, isotic, frigid Vitrandic Argixerolls
Texture: ashy sandy loam
Slopes: 0% to 4%
Depth class: very deep (greater than 150 cm)
Drainage class: well
Parent material: alluvium or eolian deposits

1090 - Name: Bigtoe series
Taxonomic class: Fine, smectitic, frigid Aquandic Argialbolls
Texture: ashy sandy clay loam
Slope: 0% to 2%
Depth class: moderately deep (50 to 100 cm) to duripan
Drainage class: poorly
Parent material: tephra over alluvium or residuum

1316 - Name: Shukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 2% to 12%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic rock or tephra

1317 - Name: Sukash series
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic Xeric Vitricryands
Texture: paragravelly ashy loamy coarse sand
Slope: 35% to 60%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat excessively

Parent material: volcanic ash and pumice derived from dacite over colluvium or residuum weathered from volcanic rock or tephra

1391 - Name: Maset taxadjunct
Taxonomic class: Ashy over loamy, glassy over isotic, frigid Alfic Humic Vitrixerands
Texture: ashy over loamy soils
Slope: 20% to 40%
Depth class: moderately deep (50 cm to 100 cm) to bedrock (lithic)
Drainage class: well
Parent material: volcanic ash and pumice derived from dacite over residuum weathered from volcanic sandstone or siltstone

2001 - Name: Mesquito series
Taxonomic class: Ashy-skeletal, glassy, nonacid Typic Cryaquands
Texture: mucky ashy sandy loam
Slope: 1% to 8%
Depth class: assume very deep (greater than 150 cm)
Drainage class: poorly
Parent material: alluvium derived from pumice over residuum or alluvium weathered from volcanic rock or tephra

2002 - Name: Mesquito series
Taxonomic class: Ashy-skeletal, glassy, nonacid Typic Cryaquands
Texture: mucky ashy sandy loam
Slope: 8% to 15%
Depth class: assume very deep (greater than 150 cm)
Drainage class: poorly
Parent material: alluvium derived from pumice over residuum or alluvium weathered from volcanic rock or tephra

2003 - Name: Mighty series
Taxonomic class: Ashy over loamy, glassy over mixed, nonacid Aquandic Cryaquepts
Texture: black loam
Slope: 0% to 1%
Depth class: very deep (greater than 150 cm)
Drainage class: poorly
Parent material: alluvium over alluvium derived from pumice over alluvium

2004 - Name: Chocknott series
Taxonomic class: Medial over ashy, glassy, nonacid Typic Cryaquands
Texture: medial coarse sandy loam
Slope: 1% to 4%
Depth class: very deep (greater than 150 cm)
Drainage class: poorly
Parent material: alluvium derived from pumice

2010 - Soil name: Tutni series
Taxonomic class: Ashy, glassy, nonacid Typic Cryaquands
Texture: paragravelly ashy loamy coarse sand

Slope: 0% to 1%
Depth class: very deep (greater than 150 cm)
Drainage class: somewhat poorly
Parent material: alluvium derived from pumice over alluvium derived from volcanic rock or tephra

2017 - Name: Cosbie series
Taxonomic class: Loamy over ashy or ashy-pumiceous, mixed over glassy, superactive, nonacid Aquandic Cryaquents
Texture: mucky diatomaceous silt
Slope: 1% to 3%
Depth class: very deep (greater than 150 cm)
Drainage class: very poorly
Parent material: grassy organic material over diatomaceous earth over alluvium derived from pumice over alluvium

2019 - Name: Humic Haploxerands family
Taxonomic class: Medial over loamy-skeletal, amorphic over isotic, frigid Humic Haploxerands
Texture: medial surface and upper subsoil layers to a depth of about 70 cm over loamy lower subsoil layers with greater than 35% gravels or cobbles
Slope: 0% to 3%
Depth class: very deep (greater than 150 cm)
Drainage class: well
Parent material: alluvium derived from volcanic rock or tephra

2020 - Name: Dilman series
Taxonomic class: Loamy over ashy or ashy-pumiceous, mixed over glassy, superactive Aquandic Cryaquolls
Texture: black mucky loam
Slope: 0% to 2%
Depth class: very deep (greater than 150 cm)
Drainage class: poorly
Parent material: alluvium over alluvium derived from pumice

2021 - Name: Hallet series
Taxonomic class: Loamy over ashy or ashy-pumiceous, mixed over glassy, superactive, frigid Vitrandic Haploxerolls
Texture: black loam
Slope: 0% to 2%
Depth class: very deep (greater than 150 cm)
Drainage class: moderately well
Parent material: alluvium over alluvium derived from pumice

B63 - Name: Ash-covered colluvial basalt plateaus
Taxonomic class: Ashy over loamy-skeletal, glassy over isotic, frigid Alfic Vitrixerands
Texture: sandy loam
Slope: 0% to 18%
Depth class: very deep
Drainage class: well to moderately well drained
Parent material: ash over basalt colluvium

EROSION POTENTIAL

Erosion is a natural process, but it can be affected by human activities. Erosion processes transport coarse and fine sediments from upland areas and streambanks to, and down, the stream channel. This movement of sediments influences soil conditions in the source area, including nutrient availability and site fertility, and sediment conditions in the receiving water. High levels of erosion can interfere with agricultural production on rangelands, crop ground, pastures and forest land. Erosion can also alter the balance between coarse and fine sediments in the stream channel, which in turn can impact species composition of vegetation and animals and rates of transition between functional states. These functional states may relate to fish spawning habitat quality, stream width-to-depth ratio and water temperature.

Several kinds of erosion are potentially significant sources of sediment to streams in the Lower Sprague-Lower Williamson subbasin, including sheet erosion, streambank erosion, erosion from unpaved roads, and rill and gully erosion. Mass movement, an important source of sediment delivery on the west side of the Cascade Mountains, may occur on occasion, but is not an important contributor to sediment delivery in streams within the Lower Sprague-Lower Williamson subbasin.

Sheet Erosion

Sheet erosion is defined as the more or less uniform removal of soil from an area without the development of conspicuous water channels (USDA 2007). Soils data can be used to evaluate the potential for sheet erosion, using the K-factor. The K-factor is defined by the U.S. Department of Agriculture (USDA) as an erodibility factor that quantifies the susceptibility of soil particles to detachment and movement by water (USDA 2006). This factor is used in the Revised Universal Soil Loss Equation (RUSLE) to calculate soil loss by water. RUSLE is included in many watershed models to simulate soil movement.

For this analysis, numeric K-factor values were classified as "Low," "Moderate," or "High" based on the ranges specified in the OWEB Manual:

Low: <0.2

Moderate: 0.2 to 0.4

High: >0.4

K-factor values are available for soils surveyed by NRCS within the Lower Sprague-Lower Williamson subbasin. Since the STATSGO general soil map covers the entire subbasin, this data was used for the K-factor analysis. In the STATSGO database, soil map units may be defined as a combination of more than one soil type. In this case, the dominant soil condition was used to represent the erodibility characteristics that are reflected in the K-factors presented here.

The distribution of K-factor classes across the Lower Sprague-Lower Williamson subbasin is summarized in Table 4-4. Of the subbasin area, 27.4 percent was considered "Low" in terms of sheet erosion potential, and 72.6 percent was considered "Moderate" in terms of sheet erosion potential. There were no areas considered to have "High" erosion potential.

Table 4-4 Breakdown of K-factor erosion potential classes derived from STATSGO data for the Lower Sprague-Lower Williamson subbasin

. (Data Source: NRCS 2006b)

K-Factor Rating Class	Area (mi^2)
Low	162.9
Moderate	431.2
High	0.0
Total	594.1

Disturbance and Erosion Potential

The effect of soil disturbance on soil erosion potential and subsequent delivery of sediment to streams can be significant. The SSURGO data for Klamath County, Southern Part (Map 4-2) covers a portion of the Lower Sprague-Lower Williamson subbasin, primarily on private lands. Data from this limited area were used to determine the relative abundance of soils with various risk classes in disturbed areas (NRCS 2006a). The data are presented in Table 4-5 and represent the hazard or risk of soil loss due to erosion from off-road and off-trail areas after disturbance activities that expose the soil surface. This soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 percent to 75 percent of the surface has been exposed by logging, grazing, mining or other kinds of disturbance. Approximately 36 percent of the soils in the area surveyed are classified as moderately sensitive to erosion in disturbed areas. A rating of “moderate” indicates that some erosion is likely and that erosion-control measures may be needed. This soil interpretation is based on a combination of factors, including the K-factor and the slope, or steepness, of the soil map unit. The more sensitive areas are located primarily in the more steeply sloped soil map units of this portion of the subbasin.

Table 4-5 Risk of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface in areas of the Lower Sprague-Lower Williamson subbasin included in the Klamath County SSURGO database

Rating Class	North Sprague River	Sprague River	West Sprague River	Williamson River	Total	
	Area (mi^2)	Area (mi^2)	Area (mi^2)	Area (mi^2)	Area (mi^2)	%
Slight	25.8	108.1	37.9	70.7	242.5	57.1
Moderate	9.5	51.6	65.4	24.5	151.0	35.6
Severe			4.1	1.3	5.4	1.3
Very Severe					0	0
Not rated	9.5	10.2	2.5	3.3	25.5	6.0
Total	44.8	169.9	109.9	99.8	424.4	100.0

Streambank Erosion

Streambank erosion is generally one of the most significant sources of erosion in areas of relatively low relief, as occur throughout the Lower Sprague-Lower Williamson subbasin. Despite the potential significance of the issue of streambank erosion, data on this issue could not be found.

ODFW has conducted stream surveys on a limited number of streams within the Lower Sprague-Lower Williamson subbasin. In the Sprague River watershed, Trout Creek was surveyed along 3.9 stream miles (Table 4-6). The majority of the creek has lower gradients, ranging from 0.5 percent to 2.7 percent. A short half-mile reach on the North Fork Trout Creek has a higher gradient of 17.1 percent. Along the North Fork Trout Creek reaches #2 and #5 (see Table 4-6), there was no bank erosion. In the lower gradient reaches of Trout Creek, there is a higher amount of bank erosion, ranging from 26.5 percent to 42.5 percent of the bank.

Not all stream bank erosion is considered bad. Streambanks will erode at a natural pace as the stream meanders back and forth across its flood plain. If the erosion becomes too great, then the excessive sediment loads may have a negative impact on water quality and fish habitat.
Graham Matthews and Associates have completed a sediment budget and Light Detection and Ranging (LiDAR) information and bathymetry of the Sprague River in portions of the main stem are also available. These studies can provide data for streambank erosion analysis.
Whether these limited data are representative of the Sprague and Williamson rivers and their tributaries is not clear, suggesting a need for additional data.

Table 4-6 Bank erosion estimates from ODFW stream surveys
(Data Source: ODFW 2006)

Watershed	Reach	Stream Miles	Gradient (%)	Bank Erosion (%)
Sprague River Watershed				
North Fork Trout Creek	1	1.2	1.5	8.7
	2	0.4	2.4	0.0
	3	0.3	2.1	15.5
	4	0.2	2.7	19.9
	5	0.5	17.1	0.0
Trout Creek	1	0.6	0.5	42.5
	2	0.7	1.4	26.5

There is no available benchmark indicating what is an "acceptable" level of bank erosion. However, a benchmark could be developed from the Appendix in Winward's (2000) Monitoring the Vegetation Resource in Riparian Areas and other ongoing Greenline analysis in the Lower Sprague-Lower Williamson subbasin.

It is important to note that a very limited number of stream reaches have been evaluated for bank erosion within this subbasin. However, the limited data suggest that bank erosion is an important concern in some, but not all, areas within the Lower Sprague-Lower Williamson subbasin.

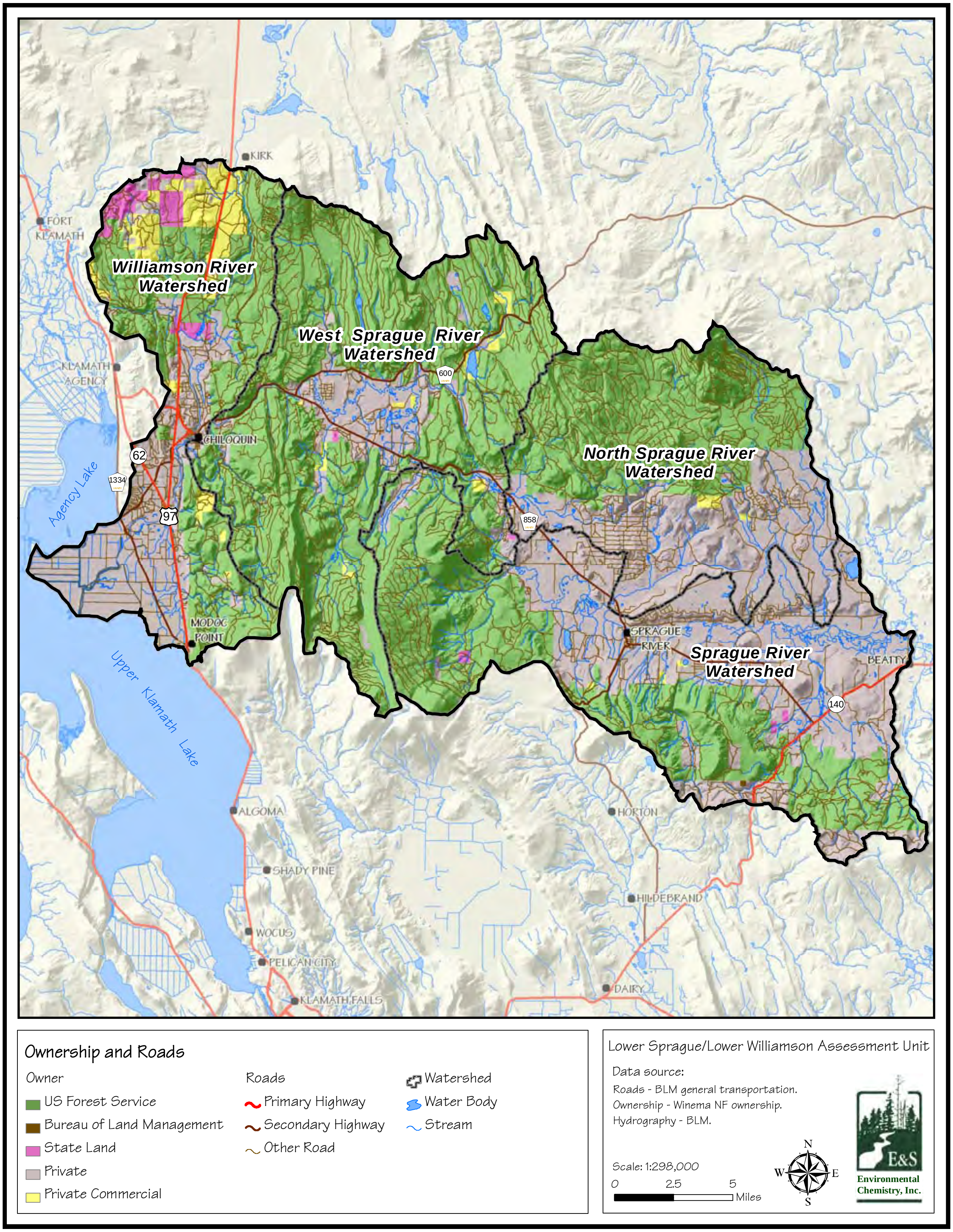
Road Erosion

The extent, density, condition and location of roads in a watershed can have a significant influence on erosion and the quantity and quality of sediment that is delivered to streams in the watershed. Information on roads was assembled for this Assessment largely from data collected by the USFS and NRCS.

There are approximately 2,299.1 miles of public and private roads mapped in the Lower Sprague-Lower Williamson subbasin. The road density is an average of 3.8 miles of road per square mile. The density ranges from 2.9 miles per square mile in the Sprague River watershed to 4.6 miles per square mile in the Williamson River watershed (Table 4-7, Map 4-5). Using mapped road miles as an estimate of actual road miles is difficult, because many unimproved dirt roads are not mapped and some roads that are mapped have been closed or otherwise have overgrown. Nevertheless, the mapped roads provide baseline information on road miles.

Table 4-7 Road density in the Lower Sprague-Lower Williamson subbasin (Data Source: BLM 2006)

Watershed	Road Length (mi)	Watershed Area (mi^2)	Road Density (mi/mi^2)
North Sprague River	497.9	123.0	4.0
Sprague River	537.3	183.9	2.9
West Sprague River	723.6	176.0	4.1
Williamson River	540.3	116.7	4.6
Total	2,299.1	599.6	3.8



Map 4-5 Distribution of roads within the Lower Sprague-Lower Williamson subbasin (Data Source: BLM 2006)

Road surface data in the Lower Sprague-Lower Williamson subbasin is based on the BLM GIS road data layer (Table 4-8). The GIS layer identified six surface types on roads in the subbasin. Please note that this information pertains to publicly owned upland areas. Little information is available for privately owned roads.

The USFS has not conducted a survey of the level of maintenance of roads, or of their direct connection to streams via ditches and road drainages. This information would be helpful in determining the amount of sediment that travels from the road surface to the streams.

Table 4-8 The amount of different types of road surface on Fremont-Winema National Forest land, by miles of road, in each watershed in the Lower Sprague-Lower Williamson subbasin, as determined by the BLM
(Data Source: BLM 2006)

Road Surface	North Sprague River	Sprague River	West Sprague River	Williamson River	Total
Aggregate Surface	45.9	85.8	111.0	34.2	277.0
Bituminous	0.0	4.1	17.5	1.3	22.8
Hard Surface	0.9	3.7	14.6	0.3	19.5
Highway	0.0	9.7	0.0	28.8	38.5
Natural Improved (Graded & Drained)	0.6	1.8	10.8	2.5	15.7
Natural Unimproved	288.8	230.9	528.5	228.4	1,276.6
Not Known	161.7	201.3	41.3	244.8	649.1
Total	**497.9**	**537.3**	**723.6**	**540.3**	**2,299.1**
			Percent		
Aggregate Surface	9.2	16.0	15.3	6.3	12.0
Bituminous	0.0	0.8	2.4	0.2	1.0
Hard Surface	0.2	0.7	2.0	0.1	0.8
Highway	0.0	1.8	0.0	5.3	1.7
Natural Improved (Graded & Drained)	0.1	0.3	1.5	0.5	0.7
Natural Unimproved	58.0	43.0	73.0	42.3	55.5
Not Known	32.5	37.5	5.7	45.3	28.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Location of Roads

Roads Close to Streams

The location of roads in relationship to streams can be an indicator of the potential magnitude of effect the road network may have on the stream. Road drainage not only delivers sediment to streams, but can also route water to streams faster. The faster routing can increase sediment loading and erosion due to the potentially higher velocities, while it can decrease the amount of infiltration.

Map 4-6 shows areas where roads are located within 200 feet of a stream. Table 4-9 summarizes the number of miles of gravel and dirt road within 200 feet of a stream. Also included in Table 4-9 is the number of stream miles within 200 feet of a road, which is perhaps more relevant to the potential effect of roads on the stream network. On average, approximately 31.0 percent of the mapped roads within the Lower Sprague-Lower Lower Sprague-Lower Williamson subbasin are within 200 feet of a stream.

Table 4-9 Length of road or stream (miles) within 200 feet of each other (Data Source: BLM 2005, 2006)

Watershed	Road Length[1]	Stream Length[2]	Percent of Total Stream Length[2]
North Sprague River	33.8	30.8	25.3
Sprague River	63.0	58.8	20.5
West Sprague River	79.2	72.5	38.1
Williamson River	76.7	76.7	44.7
Total	**252.8**	**238.8**	**31.0**

[1] Within 200 feet of stream.

[2] Within 200 feet of road.

Data methods/limitations: Using the GIS, road and stream layers were buffered by 200 feet on each side and overlaid with each other. The length of road and stream within the overlapping buffer areas was calculated and is summarized by subwatershed. These data are suitable for watershed-scale and subwatershed-scale characterization, and are not recommended for site-specific analysis or planning. Field verification is required prior to project planning.

Table 4-10 identifies roads close to streams based on the road surface types. Highways and other paved roads generally do not contribute sediment from the road surface, although sediment from ditches and cut-banks may enter the stream system. Gravel and dirt roads may experience surface erosion, as well as ditch and cut-bank erosion, and are the most prevalent in the Lower Sprague-Lower Williamson subbasin (Table 4-10). The West Sprague River watershed contains the most dirt and gravel road miles near streams (68.3 miles), whereas the North Sprague River watershed contains the least, at 20.5 miles of roads near streams.

Table 4-10 Miles of road within 200 feet of a stream by watershed (Data Source: BLM 2006)

Data methods/limitations: Using ArcGIS, the buffered streams layer was overlaid with the roads layer. The length of roads within 200 feet of streams was calculated. These data are suitable for watershed-scale and subwatershed-scale characterization, and are not recommended for site-specific analysis or planning. Field verification should be conducted before project planning.

Watershed	Highway	Hard Surface / Paved	Aggregate / Gravel	Natural Unimproved / Improved (Graded & Drained)	Not Known	Total
North Sprague River	0.0	0.1	3.3	17.2	13.2	**33.8**
Sprague River	2.9	0.8	9.3	29.5	20.6	**63.0**
West Sprague River	0.0	5.5	14.0	54.3	5.4	**79.2**
Williamson River	2.6	0.0	3..2	21.0	50.1	**76.7**
Total	**5.4**	**6.3**	**29.7**	**122.0**	**89.3**	**252.8**

[1]Totals may not reflect numbers in this table due to rounding.

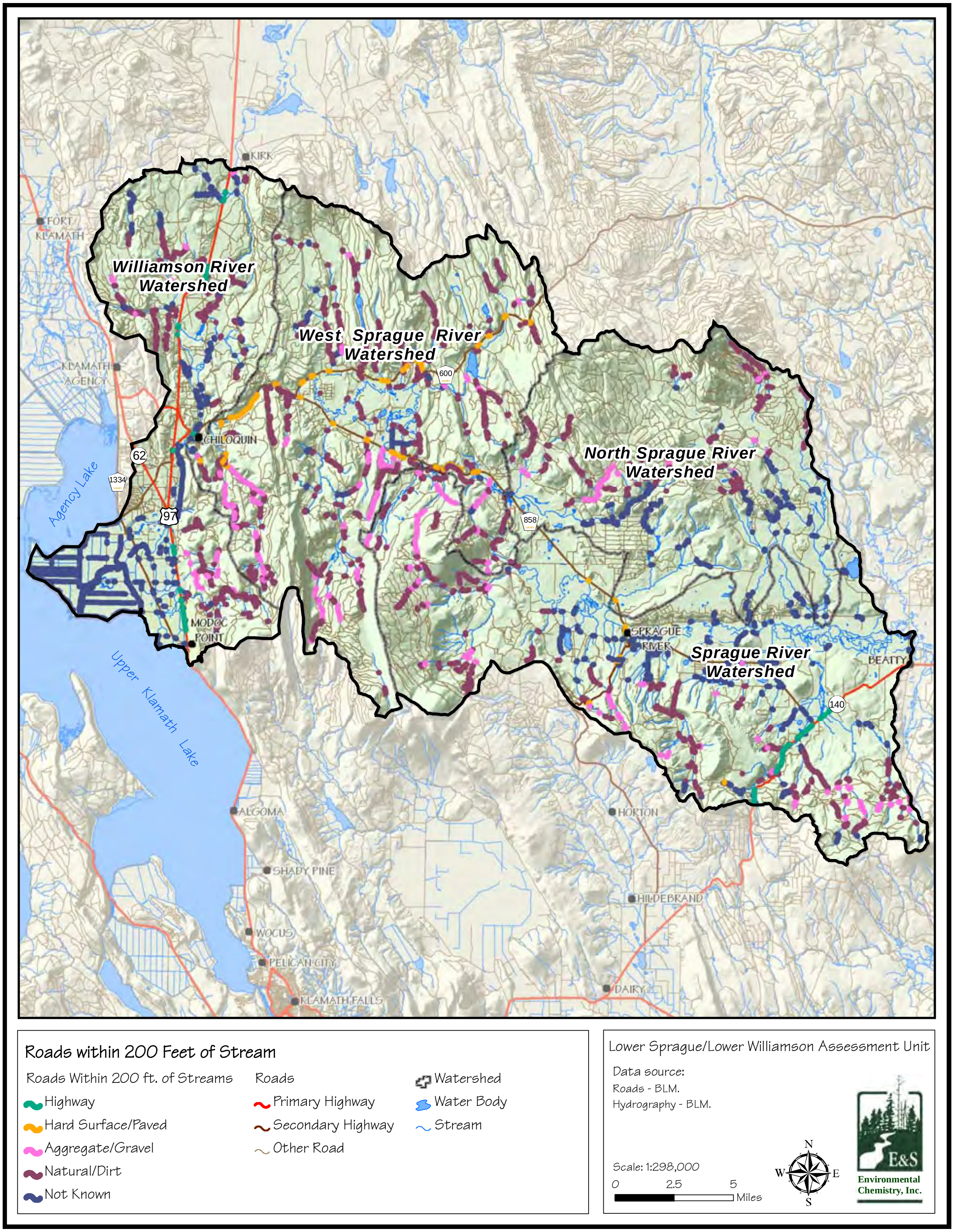
Roads Crossing Streams

GIS data for roads and streams were used to determine the number of locations where roads cross streams. Stream crossings were tallied where the BLM GIS road coverage and GIS streams coverage intersected (BLM 2005, BLM 2006). The number and location of stream crossings in each watershed are provided in Table
4-11, Map 4-7 and close-up Maps 4-7a through 4-7d. The number of stream crossings per mile of road (road/stream crossing density) ranges from 0.3 (approximately one crossing for every three road miles) in the North Sprague River watershed to 0.6 (approximately one crossing for every one mile of road) in the Sprague River watershed. The number of crossings is approximate because not all roads are mapped accurately.

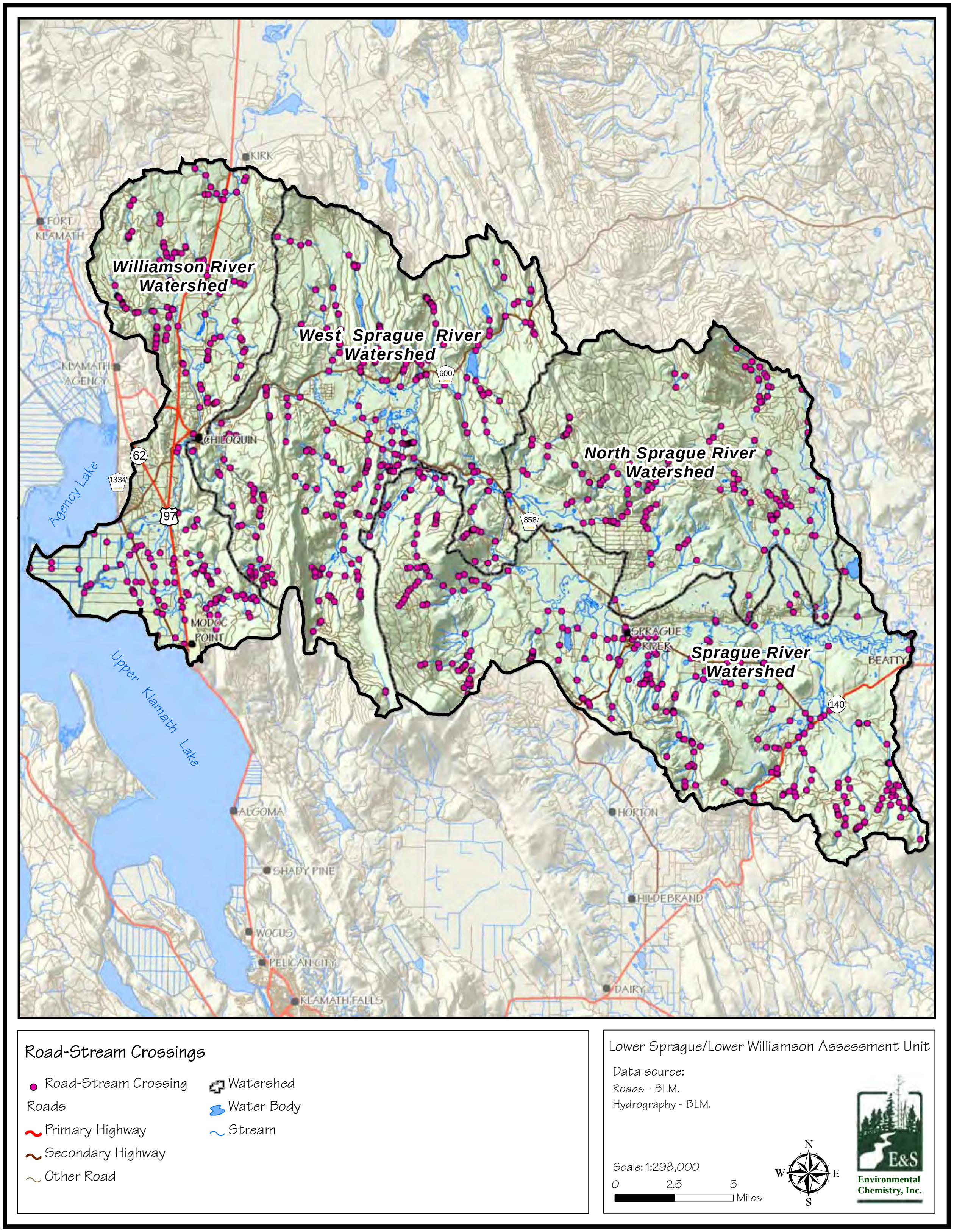
Table 4-11 Road-stream crossings in the Lower Sprague-Lower Williamson subbasin (Data Source: BLM 2005, 2006)

Watershed	Total	Density (crossings/mi of road)	Density (crossings/mi of stream)
North Sprague River	137	0.3	1.1
Sprague River	302	0.6	1.1
West Sprague River	310	0.4	1.6
Williamson River	214	0.4	1.2
Total	**963**	**0.4**	**1.2**

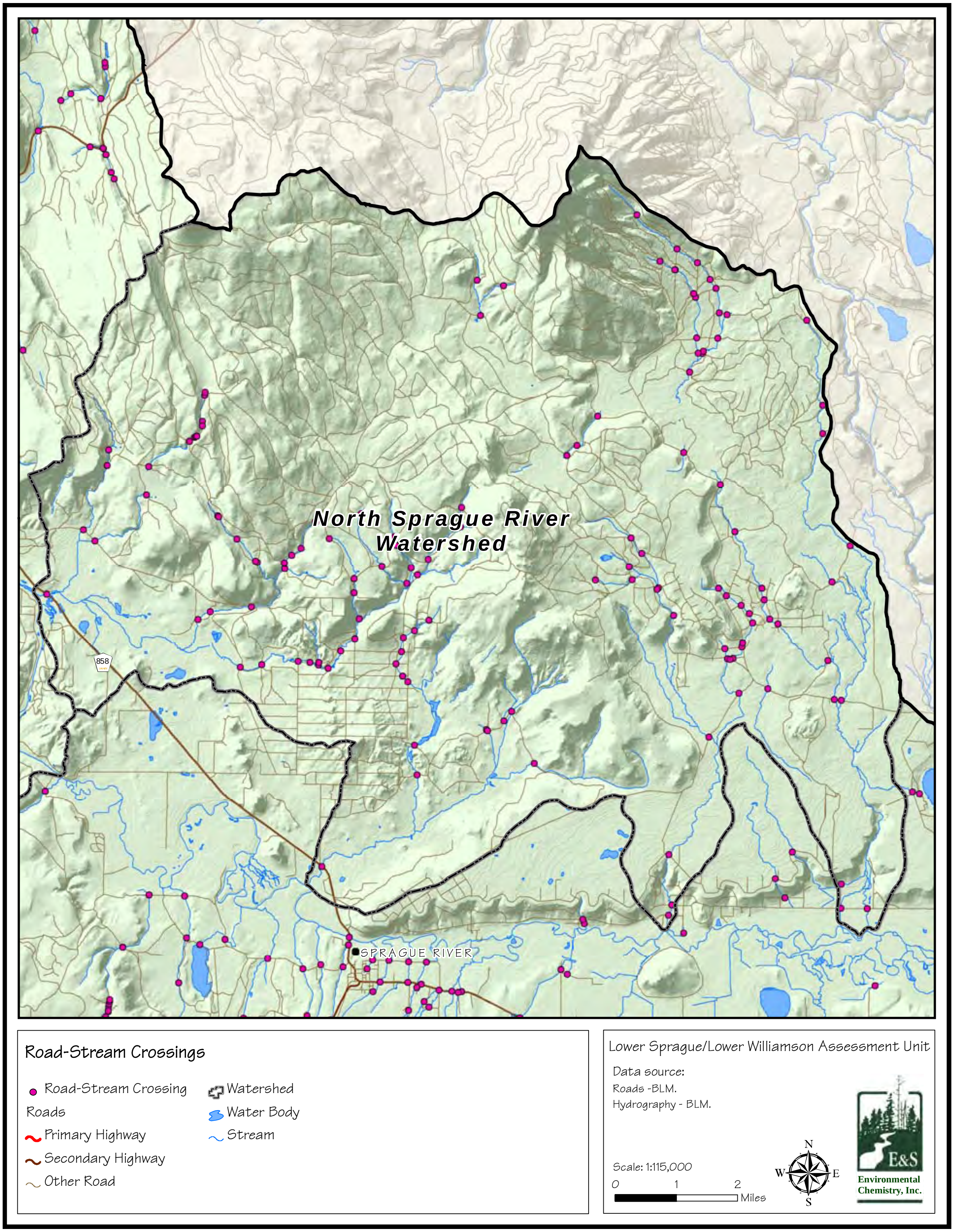
Data methods/limitations: Road-stream crossing point locations were generated by overlaying the road and stream layers using the GIS. The density of road stream crossings is calculated as the number of road-stream crossings divided by the area of the subwatershed. The accuracy of this layer is determined by source data limitations. These data area suitable for watershed-scale and subwatershed-scale characterization, and are not recommended for site-specific analysis or planning. Field verification is recommended prior to project planning.



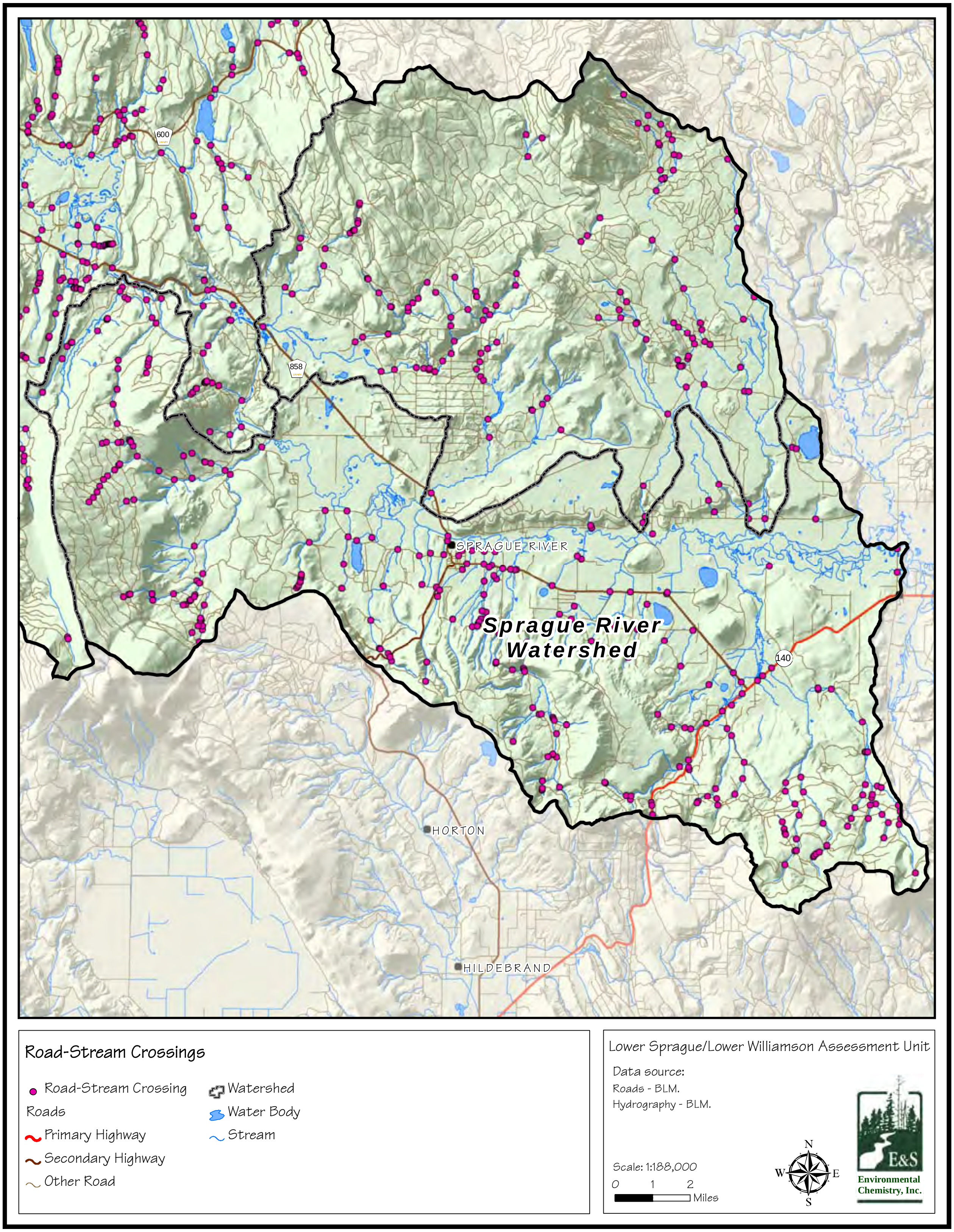
Map 4-6 Roads located within 200 feet of streams (Data Source: BLM 2005, BLM 2006)



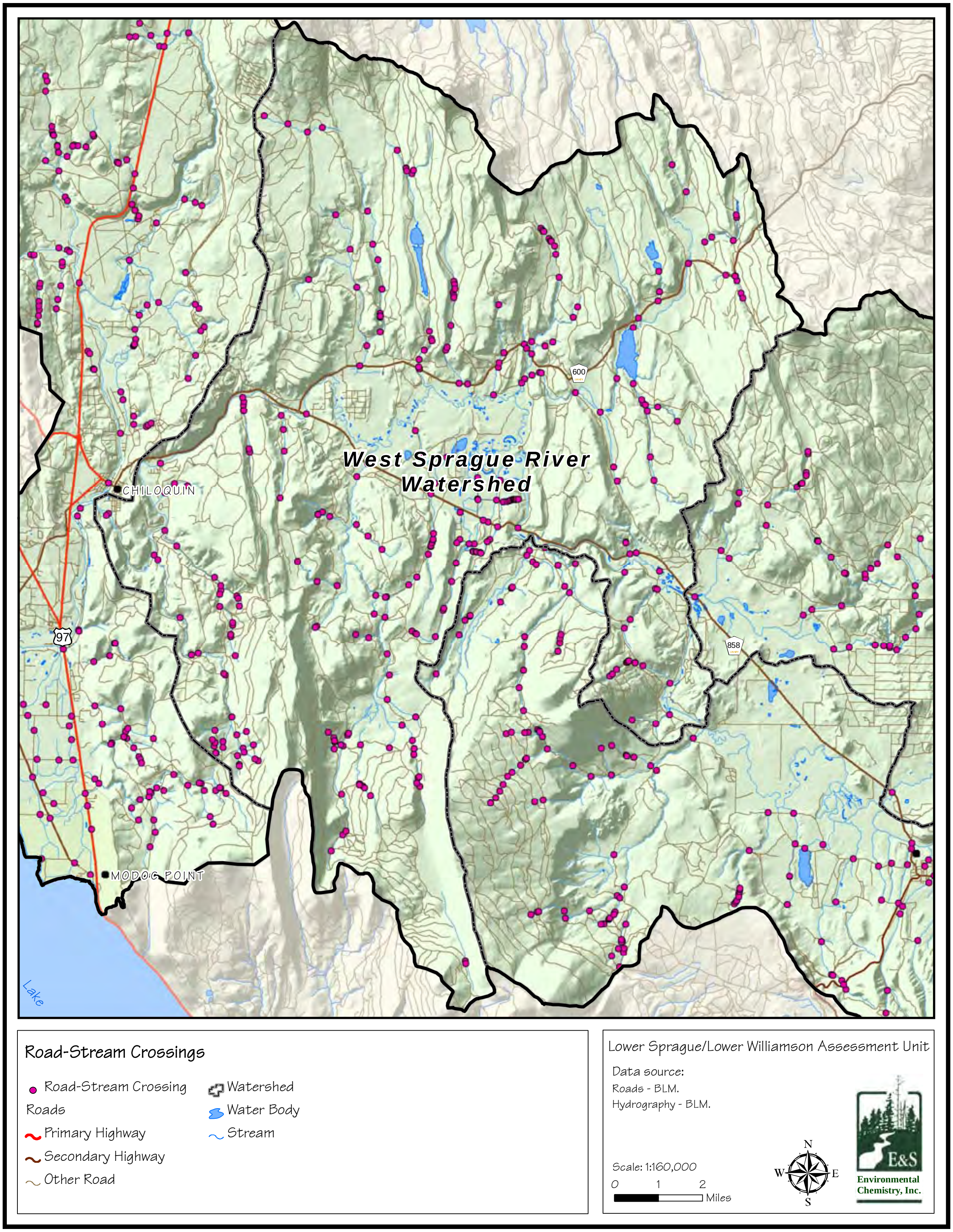
Map 4-7 Road-stream crossings in the Lower Sprague-Lower Williamson subbasin (Data Source: BLM 2005, BLM 2006)



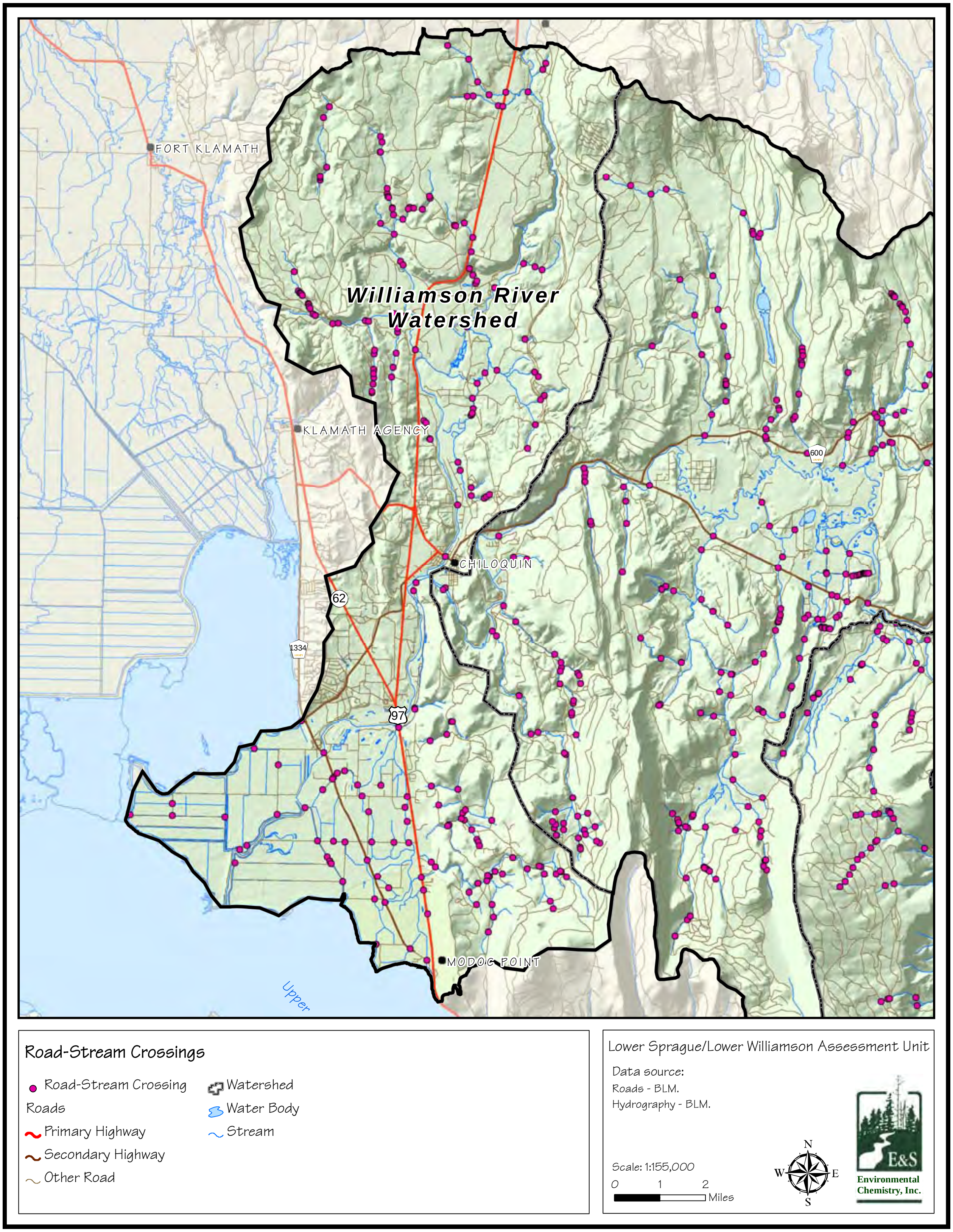
Map 4-7a Road-stream crossings in the North Sprague River watershed (Data Source: BLM 2005, BLM 2006)



Map 4-7b Road-stream crossings in the Sprague River watershed (Data Source: BLM 2005, BLM 2006)



Map 4-7c Road-stream crossings in the West Sprague River watershed (Data Source: BLM 2005, BLM 2006)



Map 4-7d Road-stream crossings in the Williamson River watershed (Data Source: BLM 2005, BLM 2006)

Roads and Erosion Potential

The effect of roads on delivery of sediment to streams can be influenced by the erosion potential of the soil, especially for roads surfaced with natural materials. The SSURGO data for Klamath County, Southern Part covers a portion of the Lower Sprague-Lower Williamson subbasin, primarily on private lands (Map 4-2). Data from this limited area were used to determine the relative abundance of soils of various erodibility classes (NRCS 2006a). The data are presented in Table 4-12, and represent the hazard or risk of soil loss due to erosion from unsurfaced roads and trails. Approximately 35 percent of the soils in the area surveyed are classed as severely sensitive to road-related erosion. A rating of "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised. The more sensitive areas are located primarily in the higher-sloped, or steeper, soil map units of this portion of the subbasin.

Table 4-12 Soil sensitivity to road-related erosion in areas of the Lower Sprague-Lower Williamson subbasin included in the Klamath County SSURGO database (Data Source: NRCS 2006a)

Rating Class	North Sprague River	Sprague River	West Sprague River	Williamson River	Total	
	Area (mi²)	Area (mi²)	Area (mi²)	Area (mi²)	Area (mi²)	%
Slight	9.0	39.3	16.0	43.6	107.9	25.4
Moderate	14.8	76.4	22.8	27.7	141.7	33.4
Severe	11.4	44.1	68.6	25.2	149.3	35.2
Very Severe	0	0	0	0	0	0
Not rated	9.5	10.2	2.5	3.3	25.5	6.0
Total	**44.7**	**170.0**	**109.9**	**99.8**	**424.4**	**100.0**

Rill and Gully Erosion

Rill and gully erosion are significant sources of sediment delivery to streams throughout the subbasin. Although quantitative data are generally not available, several generalizations can be made based on field observations. The soil resource inventory prepared for Winema National Forest (Carson 1979) identified land types within the forest that were more prone to rill and gully erosion.

Those judged to be most susceptible were rated as having extreme risk. They were characterized as having:

- Steep slopes on dome-shaped uplifts;
- Steep ridges and side-slopes; and
- Ashy soils overlying buried residual and colluvial (sloped) soils with mixed timber types (this land type typically occurs on shield volcanoes, basaltic eruptive centers and block faults on steep lands).

Each of these high-risk land types occurs on slopes greater than 40 percent, and each was rated as having extreme rill and gully erosion potential. A variety of other land types were found to be associated with high risk for gully and rill erosion. These included land types associated with such features as the following: old lake beds; volcanic features, such as cinder cones, lava table lands, rhyolitic dome uplifts and eruptive centers; alluvial and colluvial deposits, valleys and bottomlands; toeslopes, benches and footslopes where soil has accumulated by downslope movement; and steep ridges and side-slopes less than 40 percent.

Mass Movement of Soil

Although mass movement does not appear to have been an important source of sediment to streams within the study area, the potential exists for movement in some areas. Data on soil mass movement potential are not available for the watershed assessment area. This would be an area for future study to determine the potential of mass movement of soil and its contribution to stream sediment loads.

Wind Erosion

Wind erosion is the physical detachment and movement of soil particles by wind. Generally, wind erosion is considered to be a potential problem only in cultivated areas where soils are left bare for extended periods of time. In the Lower Sprague-Lower Williamson subbasin, wind erosion is not a great concern due to the minimal amount of intensively cultivated areas in the subbasin. Wind erosion is generally not a concern in forested areas, even when cleared, due to the presence of remaining understory vegetation or litter on the ground, which breaks up the force of the wind. However, it is important to note that the primarily sandy, diatomaceous or ashy soils found in the area are very susceptible to blowing when they are left bare and unprotected. This commonly happens when fields are being worked or when roads consisting of a bare soil surface are being used.

INFLUENCE OF HUMAN ACTIVITIES ON EROSION POTENTIAL

Human activities and land use practices within the watershed have altered the natural balance between sediment sources, transport and deposition within the stream system. The principal activities that have likely contributed to increased erosion are road building, railroads and logging in the uplands and stream channel modifications in the lowlands especially from vegetation removal, channel straightening, diking and wetland draining, as well as grazing on the streambanks. Management-related effects in the uplands are largely attributable to roads, which are subject to erosion of fillslopes, cutslopes, road surface (of unpaved roads) and ditches. Road-related erosion is probably high in the Lower Sprague-Lower Willimson subbasin because there is a very high density of roads and many of those are adjacent to streams. In steep areas, roads increase the risk of slope failure on both the underlying slope (oversteepened and low strength) and the slope above the road (oversteepened) (Biosystems 2003).

Drainage ditches associated with roads route surface runoff, thereby contributing increased sediment delivery if the ditches are hydrologically connected to streams (Biosystems 2003). Ditches can potentially expand the stream network during storms if they capture enough water to keep it channelized during runoff events and/or are directly connected to streams. The water that is captured and routed down a road or ditch can alter both the sediment load and the timing of the delivery of runoff to the stream.

Roads provide many useful benefits, including access for timber extraction and management, fire suppression and recreation. However, road construction can result in a high level of disturbance to the forest ecosystem, potentially affecting the hydrology, soil stability, fish passage, upland habitat fragmentation and downstream transport of material through the stream network. Road construction can expose bare soil on disturbed slopes and ditches, which are vulnerable to erosion until they become vegetated. In order to withstand traffic by log trucks and heavy vehicles, a compacted, impervious surface is created, and in some cases runoff is redirected along roadside ditches. Roads have long been the focus of concern regarding sedimentation of streams. However, the extent of the effect depends on many factors, including road location, proximity to the stream, slope, maintenance and construction techniques. Valley bottoms and mid-slope roads, especially those on steep slopes or near streams, can have large effects on sediment delivery to stream (Biosystems 2003, WPN 1999).

Road construction practices have changed significantly over the last 30 years. Improved road location, design, drainage and maintenance practices have all served to address problems associated with roads. Improved, frequent cross-drain culverts divert road surface runoff before it reaches a stream channel. Changes in timber harvesting practices have reduced the need for roads, and road obliteration or blocking projects have reduced overall road density. Protection zones around streams and riparian buffer strips have served to mitigate negative road effects (Biosystems 2003). Continued improvement of the road system, including closure of unnecessary or problematic road segments, replacement of undersized culverts and ongoing maintenance, will be necessary to minimize the effect of roads on sediment delivery to streams.

Ditches can potentially expand the stream network during storms. They can alter both the sediment load and the timing of delivery of runoff to the stream. Proper drainage of roads, including the use of well-designed and maintained ditches, is important to minimize the adverse effects of roads on water quality and aquatic habitat. Land management agencies and some private landowners have begun programs to minimize erosion from roads and ditches on their lands.

Logging practices changed substantially after passage of the Oregon Forest Practices Act in 1973. There are now required practices, such as riparian buffers, low compaction vehicles and road watering, that reduce soil disturbance and retain riparian vegetation during logging operations. More recent forestry operations typically cause less erosion than previous ones, but effects from past practices probably persist to some extent.

Channel modifications and vegetation removal during the nineteenth and twentieth centuries contributed to streambank and surface erosion. The increased peak stream velocity that has resulted from channelization and diking, and reduction in the amount of wetlands, have increased the erosive capability of streams within the subbasin, but to an unknown degree. In addition, the clearing of riparian vegetation has reduced the resistance of streambanks to erosion. More recently, implementation of Best Management Practices (BMPs), including many riparian fencing projects on private lands, has reduced erosion caused by agricultural practices. Riparian restoration and planting efforts should continue to improve overall bank stability conditions.

The legacy of past land use practices within the watershed is associated with erosion today, but the magnitude of effect from past land management is difficult to quantify. In the uplands, human-caused erosion is probably still most strongly associated with the presence of roads, especially those closest to stream channels and on steep slopes. In the lowlands, where there is an absence of intact riparian vegetation and the continuation of land-disturbing activities, excessive bank erosion will likely continue. Future sources of sediment to the stream system will continue to include legacy effects of past road construction, agricultural practices, government projects, channel engineering and straightening, and logging operations. In general, however, such sources will probably diminish in significance over time as problem culverts are replaced, roads are upgraded or decommissioned, and riparian vegetation is restored. Future logging and associated road building may contribute new sources of erosion, but proper road design, maintenance practices and careful adherence to current best management practices should minimize such effects (Biosystems 2003).

DATA, METHODS AND LIMITATIONS

The information presented in the tables for Tables 4-2, 4-3, and 4-4 was based on analysis of digital map data obtained from the BLM (BLM 2005, BLM 2006). This information was the most accurate information available at the time of analysis. ArcGIS, a Geographic Information System (GIS), was used to buffer and overlay the mapped road and stream data to provide a watershed-scale and subwatershed-scale understanding of the interactions between these landscape features.

The most accurate roads layer available is the BLM's "General Transportation" layer. This layer contains the most complete spatial coverage, as well as the most information regarding road surface conditions, and consequently was used for road analyses in this chapter. However, it must be noted that this layer was created by the BLM by merging road layers from a variety of sources and scales ranging from 1:12,000 to 1:100,000, so road density may sometimes be inconsistent. Similarly, the streams layer was developed by the BLM in a multi-agency effort and is generally at 1:24,000 in scale, but may include data at the scale of 1:100,000. Consequently, these data are not recommended for site-specific planning or project implementation. Field verification is necessary prior to any site-specific work. Due to changes through time and inaccuracies in the source data, some roads and streams may be in the wrong location or may not appear at all. Nonetheless, based on discussions with professionals working in the watershed and residents of the watershed, we believe the data are suitable for characterization of conditions at the scale of the Watershed Assessment.

The proximity of roads to streams provides a means of characterizing the potential opportunity for roads to contribute sediment to streams and makes it possible to compare subwatersheds with regard to sediment movement in the watershed. However, that characterization does not imply that sediment is being contributed by the road at every identified location. There are many other factors in addition to proximity, such as slope steepness, soil characteristics and road maintenance condition, that influence the likelihood of sediment movement. The purpose of this analysis is to identify *potential* areas of sediment contribution to streams and to characterize how potential sediment-producing areas are distributed throughout the landscape.

DATA GAPS

- Operation maintenance level of roads (miles) in the portions of the Lower Sprague River subbasin within the Fremont portion of the Fremont-Winema National Forest.
- Classification of the natural stability of soil, by watershed (indicating the potential for mass movement), as determined by Fremont National Forest. NOTE: Fremont-Winema National Forest digital data for soil stability are not available for the Lower Sprague River subbasin.
- Survey of streambank erosion along reaches of Sprague River, Williamson River and larger tributaries. Survey should include causes/explanation of excessive amounts of streambank erosion, particularly in terms of riparian-wetland functions.

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CHAPTER 5. HYDROLOGY AND WATER USE

INTRODUCTION

The subjects of hydrology and water use in the Lower Sprague-Lower Williamson subbasin are complicated, because regional stakeholders are currently involved in contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Some information has been produced by state and federal agencies, some has been produced by tribes, some by private consultants, and some has been compiled by citizens, landowners and advocacy groups. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced are frequently disputed by entities with competing claims.

This Watershed Assessment is built upon the premise that differing opinions regarding natural resources issues should be respected and given voice. It is also built upon the premise that there are many different sources of legitimate information about watershed conditions and functions, and that not all of these sources come in the form of published, peer-reviewed reports prepared by professional scientists. Given these premises, and given the pervasive influence of the adjudication on stakeholders' views with regard to hydrology and water use, the preparation of this chapter demanded a substantial additional investment of time and attention in an attempt to ensure that the information presented did not constitute an inadvertent endorsement or validation of contested information.

It is perhaps inevitable that the information presented in this chapter will be unsatisfactory to some stakeholders involved in the adjudication. It is hoped, however, that the bulk of the information is found to be useful to landowners that are required to make day-to-day management decisions and to stakeholders as they work together to sustain both the natural and human communities in the Lower Sprague-Lower Williamson subbasin.

HYDROLOGY

Limited water availability influences virtually all aspects of stream and watershed health, from water temperature and pool depth to the quality of the habitat for fish and other life forms. It affects agricultural and domestic water uses and constrains human use of the land and enjoyment of the natural resources. Furthermore, water availability concerns will almost certainly be exacerbated if climate projections are realized. Currently, most natural resource management studies do not include a discussion of climate change unless it is the direct focus of the study. However, there is a clear scientific consensus that our climate is warming and that precipitation patterns are changing (IPCC 2001, INR 2004). Such changes are expected to have important effects on natural resource issues in the Lower Sprague-Lower Williamson subbasin.

Current models of the effects of climate change in the Pacific Northwest suggest that maximum snow pack depth will shift to earlier in the year, resulting in earlier maximum stream flow and decreased late-summer flows. Projected population growth is likely to increase water demand at the same time that water availability is projected to be declining (INR 2004). Additional effects may include a lengthening of the growing season, longer fire season, earlier plant flowering and animal breeding, and changes in elevational plant distributions (INR 2004).

Precipitation

The Lower Sprague-Lower Williamson subbasin lies in the semi-arid rain shadow east of the Cascade Mountains. The majority of precipitation falls as snow from October through March. The subbasin receives rain and snow totaling between 15 inches and 42 inches of precipitation each year, depending on elevation, with the highest elevations receiving the greatest depths (OCS 2007). Winter temperatures drop below 0º F. Frost and snow may occur in all seasons at higher elevations. Although summers are dry, they are characterized by intense localized convective thunderstorms.

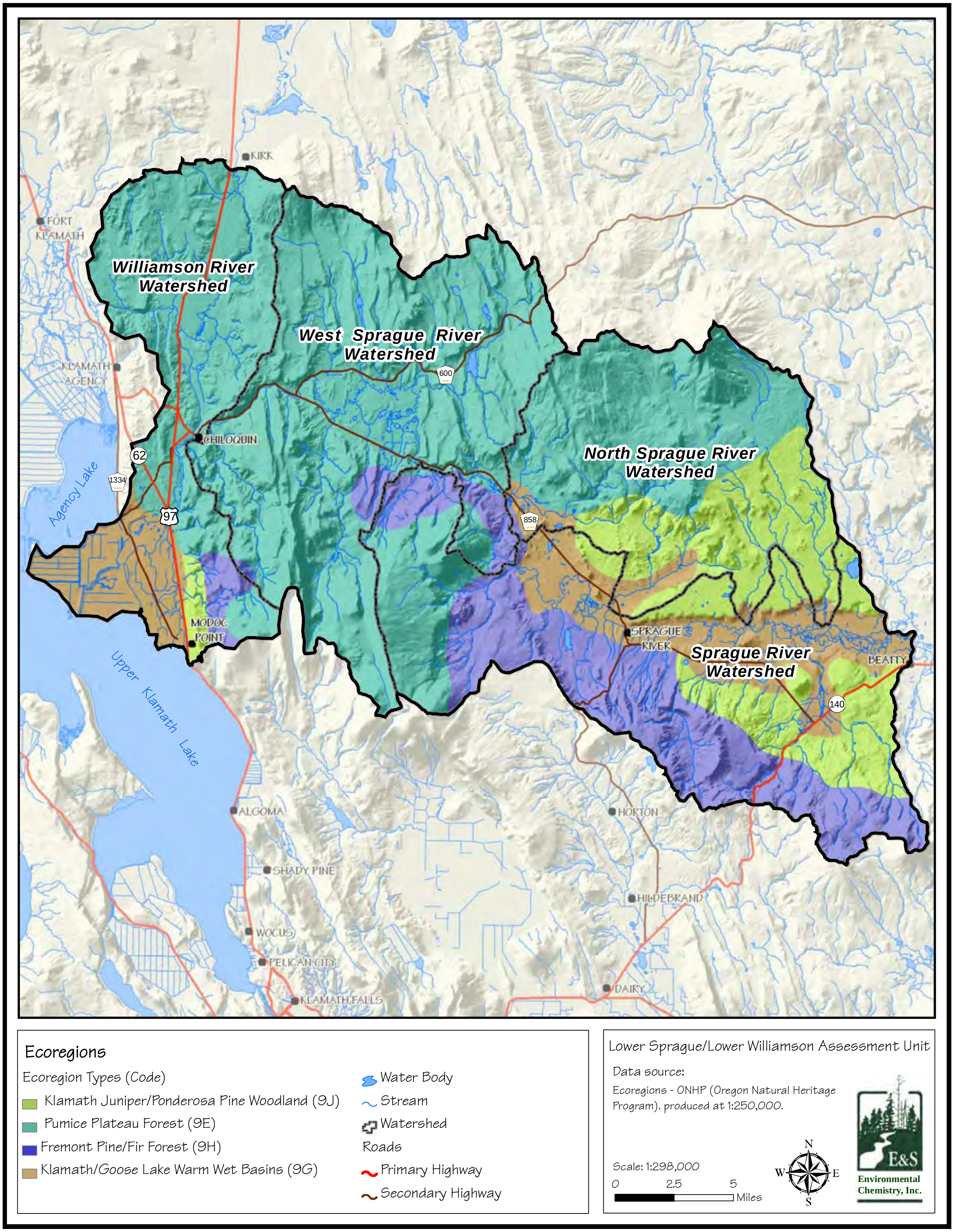
It is important to note that while the majority of precipitation that falls is snow, snow acts much differently than rain in the watershed. Rain results in peak flows and run-off relatively quickly compared to the snow event. In contrast, snow fall does not result in peak flows, runoff and infiltration until the snow melts. Therefore, instead of seeing peak flows and runoff events during the months with the highest precipitation (December through February), peak flows and runoff events are seen in spring, during snowmelt or rain-on-snow events. When the ground is frozen, no infiltration of precipitation or snowmelt will occur. The ground needs to be thawed to allow infiltration. Juniper trees also limit the amount of precipitation that infiltrates, because they catch the precipitation in their canopy. Once captured in the canopy, the precipitation often evaporates before hitting the ground surface and infiltrating (Barrett 2007).

Just because there is an average precipitation year does not mean there is an average water year. The water year is dependent on the timing of the water availability and type of precipitation. An adequate snowpack is needed to ensure an average water year. Lots of rain does not necessarily mean there will be adequate water later in the season (late summer and fall). The late water typically results from snowmelt occurring over a longer season due to a higher snowpack.

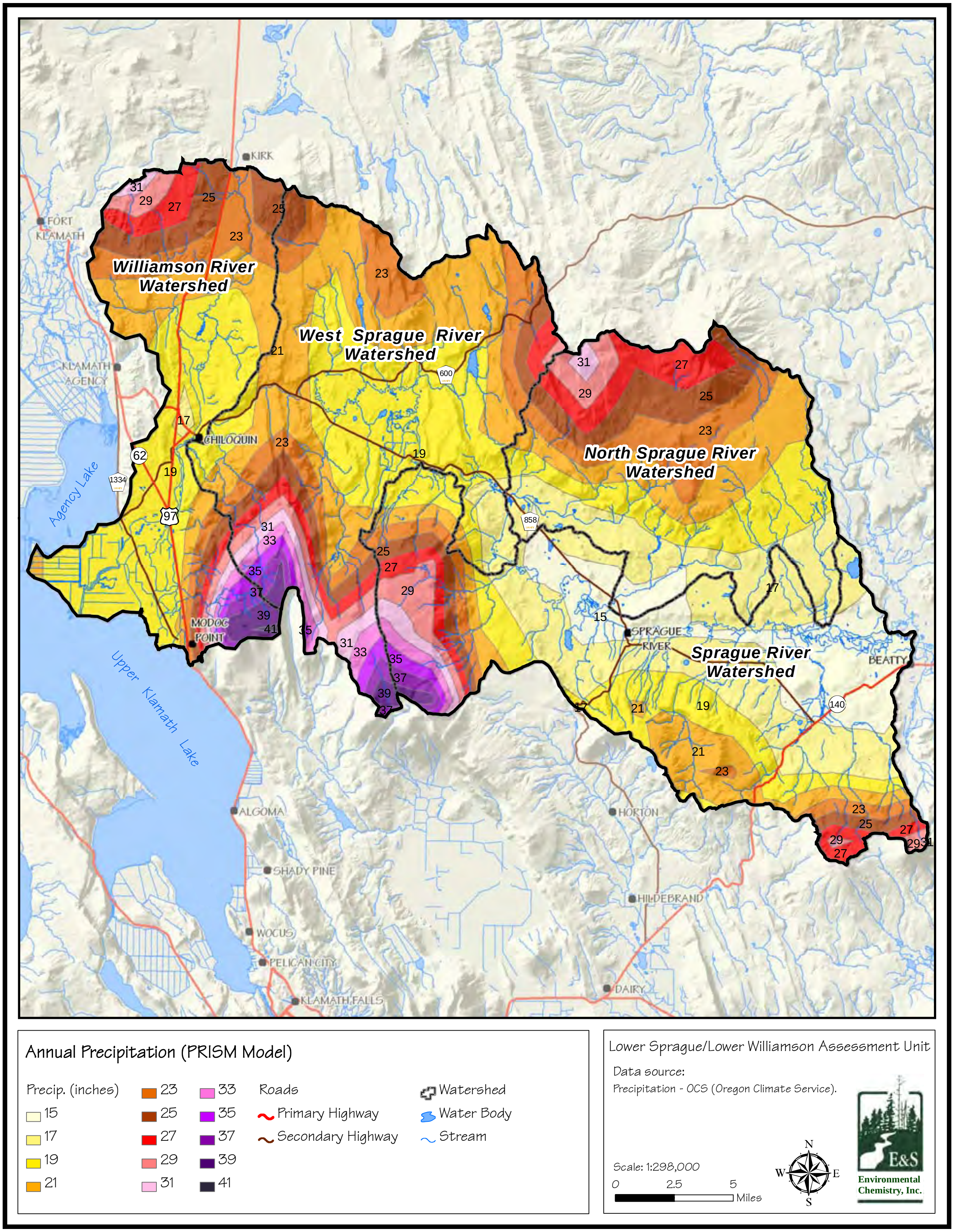
The Lower Sprague-Lower Williamson subbasin contains four watersheds (USGS 5th-field) spanning several ecoregions that vary somewhat in their general hydrologic characteristics (Map 5-1). The ecoregions included in the Lower Sprague-Lower Williamson subbasin and their hydrologic characteristics are listed in Table 5-1. The Pumice Plateau Forest and Fremont Pine/Fir Forest ecoregions experience the highest amounts of precipitation, while the Klamath/Goose Lake Warm Wet Basins and Klamath Juniper/Ponderosa Pine Woodland ecoregions are the driest (Table 5-2; Map 5-2).

Table 5-1 Ecoregions of the Lower Sprague-Lower Williamson subbasin (Data Source: ONHP 1995)

Ecoregion	Area (mi^2)	Characteristics
Fremont Pine/Fir Forest	87.4	Steeply to moderately sloping mountains and high plateaus with high gradient intermittent and ephemeral streams. Reservoirs, a few glacial rock-basin lakes and many springs occur.
Klamath Juniper/Ponderosa Pine Woodland	88.4	Undulating hills, benches and escarpments containing medium gradient streams. A few small plateau lakes occur, but reservoirs are common.
Klamath/Goose Lake Warm Wet Basins	76.0	Pluvial lake basins containing floodplains, terraces and low gradient streams.
Pumice Plateau Forest	347.8	High elevation, nearly level to undulating volcanic plateau with isolated buttes, marshes, spring-fed creeks and streams with low to medium gradients.



Map 5-1 Ecoregions in the Lower Sprague-Lower Williamson subbasin (Data Source: ONHP 1995)



Map 5-2 Modeled annual precipitation for the Lower Sprague-Lower Williamson subbasin, using PRISM
(Data Source: OCS 2006)

There are several types and sources of precipitation information for the Lower Sprague-Lower Williamson subbasin. Continuous precipitation records have been collected in the vicinity of the town of Sprague River, within the Sprague River Valley reach of the study area. These records include some data gaps, but they span a sufficient time period to provide a reliable estimate of average conditions (WRCC 2006). Climatologists at Oregon State University (OSU) have developed the Parameter-elevation Regressions on Independent Slopes Model (PRISM), which estimates average annual precipitation throughout Oregon (OCS 2006). These data are probably best for estimating precipitation amounts. Finally, the Snowpack Telemetry (SNOTEL) program of the Natural Resource Conservation Service (NRCS) collects data on snow accumulation. There are several SNOTEL stations within the subbasin.

Figure 5-1 presents average annual precipitation by year (WRCC 2006). Although the record extends from 1953 through 2001, years in which more than five consecutive days of data are absent in a single month were removed. Average annual measured precipitation at Sprague River is 17 inches and at Chiloquin is 20 inches (Figure 5-1). In some parts of the assessment area, annual average precipitation may be less. Annual precipitation has been below average since 1999, with with 2004 being a slight exception. Average monthly precipitation as measured at Chiloquin is presented in Figure 5-2. December typically has the most precipitation and July/August has the least. Four months, November through February, account for more than half of annual precipitation (WRCC 2006).

PRISM was developed by researchers at OSU to estimate climatological conditions across the state of Oregon (Daly et al. 1994, OCS 2006). The GIS precipitation data available from OSU for the Lower Sprague-Lower Williamson subbasin are shown in Map 5-2. Mean annual precipitation ranges from 15 inches near Beatty to 37 inches in the upper elevations of Swan Lake Point. The average annual precipitation for the subbasin as a whole, as estimated by PRISM, is approximately 25.8 inches, but varies considerably among the constituent watersheds. The precipitation characteristics modeled by PRISM for the watersheds are provided in Table 5-3.

Table 5-2 Hydrologic characteristics of ecoregions within the Lower Sprague-Lower Williamson subbasin
(Data Source: ONHP 1995)

Ecoregion	Code	Precipitation	Precipitation Pattern	Runoff Pattern	Peak Flow
Pumice Plateau Forest	9E	16 to 30 inches	Most precipitation occurs in the winter months from November to January.	Average monthly stream flows are highest in the late spring and early summer months. Some streams also experience high flow values in the fall and winter.	Primarily spring rain-on-snow, spring snowmelt and spring rainstorms; winter rain-on-snow can also produce peak flows, though they are less common.
Klamath/ Goose Lake Warm Wet Basins	9G	10 to 18 inches; up to 40 inches in higher elevations	Most precipitation occurs in the winter months, predominately in November to January.	Average monthly stream flows tend to be slightly higher in winter and spring; many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Fremont Pine/Fir Forest	9H	15 to 40 inches	Majority of the precipitation occurs during the winter and early spring months from December to April.	Average monthly stream flows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Klamath Juniper/ Ponderosa Pine Woodland	9J	12 to 20 inches	Most precipitation occurs in the winter months, predominately in November to January.	Average monthly stream flows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.

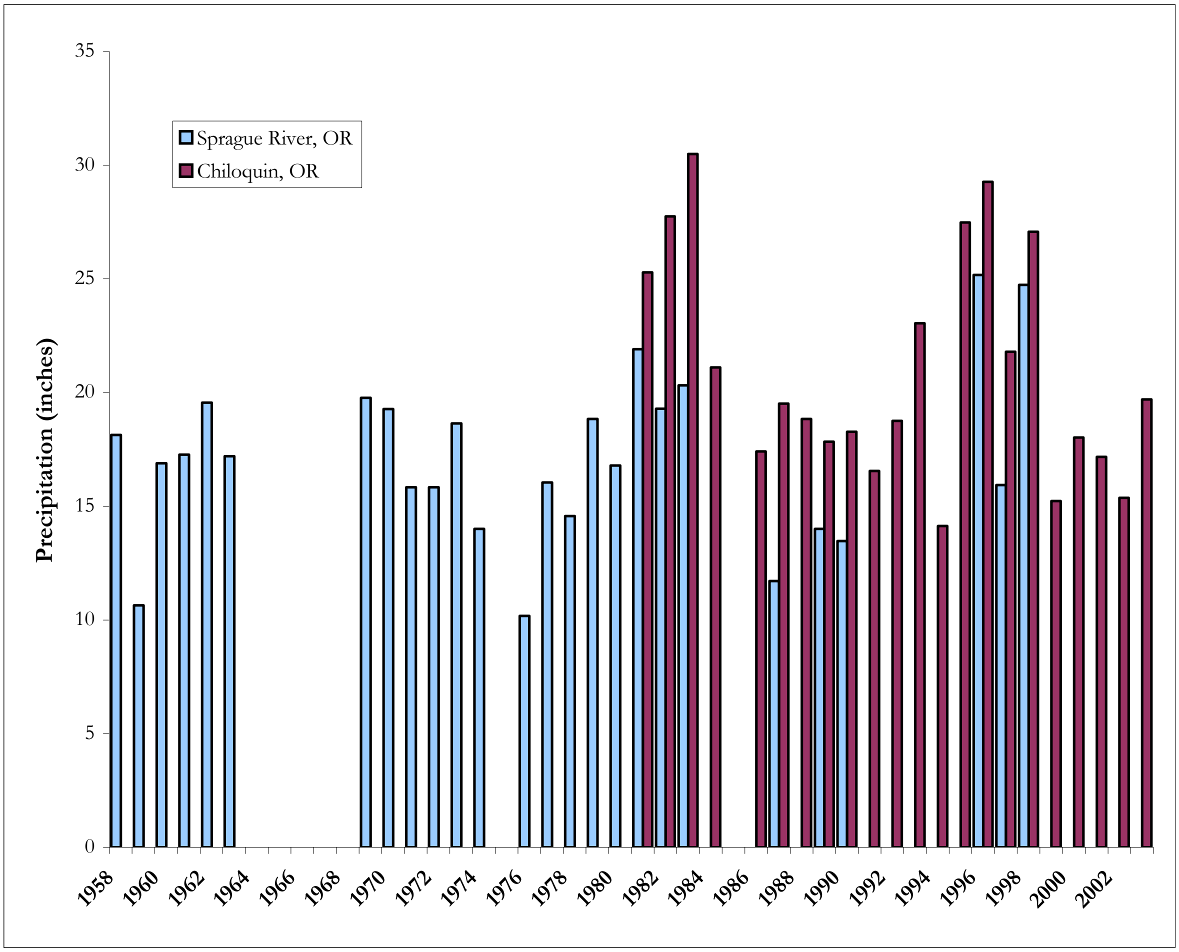


Figure 5-1 Annual precipitation measured at Chiloquin and Sprague River, showing long-term patterns in regional precipitation
(Data Source: WRCC 2006)

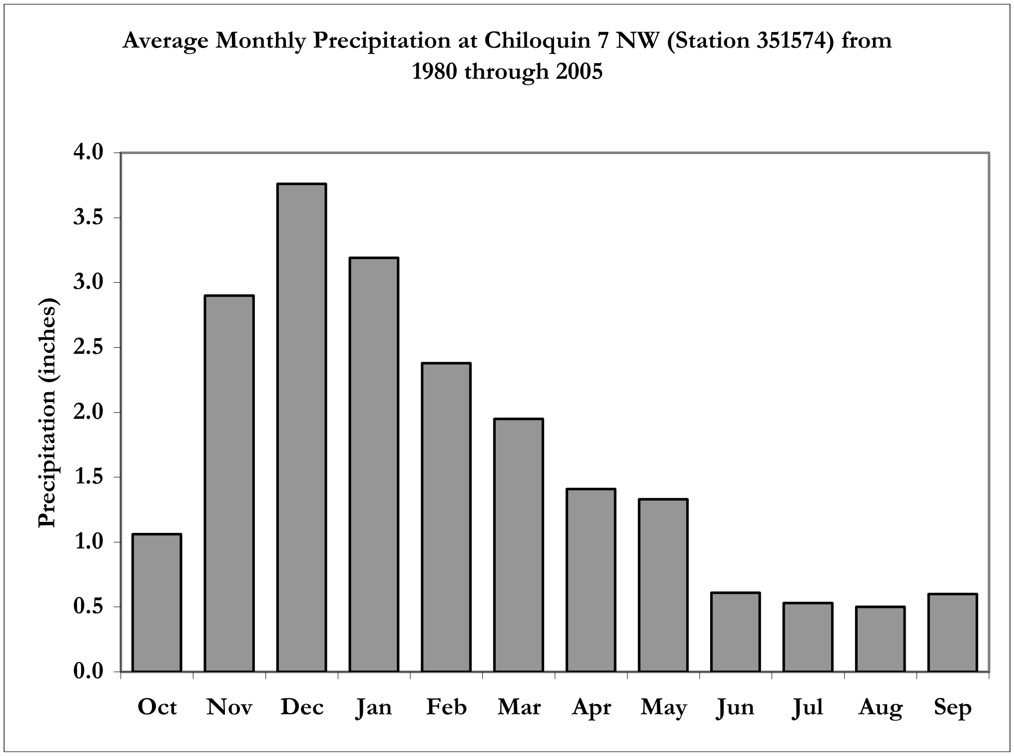
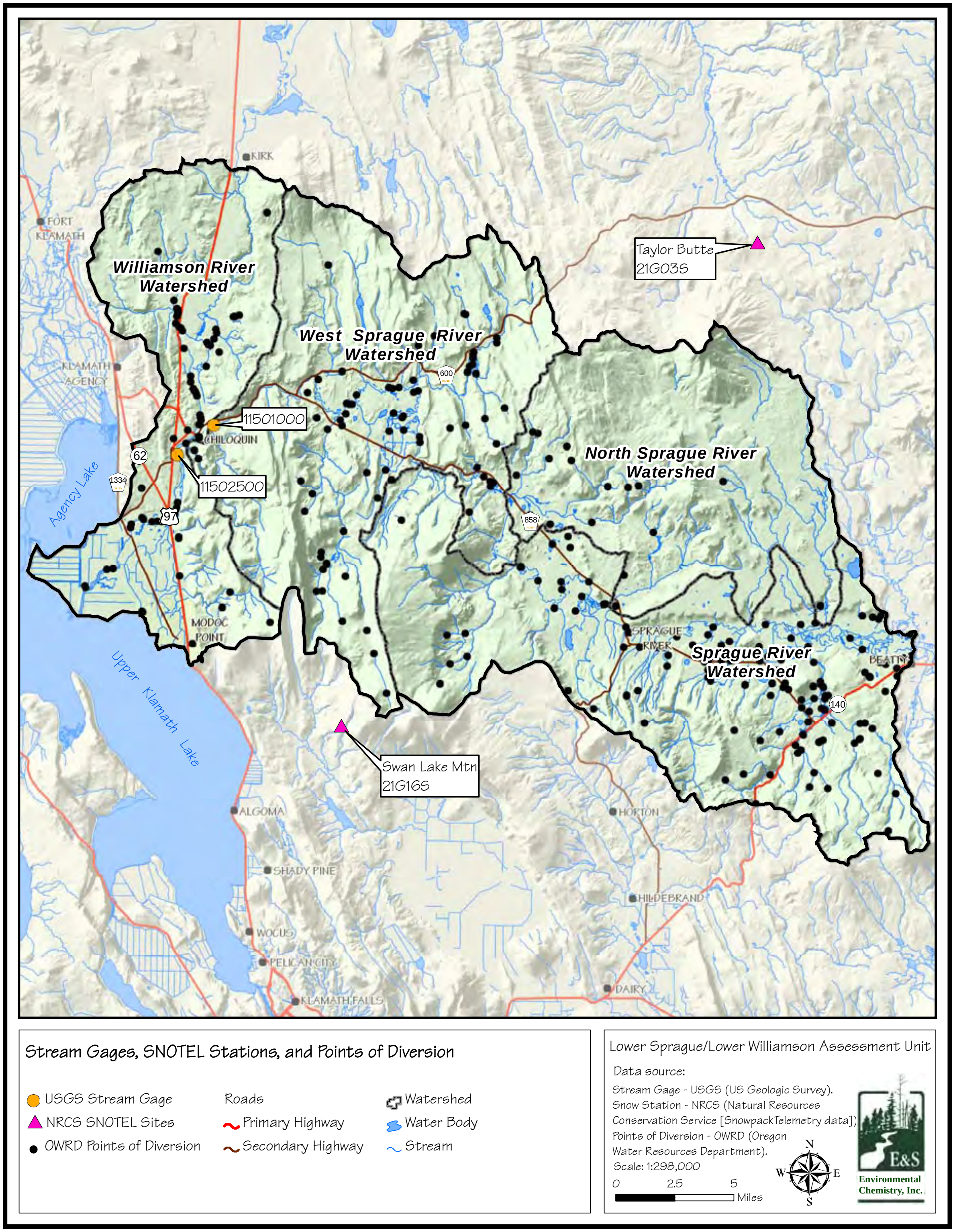


Figure 5-2 Annual distribution of precipitation as shown by average monthly precipitation at Chiloquin, Oregon
(Data Source: WRCC 2006)

Table 5-3 PRISM annual precipitation values for watersheds of the Lower Sprague-Lower Williamson subbasin
(Data Source: OCS 2006)

Watershed	Minimum Precip. (in)	Average Precip. (in)	Maximum Precip. (in)	Minimum Elevation (ft)	Maximum Elevation (ft)	Area (m^2)
North Sprague River	15	21	31	4,278	6,926	123.0
Sprague River	15	25	39	4,265	7,261	183.9
West Sprague River	17	28	41	4,164	7,011	176.0
Williamson River	17	29	41	4,124	6,490	116.7

Winter precipitation typically falls as snow and accumulates throughout the Lower Sprague-Lower Williamson subbasin. Snow pack data were obtained from the Natural Resource Conservation Service (NRCS 2006) for approximately the last 25 years at four SNOTEL snow survey sites near the subbasin. These are listed in Table 5-4, and shown on Map 5-3. Annual snowpack is quite variable from year to year. Figure 5-3 illustrates the peak annual snow pack for the period of record for the Taylor Butte and Cold Springs Camp snow survey sites. Although the greatest amount of precipitation typically occurs in December (based on the Sprague River data), maximum snow accumulation typically occurs in February, as measured at Taylor Butte (Figure 5-3).



Map 5-3 **Locations of stream gages, SNOTEL stations, and points of diversion in the Lower Sprague-Lower Williamson subbasin**
(Data Sources: USGS 2005, NRCS 2006, OWRD 2007)

[Note: The Cold Springs Camp SNOTEL site is outside the mapped region but is included in this figure because of its proximity to the subbasin. This SNOTEL site is located in a high zone area of the southern Cascades and most likely overestimates the snow amounts within the watershed assessment area. The Swan Lake SNOTEL site has only one data year and is not included in this figure.]

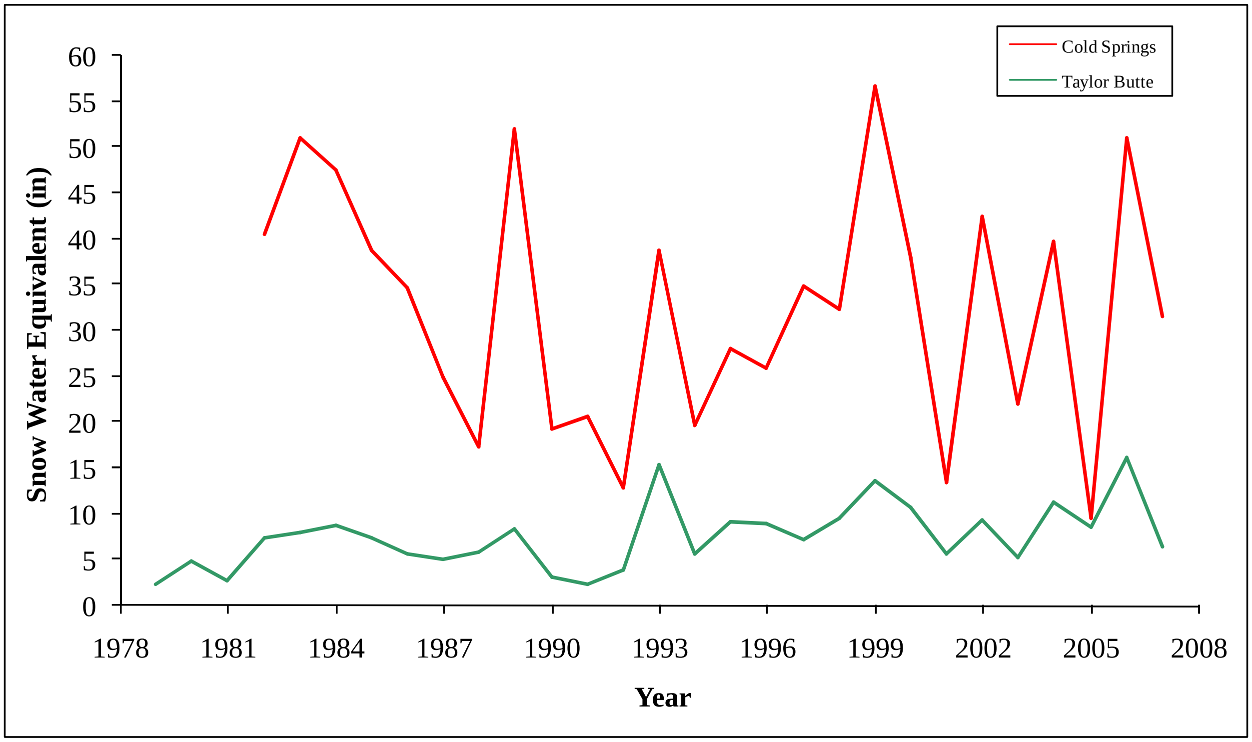


Figure 5-3 Maximum annual snow pack (snow water equivalent) at snow survey sites in the vicinity of the Lower Sprague-Lower Williamson subbasin
(Data Source: NRCS 2006)

Table 5-4 Snow survey sites in the vicinity of the Lower Sprague-Lower Williamson subbasin
(Data Source: NRCS 2006)

Site Name	Site ID	Elevation (ft)	County	Land Ownership	HUC	Latitude (degrees)	Longitude (degrees)	Installed in Water Year
Cold Springs Camp	22G24S	6,100	Klamath	Winema NF	18010203	42.53	-122.18	1982
Swan Lake Mtn	21G16S	6,800	Klamath	Private	18010204	42.40	-121.70	2006
Taylor Butte	21G03S	5,100	Klamath	Winema NF	18010201	42.70	-121.40	1979

Groundwater

Subsurface geology in the Sprague River valley is complex, and groundwater dynamics are not well understood. Studies have been completed by the U.S. Geological Survey to attempt to clarify groundwater relationships in the Sprague basin (Gannett et al. 2007). Information below was taken from this report. Some of the information for the material below was taken from a report prepared in 1974 (Leonard and Harris 1974). In the 1980s, the Oregon Water Resource Department conducted groundwater studies within the Whiskey Creek drainage. Although more recent work indicates that the geology and water-bearing characteristics may be more complex than previously described, it provides a useful introduction to a complex issue.

The source of most groundwater in the Klamath Basin is precipitation that falls within the basin and infiltrates into the ground, largely in the mountains. The porous pumice and fractured volcanic rocks in the mountains readily absorb precipitation and transmit it toward the lowland areas. Infiltration and recharge are greatest along the eastern slope of the Cascades and the northern end of the basin (Leonard and Harris 1974).

Part of the groundwater occurs in a relatively shallow zone under water-table or perched conditions, and part in a deeper zone, largely under confined conditions. Groundwater in the shallow zone generally moves only a short distance from its source before it is discharged through springs along the mountain slopes (Leonard and Harris 1974).

A large part of water that infiltrates into the ground seeps downward to deep zones and moves laterally toward and beneath the lowlands. Where favorable permeable zones for fracture are intersected by streams, some of this water is discharged into the stream by springs. The general movement of groundwater in the deeper zone is from north to south and from the uplands toward the valleys. At least some of the lowlands are areas of discharge, where groundwater is discharged by upward seepage from confined aquifers and through springs (Leonard and Harris 1974).

Inflow to the lowlands of the Sprague River valley is largely from the north and east, although some groundwater moves toward the valley from the southeast and south. There is also a downstream component of groundwater movement within the lowland area. Water levels in the main aquifer along the Sprague River are 100 to 200 feet higher than in neighboring valleys. This suggests that groundwater could move from the Sprague River valley to the Swan and Yonna valleys, but data from Leonard and Harris (1974) are not adequate to verify such movement. There is a some debate over this assumption, because there is not adequate data to support this theory (Bruce Topham, pers. comm. 2008).

Range and upland areas in the Upper Klamath Basin interior and eastern margins drain toward stream valleys and interior subbasins. Groundwater discharges to streams throughout the basin, and most streams have some component of groundwater (baseflow). Some streams, however, are predominantly groundwater-fed and have relatively constant flows throughout the year. Large amounts of groundwater discharge in the Wood River subbasin, the lower Williamson River area, and along the margin of the Cascade Range. Much of the inflow to Upper Klamath Lake can be attributed to groundwater discharge to streams and major spring complexes within a dozen or so miles from the lake. This large component of groundwater buffers the lake somewhat from climate cycles (Gannett et al. 2007).

There are also groundwater discharge areas in the eastern parts of the Upper Klamath Basin, for example in the upper Williamson and Sprague River subbasins and in the Lost River subbasin at Bonanza Springs. One such groundwater discharge creek is Spring Creek. This creek originates from a large spring in Collier State Memorial Park on the western side of Highway 97. This creek delivers clean, cold water to the lower Williamson River some distance above the confluence of the Sprague and Williamson rivers.

Throughout the Lower Sprague-Lower Williamson River subbasin, there are groundwater discharge areas. However, seepage is not uniform, but rather is concentrated in a few parts of the valley. Seeps and large springs are the principal sources of discharge (Leonard and Harris 1974).

Artesian wells were developed in a broad area from near Beatty to the town of Sprague River. Some wells are in use, some are no longer flowing, and some have been capped and are not currently being used. The current status of these artesian wells was unavailable. At least 35 flowing wells existed in this area in the 1970s (Leonard and Harris 1974).

The groundwater system in the Upper Klamath Basin responds to external stresses such as climate cycles, pumping, lake stage variations and canal operation. This response is manifested as fluctuations in hydraulic head (as represented by fluctuations in the water-table surface) and variations in groundwater discharge to springs. Basin wide, decadal-scale climate cycles are the largest factor controlling head and discharge fluctuations. Climate-driven water-table fluctuations of more than 12 feet have been observed near the Cascade Range, and decadal-scale fluctuations of 5 feet are common throughout the basin. Groundwater discharge to springs and streams varies basin-wide in response to decadal-scale climate cycles (Gannett et al. 2007).

Stream Flow

The hydrology of the Lower Sprague-Lower Williamson subbasin is complex. It includes large marshes, numerous small wetlands, springs and multiple patterns of groundwater discharge. Stream flow is supplied primarily by snowmelt and groundwater. Many small streams are seasonal, drying up in the summer. In other parts of the subbasin, perennial streams, such as Spring Creek, receive substantial groundwater inputs, maintaining cool water temperatures throughout the summer and fall.

Stream flow can be influenced by precipitation patterns and amounts, snowpack development and melting, pumping of groundwater to the surface, whether water infiltrates into the soil or runs off, vegetative cover, and water loss to the atmosphere through evapotranspiration (ET). ET includes water loss by evaporation from water bodies and the soil, and also loss from plants through transpiration. Plants exchange oxygen and carbon dioxide with the atmosphere through tiny pores called stomata. When stomata open to allow gas exchange, the plant also loses some water to the atmosphere through the process called transpiration.

In addition to climatic limitations on the availability of water, various human activities have exacerbated the limited water supply and time of availability. These activities have included ecological changes that have contributed to denser and more extensive forest ecosystems, reduction in the amount of wetland acreage, construction of water impoundments, widening of stream channels, construction of the Chiloquin Dam and increased water use. Changes in forest age, distribution and species composition from historic conditions have probably resulted in changes to the hydrologic regime, although the magnitude of such changes is unknown. Changes to riparian areas may also have affected the hydrology of the streams. The net effect of different riparian plant communities on stream flow, in comparison to irrigated plants such as pasture grasses and hay, is not well understood. A stream system that is in proper functioning condition (PFC) can store a large amount of water in the soil and the deep root systems of native plants in the floodplain and riparian zone. However, the rate of water loss by ET for some native plants is higher than irrigated plants. Consequently, it is difficult to state with certainty how changing the vegetation community will ultimately affect stream flow.

Two USGS stream flow gages collect stream discharge (flow) data in the Lower Sprague-Lower Williamson subbasin. They are listed in Table 5-5 and illustrated on Map 5-3. These two gages have adequate data, which has been recorded for more than 86 years (USGS 2005).

Table 5-5 Stream flow records from the Lower Sprague-Lower Williamson subbasin (Data Source: USGS 2005)

Gage Number	Gage Name	Period of Record
11501000	Sprague River near Chiloquin	03/1921 - 10/12/2007
11502500	Williamson River below Sprague River near Chiloquin	10/1/1917 - 10/9/2007

The annual cycle of discharge in streams in the Lower Sprague-Lower Williamson subbasin is offset from the annual precipitation cycle, because much of the precipitation falls as snow and accumulates until spring, when it melts. Peak discharge in subbasin streams usually occurs in the spring, well after the period of maximum precipitation. Maximum discharge can be influenced by rain-on-snow events that can occur at any time throughout the winter, depending on local climatic events. Monthly flows for streams in the Lower Sprague-Lower Williamson subbasin are illustrated in Figure 5-4. Peak flows in the Sprague River near Beatty typically occur in May, whereas peak flows in the lower Sprague River (near Chiloquin) occur in April. The lower Williamson River below the Sprague River confluence also exhibits peak flows during April. Minimum flow at both gages occurs in August and September. Flows in the Sprague River near Beatty, lower Sprague River, and Williamson River, typically begin increasing in December and gradually increase to the peak flow.

Minimum Flow

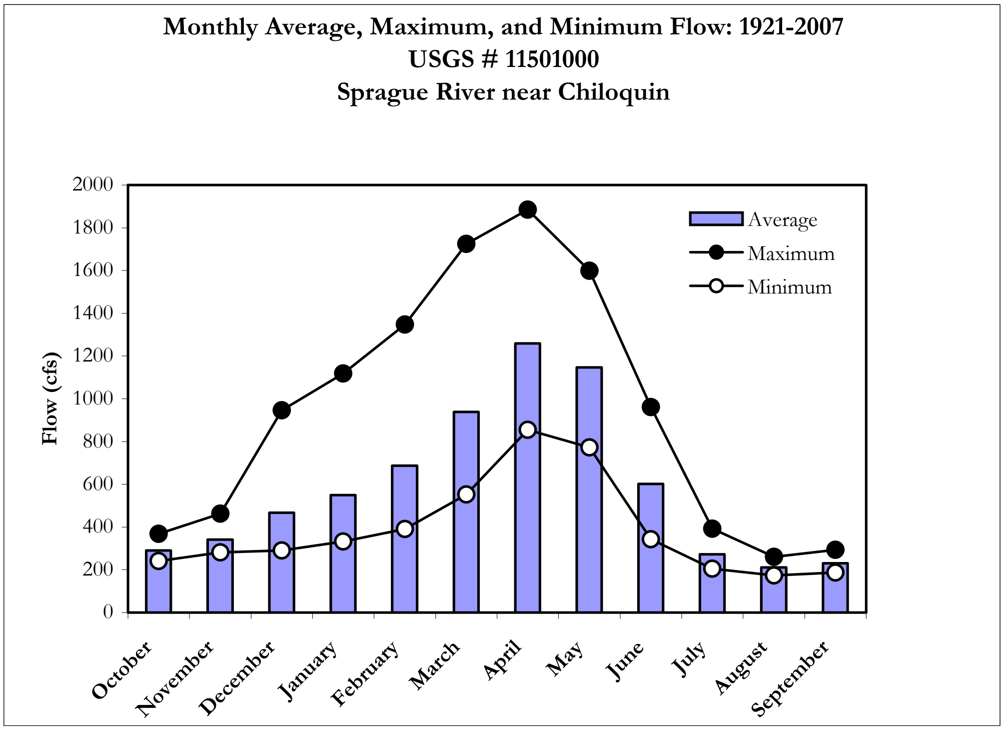
The dependence of flow on snowmelt combined with a lack of substantial snow in the late summer leads to the minimum flows exhibited from July through October. Only 15 to 17 percent of average annual flow occurs in the Sprague River near Beatty from July through October. Minimum daily average flow during July through October is about 58 percent of normal daily flow in the Sprague River near Beatty, The low-flow history in the Sprague River near Chiloquin and the Williamson River below the Sprague River confluence is summarized in Figure 5-5. The available data show several drought cycles, with lowest flows occurring around 1955, 1981, 1994 and 2002 (USGS 2005).

Peak Flow

Annual peak flows of streams within the Lower Sprague-Lower Williamson subbasin can occur during winter, spring or summer. Furthermore, peak flows can occur in response to rain, rain-on-snow or snowmelt events. An investigation of the hydrology of the region including the Lower Sprague-Lower Williamson subbasin (WPN 1999) identified that 57 percent of all annual peak flow values recorded at the 19 flow monitoring stations in the southern portion of the East Cascades ecoregion occurred in the spring months, while 25 percent occurred during winter. Peak flows are usually associated with a warm spell and rain-on-snow events. In combination, the spring snowmelt and spring rain or rain-on-snow events accounted for slightly more peak flows than did winter rain and rain-on-snow processes. Summer rainstorms were also identified as a regular producer of annual peak flows in some streams.

Peak flows are associated with spring snowmelt and summer rainstorms for all ecoregions, although the Pumice Plateau Forest ecoregion also experiences rain-on-snow events in the spring and sometimes in the summer. Stream flows tend to be slightly higher in the winter and spring than at other times of the year for the Klamath/Goose Lake Warm Wet Basins, Fremont Pine/Fir Forest and Klamath Juniper/Ponderosa Pine Woodland ecoregions. The Pumice Plateau Forest ecoregion experiences high stream flows in both late spring and in the fall and winter for some streams. The other three ecoregions exhibit the highest stream flows in spring, with a small peak again from late summer rains (Table 5-2).

Peak flow patterns for the two stations with the most comprehensive flow data are illustrated in Figure 5-6. The two largest flow events recorded for the Sprague River, Fall 1964 and Winter 1997, were the result of rain-on-snow events. Eyewitness accounts of the flood in 1997, including one by Craig Bienz, describe the flood as stretching "from valley wall to valley wall." Cliff Rabe comments on the flood of 1997, "I have never seen the river [Sprague River] so high. The river even flooded the stack yard [for hay bales]."



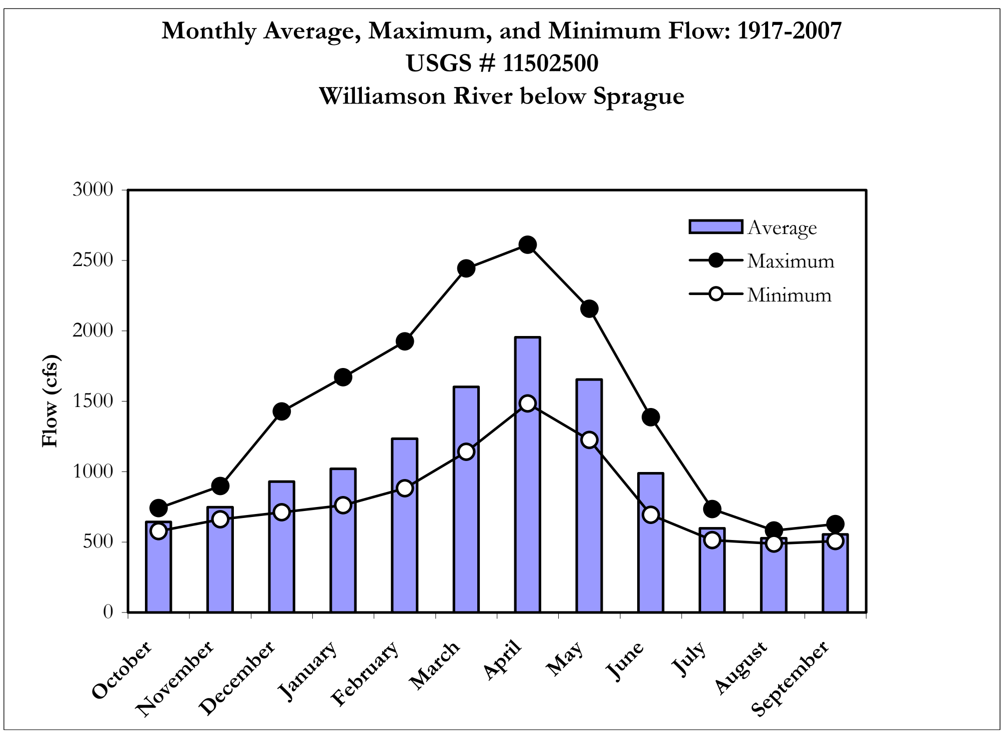
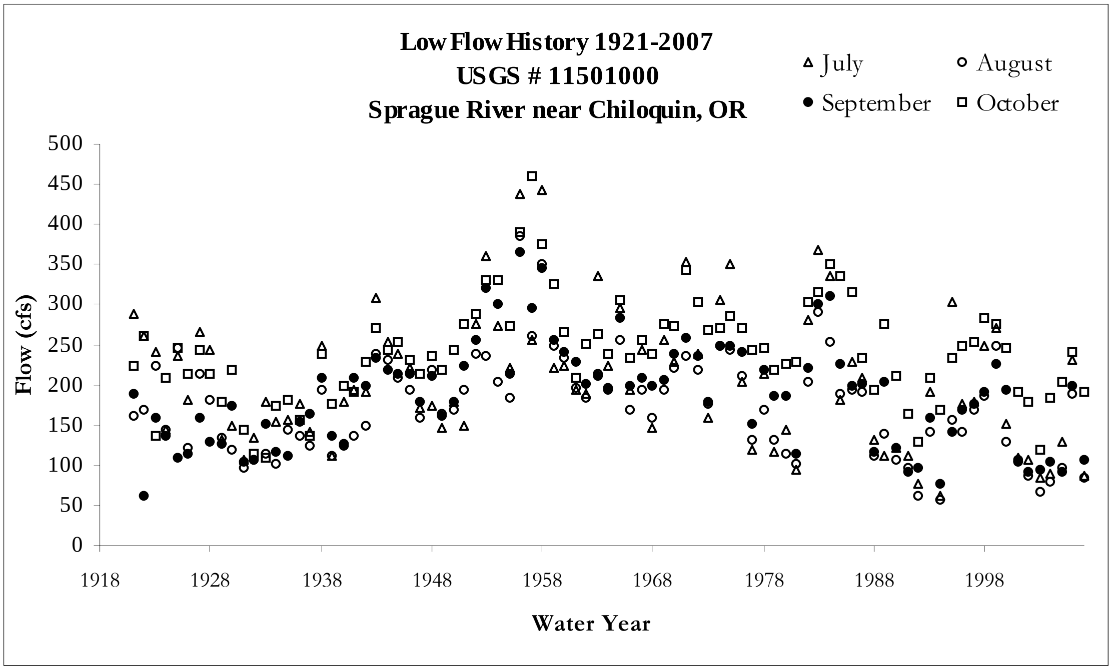


Figure 5-4 Monthly stream flow throughout the period of record in the Sprague River near Chiloquin and the Williamson River below Sprague confluence (Data Source: USGS 2005)



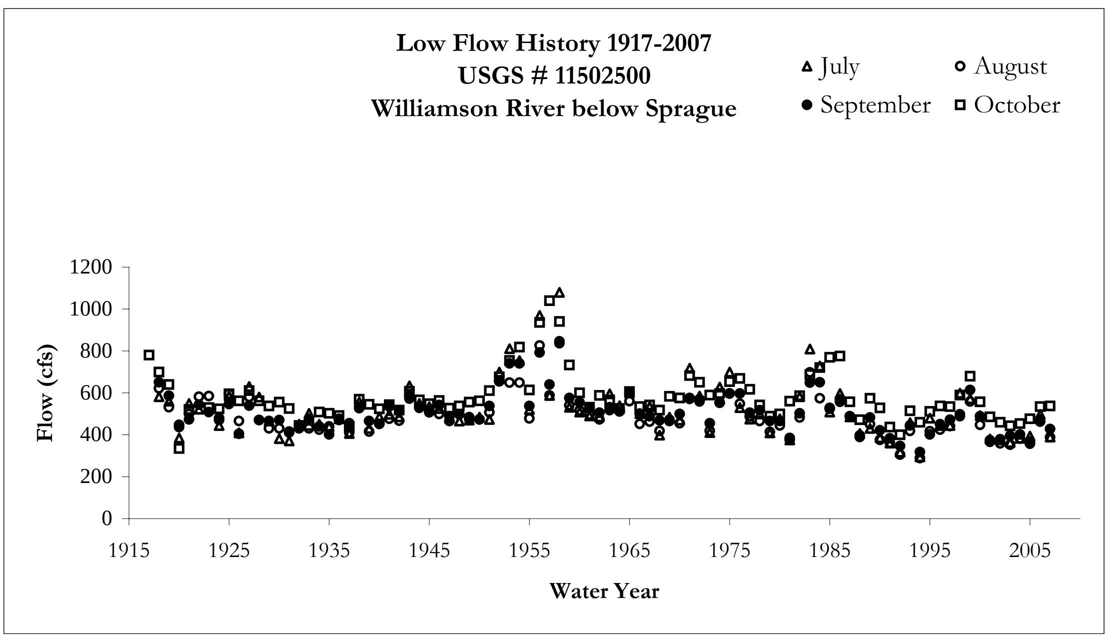
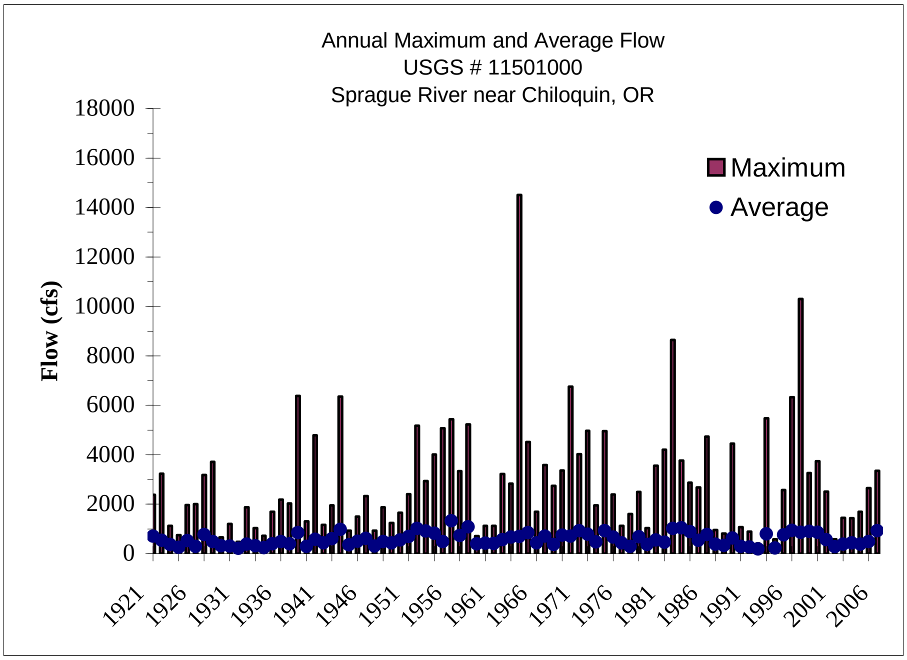


Figure 5-5 Low-flow history for the period of record for the Sprague River near Chiloquin and Williamson River below Sprague confluence
(Data Source: USGS 2005)



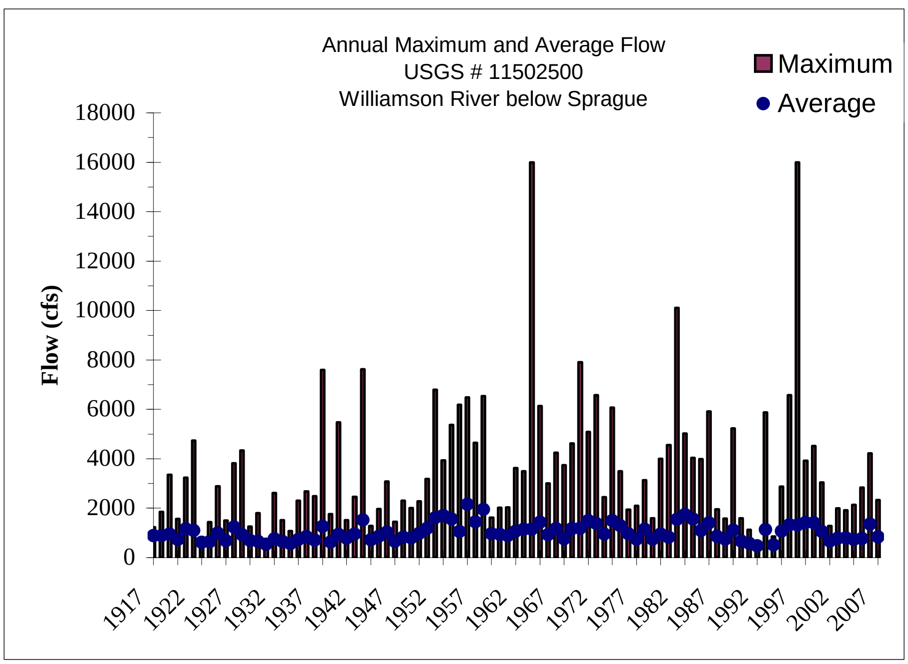


Figure 5-6 Annual peak flow measured in the Sprague River near Chiloquin and the Williamson River below Sprague confluence
Data Source: USGS 2005)

WATER USE

Irrigated agriculture is an integral part of the economy of the Upper Klamath Basin. Although estimates vary somewhat, roughly 500,000 acres are irrigated in the Upper Klamath Basin, about 190,000 acres of which are part of the U.S. Bureau of Reclamation's Klamath Project. Most of this land is irrigated with surface water. Groundwater has been used for many decades to irrigate areas where surface water is not available, for example, outside of irrigation districts and stream valleys. Groundwater has also been used as a supplemental source of water in areas where surface water supplies are limited and during droughts. Groundwater use for irrigation has increased in recent years due to drought and shifts in surface water allocation from irrigation to in-stream uses.

This section presents information on water use within the Upper Sprague River subbasin. Under Oregon law, most available water is publicly owned (Bastasch 1998). A water right entitles a person or organization to withdraw publicly owned water for a specific type of use, for example, domestic use, livestock watering, or irrigation. The Oregon Water Resources Department (OWRD) issues water rights to both private and public users through a permitting process (Bastasch 1998). In Oregon, water rights are distributed according to the "principle of prior appropriation," which means that older water rights have priority over newer ones. If water becomes scarce during dry years, the holders of the most recently issued water rights will be the first who are required to cease withdrawing water to ensure that an adequate supply is available for the holders of more senior water rights (OWRD 2001).

Regional stakeholders are currently involved in a contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced are frequently disputed by entities with competing claims.

Water is withdrawn for a broad array of beneficial uses. Water is used to grow crops or forage for livestock. Towns and cities withdraw water, as do rural residents, for domestic use. Water is also required by the fish and other organisms that live in the streams. Frequently, the need for water for a multitude of beneficial uses results in conflicting opinions on how priorities should be set.

Consumptive Water Use

In this section, information regarding the maximum diversion rate permitted for consumptive use is summarized from available information on OWRD's website (OWRD 2006). This maximum diversion rate represents the maximum potential diversion from all surface water right permits, not necessarily the amount that is actually used. The actual amount diverted for use varies seasonally and from year to year, and is usually less than the maximum allowed amount (OWRD 2006). Consumptive water use does not include groundwater or storage (i.e., wells or reservoirs). In-stream water rights are also excluded from these analyses because they do not entail removing water from the hydrologic system, but they are discussed in the subsequent section.

Permitted flow rates for water withdrawal do not provide an accurate indication of the amount being withdrawn, which varies seasonally, because not all permit-holders use all of their allocated water. Also, most of the withdrawn water returns to the stream, and may be withdrawn again by another downstream user (Cooper 2002).

Oregon Water Resources Department (OWRD) categorizes consumptive uses into three categories: irrigation, municipal, and all other uses. The categories are based on water right and in some cases actual diversion is less than maximum allowable diversion. (Cooper 2002)

The following methods are widely used to estimate irrigation consumptive use in a watershed (Cooper 2002):

1. Multiply the number of acres permitted to be irrigated by all water rights by the permitted duty;
2. Summing the permitted rates of diversion for all water rights;
3. Summing the actual diversions; and
4. Taking a census of the actual number of acres irrigated and the type of crops grown, then finding the consumptive use based on crop water requirements.

OWRD describes the methods #1 through #3 (above) as over-estimating consumptive use. Using the method #4 (described above), OWRD estimates that, in Oregon, over 80 percent of water use is for irrigation. In 1990, 91 percent of diversions for irrigation were from surface water, and 43 percent of the water diverted was used consumptively by the crops (Cooper 2002). This method (#4) does not account for the remaining 48 percent diverted, but not consumed, and this amount would presumably vary by irrigator.

Groundwater pumping may augment stream flows. Alternatively, groundwater pumping can reduce natural spring and groundwater input to streams. The effects of the timing and location of withdrawal are additional considerations.

The following water uses may not require a water right: natural springs, stock watering, salmon propagation, fire control, forest management, and rainwater collection (OWRD 2001). Groundwater uses that are exempt include stock watering, lawn and garden watering (less than one-half acre) and domestic water uses of no more than 15,000 gallons per day.

OWRD also approves in-stream water rights, which are rights that keep water in the stream for the benefit of fish, minimizing the effects of pollution or maintaining recreational uses (OWRD 2001). In-stream water rights designate monthly flows and are regulated in the same manner as other water rights. They do not guarantee that a certain quantity of water will be present in the stream, because they cannot affect a use of water with a senior priority date (OWRD 2001).

If water has been continuously used since before the establishment of water laws in Oregon in 1909, the property owner may have a "vested" water right. These uncertified rights, or "claims," can be found valid in a judicial (court) process known as adjudication. The process of adjudicating water rights is currently under way in the Sprague River basin on lands that were formerly part of the Klamath Indian Reservation. The area outside of the former reservation is not included in the ongoing adjudication process, because that area has already been adjudicated. Most of the land under adjudication lies outside the assessment area. Once the adjudication process is complete, OWRD will issue water right certificates for each decreed right (OWRD 2001).

Information on water rights that have been adjudicated or permitted is available from the OWRD. OWRD provides online access to databases including the Water Rights Information System (WRIS) and the Water Availability Reporting System (WARS). Using the WRIS database, it is possible to download a list of water rights or claims for drainage basins within Oregon. However, this list may

change in the Lower Sprague-Lower Williamson subbasin as a result of the ongoing adjudication process.
A consumptive use is defined as any water use that causes a net reduction in stream flow (Cooper 2002). Oregon Revised Statute (ORS) 536.340 authorizes the Water Resources Commission to classify water for beneficial use. A classification indicates the uses for which new water permits can be issued, including domestic, municipal, irrigation, power development, industrial, mining, road construction, manufacturing, recreation, wildlife, fish and pollution abatement. These uses are usually associated with a loss from evaporation or transpiration, or the water may be withdrawn from the system (Cooper 2002).

Water uses are generally not considered to be 100 percent consumptive. Consumptive use is estimated by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the nonconsumed part of a diversion returns to the stream from which it was diverted (Cooper 2002). The exception is when diversions are from one watershed to another, in which case the use is considered to be 100 percent consumptive (i.e., the consumptive use equals the diversion rate (Cooper 2002)).

Locations where water is withdrawn for consumptive use are referred to as points of diversion. Points of diversion are broadly distributed throughout the Lower Sprague-Lower Williamson subbasin, although the highest density is in the valley reaches and Williamson River Delta portions of the study area (Table 5-6, Map 5-3). According to the OWRD database, there are 303 points of diversion in the Lower Sprague-Lower Williamson subbasin. The Sprague River watershed has the most points of diversion, at 138. The West Sprague River watershed has 75 points of diversion, and the Williamson River watershed 72. The North Sprague River watershed has the least points of diversion, at 17. It should be noted that more than one water right may be associated with a single point of diversion, so the number of points of diversion does not correspond to the total number of water rights or water right claims in the subbasin.

Table 5-6 Number of points of diversion by watershed in the Lower Sprague-Lower Williamson subbasin
(Data Source: OWRD 2007)

Watershed Name	Number of Water Rights	Number of Points of Diversion
North Sprague River	19	17
Sprague River	163	138
West Sprague River	82	75
Williamson River	83	72
Total	**347**	**302**

In-stream Rights

Water that is withdrawn from a stream has the potential to affect in-stream habitat for aquatic organisms by changing flow or dewatering the stream. Some of the water that is removed from the channel for irrigation is permanently lost from that stream as a result of plant transpiration and evaporation. Some is returned to the stream channel. The permanent removal of water from the stream channel lowers the in-stream flows. Water can also be added to the stream channel via pumping of groundwater. Possible effects of changes to water availability include increased water temperatures, the creation of fish passage barriers, altered sediment transport capacity, and altered habitat quality for aquatic organisms. This Assessment does not attempt to quantify either the removal of water from the system through consumptive use or any increase in water that may occur from groundwater pumping. The assessment is only summarizing available data.

In-stream water rights were established by Oregon Department of Fish and Wildlife (ODFW) throughout much of the subbasin in 1990 to prevent additional withdrawals, in order to retain water in the stream for fish and other aquatic species. Because these water rights are junior to the majority of the consumptive water rights, there is no guarantee that in-stream rights will be met. Flow of the Sprague River near Beatty falls below the designated in-stream water right for resident fish habitat only infrequently, most commonly in August (a total of 36 days in August over the period of record for the stream flow data).

All of the watersheds in the Lower Sprague-Lower Williamson subbasin have in-stream water rights created by ODFW for anadromous and resident fish habitat, most of which were established on October 26, 1990 (OWRD 2006). The in-stream rights were established by ODFW primarily to ensure that later claims can be prevented from removing water that may adversely affect aquatic species. Additionally, although the purpose of the in-stream water rights is to protect aquatic habitat by retaining water in the stream, the flow rates of the in-stream rights are not exact, site-specific determinations of habitat requirements.

DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies. The information used in this Assessment should be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data are determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies. In other words, the data accuracy is acceptable for the watershed scale, but not refined enough for the farm or ranch planning scale.

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CHAPTER 6. TERRESTRIAL VEGETATION

PRE-SETTLEMENT TERRESTRIAL PLANT COMMUNITIES

At the time of European settlement, the Lower Sprague/Lower Williamson River subbasin consisted of a mosaic of coniferous forests, marshes, shrublands and grasslands (Franklin and Dyrness 1988). Table 6-1 provides details of nineteenth- century vegetation composition in the Lower Sprague-Lower Williamson subbasin (ONHP 2002). Ponderosa pine (*Pinus ponderosa)* and lodgepole pine (*Pinus contorta*) coexisted in the pumice region in the northern reaches of the Williamson River Watershed, the West Sprague River Watershed and the North Sprague River Watershed. Outside of the pumice region, ponderosa pine forests graded into ponderosa pine dominant mixed conifer forests (*Abies concolor* and *Abies lasciocarpa* becoming more abundant*)* at their upper limits. At the forests' lower elevational limits, they abutted with sagebrush (*Artemisia tridentata*) shrublands or western juniper *(Juniperus occidentalis)*-sagebrush woodland. Riparian shrublands were exhibited in a band following rivers, streams and shorelines of lakes. At the mouth of the Williamson River, where the subbasin drained into Upper Klamath Lake, a 12-square-mile sediment-rich delta sustained a vast network of marshes (TNC 2007).

Table 6-1 Nineteenth-Century landscape composition of the Lower Sprague / Lower Williamson River subbasin
(Data Source: ONHP 2002)

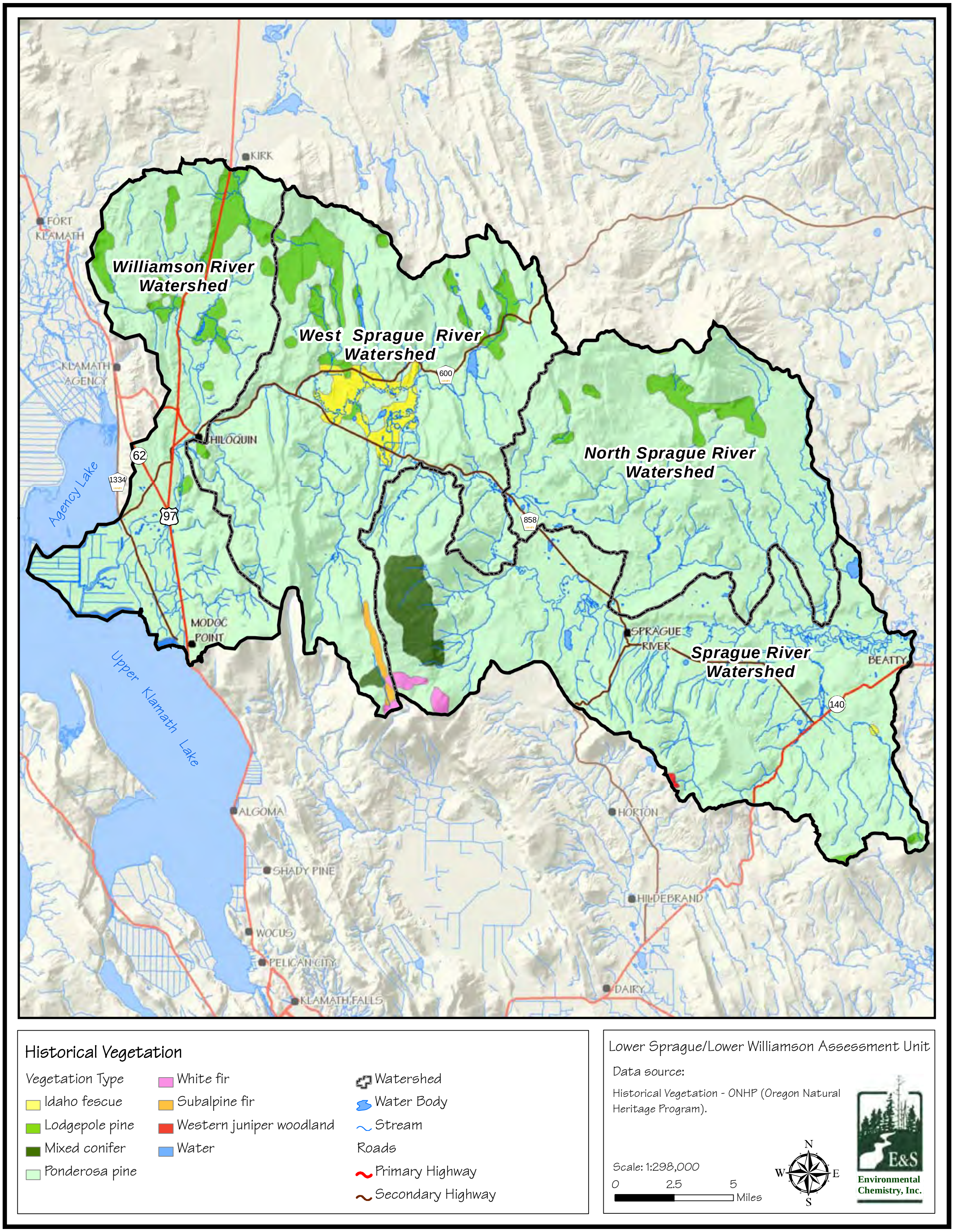
Watershed	Historical Vegetation*	Area (mi^2)	Percent
North Sprague River	Lodgepole pine	5.8	1.0
	Ponderosa pine	117.2	19.7
Sprague River	Idaho fescue	0.1	0.0
	Lodgepole pine	0.6	0.1
	Mixed conifer	7.7	1.3
	Ponderosa pine	173.9	29.4
	Shasta fir-white fir	1.4	0.2
	Western juniper woodland	0.2	0.0
West Sprague River	Idaho fescue	8.3	1.4
	Lodgepole pine	13.2	2.2
	Mixed conifer	0.7	0.1
	Ponderosa pine	152.1	25.6
	Shasta fir-white fir	0.5	0.1
	Subalpine fir	1.3	0.2
Williamson River	Lodgepole pine	11.9	2.0
	Ponderosa pine	99.5	16.7
Total		**594.4**	**100.0**

* Open water was removed from the total area.

Forested Landscapes

Within the forested landscapes of the subbasin, species composition (forest type) varied along environmental gradients defined by physical factors, the main factors being soils, moisture and temperature. Another very significant influence on vegetation in the assessment area was the disturbance regime, most notably fire. The ponderosa pine community's fire regime can be characterized as frequent, low intensity/severity wildfire. Fire burned through the equivalent of the entire community every 5 to 15 years, consuming surface litter and portions of downed logs. Most understory tree regeneration was killed; while shrubs, perennial forbs and grasses (which regenerate from root crowns or subsurface perennating organs) were often only top-killed (USFS 1995). Although lightning undoubtedly ignited many of the fires, accounts by the first white explorers of the southern Cascades give evidence of widespread fire-setting by the Klamath and Modoc tribes (Robbins and Wolf 1994). Lieutenant Henry L. Abbott's survey in the autumn of 1854 of a prospective railroad route from the Sacramento Valley to the Columbia River furnished detailed descriptions of fire-nurtured landscapes, firsthand observations of Indian burning practices and frequent reference to sizable Indian horse herds (Robbins and Wolf 1994).

Historically, ponderosa pine existed as a climax species at low elevations and warm sites throughout the eastern Cascade Mountains (Franklin and Dyrness 1988), and ponderosa pine forests clearly dominated the landscape in the Lower Sprague/Lower Williamson River subbasin. These forests were dominated by a diversity of age classes, including late-seral and old-growth stands, usually with an even-aged structure (Franklin and Dyrness 1988, USFS 1995). The forests were open-canopied and had a continuous large-tree structure, with occasional clumps of reproduction (up to 5 acres). Trees were often growing in clumps of two or three, with 50-foot to 100-foot openings between the small groups of trees. Proportionately less growing space was occupied by conifers, while grasses, sedges, and brush covered a larger percentage of area within the stands. Anecdotal notes and inventory entries during this period often comment on a lack of understory vegetation (USFS 1995).



Map 6-1 Historical vegetation in the Lower Sprague/Lower Williamson subbasin (Data Source: ONHP 2002)

The historical vegetation coverage used to produce Map 6-1 was acquired from the Oregon Natural Heritage Program (ONHP). The coverage was derived from an eastern Oregon rangeland cover developed by the ONHP and a forest coverage developed by H.J Andrews in the 1930s. Although useful, the map generalizes forest types and omits vegetative communities that are non-timber.

The reports of the Northwest Boundary Survey Commission offer an excellent cross-sectional description of the transition in forest types that existed on the western and eastern slopes of the Cascade Range. On the western side, the timber was dense, "being a heavy growth of pine and fir that in many places stands over a fallen forest not yet decayed." However, east of the summit, the commission noted, "[T]he timber becomes more open, and survey operations less difficult" (Robbins and Wolf 1994).

The low tree densities and scarcity of true firs made pre-settlement ponderosa pine stands much less susceptible to insect outbreaks and tree diseases than contemporary forests in the ponderosa pine zone (Campbell and Liegel 1996). Nevertheless, western pine beetle (*Dendroctonus brevicomis*) and pine engraver (*Ips pini*) infestations did occur during drought conditions and on poor sites (USFS 1995).

At the time of European settlement, the Lower Sprague/Lower Williamson River landscape contained very minimal components of mixed conifer and true fir forests, which are found at the higher elevations where the fire regime was characterized by less frequent, stand replacement fires. Pure stands of lodgepole pine were scattered throughout the pumice zone (Table 6-1; ONHP 2002). In this zone, lodgepole pine was able to persist in topographic depressions and "frost pockets" where ponderosa pine could not, because lodgepole pine is more cold-tolerant than ponderosa pine (USFS 1995). Lodgepole pine was also able to co-exist within the same stands as ponderosa pine on the coarse, pumice soils common in the northern reaches of the Lower Sprague/Lower Williamson River subbasin.

Pre-European settlement understory plant composition and structure varied widely across forestlands according to soil type, elevation and fire history. Franklin and Dyrness (1988) described a number of plant community associations in the ponderosa pine and lodgepole pine forest zones. In general, shrubs were a more prominent component of forest stands at higher elevations. Common understory species in ponderosa pine stands were likely big sagebrush (*Artemisia tridentata)*, antelope bitterbrush (*Purshia tridentata*), and greenleaf manzanita (*Arctostaphylos patula*) (USFS 1995). An account by William E. Lawrence, an amateur botanist who traveled through Chiloquin on August 17, 1934, talks of traveling through a ponderosa-sage-rabbitbrush association with both green rabbitbrush (*Chrysothamnus viscidiflorus*) and gray rabbitbrush (*Chrysothamnus nauseosus*), Klamath plum (*Prunus subcordata*) and chokecherry (*Prunus virginiana*).

Nonforested Areas -- Shrublands and Wetlands

The 19th Century landscape mosaic in the assessment area also contained a number of nonforested areas dominated by sagebrush shrublands, riparian shrublands (some with a hardwood component), grassland meadows, juniper-sagebrush woodlands, and wetlands and marshes. Although these communities are not represented in Map 6-1 (ONHP 2002) because the map and the data the map was derived from tend to generalize plant communities, they were present in the pre-settlement landscape.

Prior to Euro-American settlement and agriculture, the low-gradient bottoms of the Sprague River were probably characterized by plant community assemblages of willow, sedges, rushes and riparian shrubs. Soil survey maps for the Sprague River Valley delineate an extensive floodplain that undoubtedly contained significant wetland acreage (McCormick and Campbell 2007). Three main communities were found in the valley: wet sedge meadows, moist hairgrass meadows and riparian shrub communities (USFWS 2002). These communities are all considered late seral due to the infrequency of disturbance and stability in plant composition and function (USFWS 2002).

The Klamath and Modoc tribes manipulated the wetlands and riparian areas to increase their resources. For example, the Klamath burned riparian areas because women preferred to weave baskets with the supple young stems that sprouted after a fire. They burned wet meadows in fall to increase production of root plants, to lure animals that were attracted to the protein-rich shoots that grew after fire and to protect their shelters from wild grassland fires. Intensive digging, particularly for roots, also altered riparian areas (DEA 2005).

Wet sedge meadows in the Sprague River valley were structurally simple, often homogeneous communities usually occurring along low-gradient C and E stream types (USFWS 2002, Rosgen and Silvey 1996). They remained inundated for most of the year, and included the following sedges: slender sedge (*Carex lasiocarpa*), Chamisso sedge (*Carex pachystachya*), buxbaum sedge (*Carex buxbaumii*), Nebraska sedge (*Carex nebrascensis*), Baltic rush (*Juncus balticus*), northern reedgrass (*Calamagrostis stricta*) and orange arnica (*Arnica chamissonis*) (USFS 1988). Willows often formed hedges in and amongst sedge meadows, sometimes developing into shrub mantles near stream edges (USFWS 2002).

The moist hairgrass meadow type was structurally and compositionally simple, existing in continuous patches, usually dominated by tufted hairgrass (*Deschampsia cespitosa*) with various combinations of sedges and grasses (USFWS 2002, USFS 1988). Northern reedgrass, longstem clover (*Trifolium longipes*), and Baltic rush were major species in this association, with lesser amounts of western aster, Chamisso sedge and slender sedge. Sage may have encroached on the driest sites. Moist meadows typically had elevated water tables, saturating the rooting zone throughout most of the growing season (USFWS 2002).

Riparian shrub communities bordering the Sprague River were found on stream bars and floodplains in moderately inundated soils. They were in good condition, and cycled through most catastrophic events (major storms and fires) without suffering major impacts. The primary users were beaver, big game, insects and neotropical birds (USFS 1995). Willow species included Geyer willow (*Salix geyeriana*), whiplash willow (*Salix lasiandra*), and Booth's willow (*Salix boothii*) (USFS 1995). Other deciduous shrub or tree species present in shrub associations included quaking aspen (*Populus tremuloides*), black cottonwood (*Populus trichocarpa*), and thinleaf alder (*Alnus incana*). Fire reduced any conifer encroachment and facilitated riparian hardwood and grass species rejuvenation. Historical documents refer to large numbers of aspen and cottonwood, and some willow at the ends of the Sprague River valley, because the flood plain was constrained. These same references reported fewer willow in the upland riparian areas; it was mostly limited to channel areas. Sagebrush was also present in some riparian edge areas (USFS 1995).

An interesting account by an amateur botanist in 1934 mentions the discrepancy in riparian vegetation along different stretches of the Sprague River. He notes the lack of riparian shrubs just east of the town of Sprague River, while noting the abundance along stretches of the river to the east and west:

This is an extensive hay flat along the Sprague River west of the town of Sprague River. No willows or bushes or trees grow along the Sprague River. This was quite in contrast to the large number of willows usually seen along the Sprague River both to the east and to the west. (Lawrence 1934)

There is not much historical information regarding the sagebrush shrublands found in the Sprague River Valley. James A. Young and B. Abbott Sparks provide a description of sagebrush shrublands that existed before European Settlement:

The vegetation of the pristine sagebrush/grasslands was rather simple and extraordinarily susceptible to disturbance. The potential of the environment to support plant and animal life was limited by lack of moisture and often by accumulations of salts in the soil.

Freshwater Deltaic Wetlands

Before European settlement, freshwater deltaic wetlands occupied approximately 7,000 acres at the interface of the Williamson River and Upper Klamath Lake (DEA 2005). The delta was connected to the river and Agency and Upper Klamath lakes by seasonal flooding, creating wetlands and a moving shoreline that migrated back and forth across the delta with changes in lake water elevations. The Native Americans took advantage of the natural irrigation that occurred when the river delta flooded and produced "wild hay" for livestock use (DEA 2005).

Leiberg (1900) reported that the delta consisted of "overflowed lands producing sedge and tule and lands deeply covered by waters of the lake…[with] no forested areas.…in some places on the overflowed marshes semidry hummocks covered with willow brush are beginning to appear, which is evidence of a gradual lowering or drying up of the lake through natural causes."

Historical accounts of vegetation mapped by Christy (1996) using General Land Office survey notes from 1871 to 1898 and soil and forest reserve surveys show four plant communities in the delta: greasewood/bunchgrass prairie, wet prairie, tule swamp and willow swamp. Tule swamp, mapped as the dominant vegetation type, consisted of hardstem bulrush (*Scirpus acutus*), common reed (*Phragmites australis*) and duckweed (*Lemna* sp.), with wocus in deeper water zones. Within the tule swamp were scattered stands of willow (*Salix* sp.) and wet prairie vegetation consisting of cattail (*Typha* sp.), mannagrass (*Glyceria* sp.), Nebraska sedge (*Carex nebrascensis*), meadow barley (*Hordeum brachyantherum*) and tufted hairgrass (*Deschampsia cespitosa*) in shallower zones (DEA 2005). Tule marshes undoubtedly regulated several aspects of the lake's water quality (McCormick and Campbell 2007). Greasewood/bunchgrass prairies consisting of greasewood (*Sarcobatus vermiculatus*) and Great Basin wildrye (*Elymus cinereus*) were mapped in the uplands (DEA 2005). The riverbanks along the last stretch of river were lined with dense stands of willow and cottonwood, along with patches of emergent species such as cattail, tule and bur-reed (Dunsmoor et al. 2000). This matrix of vegetation and channel morphology was structurally complex.

CURRENT TERRESTRIAL PLANT COMMUNITIES

Mapping Methods

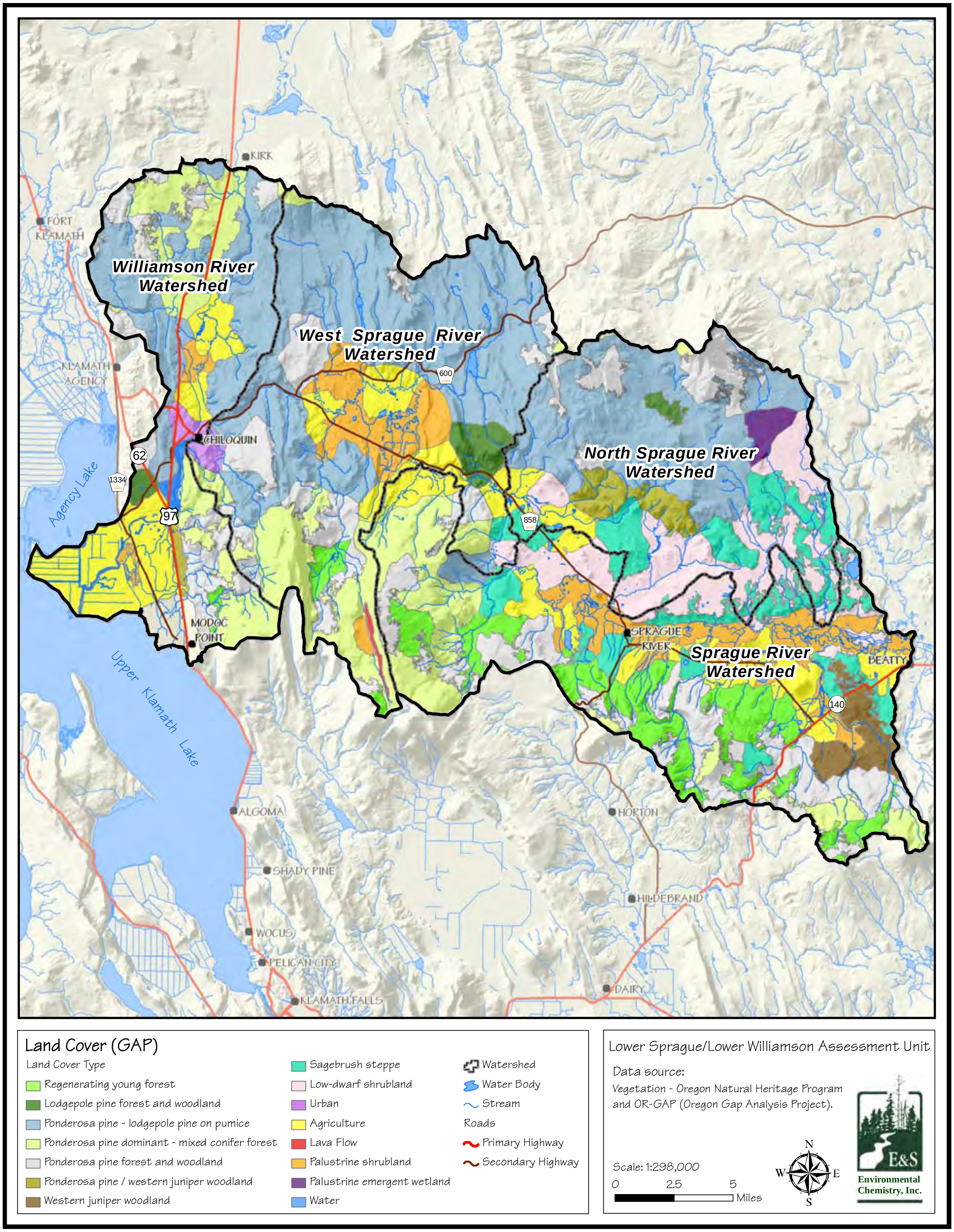
The distribution of different plant communities in the assessment area was mapped using data from the Oregon Gap Analysis Program. The data were derived from Landsat (remote sensing satellite) imagery originally acquired between 1991 and 1993 and updated in 1998 (Kiilsgaard 1999). Although the data are more than six years old, it was assumed for the purpose of this analysis that major compositional patterns of vegetation have not changed significantly during the intervening period. Alternative vegetation maps and data were considered for the analysis, but were rejected because they were only available for a portion of the assessment area (e.g., Fremont-Winema National Forest stand type data) or because their land cover classification did not distinguish between important plant communities (e.g., USGS 1992). The 1999 Oregon Gap Analysis Program map includes 87 different classes of land cover, of which 15 types were found to occur in the assessment area.

The Oregon Gap Analysis Program land cover map was acquired for this assessment as Environmental Systems Research Institute (ESRI) shape files downloaded from the Oregon Geospatial Data Clearinghouse (OGAP 1998). Using ArcGIS 9, the assessment area plant community map was clipped from the statewide coverage. Acreages in the subbasin for each of the 15 land cover types in the assessment were calculated in ArcGIS 9 and are reported in Table 6-2. Table 6-3 shows land cover and vegetation in square miles, by watershed, that was obtained from the USGS. Maps 6-2 and 6-2a through 6-2d show the land cover by vegetation type.

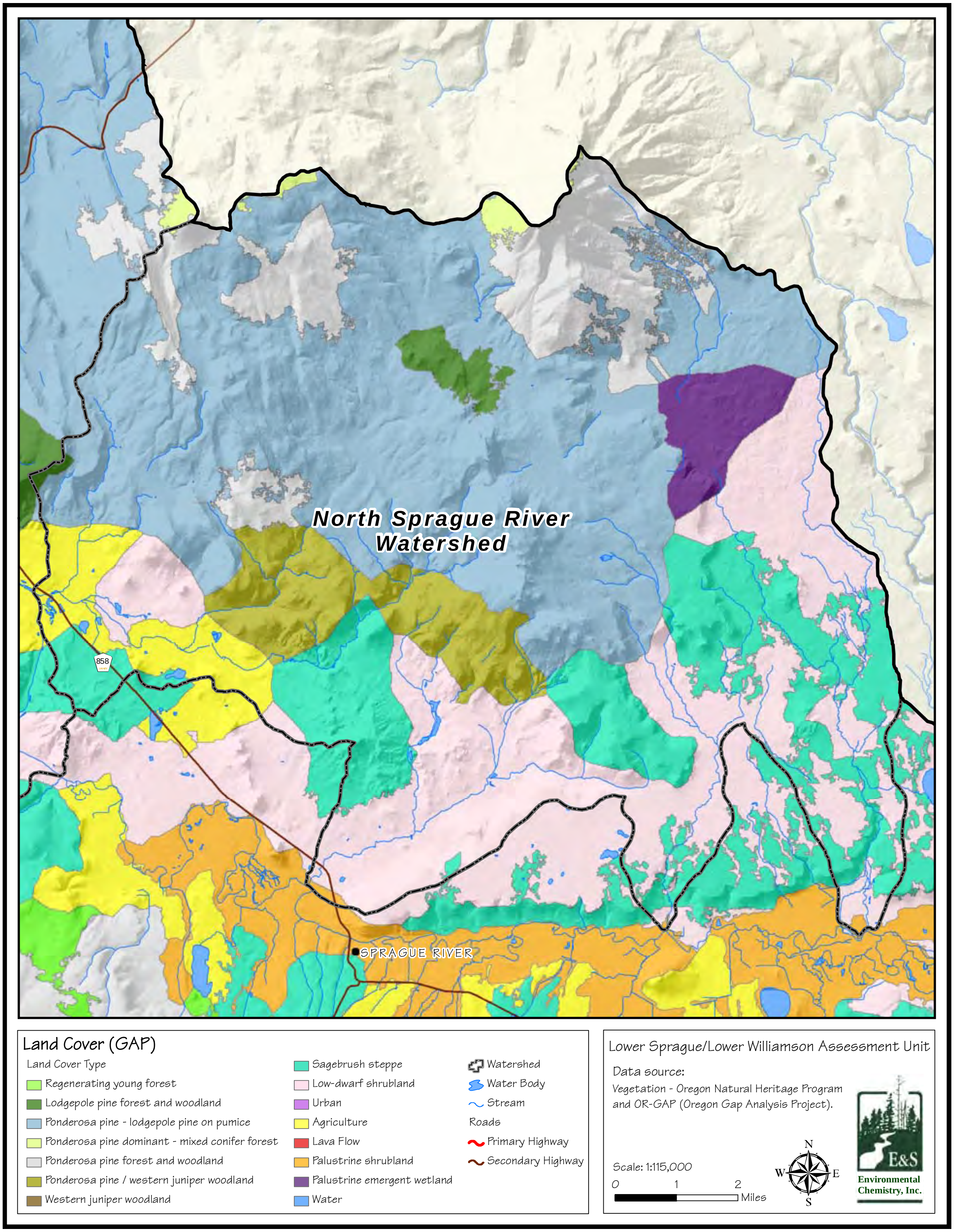
Table 6-2 Square miles and percent subbasin area of 14 land cover types (GAP) occurring in the Lower Sprague-Lower Williamson subbasin
(Data Source: Kiilsgaard 1999)

Land Cover Name*	Gap Type	Acres	Area (mi²)	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**	**100.0%**

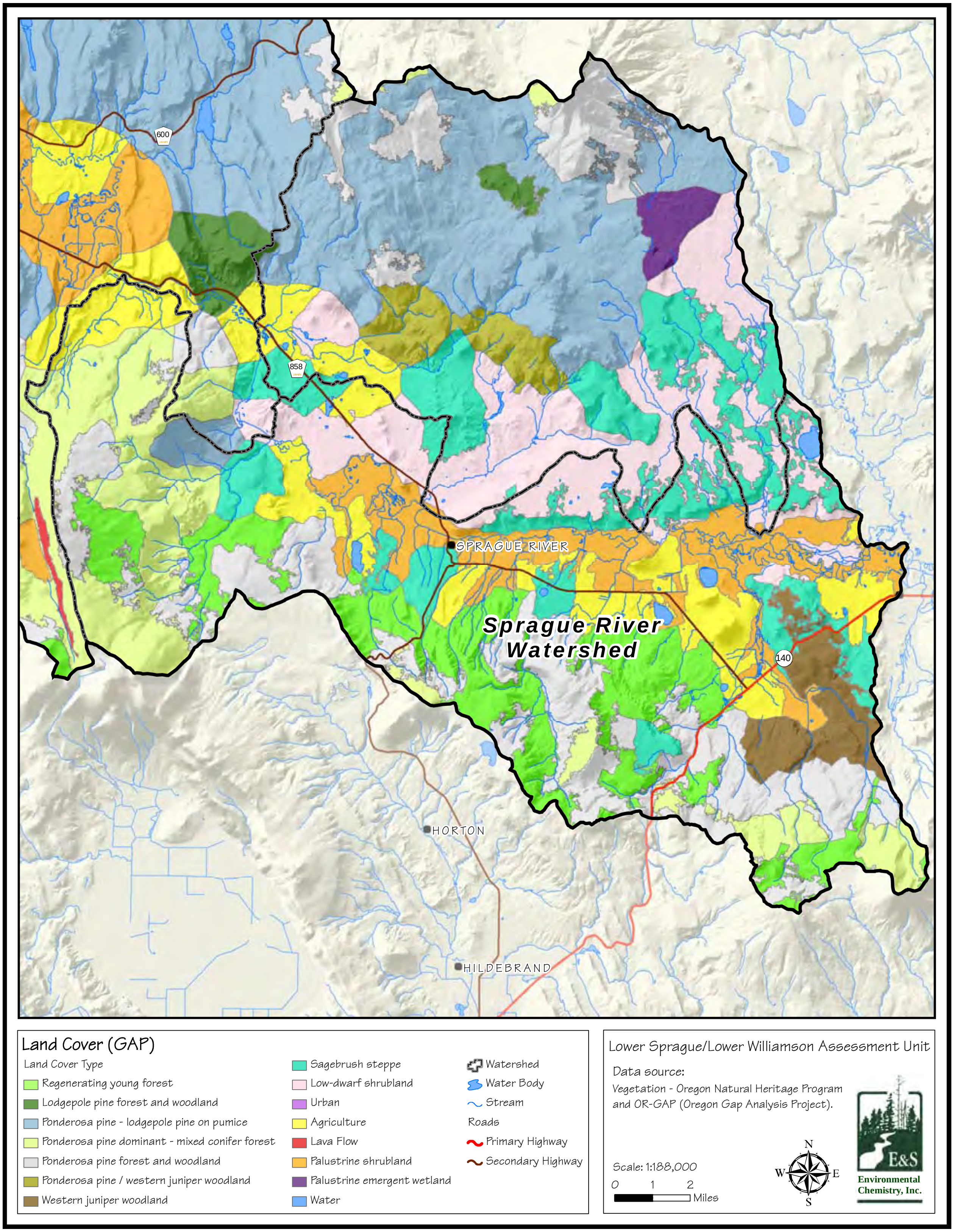
* Open water was removed from the total area.



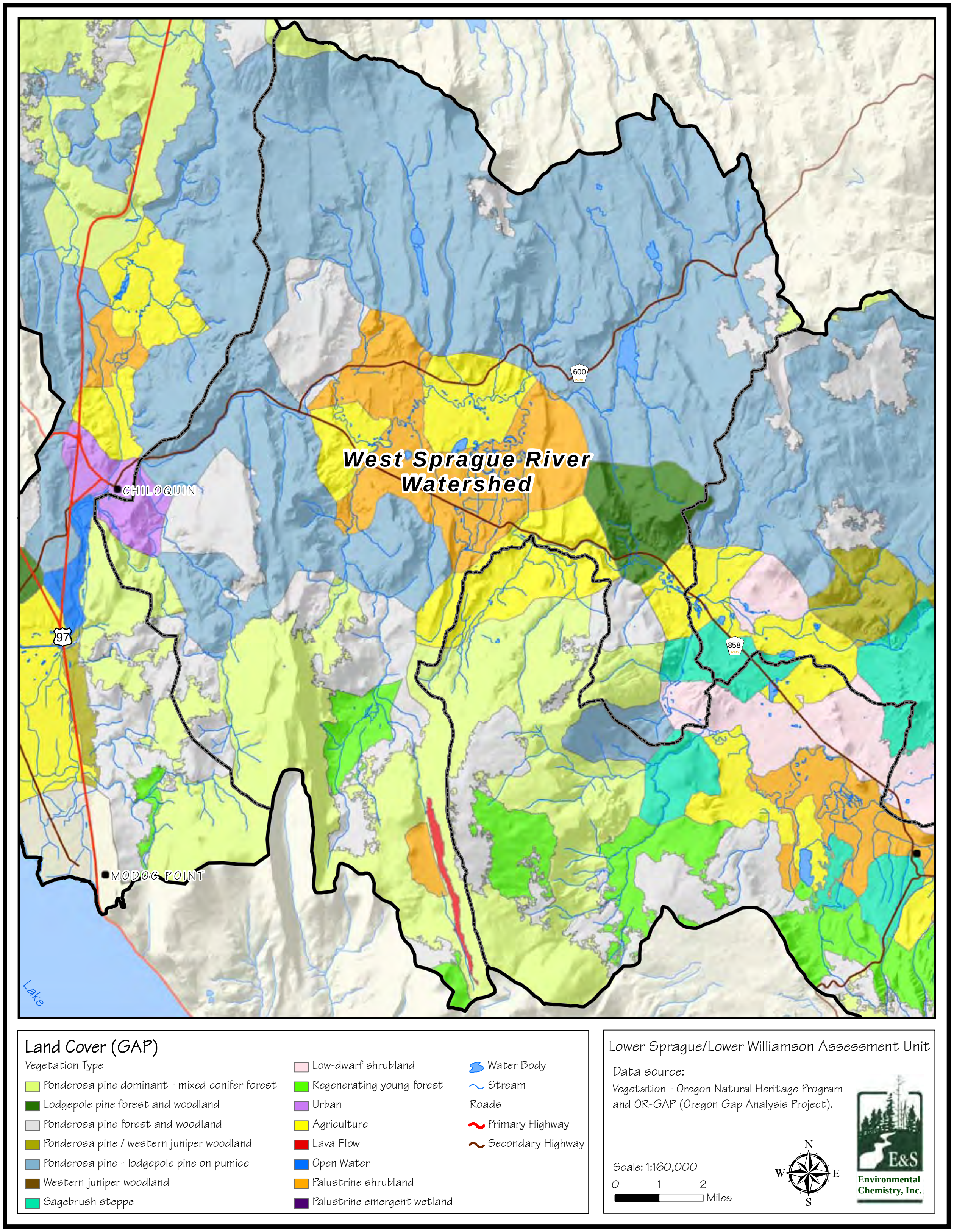
Map 6-2 Land cover for the Lower Sprague-Lower Williamson subbasin (Data Source: Kiilsgaard 1999)



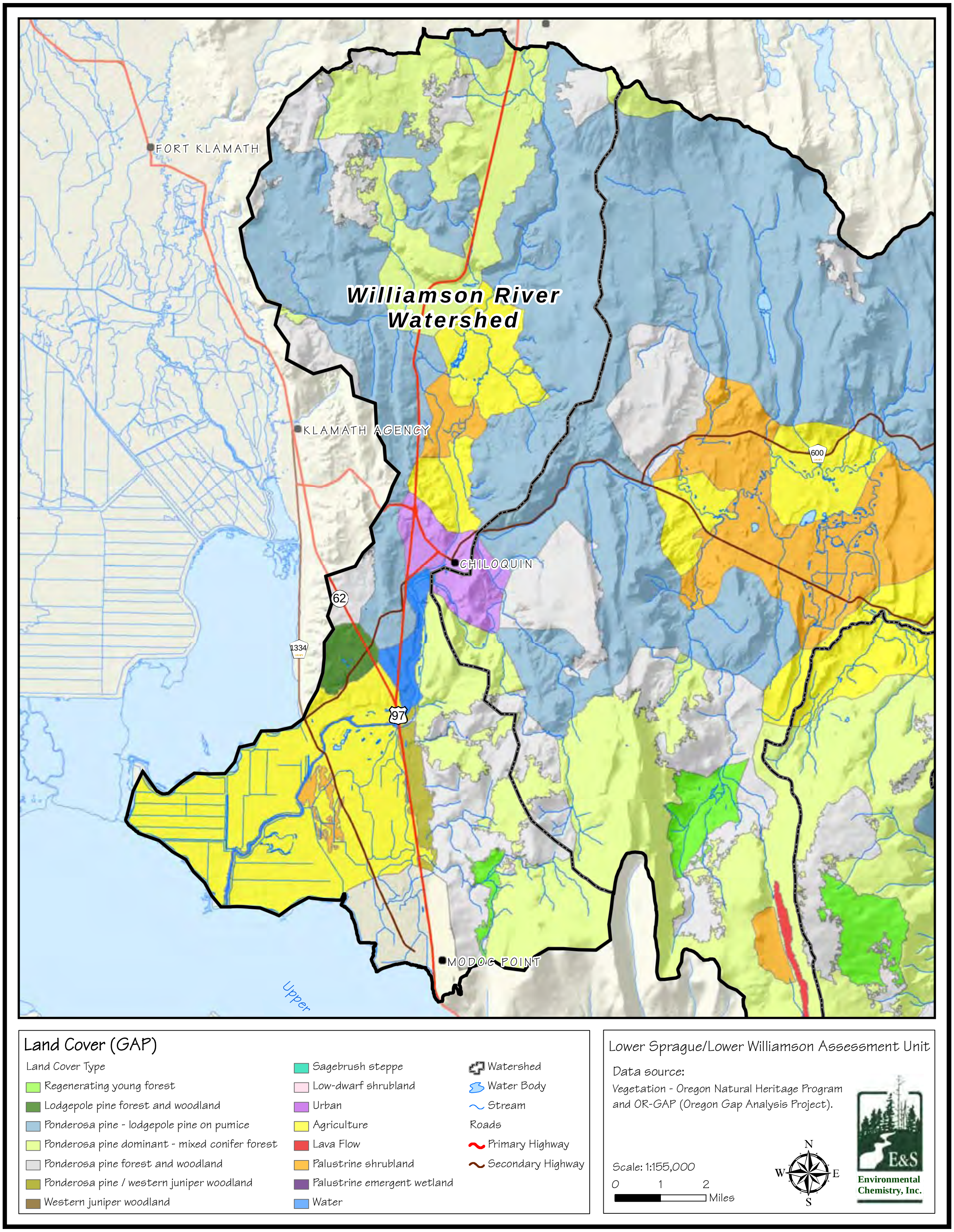
Map 6-2a Land cover for the North Sprague River watershed (Data Source: Kiilsgaard 1999)



Map 6-2b Land cover for the Sprague River watershed (Data Source: Kiilsgaard 1999)



Map 6-2c Land cover for the West Sprague River watershed (Data Source: Kiilsgaard 1999)



Map 6-2d Land cover for the Williamson River watershed (Data Source: Kiilsgaard 1999)

Table 6-3 Area of land cover and vegetation (square miles) in the Lower Sprague-Lower Williamson subbasin, by watershed
(Data Source: USGS 1992)

Landcover*	North Sprague River	Sprague River	West Sprague River	Williamson River	Total
Low Intensity Residential	0.0	0.0	0.0	0.2	0.2
Commercial/Industrial/Transportation	0.0	0.3	0.3	0.8	1.5
Bare Rock/Sand/Clay	0.1	0.2	0.6	0.3	1.1
Quarries/Strip Mines/Gravel Pits	0.0	0.0	0.0	0.0	0.0
Transitional	0.3	0.4	1.5	0.9	3.0
Deciduous Forest	0.0	0.1	0.0	0.1	0.3
Evergreen Forest	74.6	102.4	148.5	80.4	406.0
Mixed Forest	0.0	0.3	0.2	0.2	0.8
Shrubland	33.1	28.4	8.2	4.6	74.3
Grasslands/Herbaceous	6.0	14.4	5.4	5.2	31.0
Pasture/Hay	5.4	14.8	0.1	17.5	37.7
Row Crops	0.0	1.0	0.0	1.4	2.4
Small Grains	0.7	11.8	0.0	2.3	14.8
Urban/Recreational Grasses	0.0	0.0	0.0	0.0	0.0
Woody Wetlands	0.0	0.2	0.3	0.1	0.6
Emergent Herbaceous Wetlands	2.5	8.3	9.8	1.8	22.4
Total	**122.7**	**182.6**	**174.9**	**115.8**	**596.1**

* Open water was removed from the total area.

Forests and Woodlands

Ponderosa Pine Forests

Ponderosa pine-lodgepole pine on pumice is currently the most extensive plant community in the Lower Sprague-Lower Williamson subbasin. Approximately 111,084 acres of this forest type occurs in the assessment area. Another 54,132 acres are ponderosa pine woodlands, and another 50,680 acres are ponderosa pine dominated mixed conifer forest (OGAP 1998). Historically, natural wildfires were frequent across ponderosa pine forests in the eastern Cascades. Although mature ponderosa pines are resistant to low-intensity fires, young pines and other species such as the true firs usually did not survive the flames. Therefore, ponderosa pine forests tended to occur in pure, even-aged stands of widely spaced trees under the natural fire regime. At lower elevations in the subbasin, conditions are generally too hot and arid to support large trees. In such locations, stands of ponderosa pine transition into western juniper (*Juniperus occidentalis*) woodlands. The distribution of vegetation types in the Lower Sprague-Lower Williamson subbasin is presented in Table 6-2 and shown in Map 6-2.

More than 50 years of effective fire suppression has allowed white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*) and other tree species to establish in the understory of these stands, creating conditions in which ponderosa pine is unable to maintain its dominance. Selective logging has further hastened the conversion of ponderosa pine forests and woodlands to mixed conifer forest. At higher elevations within the ponderosa pine zone, shrubs are an important component of stand structure. The most commonly associated shrub species are bitterbrush, big sagebrush, greenleaf manzanita and snowberry (*Symphoricarpos albus*). At lower elevations, the shrub layer becomes sparser and less diverse.

Lodgepole Pine Forests

Stands of lodgepole pine are found southeast of Chiloquin along Highway 62 and near Road 858 at the base of Saddle Mountain. Approximately 5,039 acres of this forest type occurs in the assessment area (Table 6-2). Lodgepole pine can grow well under a wide range of site conditions; its distribution tends to follow forest fire patterns rather than environmental gradients. Lodgepole pine stands typically develop a dense, single-layer canopy structure immediately after a fire. As the forest matures, other tree species such as Douglas-fir, grand fir, and white fir become established in the understory and create an uneven, multi-storied canopy structure. Eventually these other tree species replace lodgepole pine on the site until the next fire occurs. A layer of dense shrubs is often found in lodgepole pine forests. Common shrub species include mountain snowberry (*Symphoricarpos mollis*), serviceberry (*Amelanchier alnifolia*), shiny-leaf spirea (*Spiraea betulifolia*), bitterbrush and huckleberry (*Vaccinium membranaceum, V. scoparium).*

Western Juniper Woodlands

Western juniper woodlands occupy a transition zone between the forested foothills of the eastern Cascades and shrub-dominated rangelands. In the assessment area, there are approximately 5,392 acres of this cover type, mostly occurring just southeast of Beatty. Western junipers have been expanding and replacing shrub-steppe cover types since the late-1890s (Bedell et al. 1993). These new western juniper woodlands are much denser than the original cover type and are usually dominated by trees in young age-classes.

Western juniper invasion can significantly alter the hydrological regime and plant community diversity. In addition to water use from evapotranspiration, rainfall on a dense juniper canopy is partially intercepted and evaporates before reaching the soil. Up to 38 percent of the total annual rainfall may be intercepted by the canopy in a juniper woodland and is unavailable to other plants (Bedell et al. 1993). The subsequent reduction in shrubs and ground cover vegetation may lead to greater overland flows of water during storms and greatly increased sediment input into streams (Bedell et al. 1993).

A fair amount of research has been conducted by Oregon State University and other researchers characterizing this vegetation type and the historic versus current day levels of juniper cover. Research areas have focused on impacts of juniper on range conditions, water availability, response to fire regime, conditions with fire suppression and canopy cover intercepting precipitation. Resources on the topic include Barrett (2007), Karl and Leonard (1996), Miller et al. (2005), and Soulé and Knapp (1999).

Shrublands

Sagebrush Steppe and Low-Dwarf Shrubland

The assessment area contains approximately 24,787 acres of this plant community. The shrub layer of sagebrush steppe communities is always dominated by one or more of the big sagebrush species

(OGAP 1998): Wyoming (*Artemisia tridentata* var. *wyomingensis*), basin (*A. tridentata* var. *tridentata*) or mountain (*A. tridentata* var. *vaseyana*) sagebrush. Shorter shrubs such as rigid sagebrush (*Artemisia rigida*), low sagebrush (*A. arbuscula*) and rabbitbrush (*Chrysothamnus viscidiflorus* and *C. nauseosus*) may also be present. Native grasses associated with sagebrush steppe include: Great Basin wildrye (*Elymus cinereus*), Thurber needlegrass (*Stipa thurberiana*), Indian ricegrass (*Oryzopsis hymenoides*), blue bunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*). However, grazing pressure and changes in the fire regime have generally shifted the understory composition of these shrub communities to include introduced species such as cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum*). In some areas, sagebrush is prominent on many terraces that were once active floodplains. With channel incision and lowered water tables, nearby riparian areas have experienced declining soil moisture and shifts to dry site plants. Big sagebrush species can readily move into sites that experience changes in hydrology (Boggs and Weaver 1992).

The assessment area contains approximately 27,492 acres of low-dwarf shrublands. This plant community occurs where soils are too shallow or rocky to support big sagebrush. Low sagebrush (*A. arbuscula*) or rigid sagebrush (*Artemisia rigida*) typically dominate these stands. Low-dwarf shrublands are most extensive in the 4,200-foot to 5,200-foot elevation band.

Riparian (Palustrine) Shrublands

Riparian zones currently comprise about 7 percent of the Sprague River subbasin, yet contribute a disproportionately large amount of biological diversity and productivity to the greater ecosystem (Kovalchik and Elmore 1992). The existing riparian shrublands have been shaped by anthropogenic forces, most notably past and present agriculture. These communities result from significant or repeat disturbance and represent an assemblage of plant species different from those that are characteristic of older, more stable communities. Theoretically these communities, if left alone, would likely develop through plant succession to become dominated by native, late-seral plant species (USFWS 2002).

Riparian vegetation, along with its capacity to hold water, has decreased due to grazing and streambank erosion. Also, conifer and brush stocking levels have increased over time with fire suppression. This increased stocking, along with a general lowering of water tables in the assessment area, has affected timing and quantity of water flows. This change in water flows has decreased the riparian shrub component, in turn decreasing the diversity of native plants that grow in such areas, altering their usability by wildlife (USFS 2005). Riparian areas along the lower Williamson River reach are currently characterized by narrow bands (2 to 23 feet wide) of vegetated habitat (primarily willow, reed canarygrass, and several species of emergents) as well as reaches that are completely devoid of vegetation (DEA 2005).

Agricultural Land

Agricultural plant cover types occupy areas recently or currently managed for agriculture along the Sprague and Williamson rivers. These types have been altered for agricultural production, as evidenced by mowing patterns, crop species, and a scarcity of riparian and woody vegetation (USFS 2000). It is likely that many of these areas were once wetlands, though historical boundaries of wetlands and riparian zones may now be difficult to determine. Because of agricultural practices, many of these areas have experienced significant shifts away from sedge meadows or shrub wetlands to drier sites dominated by exotic grass and crop species. Soils in agricultural areas are often drier as a result of incised stream channels, excavated drainage channels, or ground hardening by livestock (USFWS 2002).

Williamson River Delta Wetlands

A comparison of the historical and current aerial photos indicates that there has been a significant loss in the once-extensive riparian and wetland aquatic habitat along the lower Williamson River (DEA 2005). Beginning before 1900, dikes were built in the low-lying marshy areas of the delta to prevent flooding of the wetlands where farmers cut wild hay (Dicken and Dicken 1985). The delta was subsequently drained and converted to pasture for grazing of cattle, because cool temperatures make the delta less suitable for cultivated crops (Snyder and Morace 1997).

By 1941, lakefront levees were being constructed around most of the perimeter of the delta, and soon thereafter the emergent marsh wetland was completely drained for farming (DEA 2005).

Channel dredging and levee construction projects also significantly reduced the length of the lower river, which is now less complex and dynamic than it was historically, and have replaced the once extensive emergent vegetation with pasture lands (DEA 2005). As a result, the hydric, peat soils have dried. The Nature Conservancy (DEA 2005) has estimated that, in some areas, the topography has subsided as much as eight feet due to the drying of the peat soils.

The aerial photographs on the following page show the Williamson River Delta during its agricultural use and in its historical condition. The upper photograph of the Williamson River Delta was taken in 1991, and the lower aerial photograph mosaic dates from 1940 to 1941.


CNO-5A -61

Kentucky Bluegrass Pastures (Irrigated Wetlands)

Pastures dominated by Kentucky bluegrass (*Poa pratensis*) are found throughout the Sprague River Valley and are mostly a result of human activity and agriculture. Kentucky bluegrass cover types often represent transitional communities with mixtures of exotic species—Kentucky bluegrass, dandelion (*Taraxicum officinale*) and redtop (*Agrostic alba*)—and native plants—slenderbeaked sedge (*Carex athrostachya*), Baltic rush (*Juncus balticus*) and western aster (*Aster occidentalis*) (USFS 1988). Haying and livestock grazing in the valley bottoms of the Sprague River subbasin often involved drainage, soil tillage, and surface hardening that facilitated the transition away from native communities towards introduced assemblages. Conversion of these lands included the purposeful introduction of exotic grasses for hay and grazing fodder, thus altering the plant communities of the assessment area (USFWS 2002).

THREATENED, ENDANGERED AND SENSITIVE PLANT SPECIES

A number of native plant species that inhabit the assessment area face uncertain futures. Some plant populations are affected by land use practices that change their habitats, and others are at particular risk because of non-native invaders such as Canada thistle (*Cirsium arvense*). The most vulnerable species tend to be those that are naturally rare or have very particular habitat requirements. The purpose of this section is to identify the plant species in the assessment area that are currently suspected of being most at risk so that stakeholders can plan conservation actions to protect their habitats and populations.

A species, subspecies or variety of plant is "endangered" when the prospects of its survival and reproduction are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, over-exploitation, predation, competition or disease. A plant is "threatened" when it is likely to become endangered in the foreseeable future in the absence of protection measures. A plant is "rare" when, although not presently threatened with extinction, the species, subspecies or variety is found in such small numbers throughout its range that it may be endangered if its environment worsens.

To determine which plant species are most vulnerable in Oregon, the following lists of protected and special status species were reviewed:

- Species protected under the Federal Endangered Species Act (ESA),
- Federal Candidate Species,
- Federal Species of Concern,
- State Threatened & Endangered Species,
- State Sensitive Species, and
- Oregon Department of Agriculture lists of protected plants.

Plant species that occurred on any one of these lists were then checked for the probability of their presence in the assessment area. For this task, a sensitive plant GIS file from Sarah Malaby at the USFS was reviewed for special status plants that presently occur within the assessment area. Geographic range maps were also used, as well as plant reference guides, interviews with local experts and online databases. The review resulted in a list of 17 species with special conservation status that may be likely to occur in the assessment area (Table 6-4). A short description of each species is provided below. For more information and pictures of some of the plants, please refer to *Special Status Plants of Klamath County: A Field Identification Guide* (Rabe Consulting 2003). Other sources for information are the Oregon Flora Project, which can be visited at http://www.oregonflora.org, and the Calflora project at http://www.calflora.org.

Table 6-4 Plant species that have special conservation status and are likely to occur in the Lower Sprague-Lower Williamson subbasin
(Data Sources: ORNHIC 2007; Sarah Malaby, USFS Botanist, pers. comm. 2007)

Scientific Name	Common Name	Federal Status*	State Status**
Astragalus applegatei	Applegate's milk-vetch	LE	LE
Arabis suffrutescens var. horizontalis	Crater Lake rockcress	SOC	C
Calochortus greenei	Greene's mariposa lily	SOC	C
Eriogonum prociduum	Prostrate buckwheat	SOC	C
Limnanthes floccosa ssp. bellingeriana	Bellinger's meadowfoam	SOC	C
Perideridia erythrorhiza	Red-root yampah	SOC	C
Mimulus evanescens	Disappearing monkeyflower	SOC	C
Penstemon glaucinus	Blue-leaved penstemon	SOC	
Plagiobothrys salsus	Desert allocarya	SOC	
Pogogyne floribunda	Profuse-flowered pogogyne	SOC	
Thelypodium brachycarpum	Short-podded thelypody	SOC	
Phacelia inundata	Playa phacelia	SOC	
Thelypodium howellii ssp. howellii	Howell's thelypody	SOC	
Asarum wagneri	Green-flowered wild-ginger		C
Rorippa columbiae	Columbia cress		C
Astragalus peckii	Peck's milk-vetch		LT
Botrychium pumicola	Pumice grape-fern		LT

* Federal Status: LE=Listed Endangered; SOC=Species of Concern

** State Status: LE=Listed Endangered; C=Candidate Taxa; LT=Listed Threatened

Applegate's Milk-vetch (*Astragalus applegatei*)
This plant is a taprooted, herbaceous perennial that is endemic to Klamath County and one of the rarest plants in Oregon. Approximately 12,000 individuals remain (Guerrant unknown date), but no populations have been found within the assessment area. Applegate's milk-vetch is distinguishable in mid-summer (from early June to August) by its small, whitish flowers with purple tips (Guerrant unknown date). The leaves are on petioles that have 7 to 11 linear to linear-elliptic leaflets, and the inflorescences are racemes with 5 to 20 flowers. The plant is unique because it survives only in flat, open, seasonally moist remnants of floodplain alkaline grassland of the Klamath Basin at around 4,100 feet in elevation (USFWS 1998). When fruiting, the plant has fruit pods (which usually contain fewer than three seeds) that have short hairs and frequently have green or purple speckled valves. Land development, noxious weed introduction (most notably *Elytrigia repens*), and the suppression of fires within its limited range have dramatically reduced suitable habitat for the plant (Guerrant unknown date).

Crater Lake Rockcress (*Arabis suffrutescens var. horizontalis*)
The plant is a perennial herb with 6-inch to 36-inch stems that are hairy lower in the stem. The leaves are basal and also hairy, and the flowers have spoon-shaped petals that are rose to purplish. The fruits of this plant are slender, more or less recurved, and lack hairs. Crater Lake rockcress inhabits gravelly or stony slopes and dry pumice slopes above 5,000 feet in sparse pine, fir or hemlock forests. The plant flowers from July to August and occurs in Klamath County on only four sites at Crater Lake National Park. No occurrences are recorded within the assessment area.

Greene's Mariposa Lily (*Calochrotus greenei*)
A perennial herb with 6-inch to 12-inch branched stems, this plant has petals that are lilac on the outside and banded at the base with yellow and deeper lilac. One basal leaf is as long as the flowering stem, and leaf-like bracts are present where the stem divides into flower heads (Eastman 1990). The inner surface of the petals is covered with dense white hairs that turn yellowish towards the base. This plant flowers between June and August, with one to five flowers per inflorescence. Greene's mariposa lily inhabits foothills and low mountains, and is often associated with rock outcrops. No populations have been recorded within the assessment area.

Prostrate Buckwheat (*Eriogonum prociduum*)
This plant is a perennial herb that forms low mats of leaves and has erect flowering stems. The stems bear rounded clusters of yellow flowers and rise 2 to 6 inches above the leaf mats. The plant blooms from May to July and occurs on basalt flows (occasionally on barren volcanic tuff) and barren hill slopes above 4,200 feet elevation (NNHP 2001). There are no recorded observations of prostrate buckwheat from the Lower Sprague River subbasin. However, the species has been recorded at many localities less than 50 miles from the assessment area (OFP 2005).

Bellinger's Meadowfoam (*Limnanthes floccosa ssp. bellingeriana* **)**
This plant is a diminutive annual with self-pollinating creamy white flowers. Its flowers are bell- to urn-shaped and do not open widely. Leaves have 4 to 10 leaflets and less than 4 inches long. Bellinger's meadowfoam inhabits rocky, shallow soils that are at least partially shaded in the spring. It is also found growing in vernal pools and is adapted to soil that is inundated during the winter and spring, and dry in the summer and fall. The plant is found at elevations ranging from 3,600 to 4,400 feet. There are no recorded observations of this plant within the assessment area.

Red-root Yampah (*Perideridia erythrorhiza*)
This plant has many tiny white flowers that are packed into dense, showy clusters. Tuberous roots are shaped like a torpedo and range in color from off-white to chestnut brown. Two key identification tips are that the fruits are longer than they are wide and that many fruits may have only one seed. Klamath County populations are said to flower on the earlier end of the spectrum, most likely between early July and September. If the assessment area contains red-root yampah, it would most likely be found at the margins of coniferous forests and meadows (CPC unknown date). As of 1998, there were approximately 21 populations located in three major geographical areas (Roseburg, Grants Pass and Klamath Lake). Sizes of these populations ranged from fewer than 100 to more than 250,000 individuals. At least three populations had more than 10,000 individuals (Meinke 1982).

Ephemeral (Disappearing) Monkeyflower (*Mimulus evanescens*)
Associated with western juniper-bluebunch wheatgrass plant communities, ephemeral monkeyflower is found along streams and drying creek beds. The species is considered extremely vulnerable to grazing and has disappeared from much of its former range (Meinke 1995b). Ephemeral monkeyflower has not been found in the Lower Sprague-Lower Williamson subbasin (OFP 2005).

Blue-leaved Penstemon (*Penstemon glaucinus*)
This penstemon is associated with ponderosa pine and whitebark-lodgepole pine forests, at middle to high elevations, and is usually found in sandy, volcanic soils, often on rocky ridge tops. The species seems able to colonize disturbed areas such as slash burn piles and other areas cleared of vegetation (Meinke 1995a). It may benefit from prescribed fire in areas where woody debris has accumulated due to past fire suppression. Blue-leaved penstemon has been found at many sites in the assessment area (ONHIC 2005).

Desert Allocarya (*Plagiobothrys salsus*)
This plant is an annual with stiff hairs that spread and stems that lay down but that have erect or rising tips. The leaves of this plant grow directly on the stems and are up to 3 inches long. Flowers are white, bisexual and yellow inside the tube, with fused sepals below the middle. The desert allocarya lives in moist, alkaline mud flats. No populations have been recorded within the assessment area.

Profuse-flowered Pogogyne (*Pogogyne floribunda*)
Profuse-flowered pogogyne is an annual that is erect and branched at the base, with a square stem reaching a maximum of 4 inches in height. The plant can be either hairy or not and expels a smell of mint when crushed. It is dotted with glands, and the inflorescence is a dense spike running from the plant base to the top. The plant flowers from June to August and can be found in vernal pools, seasonal lakes and flats between 3,200 feet and 5,100 feet. No populations of this plant have been found within the assessment area, but known populations exist in the Gerber Reservoir area.

Short-podded Thelypody (*Thelypodium brachycarpum*)
This plant is a biennial with thick basal leaves that have a powdery coating and that can either have hairs or not. The leaves on the stem (which can be branched or not) do not have a stalk and have the same powdery coating. The inflorescence of short-podded thelypody is spike-like and dense, with crinkled, white flowers that have four petals each. The plant can be found in sagebrush scrub, pond margins, damp ground near streams and meadows adjacent to ponderosa pine forests. No populations of this plant have been found within the assessment area.

Playa Phacelia (*Phacelia inundata*)
Playa phacelia is an annual that is about 4 to 16 inches tall with yellow, bell-shaped flowers and branched stems with short, stiff hairs. This species grows in alkali playas and seasonally inundated areas with clay soils, and the best time to find it is between June and August (NNHP 2001). There are no recorded observations of this plant within the assessment area.

Howell's Thelypody (*Thelypodium howellii ssp. howellii*)
This plant is a herbaceous, short-lived biennial that can grow up to 2 feet tall, with branches arising from near the base of the stem. The basal leaves are arranged in a rosette and have wavy edges and either no hair or sparse hairs. The leaves on the stem are clasping the stem and are shorter and narrow and have smooth edges. The flowers appear on loose spikes at the end of the stems and bear four spoon-shaped; lavender to purple petals. Filaments are partly to completely fused. This plant can be found in alkaline meadows and sagebrush scrub between 4,000 feet and 5,200 feet, but has not been observed within the assessment area.

Green-flowered Wild-ginger (*Asarum wagneri*)
Asarum wagneri is a low-growing plant with one pair of alternate green leaves shaped like hearts. The leaves can have scattered hairs along the veins on top and are covered with small hairs on the underside. Flowers are light green, and have a faint foul odor and a red maroon band along the top and sides. This plant can be found in the understory of fir forests and open boulder fields in pine forests near timberline and flowers between May and July. The plant is endemic to the Cascade Range of southern Oregon (Lu and Mesler 1983), but has not been found within the assessment area. Many populations exist west of Upper Klamath Lake.

Columbia Cress (*Rorippa columbiae*)
Coulumbia cress is a low-growing rhizomatous perennial with stems that usually are 4 to 12 inches long. Stems generally grow flat on the ground but are sometimes erect and branched. The plant's leaves are divided almost to their center into several pairs of opposite leaflets and are sometimes toothed. The flowers have four bright yellow petals; sepals are flat and ovate to oblong and will sometimes remain on the plant through fruiting. Flowering of the plant fluctuates widely between and within years according to weather and water availability, but usually happens from May to late October. Fruits are almost oblong and are usually curved into an arc. Most sites are located on moist areas in gravelly soil, generally along rivers, or in vernal pools. The plants are also found along the drying edges of shallow lakes and along seasonal riverbeds (Hitchcock and Cronquist 1973). Columbia cress is found in the assessment area near Bly Mountain.

Peck's Milk-vetch (*Astragalus peckii*)
This plant is a rare legume endemic to the central Oregon Cascades. Peck's milk-vetch grows on sandy or pumice soils (Hitchcock and Cronquist 1973). The species is associated with open-canopy lodgepole pine forest and sagebrush or bitterbrush shrublands between 3,000 and 6,000 feet elevation (ODF 1995). Peck's milk-vetch has been observed on U.S. Forest Service lands in the West Sprague River watershed (Sarah Malaby, USFS Botanist, personal communication 2007).

Pumice Grape-fern (*Botrychium pumicola)*
The plant is a rare, fern-like plant that is endemic to pumice substrates found near Crater Lake. The stem of the plant is stout, grayish-green and about four to nine inches tall (Eastman 1990). It has a sterile leaf and a fertile leaf. The fertile frond is taller than the sterile, has branches and carries round and yellow sporangia (Eastman 1990). The sterile frond is leathery, is 1 to 1.5 inches long, and has a powdery-like surface. The best time of year to look for this plant is from July to September. Pumice

grape-fern was originally believed to be restricted to the treeless alpine zone, but has more recently been discovered on dry, pumice gravels in lodgepole pine woodlands above 5,000 feet elevation (ODF 1995). It was estimated in 1997 that 118 populations exist, 60 percent of which contained less than 20 individuals, and that the total number of plants is less than 15,000 (NatureServe Explorer 2002).

There are no recorded observations of the species from the Lower Sprague-Lower Williamson subbasin. However, pumice grape-fern has been found at many sites in northern and western Lake County (OFP 2005). It is possible that the species exists at high elevations in the assessment area. A federal conservation plan for pumice grape-fern has been implemented for the Fremont-Winema National Forest and the Prineville District of the Bureau of Land Management.

EFFECTS OF HUMAN ACTIVITIES ON PLANT COMMUNITIES

Landscape patterns of species composition and stand structure in the Lower Sprague-Lower Williamson subbasin are noticeably different today than at the time of Euro-American settlement. In the uplands, extensive late-successional ponderosa pine forests, interspersed with early- to mid-successional forests and openings created by natural disturbance, have largely been replaced by much more homogeneous young forests. In lowland areas, the former mix of forests, woodlands, wetlands, shrublands and prairies has largely been replaced by agricultural land, with some urban and rural residential development. Both natural processes and anthropogenic activities have influenced the size, composition and distribution of plant communities within the Lower Sprague-Lower Williamson subbasin. These changes have contributed, by an unknown amount, to the limited water availability currently experienced in the subbasin.

Logging and Fire Suppression

Extensive timber harvesting over the past century has significantly changed the forest. Fire suppression and timber harvesting have created a forest characterized by dense stands with weakened overstories and high fuel levels. Early logging practices generated levels of downed woody debris greatly in excess of historical volumes under the frequent, low-intensity fire regime (Campbell and Liegel 1996). Steam-powered yarding machines and railroad engines frequently ignited logging slash, causing intense, stand-replacement fires. As a result of early tree harvesting and the altered fire regime, the volume of ponderosa pine saw timber in the assessment area was greatly reduced, while overall stocking levels (tree density) increased dramatically (USFS 1995). Climax species such as white fir and grand fir were able to establish in much greater densities in the wake of the fires.

Since the early 1900s, the frequent and low-intensity fires that once maintained vast open ponderosa pine forests have been suppressed, allowing a high density of undergrowth to develop. Historically, the ponderosa pine forests of the region were characterized by large trees, an open understory, and less brush than is evident today. Effective fire control was also established on federal and private timberlands when commercial harvesting began on the Fremont National Forest during the 1950s (USFS 1995). Fire suppression led to increased fuel loadings, more widespread mixed-species (ponderosa pine-dominant) stands and a general change from even-aged to uneven-aged forest structure. It is true that decades of fire suppression have also been associated with a decline in the extent of native grasses that co-evolved in the presence of frequent, low-intensity fire.

The high-intensity fires of today also have affected nutrient cycling in the forest. Forest conditions influence soil productivity through gradual accumulation of ecosystem nutrients in organic form that are deposited much faster than they decompose in the cold, dry climate of the subbasin. In the past, organic residues were mineralized on a regular basis by frequent, low-intensity or low-severity wildfire. Most of the overstory remained alive and capable of utilizing this natural flush of nutrients. Today, high-intensity fires mineralize nutrients in much larger quantities and kill most of the overstory in the process, loosing the available nutrients to the ecosystem from volatilization and leaching before revegetation can utilize them (USFS 1995). This present-day rapid mineralization of nutrients decreases the productivity of the plant community.

Fire suppression has also been associated with expansion of juniper into areas where juniper was not present before. In the past, frequent fires would have kept junipers restricted to sites of poor soils, such as rocky hillsides and ridges (Bedell et al. 1993). Juniper woodlands were typically composed of ancient trees (western junipers can live more than 800 years) spaced widely apart. However, junipers have been expanding and replacing shrub-steppe cover types since the late-1890s (Bedell et al. 1993). Most of the invasion has been into areas previously dominated by mountain big sagebrush. The reasons for the shifting distribution are unclear, but are generally believed to be related to fire suppression, over-grazing or climate change (Miller et al. 1995). These new western juniper woodlands are denser than the original cover type and usually are dominated by trees in young age-classes. Effects of juniper encroachment may include soil nutrient loss, reduced water storage, increased runoff and erosion. Unless the natural fire regime is restored, juniper encroachment into sagebrush shrublands and riparian areas is likely to continue.

Fire suppression has also altered nonforest plant communities in the subbasin. Areas once dominated by perennial bunch grasses such as tufted hairgrass have transitioned to shrublands. It has been estimated that 60 percent to 70 percent of the shrub-steppe communities were maintained in early-seral condition under the pre-settlement fire regime, but these communities have succeeded to late-seral shrublands, with little of the herbaceous understory remaining (USFS 1999).

Logging has also affected vegetation in the subbasin, because it requires heavy equipment that contributes to soil compaction, which in turn has been known to cause a loss of productivity in the plant community. Many studies have delved into the vegetative impacts of soil compaction, but none have been done on the Lower Sprague-Lower Williamson subbasin. Most of the studies have concentrated on the impacts of compaction on timber species, with studies designed to detect losses in timber volume, losses in germination and seedling establishment, and early growth rates on compacted soils compared to undisturbed soils (USFS 1995). Crop tree germination, seedling survival and tree growth rates are generally used to measure changes in vegetation due to soil compaction in most studies, but it appears that actual changes in vegetation types have not been studied. However, some range compaction studies have shown changes in vegetation type.

Insect outbreaks in the twentieth century may have been related to changes in the forest structure associated with the preceding half-century of fire suppression and logging. The outbreaks led to high levels of tree mortality, which provided an added urgency to harvest timber before it was lost.

Pine and mixed conifer forests became highly susceptible to insect outbreaks and tree diseases as a result of the changes in stand composition and structure. In ponderosa pine forests, western pine beetle, mountain pine beetle (*Dendroctonus valens*) and the pine engraver are the most serious insect pests. Mixed conifer stands became infested with the same insects affecting pine forests, as well as the fir engraver beetle (*Scolytus ventralis*) and several other pests associated with Douglas-fir and true fir. Annosus root disease (*Heterobasidion annosum*) and Armillaria root disease (*Armillaria ostoyae*) are the most serious tree pathogens in the assessment area. These diseases cause significant levels of tree mortality. Dwarf mistletoe (*Arceuthobium* spp.) lowers the productivity of ponderosa and lodgepole pine forests. Treating these forest health issues has been the principal objective of stand management on private and public forests in the region for the last 25 years (USFS 1995, USFS 1999).

Recent timber harvesting activities in many areas of the subbasin have been focused on reducing fuel loading and vulnerability to insects and disease. Current efforts to improve forest health are expected to develop benefits slowly, over many decades.

Agriculture

The first livestock ranches were established in the Lower Sprague-Lower Williamson subbasin by the 1860s (USFS 1999). Livestock numbers were unregulated during the early period. By 1910, there were 110,000 sheep and 26,000 cattle (equivalent to 450,000 animal unit months [AUMs]) grazing across the Fremont National Forest. In comparison, during the 1990s, permitted AUMs had fallen to less than 75,000, or one-sixth that level (USFS 1999).

Grazing has modified the amount and species of riparian vegetation along portions of most, if not all, streams. Streambanks have been broken down by cattle and sheep in the past.

Today, many ranchers within the assessment area have altered their land management practices to benefit the native plant communities. Some of the best management practices that have been implemented include crop and grazing rotations, riparian fencing, noxious weed eradication and juniper removal.

On federal land, stricter enforcement of livestock forage utilization in meadow systems has reduced the impacts to habitat on public lands (USFS 1995). On federally administered lands within the watershed, this reduction of impacts is being accomplished through allotment administration, but where private ownership is concerned it must be a voluntary effort (USFS 1995). Less road construction near riparian areas and a restriction of management activities in or near meadows would also improve the condition of plant habitat (USFS 1995).

Beaver Extirpation

Beaver trapping and declining beaver populations have altered stream-floodplain hydrologic functions. Historically, beaver dams helped to build and maintain floodplains, dissipate stream energy and favor the deposition of sediments. Where beaver dams eventually failed or were eliminated, stream energy was confined to discrete channels, favoring channel erosion, downcutting and diminished riparian features, including healthy wetland vegetation.

INTRODUCTION OF NOXIOUS WEEDS

A noxious weed is defined as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Some non-native species in the Lower Sprague-Lower Williamson subbasin have been introduced for agricultural crops (quackgrass) or ornamental and landscape plants (purple loosestrife), but others have also been introduced unintentionally. The subbasin is also not immune to new introductions of noxious weeds, because disturbances, coupled with warm growing seasons and sufficient moisture, leave it susceptible to noxious weed invasion (USFWS 2002).

Noxious weed species are a major threat to the vegetative communities, natural ecosystems and agricultural production of the Lower Sprague-Lower Williamson subbasin. The invasion of noxious weeds reduces biological diversity, impacts threatened and endangered species, reduces or eliminates native vegetation, and destroys recreational environments. Noxious weeds also impact crop productivity, rangeland condition and forage production. A description follows of the invasive plant species that pose the biggest threat to the subbasin. Most of the information in this section has been adapted from *Noxious Weeds of Klamath County: Field Identification Handbook* (Rabe Consulting 2006).

Noxious and exotic plants are in many cases a serious problem in the assessment area and will continue to exist in the Lower Sprague-Lower Williamson subbasin. This problem is most pronounced, and will continue to be most pronounced, in roadside, agricultural, urban, timber harvest and other disturbed areas. Many of the exotic plants require high amounts of sunlight to grow rapidly and reproduce. While these plants are a concern, particularly in reforestation efforts, they are not considered to be a long-term threat to the integrity of the forest ecosystem, because they quickly disappear when overtopped by other vegetation. Effects of noxious plants are expected to be more severe in wetlands and pasturelands. In such areas, noxious plants can have major effects on forage quality, quantity and plant species diversity.

Noxious Weed Species

Bull Thistle (*Cirsium vulgare*)
This plant is a biennial with a dark green rosette and with highly dissected leaves exhibiting sharp spines. The plant bolts in the second season with 1-foot to 3-foot stems, and has purple flowers 1 to 3 inches in diameter. The plants spread by seeds, but naturally die out if the population becomes too dense in a specific location. Bull thistles inhabit roadsides, pastures, ditch banks and other disturbed areas.

Canada Thistle (*Cirsium arvense*)
This plant is a perennial with 1-foot to 4-foot stems that are ridged and branched. Leaves are alternate divided into spine-tipped irregular lobes. The plant flowers in July to August. Flowers are purple, occur in heads 1/2 inch to 3/4 inch in diameter, and have spineless bracts. It is identifiable when in fruit because the fruits have tufts of white hairs on top. Colonies spread through seeds and extensive root systems. Canada thistle is native to southeastern Eurasia and differs from other thistles because it has male and female plants. It occurs in various habitats in pastures, roadsides, and rangelands and is one of the most widespread weeds in Klamath County. It infests crops, pastures, forests, rangelands, roadways and lawns. The plant is a major pest, because it is very hard to control or eradicate.

Dalmatian Toadflax (*Linaria dalmatica*)
Toadflax is a perennial plant that grows up to 4 feet tall, with blue-green leaves that are waxy and heart-shaped and clasp the stems. It has yellow flowers that resemble snapdragon flowers, with orange hairy centers that occur on upper stems from July to August. Originally an ornamental from the Mediterranean, these plants can be found in disturbed areas, along roadsides and in rangelands. Toadflax is an aggressive plant that crowds out desirable vegetation. Plants spread by seeds or creeping roots and, due to their deep root systems, are very hard to control.

Diffuse Knapweed (*Centaurea diffusa*)
This plant is an annual to short-lived perennial that is diffusely branched and is 1 to 2 feet tall. Stems are rough, and flowers are white to rose and tipped with a slender spine (the plant flowers in July to September). Diffuse knapweed is native to the Mediterranean region. Plants rapidly invade and dominate roadsides, waste areas, dry rangelands and pastures, where they out-compete and exclude desirable vegetation.

Dyer's Woad (*Isatis tinctoria*)
Dyer's woad grows 1 foot to 4 feet tall, with leaves that are blue-green and alternate, and that have a white vein on the top surface. It has small, yellow flowers that occur in dense flat-topped clusters from April to June. Large taproots extend up to 5 feet and can resprout. Seeds are purple-brown, with one per pod. Native to Europe, this plant occurs in dense infestations and inhabits grain fields, pastures, alfalfa, waste areas, roadsides, railroads and fence lines. The presence of dyer's woad in hay decreases feed and economic values, and it is hard to control because of its large taproots that can resprout.

Field Bindweed (*Convolvulus arvensis*)
This plant is a perennial plant that has stems creeping 1 foot to 4 feet, forming an entangled mat. Alternate leaves are arrowhead-shaped, and the flowers are white to pinkish, trumpet-shaped and 1 inch in diameter (this plant flowers from June to September). Field bindweed is native to Europe, and plants invade disturbed areas such as cultivated fields and waste places. It is a troublesome pest in agriculture and extremely hard to control due to its deep taproot (up to 10 feet) and the long viability of its seed (50 years). Also, plants are adaptable and may occur at elevations up to 10,000 feet.

Houndstongue (*Cynoglosum officinale*)
Houndstongue is a biennial or short-term perennial that stands 1 foot to 4 feet tall. It has soft, hairy leaves that are about 3 inches to 8 inches long and reddish-purple flowers. Fruits are nutlets, with barbed hooks and raised edges that attach readily to animal fur and clothing. It is thought to have originated in western Asia and eastern Europe, and has spread throughout all but six states in the contiguous United States. It is found in dry habitats in open woods and disturbed areas such as fields and roadsides. Plants can cause liver damage or liver failure in horses and cattle when grazed directly or if cut and dried with harvested hay.

Leafy Spurge (*Euphorbia esula*)
This plant is a hairless perennial standing 2 feet to 3 feet tall, with milky juice and large root reserves. Leaves are narrow, alternate, and 1 inch to 4 inches in length, and they tightly cluster around stems. Small, yellow-green flowers are subtended by two bright yellow-green, heart-shaped bracts (the plant flowers from June to July). Leafy spurge grows in a wide range of habitats, but occurs most commonly in pastureland, rangeland, woodland, prairies, roadsides, streambanks and ditchbanks, and waste sites. Plants cause irritation in the digestive tracts of cattle and may cause death in horses. They also reduce grazing productivity, crowd out native vegetation and are very difficult to eradicate because they spread by seed or creeping roots.

Matgrass (*Nardus stricta*)
This grass is a tussock-forming perennial plant 4 inches to 16 inches tall. Matgrass leaves are dark green to bluish, hard and bristle-like, up to 1/4 inch wide and folded tightly along the midrib. Flower spikes are single, narrow and one-sided. Spikelets are 1/5 to 1/3 inch long, with single

florets tipped by short, straight awns. Anthers are yellow at first, turning white with age. Originally from Eastern Europe, this grass is now widely distributed in several continents, preferring open areas such as grasslands and pastures. It is an unpalatable species for livestock that may outcompete other grasses in grazing areas. Its invasion is accelerated in pastures, because it can reproduce by clinging to mud carried in hooves of livestock animals.

Meadow Knapweed (*Centaurea pratensis*)
Meadow knapweed is a perennial growing 20 inches to 40 inches tall, with lower leaves that are up to 6 inches long and can be entire, coarsely lobed or toothed. The middle leaves are lance-shaped and entire or shallowly lobed. The uppermost leaves are smaller and not lobed. Pink to purplish-red flower heads are globe-shaped and occur at the end of branches (the plant flowers from July to September). The flowers have roundish, deeply fringed, and light to dark brown bracts. Meadow knapweed is considered to be a hybrid between black knapweed (*Centaurea nigra*) and brown knapweed (*Centaurea jacea*), so traits may be highly variable. It is native to Europe and infests roadsides, pastures, meadows and waste areas. It is considered an aggressive, invasive species that outcompetes native vegetation and crops, thereby reducing forage for livestock and wildlife.

Mediterranean Sage (*Salvia aethiopis*)
This plant is a biennial with gray woolly leaves that are coarsely toothed, and it grows 2 feet to 3 feet tall. While the first-year rosette is up to 2 feet in diameter, second year plants bolt, with branched stems. Lower leaves are up to one foot long, while upper leaves are small. Yellow-whitish flowers are profusely clustered along the stem (the plant flowers from June to August). When mature, this plant resembles a tumbleweed. Mediterranean sage is originally from Europe and is found in pastures, meadows, range sites and other open areas. It spreads easily, because a single plant can produce thousands of seeds that are deposited when winds blow the tumbleweed-like cane across landscapes.

Medusahead Rye (*Tanieatherum caput-medusae*)
This grass outcompetes almost all native vegetation, creating monocultures of medusahead rye. This grass has distinct seed heads, with 1-inch-long awns pointing upwards. Its name derives from the fact that its seed head resembles Medusa, the snake-haired gorgon of Greek mythology. The grass turns blond in late summer and is not palatable for cattle.

Musk Thistle (*Cardus nutans*)
Although musk thistle is usually a biennial, it is sometimes a winter annual. It grows up to 6 feet tall and has dark green leaves, with a white ventral vein, that are deeply lobed and have spiny margins. First-year leaves form a rosette, with bolting and flowers seen in the second year. Flower heads are solitary, are deep rose-violet, and occur on tops of stems. The seeds are yellowish brown, with plumes of white hairs. Musk thistle is native to southern Europe and western Asia. Plants are located in pastures, rangelands and forest lands, and are found along roadsides, ditchbanks, streambanks and grain fields. Musk thistle infestations can pose a major problem by outcompeting more desirable vegetation for moisture and nutrients. It can also reduce forage for wildlife and livestock.

Perennial Pepperweed (*Lepidium latifolium*)
As its name implies, this plant is a perennial that stands 1 foot to 6 feet tall. Its leaves are entire to toothed and gray to bright green, with larger leaves occurring at the plant base. Small, white flowers form dense clusters on top of branches from June to August. Perennial pepperweed seeds are round, flat, hairy and 1/16 inch in diameter. It is native to southern Europe and western Asia. Plants are found in waste areas, ditches, wet areas, roadsides, croplands, waterways, and dry habitats including

cuts and fills. Plants outcompete crops and native vegetation, forming monocultures that are very hard to control due to their profuse seed production and extensive creeping root system.

Poison Hemlock (*Conium maculatum*)
Poison hemlock is a biennial with stout stems having distinct ridges and purple spots, and it grows 6 feet to 8 feet tall. Its leaves are shiny green and are divided three to four times with segmented leaflets that are 1/8 inch to 1/4 inch long. The white flowers are located in numerous umbrella-shaped clusters on each stalk. This plant is native to Europe and occurs in edges of pastures and cropland. The plants spread readily along irrigation ditches and riparian areas because they tolerate poorly drained soils along streams and ditches. All parts of the plant are toxic to humans and animals and may cause death if ingested in high enough doses.

Puncturevine (*Tribulus terrestris*)
Puncturevine is an annual plant that is mat-forming, with sprawling stems 1/2 foot to 5 feet long. Its leaves are hairy and opposite, with four to eight pairs of leaflets. Yellow flowers have petals and are 1/2 inch long, with two to four sharp spines. Puncturevine is native to the Mediterranean. Plants prefer sandy soil and occur in pastures, cultivated fields, ditchbanks, roadsides, wastelands and other disturbed areas. The hard, spiny burs may be injurious to livestock, stick painfully in bare feet, and cause flats in bicycle and four-wheeler tires.

Purple Loosestrife (*Lythrum salicaria*)
This plant is a perennial with erect stems that grows 2 feet to 6 feet tall. Its leaves are lance-shaped, simple, entire, and opposite or whorled. It has rose-purple flowers with five to seven petals, and they cluster in spikes on terminal stems (the plant flowers August to September). Purple loosestrife is found in marshy areas, ponds, streambanks, meadows and ditches. These plants are a threat to agriculture, because they sometimes grow so dense that they impede water flow in ditches. Purple loosestrife was originally cultured as an ornamental in Europe. Riparian areas are extremely valuable to native plants and animals, and the wholesale invasion by loosestrife poses a serious threat of eventual extinction to numerous riparian-dependent species. Because of its ability to outcompete other desirable vegetation, purple loosestrife infestations reduce wildlife habitat, food and cover for waterfowl, and wetland biodiversity.

Russian Knapweed (*Acroptilon repens*)
Russian knapweed is a perennial that forms dense colonies, with shoots from spreading roots. Plants are erect, openly branched and 18 inches to 36 inches tall. The lower leaves are deeply divided and 2 inches to 4 inches long, while the upper leaves are entire to serrate. Flower heads are 1/4 inch to 1/2 inch in diameter and pink to lavender in color, and they occur in clusters on ends of branches (the plant flower from June to September). The flowers also have pearly bracts that have rounded or pointed papery margins. Seeds are small, 1/4 inch to 1/8 inch long, with numerous white hairs. Russian knapweed is native to central Asia. Plants are found in cultivated fields, orchards, pastures, roadsides and rangelands. Once established, this plant is very hard to control or eradicate, because it forms dense colonies that outcompete native vegetation and crops.

Scotch Thistle (*Onopordum acanthium*)
Scotch thistle is a biennial with broad, winged and spiny stems that can grow up to 12 feet tall. Its upper leaves are large, hairy with spines, and alternate and basal leaves may be 2 feet long and 1 foot wide. Flower heads are numerous, 1 inch to 2 inches diameter, and violet to red. Fruits are 3/16 inch long and tipped with slender bristles. This plant is native to Europe and eastern Asia. Long viability

of seeds and dense stands combine to make this plant a major pest. It may form stands so dense that wildlife, livestock and people cannot pass through it.

Spiny Cocklebur (*Xanthium spinosum*)
This plant is an annual with spreading or erect stems up to 2 feet long. Its leaves have numerous white hairs and white veins, and are deeply divided. Flowers are tightly clustered, with male flowers located on top of the plant and female flowers below. Spiny cocklebur's spiny fruit resembles a burr with hooked bristles. It is native to Europe. Plants occur in dry areas like barnyards and roadways. It is a nuisance to recreationists and is also toxic to grazing animals.

Spotted Knapweed (*Centaurea maculosa*)
Spotted knapweed is a biennial to short-lived perennial standing erect from 1 foot to 3 feet tall. Its basal leaves are narrow and up to 6 inches long, and stem leaves are finely divided when mature. Pink-purple to cream solitary flower heads occur on branch ends (the plant flowers from June to October) and have bracts with stiff tips that have dark fringes. Plants are located in disturbed areas along roadsides and waste areas and also occur in dry to moist rangelands. Invasions of spotted knapweed reduce grazing forage for wildlife and livestock. These plants may also excrete a chemical that discourages growth of other vegetation.

Squarrose Knapweed (*Centaurea virgata*)
Squarrose knapweed is a perennial that stands 1 foot to 1-1/2 feet tall and is highly branched. Its leaves are deeply divided, and the uppermost leaves are small and gray. Flower heads are numerous, with four to eight small rose to pink flowers (the plant flowers from June to August). Bract tips bend back or spread, with the terminal spines being longer than the lateral spines on each bract. Plants have a large taproot and inhabit dry disturbed, sandy or cinder soils. This plant is different from diffuse knapweed because plants have bracts that bend back and heads with loose seeds. It outcompetes and replaces native vegetation, reducing rangeland productivity and wildlife and livestock forage.

St. Johnswort (*Hypericum perforatum*)
This plant is a perennial growing 1 foot to 3 feet tall and has stems that are erect, with two ridges and many rust-colored branches. The plants leaves exhibit tiny "windows,"— small spots that are visible when the leaf is put up to a light. Bright yellow flowers are numerous in tight clusters at top of stems. The flowers have five petals, numerous stamens in three clusters, and are 3/4 inch in diameter (the plant flowers from June to September). St. Johnswort is found in sandy to gravelly soils in disturbed areas and along roads. This plant is dangerous at all stages of growth. When ingested, it causes sun sensitivity and skin irritation. It is also an aggressive plant, growing in dense patches, because it can reproduce from both seeds and short runners that allow the plant to spread easily.

Tansy Ragwort (*Senecio jacobea*)
Tansy ragwort is a taprooted biennial or short-lived perennial standing from 1 foot to 6 feet tall. Stems are slightly branched or solitary, with pinnately lobed leaves. The plant has numerous flowers that are bright yellow and clustered at the top of the stem (the plant flowers from July to September). Tansy ragwort can be found in pasture and rangelands. It is important economically because it is a poisonous plant that is toxic to cattle. All parts of the plant are poisonous both in the vegetative and dried stages.

Hoary Cress (*Cardaria draba*)
Hoary cress is a perennial with blue-green leaves that stands up to 2 feet tall. Its lower leaves are lanceolate and stalked, while its upper leaves are two-lobed and clasp the stem. Small, white flowers have four petals and occur in flat clusters at the top of the stems (the plant flowers from April to July). Hoary cress inhabits disturbed, alkaline soils along stream banks and waterways. Plants spread by deep roots and seeds. The plants are very competitive, forming monocultures that reduce desirable vegetation and wildlife habitat.

Western Water Hemlock (*Cicuta douglassii*)
Western water hemlock is a perennial with erect stems that stands 3 feet to 7 feet tall. Its leaves are alternate, with one per node, and are pinnately divided. It has small, white flowers that cluster in a compound umbel at the apex of the stalk (the plant flowers from May to July). It has two kidney-shaped seeds per flower that are ridged and brown. This plant is common in wet areas, especially untilled areas, pastures, stream edges and irrigation canals. Western water hemlock is the most poisonous plant in North America. It is toxic to all classes of animals and humans, acting directly on the nervous system. An early Klamath Falls farmer mentioned the plant on August 5, 1919: "Mr. J. A. Johnson of Merrill stated that water hemlock causes lots of losses in cattle from the first of November thru the winter and into the spring. He lost two cows last spring."

Yellow Starthistle (*Centaurea solstitialis*)
Yellow starthistle is an annual with hairy, winged, rigid branches that stands 2 feet to 3 feet tall. Its basal leaves are deeply lobed, while its upper leaves are entire and sharply pointed. Flower heads are yellow, are solitary on branch tops, and exhibit straw-colored thorns up to 3/4 inch long. Fruits are dark, without bristles. Yellow starthistle grows on various soil types usually along roadsides or in waste areas. Invasions of this weed will decrease rangeland productivity, will outcompete native vegetation and can cause "chewing" disease in horses. It is a severe threat due to its high adaptability.

Cheatgrass (Bromus tectorum)
European cheatgrass has almost entirely displaced sagebrush-grassland plants and associated animals. Cheatgrass has also seriously altered the fire regime from an average return interval of 60 to 110 years to 0 to 3 years. Cheatgrass forms a dense, uniform carpet that outcompetes native grasses and shrubs. It greens quickly, dries quickly and produces a very flammable cover that often burns completely, without allowing native plants to reestablish.

Current Invasive Species Eradication Programs

Managing and controlling invasive species requires an extraordinary coordination of programs, research and management actions at the federal, state and local levels. Invasive species affect all land ownerships and jurisdictions. Being able to recognize and identify noxious invaders is the first step in control and eradication. Early detection is the key to having a successful weed eradication program.

Federal and state land managers within the watershed assessment area have noxious weed control and monitoring programs in place as part of the overall management plans. Klamath County Public Works and Oregon Department of Transportation actively manage weed control along the roadsides. Private landowners often control their own weeds, sometimes with the help of grant funding. Integral Youth Services, an alternative youth school in Klamath Falls, Oregon, has received grants for noxious weed control in the Beatty area. As each landowner does his or her part, noxious weeds can be abated in the subbasin. To get ahead of the noxious weed problems, noxious weed populations must be addressed at a watershed scale, across ownership boundaries.

DATA, METHODS AND LIMITATIONS

The purpose of the watershed assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies. We believe the information used in this assessment to be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data are determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies. Data are presented on a watershed scale and may not be detailed enough to use on a farm or ranch scale.

HISTORICAL QUOTES DESCRIBING SUBBASIN

William E. Lawrence Quotes:

August 17, 1934 (Chiloquin to Sprague River)

"Selective logging of the ponderosa pine was being practiced where merchantable timber grew on the ridge. The brush was piled ready for burning at safe season"

"[S]ome barley grown" near where road hits the river.

"Sage brush is extensively developed through here (town of Sprague River)."

August 5, 1919 (Klamath Falls)

"Mr. J. A. Johnson of Merrill stated that water hemlock causes lots of losses in cattle from the first of November thru the winter and into the spring. He lost two cows last spring."

"Mr. M. J. Barnes of Klamath Falls mentioned larkspur as the worst poisonous plant in this country. Mr. E. H. Thomas said he was sure under some conditions larkspur would poison sheep."

August 7, 1919 (Beatty)

"Beatty is situated in an open desert valley."

August 8, 1934 (At junction of Highway 97 and Silver Lake Road)

"Here the road leads through various conditions of standing lodgepole pine to fallen dead, with and without lodgepole pine reproductions. The trees have fallen in all directions which would indicate that trees had been killed by a fire or some other cause although there was little or no evidence of a previous fire. With lodgepole was an association or society of *Purshia tridentate, Chrysothamnus, Stipa, Eriogonum, Festuca, Ribes cereum*."

August 15, 1934

"By this season of the year the forest fires have cast an obscure ness over the landscape so that it is not so clear as when we arrived here. The peaks of the Crater Lake rim are not very clear until we near the upper end of the Klamath Lake basin."

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CHAPTER 7. RIPARIAN AREAS

INTRODUCTION

Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (rivers, streams, lakes or drainage ways). They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Riparian areas have one or both of the following characteristics: (1) they have distinctly different vegetative species than adjacent areas, and (2) they have species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland. In 1997, the Western Regions of the U.S. Fish and Wildlife Service developed a classification system to identify riparian areas that fell outside of the Cowardin et al. (1979) system. Since that time, "A System for Mapping Riparian Areas in the Western United States" (USFWS 1997) is a national standard for riparian mapping, monitoring and data reporting as determined by the Federal Geographic Data Committee.

The low gradient sections of the Lower Sprague and Lower Williamson rivers are vegetation-dependent systems. Therefore, much of this chapter will focus on riparian vegetation.

High quality riparian vegetation can improve stream health and the sustainability of values such as fish and wildlife habitat, livestock forage and aesthetics. It can provide:

- rooting strength to prevent bank erosion that can fill gravel beds with fine sediment;
- roughness for dissipating energies of water;
- filtering of runoff from adjacent lands of eroded sediment, nutrients and bacteria;
- water storage and aquifer recharge;
- shading necessary to retard heating and help maintain cooler water temperatures; and
- the source for large woody debris in higher gradient reaches that dissipates energy and helps retain spawning gravels, contributes to pool formation, provides critical in-stream structure and helps moderate summer water temperature.

Because the riparian area can improve stream health and the sustainability of values, the riparian area lends itself to restoration. By restoring the riparian areas or other land features that would indirectly improve the riparian area, the stream health can also be increased.

During the course of this Assessment, three main methodologies were used to gather and interpret information about riparian conditions and function. Each methodology has its own benefits and shortcomings, but together they can provide information that will be useful in prioritizing and planning improvements.

First, Proper Functioning Condition (PFC) and "Greenline" (Winward 2000) were used to assess site-specific conditions on privately owned ranch properties. This site-specific approach has been enormously useful, due mainly to the wide variability in riparian conditions and function within the assessment area. Larger-scale methods can provide helpful general information and necessary context, but as mentioned previously in this document, restoration planning and project development must be rooted in more detailed site analysis. The first section of this chapter summarizes this site-specific approach, as well as other recent site-specific analyses that have occurred within the assessment area.

The second methodology, discussed in the second section of this chapter, involved visual analysis of aerial photographs, classifying vegetation types by interpreting color, texture and topography. This approach gives a large-scale approximation of the riparian area. The limitations of this approach are:

- It overestimates or underestimates the actual acreage of the natural riparian area. Some inherent error exists when technicians digitize riparian areas from aerial photographs. This error makes it impossible to be 100 percent accurate when calculating acreages.
- In some cases, it might misclassify the vegetation classes for the riparian area. This error can be explained by the high degree of subjectivity involved in interpreting vegetation classes from aerial photographs.

The third approach is based on a dataset collected using Light Detection and Ranging (LiDAR) technology. This dataset provided information about vegetation heights in riparian areas, which can help clarify where taller woody vegetation species are present. However, LiDAR does not allow us to distinguish between low vegetation heights resulting from poor riparian conditions and low vegetation heights resulting from very stable but low-growing sedge/rush communities. The third section of this chapter summarizes the LiDAR information and includes samples of the graphic results of the dataset.

PFC, GREENLINE AND SITE-SPECIFIC METHODS

There are many methods for assessing condition and trend in the riparian area. Two methods used include "Monitoring the Vegetation Resources in Riparian Areas" (Winward 2000) and "Riparian Area Management: A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas" (Pritchard 1998). Both methods rely heavily on the riparian vegetation to define and assess the condition and extent of the riparian area.

Proper Functioning Condition (PFC) is described as meeting the minimum conditions for a riparian area to function properly (Pritchard 1998). It is based on the physical processes and attributes of streams that make it possible for them to more easily maintain their dimension (channel shape), pattern (sinuosity) and profile (gradient) on the landscape. The PFC Technical Reference defines riparian areas that are functioning properly as having adequate vegetation, landform or large woody debris present to:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload and aid floodplain development;
- improve floodwater retention and groundwater recharge;
- develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration and temperature necessary for fish production, waterfowl breeding and other uses; and
- support greater biodiversity (Pritchard 1998).

Both of the methods include native and non-native vegetation in their assessment of the riparian areas. Native plants are indigenous to the area and would naturally occur in the given habitat. Non-native plants are plants that have been introduced to the area and would not naturally occur there. Non-native plants include weeds, but are not limited to weeds alone.

Riparian Ecological Type Classification and Scorecard Guides

As part of the riparian assessment process, guides have been developed to classify ecological types and scorecards for ecological status. The Riparian Field Guide for south central Oregon is being developed from 395 permanent plots established from 1995 to 2002 on Fremont National Forest (NF) and Lakeview District BLM lands. Ecological types are classified as combinations of vegetation community, soil type and landform. Scorecards were developed specifically for use in riparian areas in meadows. Plots were sampled intensively to provide comprehensive vegetation, soil and geomorphic data for analysis in the classification. The data, which include GIS plot locations, are available through the Area Ecology Program. The Riparian Field Guide is in its final draft stage before review and publication. Currently, the draft guide is being used for mapping and monitoring by both the Fremont National Forest and Lakeview BLM.

Lakeview BLM is using the guide to assess ecological type and condition of riparian areas in its watershed mapping project. Lakeview BLM has contracted with John Ritter, Oregon Institute of Technology, to develop an interactive database to automate the classification and scoring process from field data.

Fremont-Winema NF is using the guide for several assessments and monitoring programs:

1. Effectiveness Monitoring for the Programmatic Biological Opinion for Listed Suckers and Bull Trout
2. Range Analysis
3. Water Quality Implementation Plan Effectiveness Monitoring
4. Forest Plan Monitoring Report

A separate classification of riparian areas was done in 1987 by Bernard Kovalchik ("Riparian Zone Associations of Deschutes, Ochoco, Fremont, and Winema National Forests, R6 ECOL TP-279-87"). Data from this classification have been included in the larger document, "Riparian and Wetland Vegetation of Central and Eastern Oregon" (Crowe et. al. 2004). A map layer showing the approximate location of Kovalchik's plots is available through the Area Ecology Program. This completed riparian vegetation classification will be combined with other classification projects planned for the summer of 2008. The goal is to complete the classification of riparian vegetation communities and to develop a complete classification for the Sprague, Wood, and Sycan rivers and tributaries.

Besides the work listed above, additional references on riparian community type classification include "Humbolt and Toiyabe National Forests, Nevada and eastern California" (Manning and Padget 1995) and "Riparian Plant Community Classification, West Slope, Central and Southern Sierra Nevada, California" (Potter 2005). A vegetation community is defined as an association of plants based on the soils and the dominant plant species. By characterizing the vegetation communities, different riparian areas can be easily compared, because the characterization is a generalization of the plants present and ignores small amounts of variation in plant species composition.

The U.S. Fish and Wildlife Service (USFWS) conducted another very useful classification of riparian plants (Reed 1988). This classification established five basic categories of indicator status, reflecting different frequencies of occurrence in wetlands: (l) obligate (OBL; >99 percent of time in wetlands), (2) facultative wetland (FACW; 67 percent to 99 percent in wetlands), (3) facultative (FAC; 34 percent to 66 percent), (4) facultative upland (FACU; 133 percent), and (5) upland (UPL; <1 percent). The latter species were typically not recorded on the regional and national lists because the lists represent plants occurring in wetlands; some UPL species appear on the lists because they occur in wetlands >1% of the time in one region of the country or simply to show that they had been reviewed. For species in the "facultative" category, a + (plus) or a - (minus), representing the higher or lower end of the range of occurrence in wetlands, was assigned to species where there were differences in opinions among the reviewers or regional panel members (Reed 1988). No indicator (NI) was assigned to species with insufficient information available to project their indicator status, whereas species for which differences among reviewers could not be resolved were designated with not available (NA). A supplemental list was produced in 1993 for the northwest region (Reed et al. 1993).

While these categories seem overly detailed, this classification system is easy to use. Once a plant species is identified, the plant species is looked up in the classification tables and the indicator status is ascertained. Riparian areas contain primarily obligate, facultative wetland, and facultative plant species. Once the transition has been made from mostly facultative wetland plants to mostly facultative upland or upland plants, then that is the edge of the riparian area and beginning of the upland area.

Riparian Process, Function and Management

There are many roles served by the aquatic ecosystem in the Lower Sprague-Lower Williamson River subbasin. An important role is providing habitat for a diverse group of plants and animals. Riparian plants provide shade to the stream, helping to prevent water from warming. In addition, many species of riparian plants play a role in retaining water received from the hill slopes. Especially important in this regard are a variety of sedges, rushes, grasses, shrubs such as thinleaf alder and willow, and deciduous trees such as black cottonwood. By slowly releasing water from their sponge-like root systems, sedges and other deeply rooted plants help to augment flows during the late summer and early fall. Additional cool water, especially in the late summer, is beneficial to many fish species. Improved riparian areas, when grazed properly, can also provide important livestock forage.

In some cases, improved management of riparian areas leads to the establishment of reed canarygrass (*Phalaris arundinacea* L.), because it is a very aggressive plant and it already has a strong presence in the watershed. Most people consider reed canarygrass non-native to eastern Oregon. While possibly native to North America, European cultivars have been widely introduced for use as hay and forage in Europe; there are no easy traits known for differentiating between the native plants and European cultivars. The species grows so vigorously that it is able to inhibit and eliminate competing species. Since it often forms persistent monocultures, it poses a challenge to establishing native sedges and rushes. The root mass of reed canarygrass is intermediate between the strong, deep roots of native sedges and rushes, and the less strong and shallow roots of most pasture grasses and Kentucky bluegrass. In addition, the root masses of reed canarygrass can provide a measure of stability in a riparian area even though they are not considered native.

Ongoing research has shown that management, such as livestock grazing and establishment of shade, can keep reed canarygrass in check, or at least slow its spread so that it does not become a monoculture. However, technology to eliminate it totally while protecting functional attributes of stream and river systems is not available. If reed canarygrass becomes a monoculture along a riparian-wetland area, then the loss of a diverse composition of plants and the intermediate root mass would cause the area to have less stability than otherwise expected.

The methods outlined above can be applied on a site-by-site basis. They provide detailed information that can be used to determine the condition and extent of the riparian area in a given location. Furthermore, if applied repeatedly over time the methods will provide a picture of the riparian area trends. For example, is the riparian area increasing or decreasing in width? Is the bank stability increasing or decreasing? Is the plant species composition increasing or decreasing?

While the methods are useful on a site-specific basis, a series of PFC assessments and Greenline transects across the watershed assessment area would provide generalizations for the riparian area in the entire assessment area. The assessments and transects would need to be visited at intervals of one to five years, depending on observed change, to establish the short-term and long-term trends.

Individual landowners have already begun to develop relationships with the Working Landscapes Alliance to establish Greenline transects on their property and have conducted proper functioning assessments. With these assessments in hand, the landowner can make management changes and conduct restoration activities to positively influence the riparian area trends. A positive influence could be widening the riparian area or improving riparian vegetation. These changes can still be compatible with land use activities, including agriculture. Potential management strategies are summarized in *Riparian Areas—Functions and Strategies for Management* (National Academy of Sciences, 2002).

Riparian Assessment Studies

Many different agencies, landowners and organizations have conducted riparian assessments within the watershed assessment area. Below is a partial summary of completed and ongoing riparian assessments at the time this Assessment was being written. It is important to recognize that this is just a partial list, and it is beyond the scope of this document to present and summarize a complete list.

- Rabe Consulting (RC) conducted an assessment of riparian acreage and vegetation types on major streams in the subbasin. Rabe Consulting interpreted color aerial imagery in its assessment.
- USFS has conducted riparian area assessments and classification for many river reaches within its ownership in the assessment area using proper functioning condition methods. Unfortunately, other reaches within the assessment area have not been assessed.
- The Klamath Tribe LiDAR dataset is a collection of maps with very detailed aerial imagery of the riparian areas in portions. The dataset needs to be analyzed and a model developed to use the classification information, sediment budget data and channel geometry to better estimate recovery times.
- The Nature Conservancy is conducting ongoing studies on fish habitat, nutrient loading, and riparian and wetland conditions in the Williamson River Delta.

- Klamath Tribes are conducting a geomorphology study of the main stem of the Sprague River. This study is not yet completed.
- A vegetation classification study is currently being conducted by Tamzen Stringham, Al Winward and Wayne Elmore (funded by NRCS and the Bureau of Reclamation).
- Chris Massengill is conducting a study on the colonization of point bars and banks.

COLOR AERIAL IMAGERY INTERPRETATION

Aerial imagery interpretation is a cost- and time-effective technique for identifying riparian vegetation in watersheds at a large scale. To assess riparian acreage and vegetation type in the subbasin, aerial imagery was incorporated into a geographic information system (ArcGIS) to digitize polygons around riparian vegetation. National Agriculture Imagery Program (NAIP) natural color aerial images, acquired during the growing season from the summer of 2005, were used in the assessment.

Wetland and riparian areas were identified based on vegetation, visible hydrology and geography. These were used in conjunction with reliable collateral data such as topographic maps, soils information, and Rabe Consulting staff's local knowledge and experience of riparian vegetation in the assessment area. Mapping efforts in the mapping project include all major streams, including the main stems of the lower Sprague and lower Williamson rivers, Trout Creek, Spring Creek, Larkin Creek and Whiskey Creek. Not included within the mapping area were irrigation canals and ditches.

In order to achieve a consistent product, Rabe Consulting staff developed both a consistent methodology and consistency in interpretation. As polygons were digitized around riparian areas, technicians assigned a vegetation type attribute to the polygon. Five vegetation categories were selected to represent the major types of interest and to be compatible with riparian ecological types currently under development by the Fremont-Winema National Forest and the Lakeview Resource Area of the BLM (USFS 2005). The categories were defined as: Sedge/Rush/Grass, Willows, Willow/Aspen Mix, Willow/Hybrid Poplar, and Bare/Rock/Sand. The riparian vegetation was classified according to the vegetation type that occupied more than 50 percent of the riparian zone. There are transition areas between these vegetation types. It is important to recognize that some overlap and grey areas between vegetation categories exist. Irrigated pastures along the main stem of the Sprague and Williamson rivers and their tributaries were not considered riparian for the purpose of this study. Vegetation classifications were assigned separately for the left and right banks of the stream, because the vegetation was frequently different on each side of the stream.

The categories are loosely defined by plant communities using the dominant vegetation type and species. The Sedge/Rush/Grass category would include areas exhibiting primarily herbaceous species, with no overstory of shrubs or trees. The dominant plants within this vegetation type include, but are not limited to, reed canarygrass, Baltic rush, sedges and Kentucky bluegrass. The species composition will vary within the vegetation type. The Willow category would exhibit an overstory of willows, but would lack other dominant shrub or tree species. The species of willow will vary within the vegetation type. The Willow/Aspen Mix category would include both willows and aspens as dominant species within the overstory. The Willow/Hybrid Poplar category would exhibit both hybrid poplars and various willow species. The Bare/Rock/Sand category would exhibit areas largely devoid of vegetation.

Information was not provided on the ecological condition of the riparian area in this analysis. On-site ground truthing and investigation would be necessary to determine the function and condition of the riparian areas.

The classification of vegetation from remote sensing was subjective, because distinguishing between vegetation types by photo interpretation is somewhat based on opinion. When possible, interpreted data were verified in the field to answer questions regarding image interpretation, land use and wetland-riparian vegetation changes. Field verification access was limited due to the amount of private property in the area. Access was achievable at public road bridge crossings, along Highway 858 and Highway 140E, and within some private ownerships.

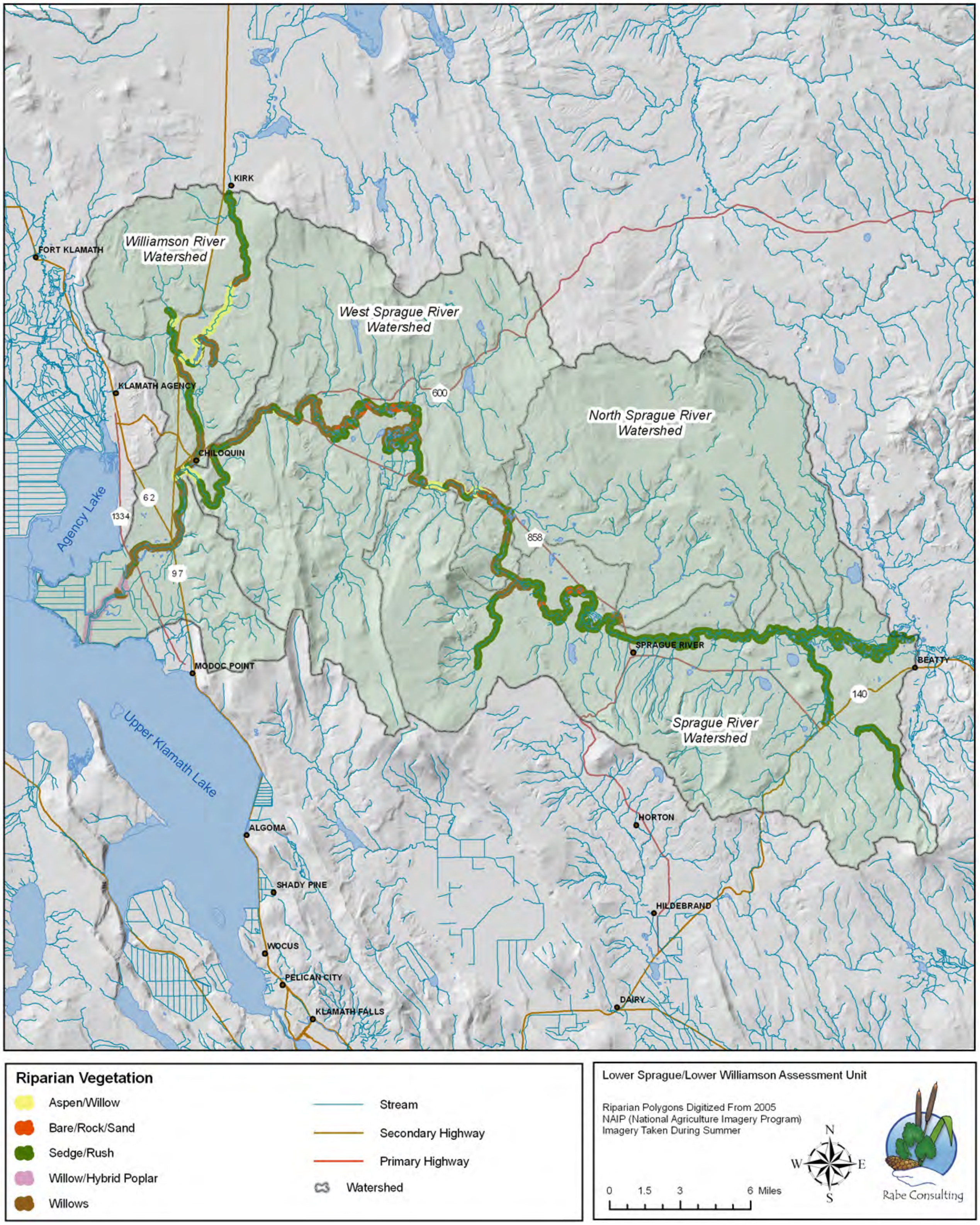
To ensure the reliability riparian vegetation assessment, Rabe Consulting adhered to established quality assurance and quality control measures for analysis, verification and reporting. All polygons within the study area were reviewed, and technicians adhered to all standards, quality requirements and technical specifications.

Results

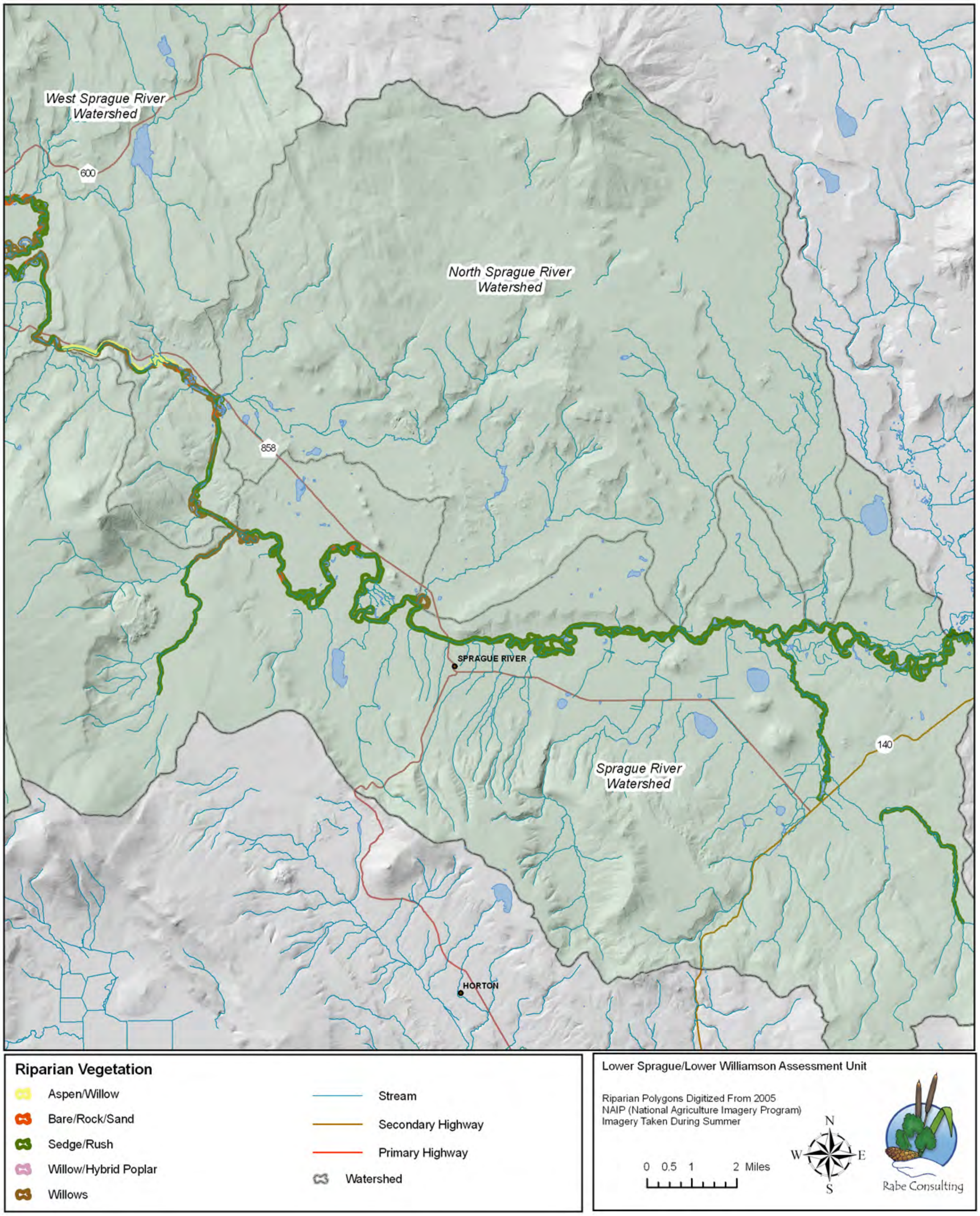
Table 7-1 summarizes the results of the mapping effort. The Lower Sprague-Lower Williamson subbasin was divided into its four distinct watersheds to present the results of the aerial imagery interpretation. The lowest riparian acreage recorded was for the North Sprague River watershed, due mainly to the fact that the main stem of the Sprague River is a part of this watershed only at two very small lengths. The largest vegetation type observed was Sedge/Rush/Grass, with the most acreage in the Sprague River watershed.

Figures 7-1 and 7-2 are visual representations of the results of the mapping effort. The smallest vegetation type found was Bare/Rock/Sand, with the Willow/Hybrid Poplar vegetation being only slightly larger. Willow/Hybrid Poplar is only found in the Williamson River Delta, which explains the low acreage for this vegetation type.

Maps 7-1 through 7-6 depict the distribution of riparian vegetation in the subbasin. Several different map scales are included in order to show detail in some cases and large areas in others. Also included are close-up examples of the imagery with transparent polygons layered over the image.



Map 7-1 Riparian vegetation in the Lower Sprague/Lower Williamson River subbasin, based on aerial photograph interpretation



Map 7-2 Riparian vegetation in the Williamson River watershed, based on aerial photograph interpretation

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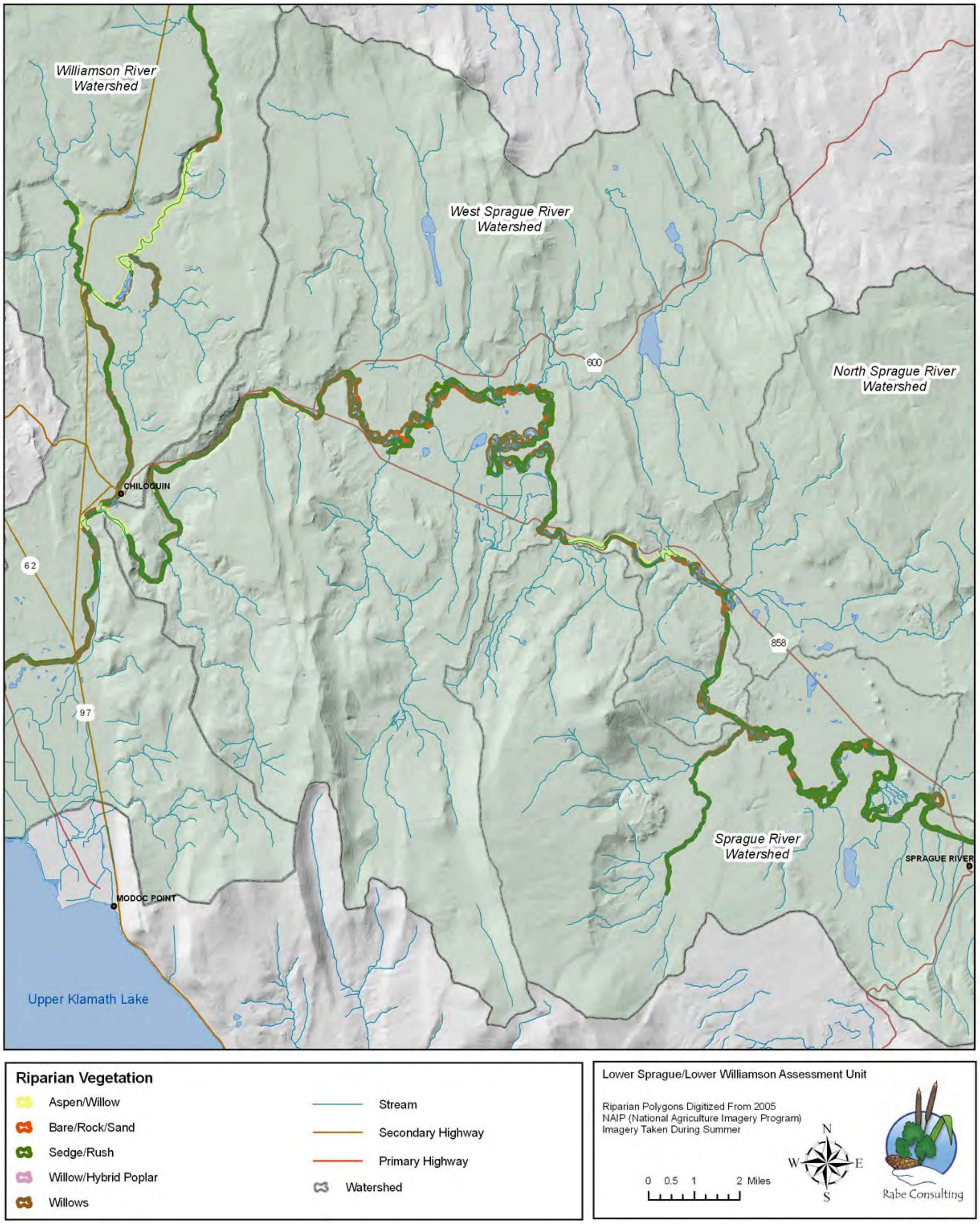
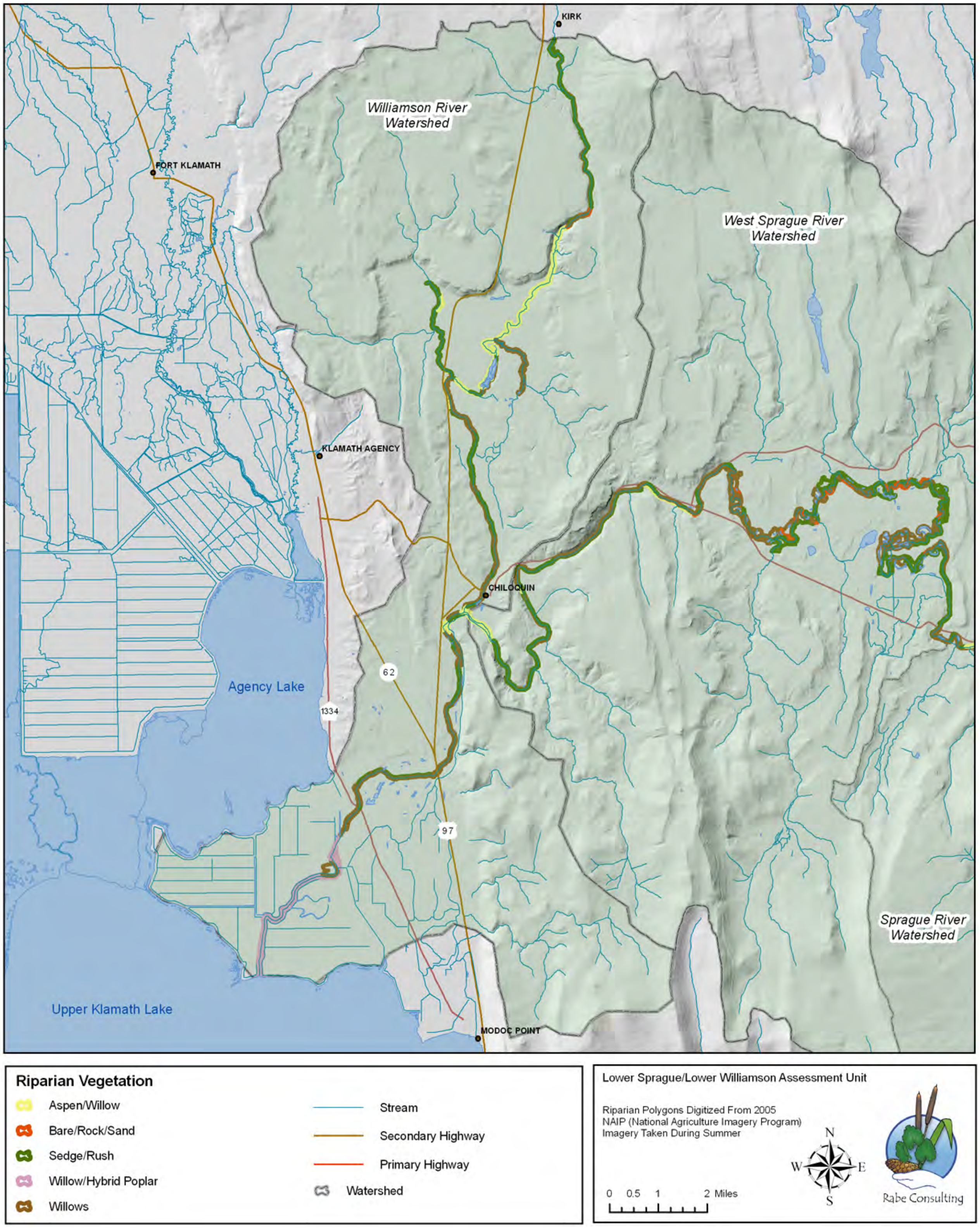
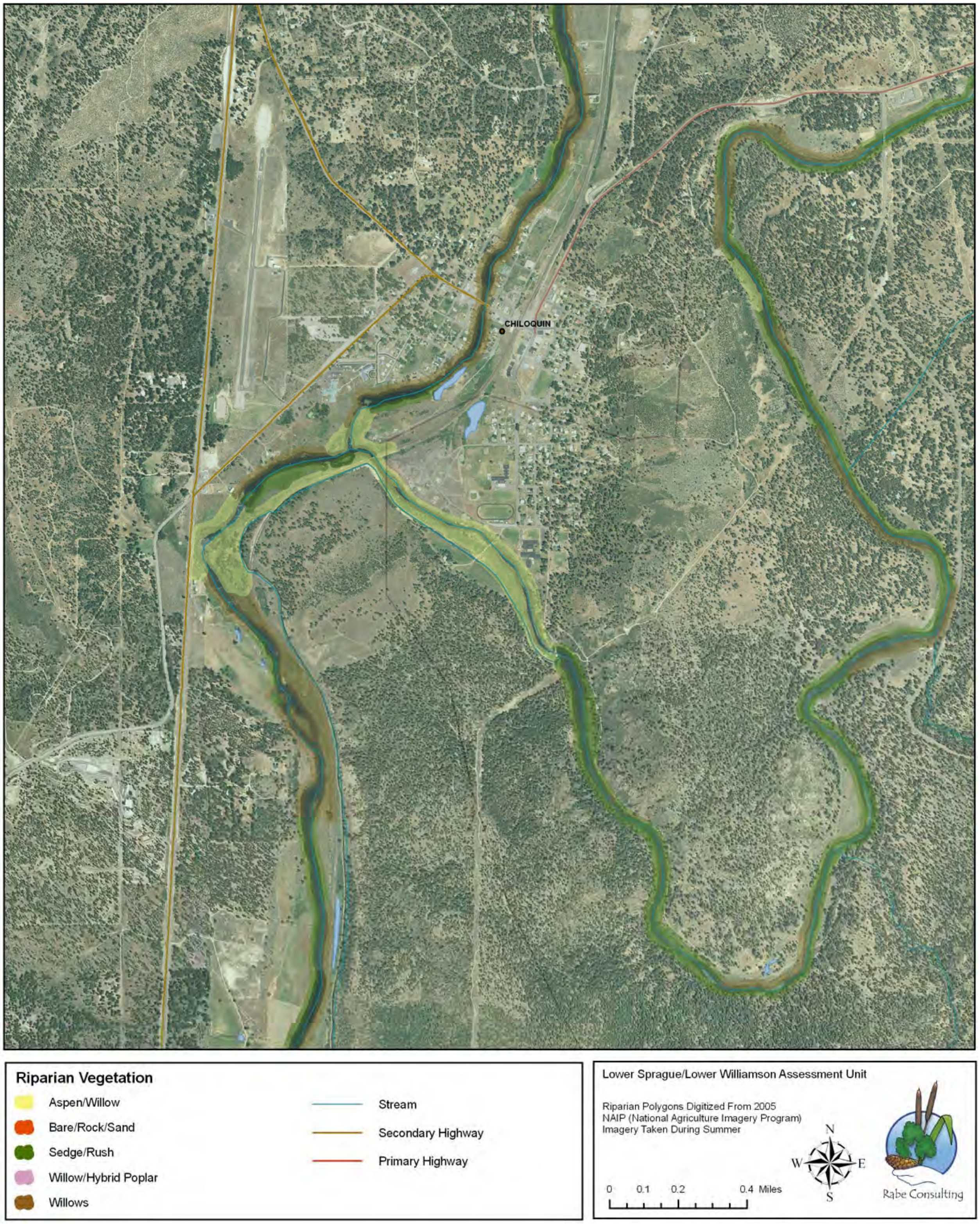


Map 7-3 Riparian vegetation in the west Sprague River watershed, based on aerial photograph interpretation



Map 7-4 Riparian vegetation in the North Sprague River watershed, based on aerial photograph interpretation



Map 7-5 Closeup of aerial photograph interpretation

Map 7-6 Closeup of aerial photograph interpretation

Table 7-1 Distribution of land (in acres in the riparian zone in the Lower Sprague-Lower Williamson subbasin watersheds among various vegetation types

Vegetation Type	Williamson River	Sprague River	West Sprague River	North Sprague River	Subbasin Total Acreage
Sedge/Rush/Grass	57.4	963.3	356.5	13.3	1378.5
Willows	204.0	46.8	686.9	33.7	971.4
Aspen/Willow	122.1	0	102.4	0	224.5
Willow/Hybrid Poplar	41.1	0	0	0	41.1
Bare/Rock/Sand	3.2	1.7	18.6	0	23.5
Total Acres	**456.6**	**1011.8**	**1167.4**	**47**	**2682.8**

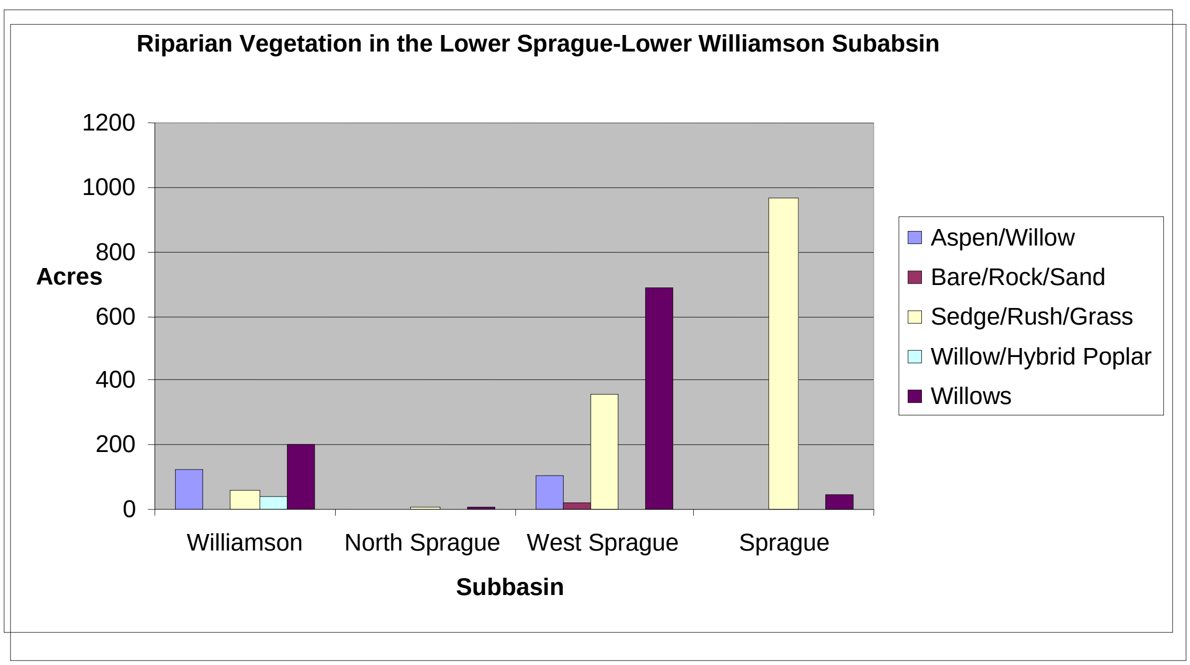


Figure 7-1 Distribution of land in the riparian zone in the Lower Sprague-Lower Williamson subbasin watersheds among various vegetation types. Acreage is represented for each individual watershed

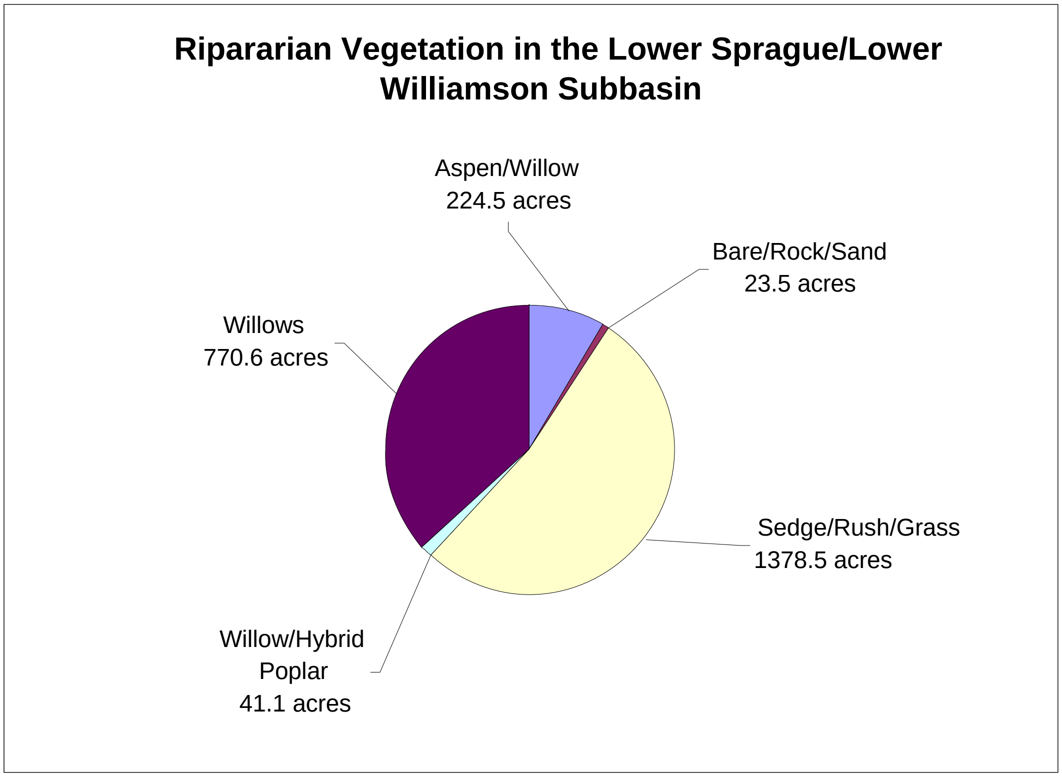


Figure 7-2. Distribution of land in the riparian zone in the Lower Sprague-Lower Williamson subbasin watersheds among various vegetation types

Within the Lower Sprague-Lower Williamson subbasin there are an estimated 2,683 acres of riparian area, based on the aerial photograph analysis. Of these total acres of riparian area, over half (1,379 acres) exhibit a Sedge/Rush/Grass riparian vegetation community. A small portion of the riparian areas are exclusively bare with rock or sand. There are potentially more areas with exposed bare rocks and soils, but at the scale of the analysis these were not the predominant riparian type or possibly were not discernible in this scale. The Willow/Hybrid Poplar vegetation type was only exhibited within The Nature Conservancy's Williamson River Delta Preserve, located just upstream of the mouth of the Williamson River. The hybrid poplars were most likely planted during the time of dike establishment and use of the Williamson River Delta for agricultural production.

Willows were scattered throughout the subbasin. These were located in patches or along reaches of the Lower Sprague and Lower Williamson rivers. The willows tended to inhabit the canyon reaches and ends of the valleys, as opposed to the central portions of the valley reaches. The Aspen/Willow vegetation type was more limited to the canyon reaches within the subbasin, although willows are present in remnant populations in groups on the old terrace.

LIDAR-BASED VEGETATION HEIGHT ANALYSIS

LiDAR data has been used in order to identify mature riparian vegetation and to provide a screening-level analysis of some of the likely locations for ecologically important willow, alder and cottonwood stands along the main stem of the Lower Sprague River.

LiDAR is a remote sensing technique that measures the vertical height of the land and vegetation canopy surfaces using a laser mounted to an aircraft. LiDAR data provide information from which vegetation canopy height can be determined. In 2004, the Klamath Tribes commissioned the collection of LIDAR data for the length of the main stem of the Sprague River and lower reaches of the Sycan, North Fork and South Fork Sprague rivers (Figure 7-3).

Methods

An analysis can be conducted using LiDAR data that uses a GIS dataset and two LiDAR data sets—one representing the ground surface and another representing the upper surface of the plant canopy. Digital images are created that depict the surface elevation of the ground and of the vegetation canopy. By calculating the difference between the two datasets, a vegetation height data layer can be created. By classifying the data into height categories, it is possible to differentiate between sedge/rush/grass (less than 1 foot), willows/shrubs (1 to 7 feet), young willow/aspen (7 to 13 feet), mature willow/aspen (13 to 26 feet) and coniferous forest (more than 26) communities. It would be important to note in any type of analysis that low vegetation height does not necessarily indicate degraded or nonfunctioning riparian areas, because in many cases highly stable but low-growing sedge/rush communities represent optimum potential for the site. Also, based on the LiDAR data it is not possible to distinguish between conifer tree species and hardwood tree species. Analysis of LiDAR data is not included in this document.

Discussion

The purpose using the LiDAR data was to provide an initial screening to identify riparian stands of shrubs such as willows, riparian forest stands such as aspens, and stands of conifers. The only region for which LiDAR data is available in the subbasin is along the main stem Sprague River and lower tributaries (Figure 7-3). Nonetheless, the vegetation height classification quickly divides vegetation in the riparian zone into several distinct zones, and through careful observation of the moist valley floor it is possible to identify stands that have a high probability of containing large deciduous trees and other zones of extensive willows. A rapid field verification effort could quickly provide a significant amount of additional information regarding the species composition of riparian vegetation within the relatively few portions of the analysis area in which it is well-developed.

It is very important to note that vegetation height, while it indicates the presence/absence of larger deciduous trees and shrubs, does not necessarily give an accurate indication of the stability and function of riparian areas. In many such areas, optimum site potential is characterized by sedge/rush/grass communities, which have low height but, in some cases, resiliency approaching that of anchored rock.

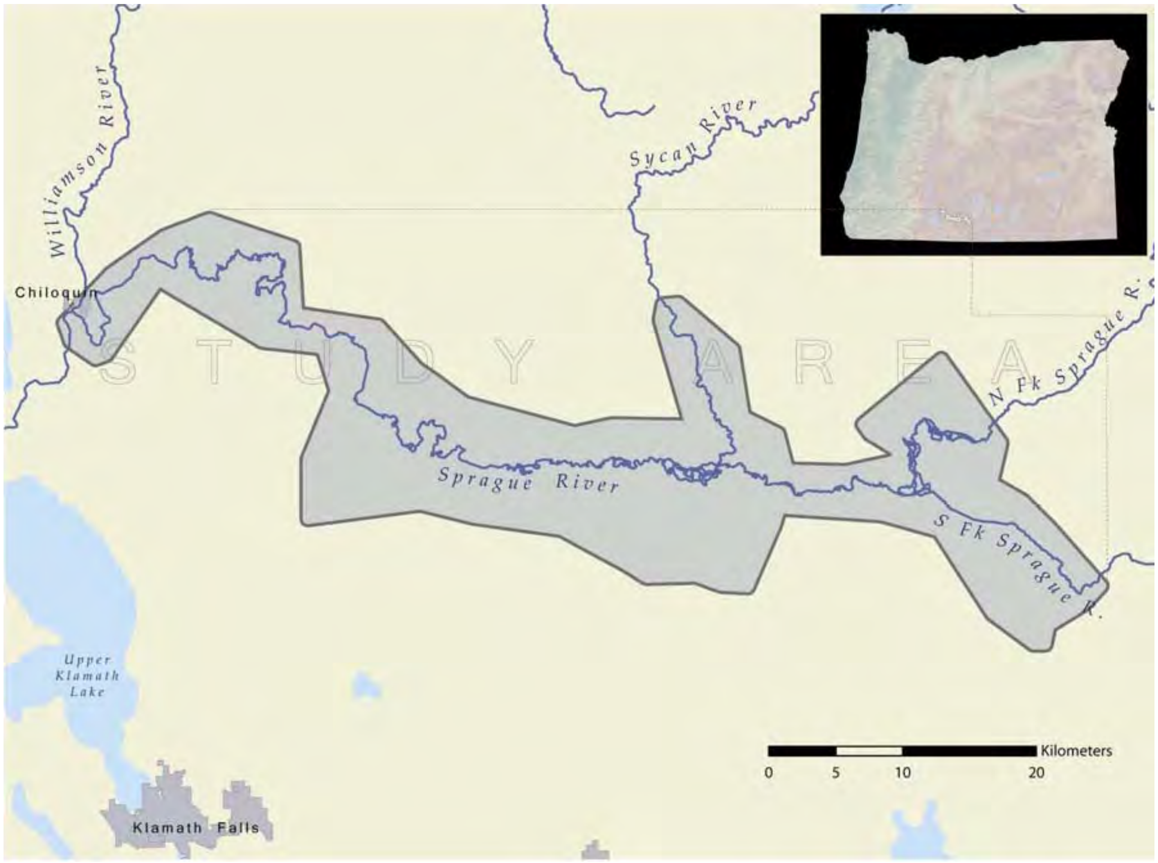


Figure 7-3 Extent of LiDAR data collection in the Sprague River Basin (Data Source: Watershed Sciences 2005)

The utilization of LiDAR for stream and floodplain analysis is demonstrated in the following illustrations. The first example shows the existing conditions at a typical one-year flow event. The second example models the area of inundation at a two-year flow event if the levees along this reach were to be removed. This use of LiDAR allows specialists to determine the most efficient and effective course of action to assist in restoration of river function.

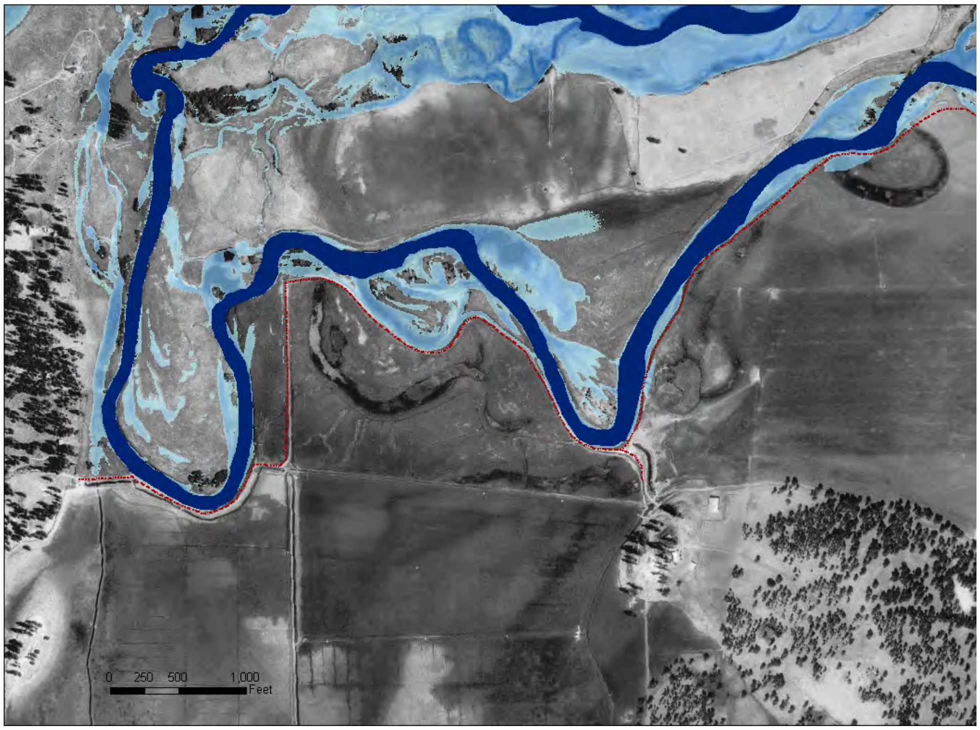


Figure 7-4 Existing conditions of one-year flood event (Provided by USFW 2008.)

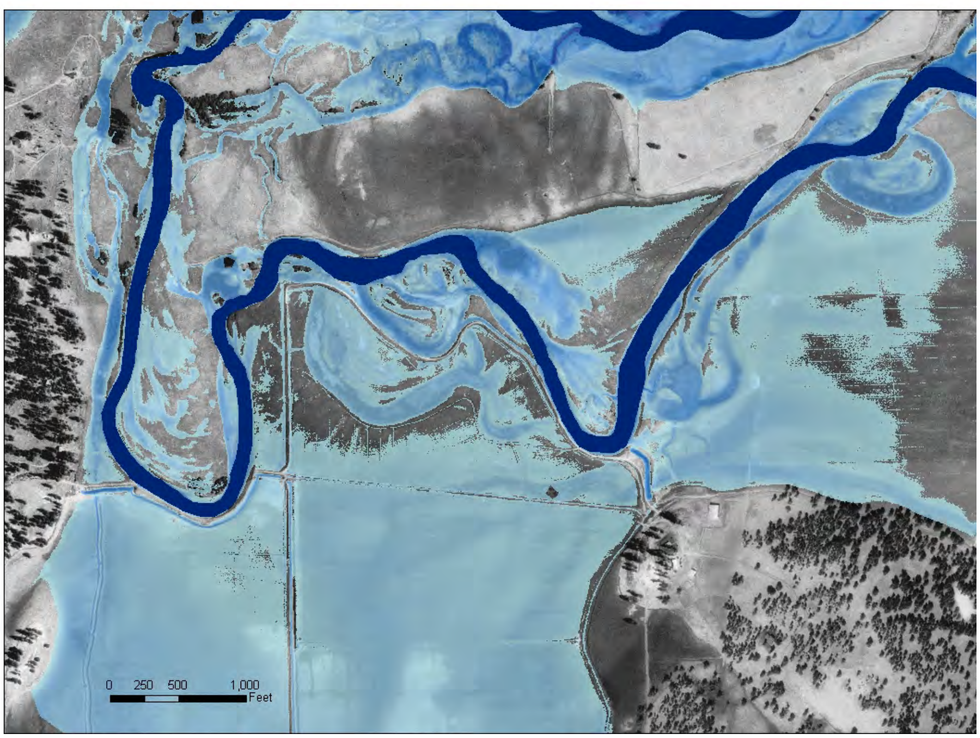


Figure 7-5 Model of two-year flood event if levees were removed (Provided by USFW 2008.)

SUMMARY: CHANGES IN RIPARIAN FUNCTION

It is very difficult to accurately assess the changes to the riparian area within the assessment area. The best estimates of historical or reference conditions are marginal. The estimates are taken from limited historical photographs, historical manuscripts, personal memories and site evidence. This assessment attempts to summarize these changes and causes, but it is a best guess and not an exact representation of past conditions.

A major change to the riparian area was the diking and dredging of the main stem of the Sprague River during the mid-1900s by the Corps of Engineers. The diking created upland dikes where the riparian vegetation should have existed and once did exist. Due to the higher elevation of the dikes compared to the original bank level, the dikes do not have the appropriate wetland hydrology to support riparian or wetland vegetation. The higher dikes also keep the Sprague River from flooding over its natural floodplain in average flood events, and they concentrate the energy of the flow within the channel.

Current riparian conditions in the Lower Sprague-Lower Williamson subbasin are different than they were historically, but it is not possible to quantify the changes that have occurred. Riparian habitat has changed in comparison to the past. Historical timber harvesting, channelization, diking, agricultural practices and urbanized-type development may have removed some of the riparian forest up to the stream channel.

Willow and hardwood vegetation may have been more prevalent in the past, especially in the lower elevation portions of the subbasin now dominated by wetland-sedge-wet pasture and meadow-grass-pasture vegetation types. There is still a debate within the scientific community as to how much willow cover existed within the assessment area in the past.

Although conditions are different today than they were historically, restoration to a specific point in time may not be feasible given the changes in hydrology, beneficial uses and human influence.

Some of the existing concerns with water quality and in-stream habitat quality within the Lower Sprague-Lower Williamson subbasin may be associated with the condition of the riparian vegetation. Such deficiencies in riparian habitat quality may occur throughout the subbasin, but they are most pronounced along lower-elevation, main stem stream reaches. Efforts to restore riparian condition should consider the plant species that are characteristic of this habitat.

A listing of native forbs, grasses, sedges, rushes and shrubs that are characteristic of, and expected to occur in, riparian areas in central Oregon is provided in Table 7-2. It is expected that most, but perhaps not all, of these plant species might occur in riparian areas of the Lower Sprague-Lower Williamson subbasin. It is important to assess site potential before replanting riparian vegetation. It is also important to address noxious weeds and invasive plants, such as reed canarygrass, through management changes and restoration efforts.

The process of recovering riparian function will be gradual. It will require working with all private and public stakeholders throughout the subbasin. Efforts to maintain and improve riparian areas will require finding management and restoration techniques that best suit each situation. If the solution does not fit the landowner's operation and objectives, is not easily maintained and is not profitable, it will be difficult to maintain at the basin scale over time. Management and restoration techniques include the management of livestock grazing, fencing, and restoration of native streamside plant communities. These practices and others will, over time, restore riparian function, resulting in improved water storage capacity, bank stability, stream shading, channel morphology including narrowing, and recruitment of large woody debris where potential exists. Such improvements are expected to occur over time frames of a few years to many decades.

During the summer of 2007, field assessments revealed that later seral plant communities still exist in places on the Sprague and Sycan rivers. It was also found that all of the communities have been described (Stringham and Elmore 2008). Common places for these later seral plant communities included oxbows, overflow channels and some long-term protected areas.

Table 7-2 Major indicator shrubs and herbs in riparian zones on national forests in central Oregon
(Data Source: Kovalchik et al. 1988)

Forbs		Grasses	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Arrowleaf groundsel	*Senecio triangularis*	Bluejoint reedgrass	*Calamagrostis canadensis*
Bog saxifrage	*Saxifraga oregano*	Cusick bluegrass	*Poa cusickii*
California false hellebore	*Veratrum californicum*	Kentucky bluegrass	*Poa pratensis*
Claspleaf twistedstalk	*Streptopus amplexifolius*	Tufted hairgrass	*Deschampsia cespitosa*
Common horsetail	*Equisetum arvense*		
Elephanthead	*Pedicularis groenlandica*		
Gray licoriceroot	*Ligusticum grayii*		
Monkshood	*Aconitum columbianum*		
Queencup beadlily	*Clintonia uniflora*		
Rosy twistedstalk	*Streptopus roseus*		
Sweetscented bedstraw	*Galium triflorum*		
White trillium	*Trillium ovatum*		
Creeping speedwell	*Veronica americanum*		
Shrubs		**Sedges and Rushes**	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Bearberry	*Arctostaphylos uva-ursi*	Aquatic sedge	*Carex aquatilis*
Bebb willow	*Salix bebbiana*	Aquatic sedge	*C. aquatilis* var. *diva*
Bog birch	*Betula glandulosa*	Beaked sedge	*C. utriculata*
Bog blueberry	*Vaccinium occidentale*	Bigleaf sedge	*C. amplifolia*
Booth willow	*Salix boothii*	Black alpine sedge	*C. nigricans*
Common snowberry	*Symphoricarpos albus*	Brewer sedge	*C. breweri*
Coyote willow	*Salix exigua ssp. exigua*	Bur-reed	*Sparganium subvaginatum*
Douglas-hawthorn	*Crataegus douglasii*	Green-fruited sedge	*C. interrupta*
Douglas spiraea	*Spiraea douglasii*	Holm's sedge	*C. scopulorum*
Drummond willow	*Salix drummondiana*	Inflated sedge	*C. vesicaria*
Eastwood willow	*Salix eastwoodiae*	Nebraska sedge	*C. nebraskensis*
Geyer willow	*Salix geyeriana var. geyeriana*	Short-beaked sedge	*C. simulata*
Geyer willow	*Salix geyeriana var. meleiana*	Sitka sedge	*C. sitchensis*
Lemmon willow	*Salix lemmonii*	Slender sedge	*C. lasiocarpa*
Mountain alder	*Alnus incana*	Slough sedge	*C. atherodes*
Pacific willow	*Salix lasiandra var. lasiandra*	Small-winged sedge	*C. microptera*
Prickly currant	*Ribes lacustre*	Widefruit sedge	*C. eurycarpa*
Pyramid spiraea	*Spiraea pyramidata*	Woolly sedge	*C. lanuginosa*
Red mountainheath	*Phyllodoce empetriformis*	Creeping spikerush	*Eleocharis palustris*
Silver sagebrush	*Artemisia cana*	Few-flowered spikerush	*E. pauciflora*
Sitka willow	*Salix sitchensis*	Baltic rush	*Juncus balticus var. balticus*
Undergreen willow	*Salix commutate*	Drummond rush	*J. drummondii*
Vine maple	*Acer circinatum*	Nevada rush	*J. nevadensis var. columbianus*
Whiplash willow	*Salix lasiandra var. caudata*	Nevada rush	*J. nevadensis var. nevadensis*
Yellow willow	*Salix lutea complex*	Small-fruit bulrush	*Scirpus microcarpus*
		Hard-stem bulrush	*S. acutus*
		Cattails	*Typha latifolia*

DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies. We believe the information used in this Assessment to be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data is determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies.

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CHAPTER 8. WETLANDS

INTRODUCTION

Wetlands constitute important features of watersheds. This is true within the Lower Sprague-Lower Williamson subbasin, and especially the valley floors of the Sprague River watershed and North Sprague River watershed, and the portion of the Williamson River watershed near Agency and Upper Klamath lakes. Wetlands serve many functions related to water quantity and quality and provide habitat for numerous plant and animal species. Historically, wetlands were present in much of the subbasin, controlling water flow rates, filtering pollutants, trapping sediments and sustaining food webs. Wetlands act to reduce flood severity by storing water and thereby buffering banks from scouring flows. Wetlands also release stored waters during base flow conditions and thereby maintain cool water temperatures with adequate dissolved oxygen. Many of the concerns with watershed condition are at least partly due to changes that have occurred to or to loss of these critical wetland ecosystems. Wetlands are dynamic ecosystems, and observed changes to wetland structure or watershed function are often difficult to diagnose.

WETLAND TYPES

Wetlands contribute to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Because of the importance of these functions, wetlands are regulated by both state and federal agencies.

For this assessment wetlands were organized using the much more detailed Cowardin classification system (Cowardin et al. 1979). In the Cowardin classification, wetlands are identified by “system,” “subsystem,” and “class” (Figure 8-1). The Cowardin classification system was chosen because it provides a more detailed description of the wetland types (more division of wetlands) than some other classification systems, including the 1999 Oregon Gap Project. The Cowardin system is also consistent with the definition and jurisdiction of wetland types of the regulatory agencies, Oregon Department of State Lands, and U.S. Army Corps of Engineers.

Wetlands present in the Lower Sprague-Lower Williamson subbasin were identified and located using the National Wetlands Inventory (NWI) dataset produced by the U.S. Fish and Wildlife Service (USFWS). The NWI database was created by interpretation of aerial photos. NWI data were available for the entire Lower Sprague-Lower Williamson subbasin, based on aerial photo imagery collected by USFWS in 1981. No newer datasets were available in 2007 for this area. It is acknowledged that wetland acreages and locations have changed since 1981, but these general data are the best available at this time. All sites should be investigated on a site-specific basis to verify the presence or absence of the NWI wetlands.

Delineating wetlands through photo interpretation alone can result in data inaccuracies. The NWI program does not attempt to characterize every individual wetland in any given watershed. The information presented with this dataset is limited in resolution by the map/photo scale and wetland delineation practices. The NWI uses a target map unit as an estimate of the smallest wetland area that it attempts to map for a given land cover type and photo scale. Forested wetlands, for example, are more difficult to discern from an aerial photograph than wetlands that exist on a treeless prairie. Furthermore, data generated from color infrared photography are typically more accurate than data generated from black and white images (USFWS 1981).

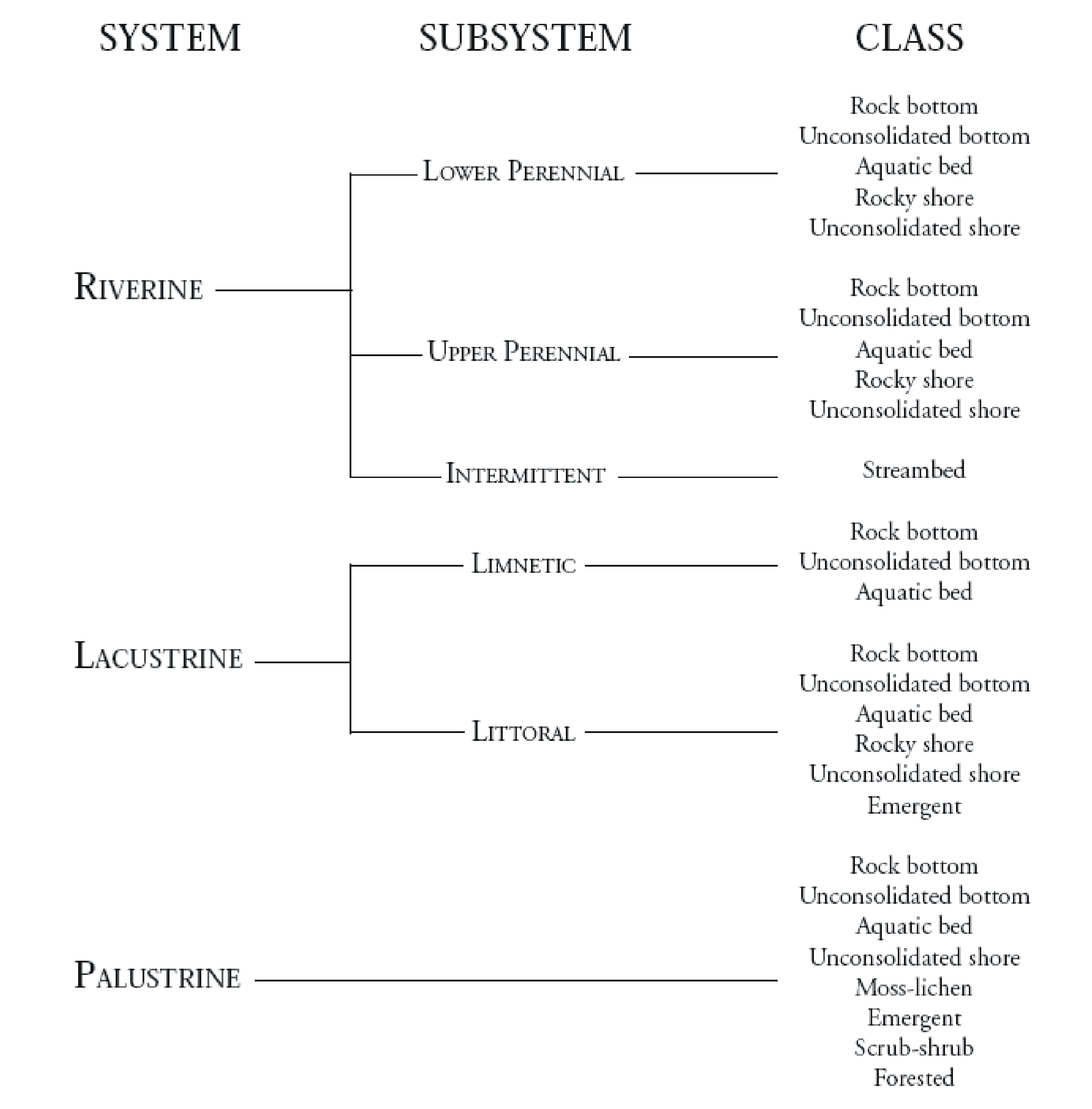


Figure 8-1 The Cowardin wetland classification system of wetlands present in the Lower Sprague River subbasin
(Data Source: Cowardin et al. 1979)

It is likely that not all wetlands within the subbasin were mapped during the NWI process, and some mapped parcels may not meet the requirements of state or federal jurisdictional wetlands. The data in this assessment do not represent exact wetland boundaries such as would be obtained through a formal, on-site wetland survey and delineation. There are transition areas between the wetland types, making boundaries less distinct. These data are best used as a screening tool to determine large-scale characteristics of general wetland types, rather than to evaluate individual wetland parcels.

Palustrine

The majority of the wetlands found in the Lower Sprague-Lower Williamson subbasin, and throughout the state of Oregon, are palustrine. Palustrine wetlands are defined as nontidal wetlands dominated by trees, shrubs and persistent emergent vegetation (Mitsch and Gosselink 1993; Cowardin et al. 1979). Palustrine wetlands include the vegetated wetlands that are traditionally called marsh, swamp, bog, fen and prairie wetlands. Small intermittent or permanent ponds are also considered palustrine (Cowardin et al. 1979). In many instances, palustrine wetlands are found in floodplains, adjacent to lakes, or isolated in the subbasin.

The composition and structure of the palustrine emergent plant community largely depends upon the water depth and duration of inundation, but all palustrine emergent wetlands are dominated by herbaceous species. Woody plant species only occur as individual plants or in small clusters. In areas subjected to relatively prolonged flooding, cattail (*Typha latifolia*), several bulrush species (*Scirpus* spp.), tule (*Schoenoplectus acutus*), and burr-reed (*Sparganium emersum* and *S. eurycarpum*) are typical. In slightly drier areas, sedge (*Carex* spp.) and rush (*Juncus* spp.), particularly Baltic rush (*Juncus balticus*), dominate the plant community. Common grasses (both native and non-native) in emergent wetlands are blue wildrye (*Elymus glaucus*), tufted hair grass (*Deschampsia caespitosa*), bluejoint reedgrass (*Calamagrostis canadensis*), reed canarygrass (*Phalaris arundinacea*) and northern mannagrass (*Glycera borealis*).

Lacustrine

Lacustrine wetlands include lakes and ponds and their margins. They generally contain less than 30 percent vegetative cover, which might include trees, shrubs, persistent emergent vascular plant species, emergent mosses and lichens. They can be either limnetic (greater than 2 meters in depth) or littoral (from shore to 2 meters in depth). Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 parts per thousand (Cowardin et al. 1979). In the Lower Sprague-Lower Williamson subbasin, the lacustrine wetlands are freshwater wetlands.

Riverine

Riverine wetlands include all of the wetlands that exist within the stream channel, except for those that are dominated by vegetation. Riverine wetlands are characterized by flowing water, and they are often found directly adjacent to palustrine wetlands that are located in the river's floodplain (Cowardin et al. 1979). Subsystems of riverine wetlands found within the Lower Sprague-Lower Williamson subbasin include:

- Lower perennial - flow through the system is continuous with a low gradient;
- Upper perennial - flow through the system is continuous with a high gradient; and
- Intermittent - water only flows through the system during part of the year

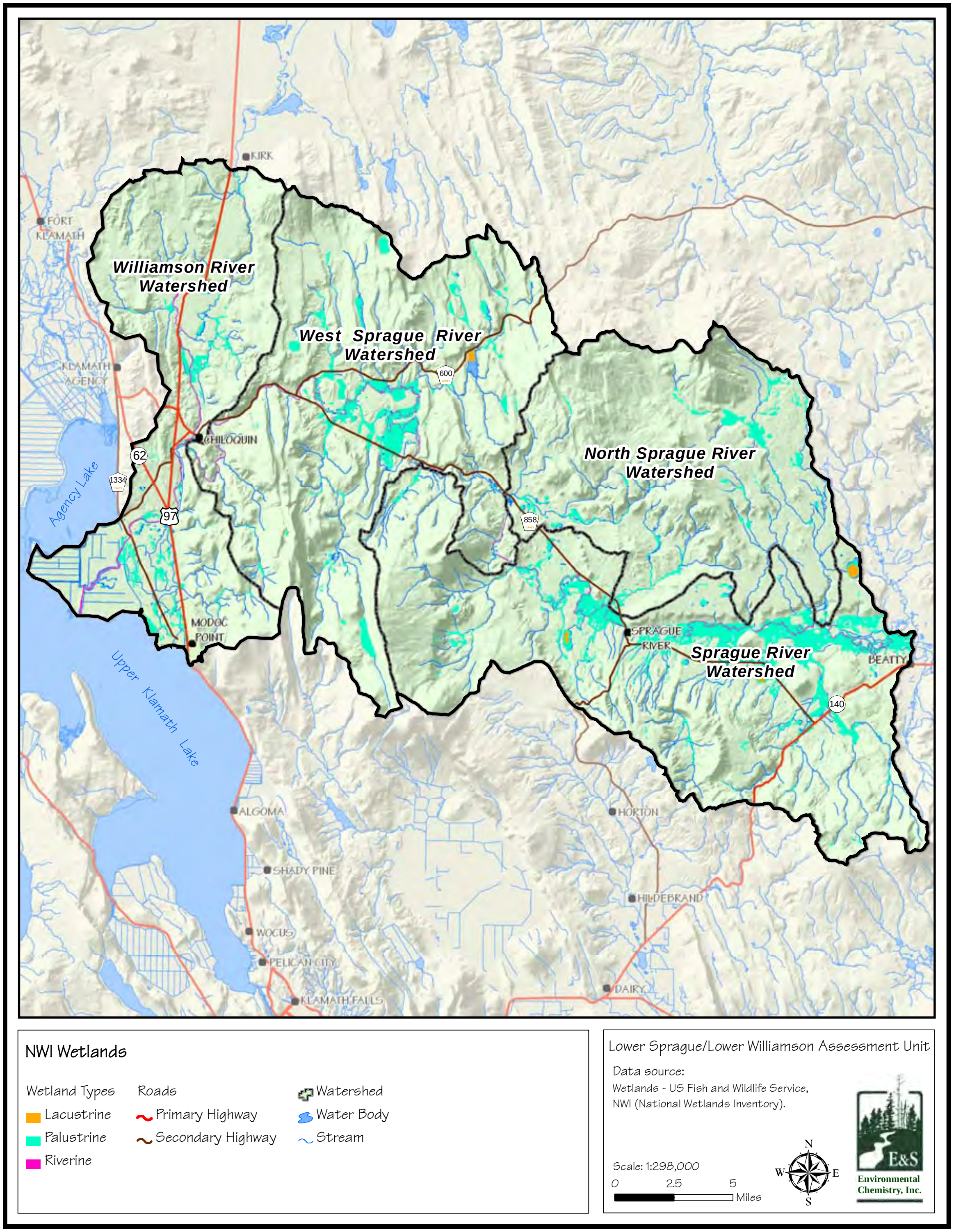
(Cowardin et al. 1979, Mitsch and Gosselink 1993).

Irrigated Wetlands

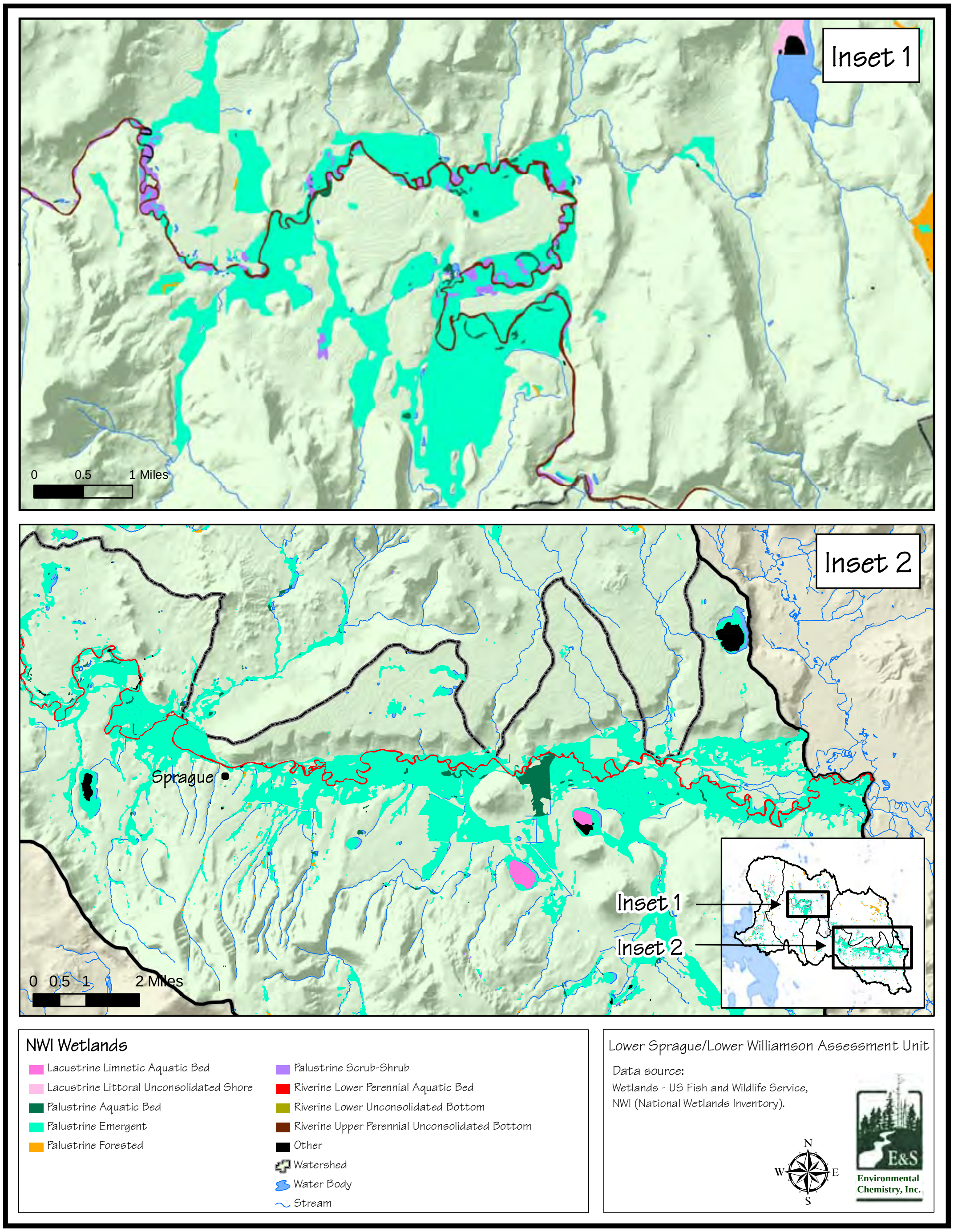
Irrigated wetlands have not been classified in a systematic manner. The most commonly applied classification systems are based on wetland location, vegetation form, water depth and seasonal duration, and water source. Location (on-farm versus off-farm, in-field versus off-field), vegetation form and water regime of irrigated wetlands are relatively easy to estimate during site visits.

However, even after visiting a site, it is difficult to determine conclusively the primary source of water that sustains a wetland. "Irrigated wetlands" can range from wetlands that are completely supported by irrigation runoff at all seasons, to wetlands that exist naturally but for which any measurable amount of their water originates from irrigation, however indirectly (e.g., through seepage or raised water tables) (Adamus 1993).

In this sense, virtually all wetlands in irrigated regions could be considered "irrigated wetlands." However, determining whether the *primary* water source of a wetland is irrigation-related in many cases requires considerable judgment, and no highly replicable approach exists that is applicable to all situations (Adamus 1993).



Map 8-1 Wetland distribution within the Lower Sprague-Lower Williamson subbasin based on NWI data
(Data Source: USFWS 1981)



Map 8-2 **Detailed depiction of wetland distribution in the portions of the Lower Sprague-Lower Williamson subbasin that exhibit the greatest wetland abundance. Not all wetland categories from the original map are present in the areas shown in the insets**
(Data Source: USFWS 1981)

LOWER SPRAGUE-LOWER WILLIAMSON SUBBASIN WETLAND STATISTICS

Wetlands cover 28,140 acres (7.3 percent) of the Lower Sprague-Lower Williamson subbasin, based on NWI data from 1981 (USFWS 1981). Most of the wetland area in the subbasin (21,932 acres) is classified as palustrine emergent wetland. This wetland type is distributed across the entire assessment area. The breakdown of wetland types found within the subbasin is shown in Table 8-1 (see Map 8-1 and Map 8-2). Wetland area within each watershed is given in Table 8-2. It should be noted that open water is not considered a wetland and is excluded from the wetland acreages. The largest amount of wetland area is located in the Sprague River watershed, which contains 12,926 acres of wetland. The North Sprague River watershed, with 2,537 acres of wetlands, contains the least wetland area. Table 8-3 shows a breakdown of the primary wetland types, along with their acreages and percentages, that were identified in the Lower Sprague-Lower Williamson subbasin from the NWI data.

Table 8-1 Wetland type, acreage and percent distribution identified in the Lower Sprague-Lower Williamson subbasin
(Data Source: USFWS 1981)

Wetland Type	Wetland Area (acres)	Percent of Total Wetland Area
Palustrine Emergent	21,932	77.9
Palustrine Forested	2,363	8.4
Riverine Upper Perennial Unconsolidated Bottom	1,127	4.0
Palustrine Scrub-Shrub	817	2.9
Palustrine Aquatic Bed	610	2.2
Riverine Lower Perennial Aquatic Bed	594	2.1
Lacustrine Limnetic Aquatic Bed	226	0.8
Lacustrine Limnetic Unconsolidated Bottom	142	0.5
Riverine Lower Unconsolidated Bottom	138	0.5
Other[1]	191	0.7
Total	**28,140**	**100.0**

[1] "Other" wetlands include: Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Unconsolidated Shore, Palustrine Unconsolidated Shore, Palustrine Unconsolidated Bottom, Riverine Lower Unconsolidated Shore, Riverine Upper Perennial Aquatic Bed, Riverine Upper Perennial Unconsolidated Shore.

Data methods/limitations: NWI wetland data were extracted from the GIS and queried for the acreage and percent distribution of each wetland type found in the Lower Sprague-Lower Williamson subbasin. NWI data do not include distinctions between natural wetlands and irrigated fields.

Table 8-2 Total wetland area in each watershed within the assessment area (Data Source: USFWS 1981)

Data methods/limitations: NWI wetland data were extracted from the GIS by each watershed in the Lower Sprague-Lower Williamson subbasin. The percent of each watershed existing as a wetland (and the subbasin as a whole) was generated from these data and is displayed in the table.

Watershed Name	Wetland Area (acres)	Watershed Area (acres)	Percent of Watershed Area Existing as Wetland
North Sprague River	2,537	78,720	3.2
Sprague River	12,926	117,696	11.0
West Sprague River	9,520	112,640	8.5
Williamson River	3,157	74,688	4.2
Total	**28,140**	**383,744**	**7.3**

Table 8-3 Acreage of wetland types found within each watershed (Data Source: USFWS 1981)

Data methods/limitations: NWI wetland data were extracted from the GIS by each watershed in the Lower Sprague-Lower Williamson subbasin. Statistics (area and percent) were generated from these data and are displayed in the table.

Wetland Type	North Sprague River		Sprague River		West Sprague River		Williamson River	
	Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%
Lacustrine Limnetic Aquatic Bed	0	0.0	158	1.2	0	0.0	68	2.2
Lacustrine Limnetic Unconsolidated Bottom	0	0.0	119	0.9	22	0.2	0	0.0
Palustrine Aquatic Bed	28	1.1	390	3.0	139	1.5	54	1.7
Palustrine Emergent	1,162	45.8	11,382	88.0	7,172	75.4	2,216	70.2
Palustrine Forested	1,281	50.5	96	0.7	849	8.9	137	4.3
Palustrine Scrub-Shrub	58	2.3	57	0.4	493	5.2	208	6.6
Riverine Lower Perennial Aquatic Bed	2	0.1	593	4.6	0	0.0	0	0.0
Riverine Lower Unconsolidated Bottom	0	0.0	0	0.0	0	0.0	138	4.4
Riverine Upper Perennial Unconsolidated Bottom	4	0.2	11	0.1	780	8.2	332	10.5
Other	3	0.1	121	0.9	63	0.7	4	0.1
Total	**2,538**		**12,927**		**9,518**		**3,157**	

WETLAND SUMMARY BY WATERSHED

North Sprague River Watershed

This watershed includes 2,537 acres of wetlands, constituting 3.2 percent of the watershed area in the subbasin. This watershed contains the least amount of wetland arces. The majority (96.3 percent) of the wetland acres within the North Sprague River watershed is made up of two wetland types—palustrine emergent and palustrine forested. The palustrine forested wetlands are dominated by a plant community that is characterized by dense, tall shrubs including red alders and willows.

Sprague River Watershed

There are 12,926 acres of wetland in the Sprague River watershed. Palustrine emergent is the primary wetland type, accounting for 88.0 percent (11,382 acres) of the wetlands located in this watershed. Most of this wetland area is located in the valley reach between Beatty and just west of the town of Sprague River. Riverine lower perennial aquatic bed wetlands account for 4.6 percent of the wetland acreage in this watershed. This wetland type is located along the main stem of the Sprague River. This wetland type is limited almost completely to this watershed in the Lower Sprague-Lower Williamson subbasin.

West Sprague River Watershed

This watershed has 9,520 acres of wetlands (8.5 percent of the watershed). Most of the wetlands that are present in this watershed are palustrine emergent (75.4 percent; 7,172 acres). The majority of these palustrine emergent wetlands are located adjacent to the Sprague River in the valley flood plains.

Palustrine scrub-shrub wetlands can be found dotted along the length of the Sprague River, accounting for 5.2 percent of the wetland acreage in this watershed. Palustrine forested wetlands are located primarily in the canyon reaches on the eastern and western portions of the watershed.

Williamson River Watershed

Wetlands in this watershed cover 2,932 acres (4.5 percent of the watershed). Most of these wetland acres are located along the Lower Williamson River and its associated delta adjacent to Agency and Upper Klamath lakes. Palustrine emergent wetlands account for 70.2 percent (2,216 acres) of the wetlands in this watershed.

Riverine wetland types account for 15.0 acres of this watershed. These acres are primarily associated with the Willliamson River and its delta. Lacustrine wetlands, associated mostly with Agency and Upper Klamath and lakes, cover 68 acres. This is the largest amount of lacustrine wetland acreage for a watershed within this subbasin.

NATIONAL WETLAND INVENTORY VERIFICATION IN THE LOWER SPRAGUE-LOWER WILLIAMSON SUBBASIN

Maps of wetlands compiled by the NWI do not always agree with the actual appearance of the landscape on the ground, because wetland areas are frequently converted to other uses. Classification of land as wetland is not necessarily dependent on current use, but on the characteristics of the soil, the seasonal hydrology and the plants that would grow there in the absence of local disturbance. Figure 8-2 shows the boundary of NWI wetlands superimposed on an aerial photo of an area just east of the town of Sprague River.

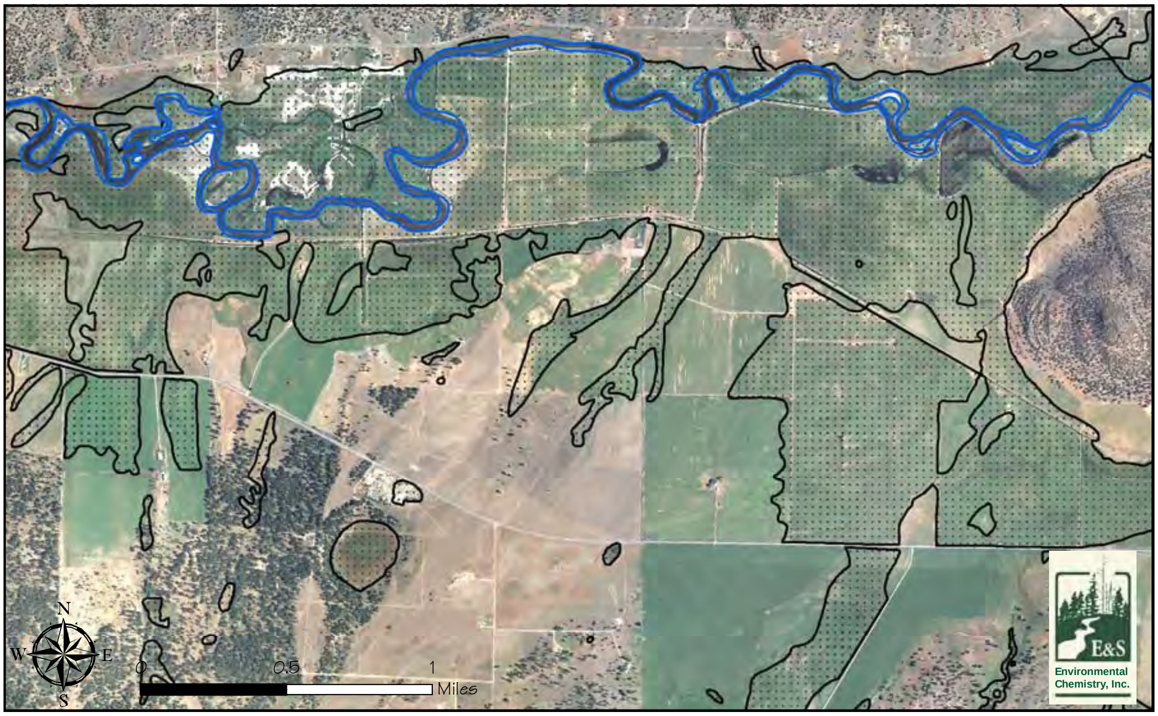


Figure 8-2 NWI designated wetlands (black lines) along the Sprague River immediately above the town of Sprague River upstream to Council Butte, overlaid on an aerial image of a portion of the Lower Sprague-Lower Williamson subbasin (Data Sources: ODSL 2005, USFWS 1981)

Data methods/limitations: National Agriculture Imagery Program (NAIP) imagery for a portion of the Lower Sprague-Lower Williamson subbasin was overlaid with NWI data (black lines). NWI data do not include distinctions between natural wetlands and irrigated fields.

Wetland Determination from NWI and Soil Maps

The information in this chapter addresses wetlands at a large scale through use of the National Wetland Inventory. While the NWI is informative, it does have limitations. The NWI was assessed using aerial photography and color variations to identify wetlands. The NWI was not ground-truthed, and therefore may not accurately represent what is found at specific sites.

The NWI does not distinguish between "natural" and "irrigated" wetlands. A natural wetland is defined as a wetland that would display wetland characteristics under natural hydrologic conditions. An irrigated wetland displays wetland characteristics due to irrigation water, not natural hydrology. In some cases, these wetlands may be the same. That is, some wetlands may be natural, but currently irrigated. The NWI classifies both natural and irrigated wetlands as wetlands. This method of classification potentially inflates the area of natural wetlands, if one considers all NWI wetlands as natural wetlands.

Consulting the NWI data is the first step in determining the existence of wetlands. After the NWI is consulted, a site visit needs to occur. During this site visit, a detailed wetland determination and delineation would be completed by a qualified wetland scientist. A wetland determination would indicate whether a wetland is indeed present. A wetland can be defined in many different ways, but the legal definition provided by the State of Oregon is as follows: "The wetland definition is identical to the federal definition (ORS 196.800[16]).” The federal definition presented by the U.S. Army Corps of Engineers (33 CFR 328.3) and the Environmental Protection Agency (40 CFR 230.3) is: “Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalance of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.”

While these definitions present the legal basis for wetlands, the U.S. Fish and Wildlife Service has developed a user-friendly definition that is more applicable to the landowner within this watershed area. It is a nonregulatory, technical definition that could have several uses, ranging from wetland conservation to scientific investigations. This definition emphasizes three important attributes of wetlands: (1) hydrology—the degree of flooding or soil saturation; (2) vegetation—plants adapted to grow in water or in a soil or substrate that is occasionally oxygen deficient due to saturation (hydrophytes); and (3) soils—those saturated long enough during the growing season to produce oxygen-deficient conditions in the upper part of the soil, which commonly includes the major part of the root zone of plants (hydric soils) (Cowardin et al. 1979; Tiner 1991). To supplement this definition and to help identify wetlands, the U.S. Fish and Wildlife Service prepared a list of wetland plants (Reed 1993; Reed 1988). In addition, the Soil Conservation Service developed a list of hydric soils (NRCS 1991).

Wetland Field Verification and Delineation

If a wetland is present, then the next step is to delineate the boundaries of the wetland. The delineation will describe the wetland, its functional values and its extent. The delineation process would be conducted according to the guidelines in the following documents: Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987) (1987 Manual); the “Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region” (USACOE 2006) (Arid West Supplement); Minimum Standards of Acceptance of Preliminary Wetland Delineations, November 30, 2001 (USACOE, Sacramento District 2001); and Oregon Department of State Lands (ODSL) regulations, permitting requirements, and agency guidance pertaining to ODSL “Administrative Rules for Wetland Delineation Report Requirements and for Jurisdictional Determinations for the Purpose of Regulating Fill and Removal within Waters of the State” (Oregon Administrative Rule [OAR] 141-090-0005 through 0055), including ODSL’s Wetland Delineation Report Guidance, July 2005 (ODSL 2005). Although these documents provide a plethora of details, the delineation of a wetland would be conducted by assessing paired sample plots (one within the wetland and one outside). At each sample plot at the estimated edge of the wetland soils, hydrology and vegetation would be assessed. If these three factors met the criteria for a wetland in one plot but not the other, then the wetland boundary would be established at this location. A trained professional is needed to complete a field investigation and delineate the wetland boundary.

Jurisdictional Wetlands and Permitting

It is important to consider the historical and current land use practices to distinguish between natural and human-influenced wetlands. For example, if known, the landowner or land manager should inform the delineator of whether the wetland was created by irrigation water applied during the past century. When restoring wetlands, it is important to recognize that, if the wetland is historical and natural or a more recent wetland caused by irrigation water applied during the past century. Regulatory agencies for wetlands (U.S. Army Corps of Engineers and ODSL) view natural and irrigated wetlands differently. The natural wetlands are regulated, whereas the agencies do not have jurisdiction over some irrigated wetlands. Regulatory implications are important for restoration activities, because they will determine when permits and mitigation activities are needed.

The U.S. Army Corps of Engineers and ODSL have regulatory purview over most natural wetlands. The job of these agencies is to ensure there is no net loss of wetland acres. If a project or management change is going to affect a wetland area through adding material or removing material, permits may be required from these agencies. Typically, the permit required is a removal-fill permit. The agencies' websites have forms and information for these permits. To obtain a removal-fill permit, one must conduct a wetland delineation, map the extent of the wetland, complete permit forms and provide a mitigation plan. The agencies will provide concurrence for the wetland delineation.

If the wetland area has materials filled or removed from it, then a mitigation plan will be needed. A mitigation plan can propose three actions to offset the impacts of the activity: (1) enhance, (2) create or (3) restore a wetland. These actions may be conducted at the same site as the activity or in similar nearby areas. It is important to note that although the proposed activity may have beneficial long-term impacts on habitats, water quality or other resources, a permit and mitigation plan may still be required. The permit and mitigation plan will have to be approved by both regulatory agencies before the proposed activity begins.

DATA, METHODS AND LIMITATIONS

The National Wetlands Inventory (NWI) dataset used for each of the display items in this chapter was produced by the U.S. Fish and Wildlife Service. These data are intended to provide consultants, planners and resource managers with information on wetland location and type. The NWI does not attempt to provide an exhaustive account of all wetlands in a given area, nor to provide exact locations of individual wetland boundaries.

The USFWS's objective of mapping wetlands and deepwater habitats is to produce reconnaissance-level information on the location, type and size of these resources. The maps are prepared by analyzing high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site will likely result in revision of the wetland boundaries or classification established through image analysis. Wetlands or other mapped features may have changed since the date of the imagery or the field work.

Wetlands included in the dataset were interpreted conservatively from U.S. Fish and Wildlife Service aerial photography. Limitations to interpretation included:

- *Photo type*: Wetlands are more identifiable on color infrared images than black and white (Color infrared images may have been used in some of the watershed areas for NWI mapping).
- *Photo scale*: Typically, the scale used is between 1:40,000 and 1:80,000; wetlands are more difficult to identify from coarser scale photos
- *Land type*: Forested wetlands (especially coniferous) are more difficult to identify compared to those found in treeless prairies.

- *Climate conditions:* Also, wetlands are more difficult to identify from photos taken during a dry year as opposed to a wet year

Dredging and diking of the river channel can restrict irrigation return flows, which in turn can potentially create non-natural wetlands, creating another compounding limitation of using NWI.

Due to these limitations, wetland boundaries are generalized in most cases. Therefore, wetland acreages presented in this chapter are approximate. NWI wetland boundaries are not as accurate as those generated from field surveys. The NWI dataset is useful for assessing wetland coverage and type at the watershed scale, and therefore was used for analysis in this document. The information presented in this chapter is at the scale of the watershed and may not be refined enough for individual farm or ranch planning.

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CHAPTER 9. CHANNEL CHARACTERISTICS

This chapter will summarize background information about stream energy, channel morphology, channel classification, pools, riffles and related topics. The background information provides a common understanding of streams, but is not overly specific to the Lower Sprague-Lower Williamson watershed assessment area. At this time, limited data are available on channel characteristics within the assessment area, particularly at a large scale. Many site-specific assessments of channel characteristics have been conducted at different stream reaches within the system, but no comprehensive study of the channel characteristics within the assessment area has been located.

STREAM ENERGY

General features of stream and river systems reflect the long-term constraints of geology, landform and climate and the resultant vegetation patterns. During landscape evolution, stream characteristics such as drainage density, stream order, and the longitudinal channel profile develop from the interaction of runoff and stream sediment transport processes.

Channels undergo many subtle and not easily detected changes from season to season, and from year to year. A riffle may scour during the high flow and immediately backfill as flow decreases and, to the casual observer, no change has occurred. Channel changes are a part of the natural equilibrium in stream dynamics. Recognizing that channels are constantly changing, both the immediate and long-term effects of changes need to be considered. Knowledge of stream dynamics and energy dissipation is fundamental for understanding how channels change.

Channels are formed in 1.5-year return interval runoff events. The floodplains are also built during these events. The interaction between channel change, migration and floodplain development are important to understand in order to evaluate management practices and restoration activities.

Precipitation that falls on a catchment is forced by gravity along a downward path toward the ocean, and a certain amount of potential energy will be dissipated in transit. The water's initial elevation above sea level determines the total amount of potential energy available to do work. Once the water heads downstream, the potential energy is converted to kinetic energy. Some kinetic energy is utilized for sediment transport, bed scour and bank erosion, but more than 95 percent is ultimately consumed as heat loss during turbulent mixing within the main flow, as well as along channel margins (Morisawa 1968).

At a given location along a stream, the availability of energy to do work depends upon the time-rate loss of potential energy (Bagnold 1966) or total stream power. Unit stream power can be defined as the time-rate loss of potential energy per unit mass of water. In this equation, the energy slope of flowing water is often assumed to be approximated by channel gradient. The unit stream power concept is important because it provides a basis for understanding the erosive capability of flowing water in open channel systems. Channels that are steep, straight, with hydraulically "smooth" banks and beds, uniform in cross-section, and of large hydraulic radius will be associated with relatively high unit stream powers. However, the unit stream power of the channel sections can be reduced in several ways.

A stream channel that changes from being relatively deep and narrow to being shallower and wider (i.e., increase in width-to-depth ratio) may experience a concurrent loss of pools, which often provide important in-stream habitat for fish. Because bed shear stress would be increased in a wide, shallow cross-section, such channels would have relatively high potential for bedload transport and bank erosion, and would generally be characterized as unstable. Channels with these types of cross-sections occur naturally but can also be the result of increased sediment loads, increased peak flows, decreased riparian vegetation (particularly woody species), mechanical damage to streambanks (by heavy equipment, livestock or grazing, or ice flows), or some combination of these factors. More detailed discussions of stream hydraulics and sediment transport can be found in Leopold et al. 1964, Bagnold 1966, Morisawa 1968, Dunne and Leopold 1978, and Richards 1982.

CHANNEL MORPHOLOGY

Methods to characterize small stream channel morphology generally use some expression of width and depth. However, channels are not uniform in their cross-sectional shape and any width-to-depth measurement is only a relative index to the actual channel shape. Channel morphology is related to a large number of interacting variables, so the expected width or depth of a particular stream reach cannot easily be predicted. In general, width usually increases faster than depth downstream. The width-to-depth ratio could be used as a dimensionless index of channel morphology and would be useful for comparing upstream and downstream reaches. Due to the complex nature of the interactions in the stream channel, however, comparisons of width-to-depth ratios should be made only for streams of equal order or drainage area. Different flows also provide different channel characteristics, as is illustrated in the differences between the effects of 5-year, 10-year, 25-year and 100-year runoff events.

Any attempt to characterize stream channel morphology must recognize its three-dimensional aspects. Even though average widths and depths can generally index the amount and quality of in-stream habitat (Beschta and Platts 1986), longitudinal variability in width and depth is also important. One stream may express a uniform depth and width and have insignificant amounts of fish-rearing habitat. Yet, in another segment of the same stream with essentially the same average width and depth, but formed so that there are shallow riffle sections that are interspersed with deep pools and overhanging banks, there may be relatively abundant rearing habitat. The patterns of variations in width, depth and channel morphology are not entirely random, but are often grouped so as to provide a hierarchical structure to a stream system (Frissel et al. 1985). Even though alluvial channels do not have fixed spacing of pools and riffles, nearly 90 percent of the pool-riffle sequences may consist of channel reaches 3 to 9 widths in length. Where bed and bank characteristics are controlled by large roughness elements, the expected size and spacing of morphological features may be more variable.

Schumm's (1977) complex response concept identifies several expected changes in channel morphology by stream systems undergoing changes in flow or sediment availability. Increased high flows tend to increase channel width and depth. Increased sediment availability and transport tend to increase width, steepen gradient by decreasing sinuosity and decrease depth. If a channel is undergoing widening, it may be responding to increases in flow, increases in sediment availability, some other factor (such as loss of streamside vegetation), or a combination of all of these.

Pools

Pools are a major stream habitat for most fish. Salmonids often require back water or dammed pools with water moving at low velocities to survive harsh winter conditions. Elser (1968) and Lewis (1969) demonstrated that deep, slow velocity pools with large amounts of overhanging cover support the highest and most stable fish populations. Platts (1974) found that high-quality pools also supported the highest fish biomass. In the South Fork Salmon River drainage of Idaho, where Platts conducted this research, pool quality was an important factor that accounted for explained variation in total fish numbers. High-quality pools alone, however, do not make the fishery. Pools of all shapes, sizes and qualities are needed. Young-of-the-year need shallow, low-quality pools that other fish will not use. Increased growth allows them to eventually compete, without undue predation, in the higher-quality pools, which have better food supplies and winter rearing habitat.

Pools generally result from localized scour during moderate to high flows. The fact that a pool has formed indicates that the location is one of intense turbulence and energy dissipation during high flows. In many instances, subtle changes in channel dimensions or roughness may be sufficient to initiate pool formation and maintain pools over time (Keller and Melhorn 1973). The narrowing of channel banks can cause a converging of flow lines and acceleration of water; the gain is kinetic energy ultimately dissipated as turbulence along the bottom of a downstream pool. Although pools may form in this manner along straight reaches of a stream, they are more commonly formed at bends, where flows are deflected by channel banks, turbulence is intense, and the bed is erodible. Pools can also be formed by large roughness elements. For instance, water flowing over a log partially or wholly buried in the bed, boulders, or bedrock outcrop may create a pool immediately downstream. The size, frequency, distribution and quality of pools in a stream depend upon the mechanisms of formation and other characteristics, such as size of channel substrates, erodibility of banks, size of obstruction and depth of flow.

Riffles

Riffles, which are seen during periods of low flow when substantial portions of the channel bed may become exposed or have relatively shallow water flowing over it, are remnant channel features formed at higher flows. Riffles are major storage locations of bed material. In a meandering stream, riffles are ideally located between successive pools at the inflection point of the thalweg (the line following the lowest points of the riverbed). Their form represents a balance between the frequency and magnitude of flows, sediment transport, and other channel characteristics such as obstructions, bank erosion or deposition. Keller and Melhorn's (1973) description of diverging flows may be an important mechanism of riffle formation, though other mechanisms undoubtedly exist. As water moves out of a highly turbulent pool during high flow, it encounters a lower effective slope, hence reduced stream power, and may deposit coarse bedload sediment in transport. As the water continues to pass over the riffle, it accelerates until again expending most of its kinetic energy, as turbulence, at the next pool. Side channel dumps of sediment also form riffles.

THEORY AND FIELD METHODS

The ability of scientists and resources managers to provide for the most efficient channel form should be based on specific conditions of the fluvial system. There are few generalizations drawn from scientific studies of channel form that can be useful in practical problems of river restoration or maintenance. Width is the morphologic parameter most easily altered by the river. If the river is deprived of some of its natural discharge, and sometimes at natural flow levels, it will narrow its channel. Bank erosion usually will follow unusual or unnatural alteration in sediment supply or a change in water sediment relation. An alteration in channel gradient (slope) is the most disruptive to the natural equilibrium. An increase in gradient is the main reason that channel straightening or channelization is so destructive to river systems. Also, river curves provide an essential source of hydraulic resistance necessary for equilibrium.

To develop maintenance and restoration objectives, a procedure might include the following steps: inspect the channel upstream and downstream of the reach exhibiting problems; inspect nearby or similar valleys that appear more natural; and choose a reach of natural river that appears to represent the condition of the problem channel before it was disturbed or disrupted.

It is important to consider the principal morphological features of the river channel that must be retained or restored. First, the slope or gradient of the channel must be the same as it is in the natural or undisturbed reach of the river. The deviation from this natural slope, as with drop structures or grade control, is the clearest reason that the channel may be making additional adjustments.

The second consideration is channel width. The width must represent the bank full dimension such that when the normal bank full discharge is exceeded, the water will overflow onto a floodplain of much greater width. Thus both width and depth at bank full discharge must be considered, and an overflow area provided for greater discharges.

If river curves that are present in the undisturbed reaches have been eliminated or importantly changed in the disturbed area, they must be reinstalled by physically constructing them. The layout of curves is the principal way the desired gradient is maintained or restored. No natural channel is straight, so the restoration of curves of appropriate size and shape is a main element in river restoration. The bed elevation should vary, in that pools occur in the curved reach and shallower zone in the crossovers.

The dimensions of width, depth, meander length, radius of curvature, slope and other features have been published for many regions in the United States. These dimensions can be used when evaluating channel morphology as a way to roughly check those same dimensions measured in undisturbed reaches of the river being studied.

By observing a river, it should be obvious that a grade control structure flattens the channel gradient upstream for only a short distance and puts an unnatural anomaly into the fluvial system. Such an anomaly will be attacked by the flow and, given time, will be eliminated. An unnatural anomaly will ultimately be destroyed by undercutting, by lateral erosion of the abutments, by scour hole erosion at the toe, or by some combination of these processes.

If a reach of channel is suffering unusual bank erosion, downcutting of the bed, aggradation, change of channel pattern or other evidence of disequilibrium, a realistic approach to amelioration of these problems should be based on restoring the natural combination of dimension and form characteristics of similar channels in quasi-equilibrium. These characteristics include appropriate values of width, gradient, pool and riffle sequence, length, radius, amplitude of curves and meanders, and hydraulic roughness.

CHANNEL CLASSIFICATION

Stream channel characteristics such as width, depth or number of pools in a section of stream are determined by many factors, including topography, geology, hydrology and climate. Additionally, vegetation conditions and the history of disturbance, such as floods, fires, landslides, road construction, channel modification, or livestock and timber management practices may influence stream channel conditions. High in the watershed, slopes are steep, and the rapid stream flows readily erode sediment, gravel and rocks from the banks and bed. Lower in the watershed, streams often meander across the valley bottoms and may divide into multiple channels. These features may provide stream channel characteristics that respond predictably to natural and human-caused modifications and may be classified into channel habitat types (CHTs). Clasifying current CHTs in the watershed helps to: (1) evaluate basin-wide stream channel conditions, (2) understand how land use activities may have affected the channel form, and (3) predict how different channels may respond to particular restoration efforts (WPN 1999). Ultimately, changes in watershed processes will affect channel form and produce changes in habitat for fish and other organisms.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). Classifying stream channels in the watershed may help identify which stream segments are most affected by disturbances, and which segments are most likely to respond favorably to restoration activities. As an example, more confined, higher gradient streams provide little response to restoration efforts.

In-channel structures and activities associated with human activities such as ditching and streambank stabilization (for example with riprap) and flood control can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of in-stream aquatic biota.

Identification of channel modification activities can help in determining the likely effect of human-caused channel disturbances on channel morphology, aquatic habitat and hydrologic functioning.

Unfortunately, not much data exist regarding the specific locations of channel modifications and historical channel disturbances. Information presented in this section is based on existing relevant data, but many sources of channel modification are undocumented.

The key questions addressed in this section are:

1. What are the channel habitat types?
2. What are the changes in watershed conditions?
3. What are the major modifications to channel morphology?

Designation of Channel Habitat Types

CHT categories, listed below, are based on stream geomorphic structure, including stream gradient, channel size and channel pattern. In "Applied River Morphology," Rosgen (1996) defined these CHT categories. Topography in the Lower Sprague-Lower Williamson subbasin is characterized by moderate to steep gradient uplands that move quickly into low gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance (see Figures 9-1 and 9-2).

Type Aa+ Channels

Rosgen Type Aa+ channels are confined, very steep gradient streams (greater than 10 percent) found in the headwaters of the stream network. During high flows, the stream may appear as a torrent or waterfall. Type Aa+ channels typically have a step/pool morphology with chutes, debris flows and waterfalls.

Type A Channels

Type A channels are similar to Type Aa+ channels but are found on slightly less steep gradients. These channels have similar landform characteristics and gradients ranging from 4 percent to 10 percent. Type A channels are often small streams high in the stream network, although sections of Type A channels may be found along larger streams as well.

Type B Channels

The B channel designation includes streams having moderately steep to gently sloped channels, with low rates of aggradation and stream bank erosion. Type B channels are moderately entrenched.

Type C Channels

Type C channels are low gradient, with generally less than 2 percent slope. They are frequently found in valleys formed by alluvial deposits. Type C channels characteristically meander across the valley floor and form point-bars on inner bends.

Type D Channels

Type D channels are shallow, wide and braided, with active bank erosion. They are low gradient and often include multiple channel systems.

Type DA Channels

Type DA channels are low gradient, multiple channel systems, which are generally stable and deep relative to channel width.

Type E Channels

Type E stream segments are characterized by a gentle gradient, similar to Type C, but Type E streams are narrower and deeper than Type C streams, and are more stable.

F Channels

Type F streams are entrenched, meandering streams that are not stable, and are continually eroding, depositing sediment and gradually re-establishing a functional floodplain. In the absence of severe disturbance to the stream system, Type F streams may transition to Type E as they become stable.

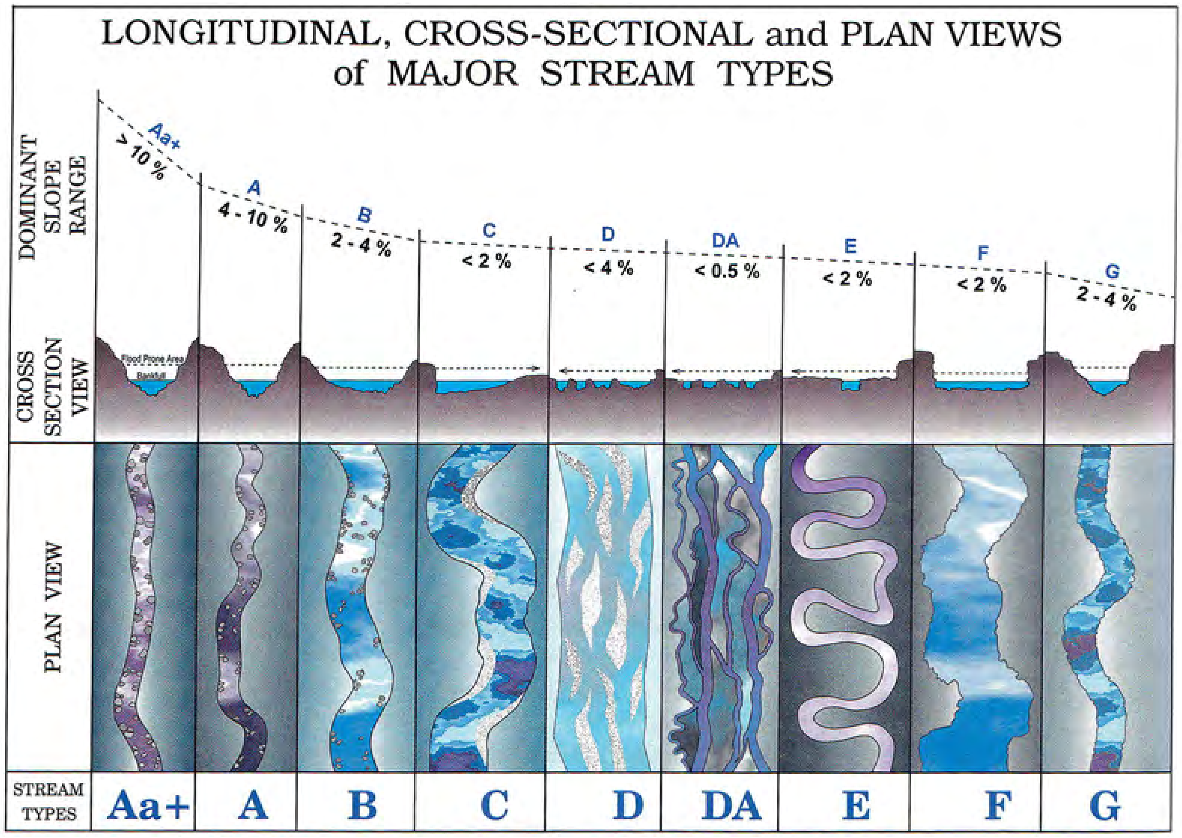


Figure 9-1 Rosgen Channel Classes
(Data Source: Rosgen 1996)

Table 9-1 Rosgen channel type descriptions for the Lower Sprague-Lower Williamson subbasin
(Data Sources: Rosgen 1996, WPN 1999)

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment Ratio	Width-to-Depth Ratio	Sinuosity	Slope (%)	Landform/Soils/Features
Aa+	VH SV	Very steep, deeply entrenched, debris transport streams.	< 1.4	< 12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock, or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	SV BC MV MH	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder-dominated channel.	< 1.4	< 12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	MH MM	Moderately entrenched, moderate gradient, riffle-dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	> 12	> 1.2	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and width-to-depth ratio. Narrow, gently sloping valleys. Rapids predominate, with occasional pools.
C	LM FP1 FP3	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	> 2.2	> 12	> 1.4	< 0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	AF FP2	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	> 40	n/a	< 0.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.

Table 9-1. Continued.

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment Ratio	Width-to-Depth Ratio	Sinuosity	Slope (%)	Landform/Soils/Features
DA	LM LC	Multiple channels that are narrow and deep, with expansive, well-vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	> 4.0	< 40	Variable	< 0.005	Broad, low gradient valleys with fine alluvium and/or lacustrine soils. Multiple channels controlled geologically, creating fine deposition with well-vegetated bars that are laterally stable and broad wetland floodplains.
E	FP1	Low gradient, meandering riffle/pool stream with low width-to-depth ratio and little deposition. Very efficient and stable. High meander width ratio.	> 2.2	< 12	> 1.5	< 0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width-to-depth ratio.
F	LC	Entrenched meandering riffle/pool channel on low gradients with high width-to-depth ratio.	< 1.4	> 12	> 1.4	< 0.02	Entrenched in highly weathered material. Gentle gradients, with a high width-to-depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle-pool morphology.

Modifications to Stream Channel Conditions

Reservoirs

A reservoir is considered to be "a constructed basin formed to contain water or other liquids" (USGS 1999b). Modifications to the stream channel in the form of dams and reservoirs can affect not only the impoundment area, but also downstream channel morphology, water quality, and fish habitat and passage. Several reservoirs exist in the Lower Sprague-Lower Williamson subbasin (Table 9-1). The reservoirs listed in Table 9-1 are mapped reservoirs. Use of mapped reservoirs only probably underestimates the number of reservoirs within the subbasin, because many smaller irrigation reservoirs and holding ponds are not large enough to be mapped at this scale.

The Sprague River and Williamson River watersheds have the least number of mapped reservoirs of the watersheds in the assessment area, with one and two reservoirs respectively. The Sprague River watershed reservoir is relatively small (0.06 acres), whereas the Williamson River watershed reservoirs are larger (0.34 and 0.59 acres).

The North Sprague River watershed exhibits seven mapped reservoirs, ranging in size from 0.05 acres to 0.59 acres. The West Sprague River watershed has eight mapped reservoirs. This watershed exhibits the largest mapped reservoir within the subbasin, the Long Prairie Reservoir (2.22 acres).

Table 9-2 Reservoir distribution in the Lower Sprague-Lower Williamson subbasin (Data Source: USGS 2007)

Watershed Name	Reservoir Name	Area (m^2)	Area (acres)
North Sprague River	Grade Reservoir	271.5	0.07
	John Smith Reservoir	804.0	0.20
	Junction Reservoir	440.0	0.11
	Pothole Reservoir	352.5	0.09
	S Grade Reservoir	319.0	0.08
	Unnamed Reservoir	2,368.0	0.59
	Wigwam Reservoir	194.5	0.05
Sprague River	Unnamed Reservoir	248.0	0.06
West Sprague River	Borrow Reservoir	590.0	0.15
	Lone Pine Reservoir	434.0	0.11
	Long Prairie Reservoir	8,990.0	2.22
	Long Reservoir	259.5	0.06
	Mahogany Ridge Reservoir	469.0	0.12
	Prairie Reservoir	440.5	0.11
	Quarry Reservoir	579.5	0.14
	Rocky Hole Reservoir	900.5	0.22
Williamson River	Hilltop Reservoir	1,378.0	0.34
	Lobert Draw Reservoir	2,376.5	0.59

Splash Dams and Stream Cleaning

Splash dams, which are small dams made of logs and shrubbery piled in the stream channel to hold back and divert water, have been used throughout the watershed. The history of stream cleaning, which is the removal of debris, vegetation and sediment from the stream channel, is somewhat unclear. It is certain that this practice has been used on both public and private lands in the Lower Sprague-Lower Williamson subbasin. Logs were transported only in the lower reaches of the Sprague and Williamson rivers, as flows were too low in other areas.

Stream Widening and Incisement

There are stream channels throughout the Lower Sprague-Lower Williamson subbasin that have experienced substantial channel modification associated with erosion activities related to gullying, stream incisement and channel widening. Such changes to the channel morphology have been caused or exacerbated by a variety of human activities in past decades and in past centuries. These activities have included over-grazing, beaver trapping, removal of riparian vegetation, land clearing, wildfires and loss of wetlands. Data are not available, however, with which to specify the locations or severity of such changes. Nevertheless, the impacts on stream structure and function are important. In particular, such changes to the channel morphology are often associated with increased sedimentation of spawning gravels, increased water temperature and diminished riparian function.

Channel Engineering and Stream Straightening

During the first half of the twentieth century, many reaches of the Lower Sprague and Lower Williamson rivers were straightened, diked and channelized. The majority of this work was conducted by the U.S. Army Corps of Engineers to control flooding and maximize use of the land for agricultural production. These impacts on the stream channel are still visible today in many of the valley reaches.

Ditches and Canals

Map 9-1 shows the locations of the mapped ditches and canals within the Lower Sprague-Lower Williamson subbasin. There are many more miles of ditches that supply irrigation water and drain flood waters, but these ditches are not mapped on Map 9-1, because they are too small to show up at this scale.

Ditches and canals were prevalent in the Williamson River Delta Preserve, owned and managed by The Nature Conservancy. This canal system historically drained the agricultural fields in spring and early summer and supplied irrigation water during the late summer and fall. The delta area was excluded from Upper Klamath Lake and Agency Lake by an extensive dike system around the perimeter of the delta. The dikes were breached in the fall of 2007, so the delta area is now hydraulically reconnected to the lakes. The dikes and canal system no longer control water levels within the delta area.

Dam

The Lower Sprague-Lower Williamson subbasin exhibited one major dam, the Chiloquin Dam. The Chiloquin Dam was located just south of the town of Chiloquin on the Sprague River about a mile above the Sprague River's confluence with the Williamson River, and about 15 miles above Upper Klamath Lake. The dam was constructed in 1917 as a control structure for the point of diversion of the United States Indian Irrigation Service project for Modoc Point. When the Klamath Indian Reservation was terminated in 1954, the dam, its canal and the Modoc Point irrigation project were transferred to the Modoc Point Irrigation District (MPID). There are approximately 5,000 acres under irrigation in the MPID. MPID and a number of Klamath tribal members who have irrigated land in the Modoc Point have filed claims in the Klamath Basin Adjudication (OWRD 2004).

The Chiloquin Dam obstructed fish passage both up and down the Sprague River, effectively preventing migration of trout and the endangered sucker fish from Upper Klamath Lake to the Sprague River. The National Research Council of the National Academy of Sciences stated in its 2003 Report on the Klamath River Basin that "removal of Chiloquin Dam has high priority and should be pursued aggressively." The National Academy of Sciences report notes that "…Chiloquin Dam may have eliminated more than 95% of the historical spawning habitat in the Sprague River" (OWRD 2004).

During the summer of 2008, the Chiloquin Dam was removed. MPID has secured a new diversion point downstream just east of Highway 97 and has developed a pumping station at the new point of diversion.

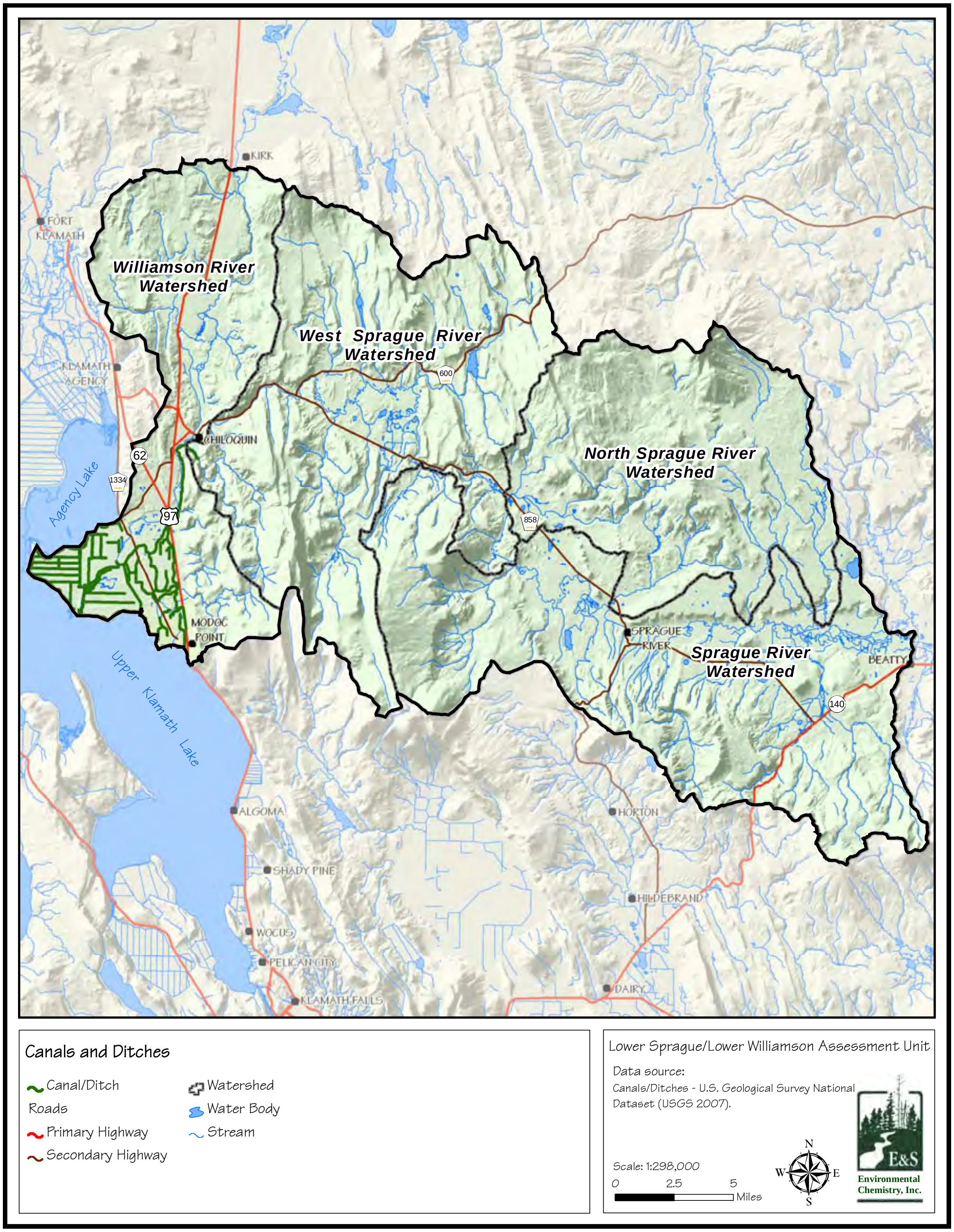
DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies and Rosgen (1996). The information used in this Assessment is expected to be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data are determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies.

The U.S. Geological Survey (USGS) created the National Hydrography Dataset (NHD) in cooperation with the U.S. Environmental Protection Agency (EPA). It is a combination of USGS digital line graph (DLG) hydrography files and EPA Reach File 3 (RF3). The NHD provides both DLG and RF3 data in a flexible and refined format. The NHD is based on 1:100:000-scale data. However, higher resolution data are continuously being incorporated into this format (USGS 1999a). Therefore, the accuracy of this data is sufficient at a watershed scale, but not at a farm or ranch planning scale.

DATA GAPS

At this time, limited data are available on channel characteristics within the assessment area, particularly at a large scale. Many site-specific assessments of channel characteristics have been conducted at different stream reaches within the assessment area, but no comprehensive study of the channel characteristics within the assessment area has been located.



Map 9-1 Location of known (mapped) ditches and canals within the Lower Sprague-Lower Williamson subbasin (Data Source: USGS 2007)

Data methods/limitations: National Hydrology Dataset (NHD) streamlines classified as "Canal/Ditch" are shown on this map. A "Canal" or "Ditch" is considered "an artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft" (USGS 1999b).

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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

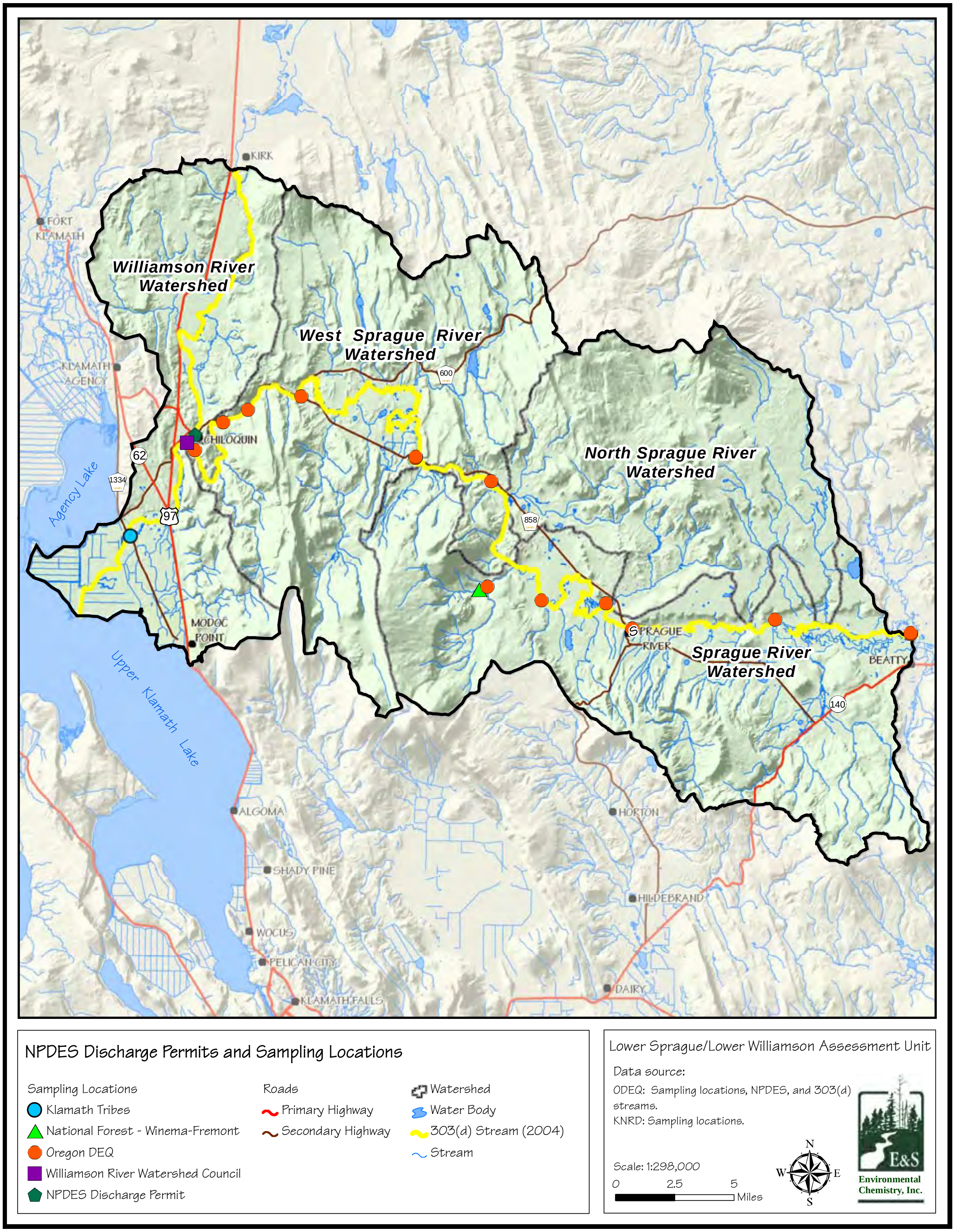
It is important to note that the main-stem streams within the assessment area are considered to have access by floating the river. However, the public cannot stop on the banks of the river without permission from the adjacent landowner. The landowner owns the ground under the river to the center of the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

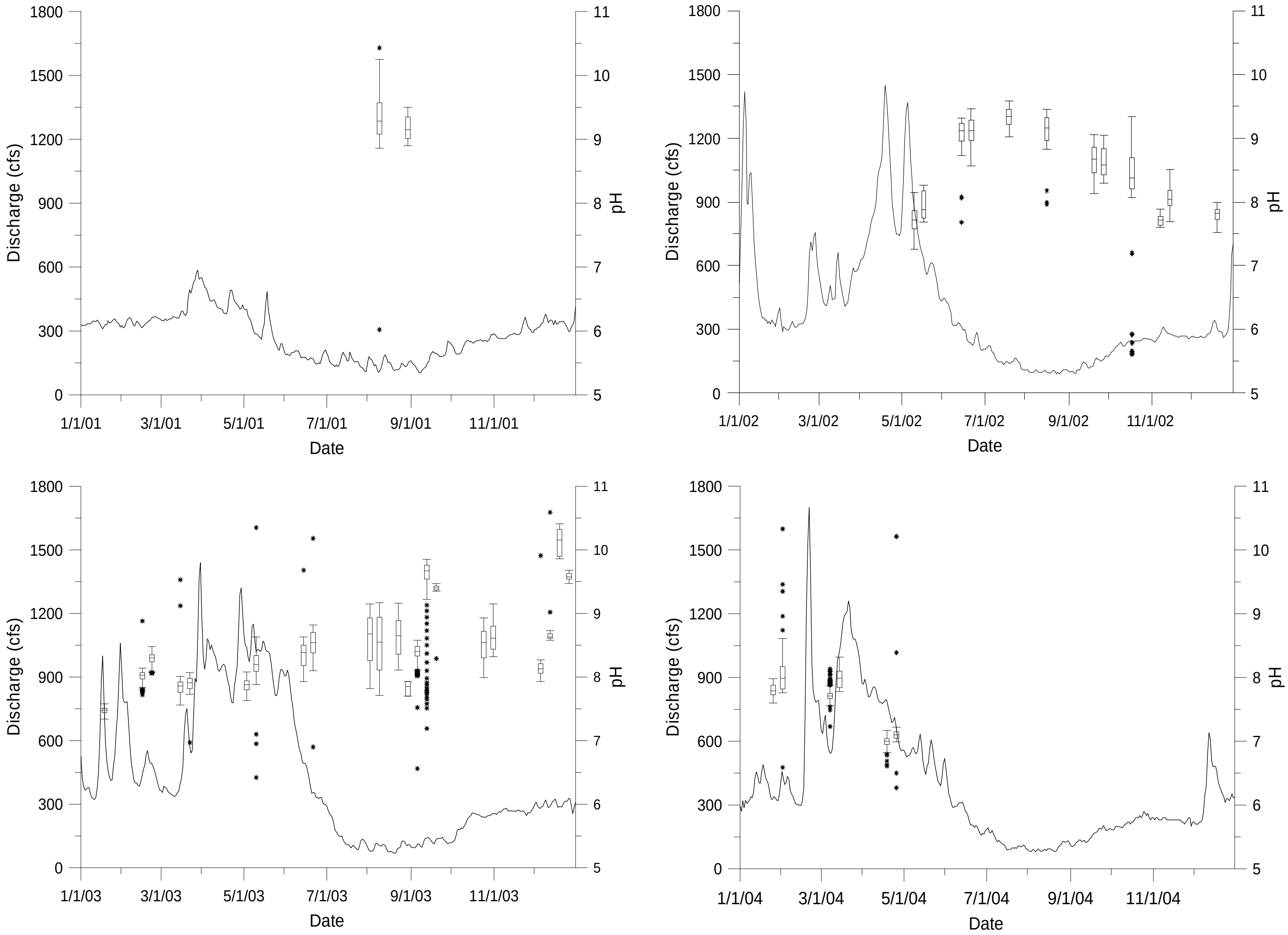

Figure 10-1 pH values measured by the Klamath Tribes Natural Resources Department in the Lower Sprague-Lower Williamson subbasin near the hatchery in 2001 through 2004 with relationship to discharge
(Data Sources: KNRD 2006, USGS 2007)

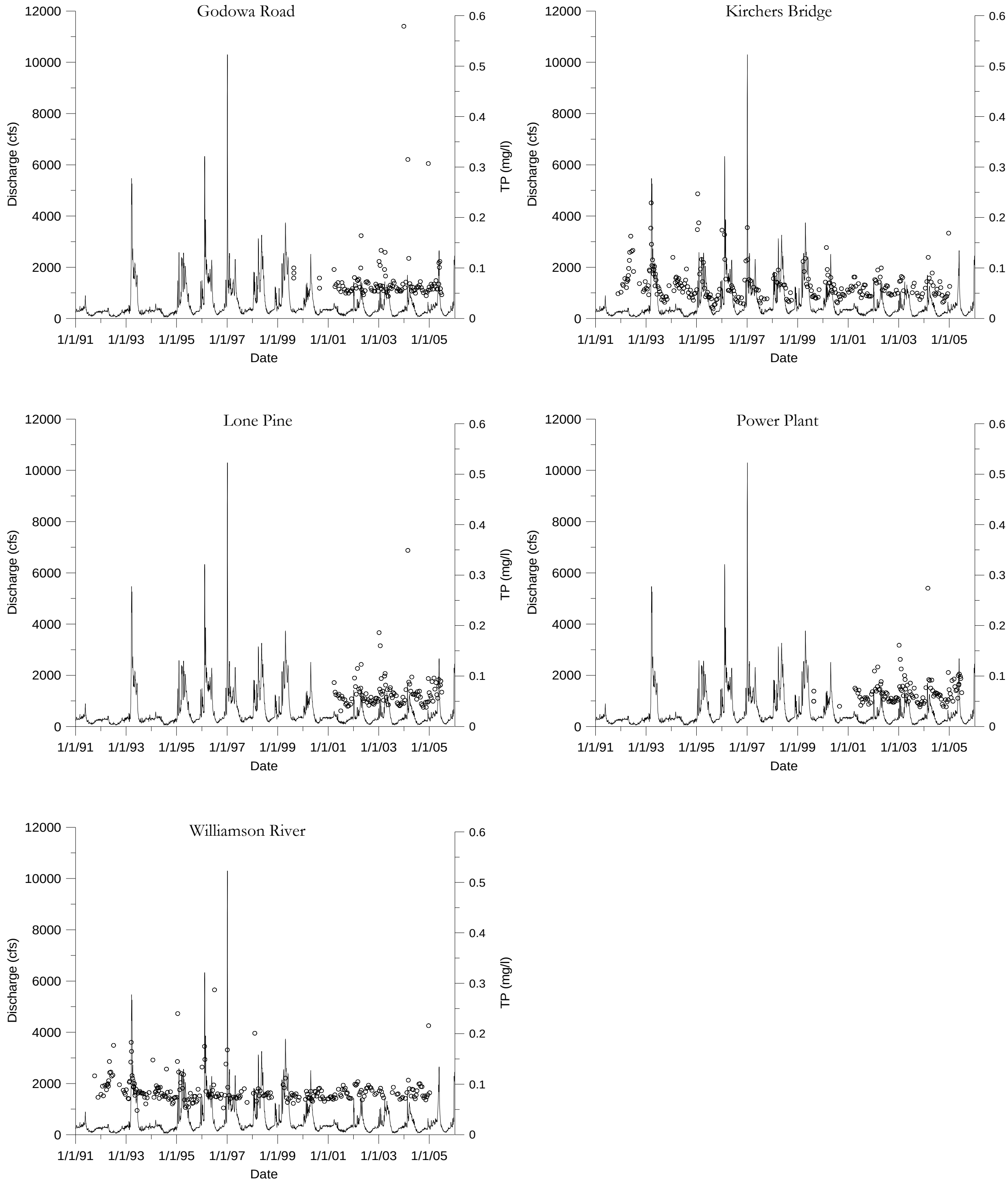

Figure 10-2 Total phosphorus (TP) values measured by the Klamath Tribes Natural Resources Department at several sites in the Lower Sprague-Lower Williamson subbasin in 1991 through 2005 with relationship to discharge
(Data Sources: KNRD 2006, USGS 2007)

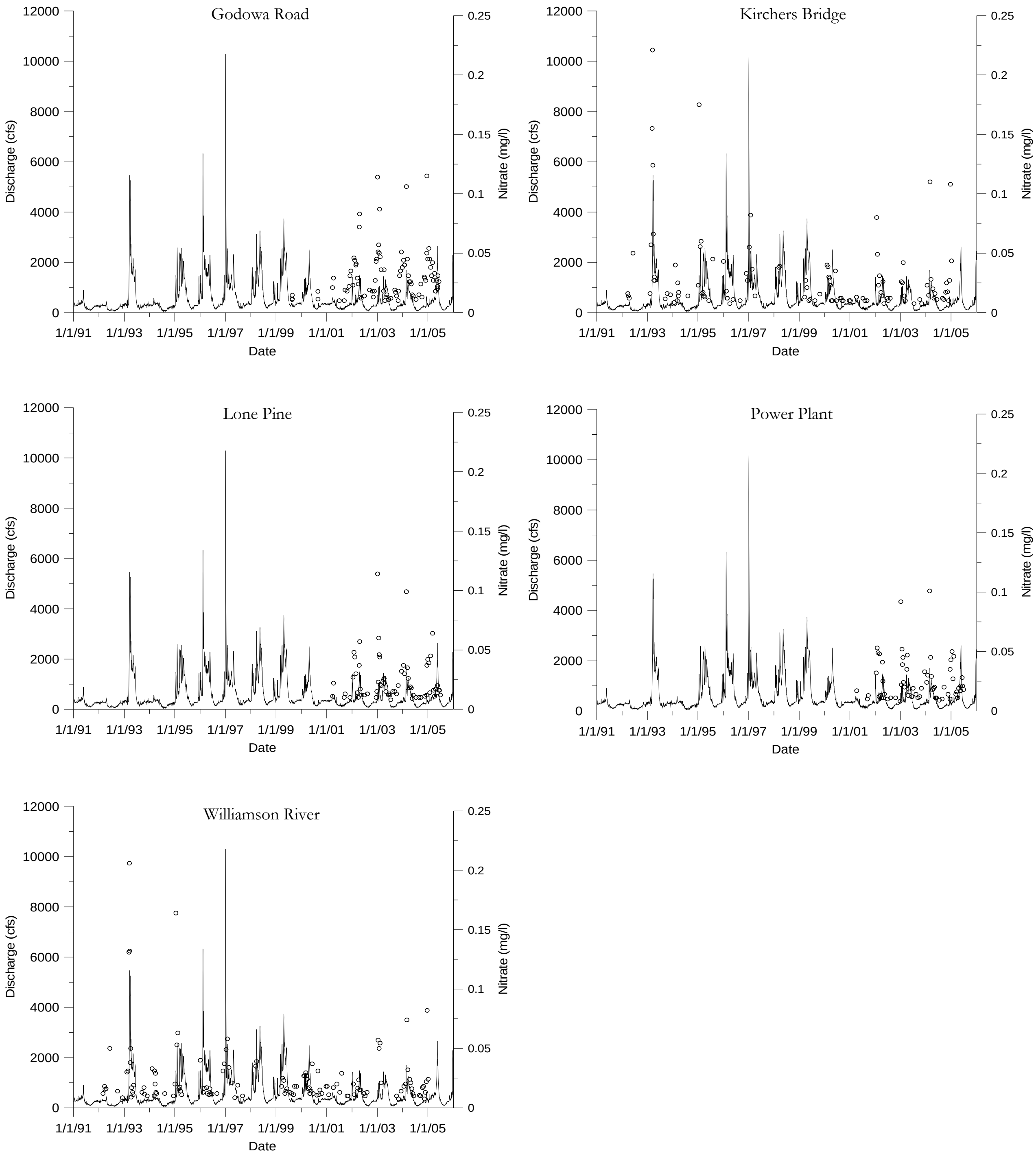

Figure 10-3 Nitrate-nitrogen values measured by the Klamath Tribes Natural Resources Department at several sites in the Lower Sprague-Lower Williamson subbasin in 1991 through 2005 with relationship to discharge
(Data Sources: KNRD 2006, USGS 2007)

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 º 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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CHAPTER 11. AQUATIC SPECIES AND HABITAT

CHARACTERIZATION

The major focus of habitat quality issues within the Lower Sprague-Lower Williamson subbasin concerns native fish species, in particular the influence of habitat quality on Klamath largescale sucker (Federal species of concern), Lost River sucker (Federally endangered), shortnose sucker (Federally endangered), redband trout (a subspecies of the rainbow trout) and two species of extirpated anadromous salmonids—Chinook salmon and steelhead trout. In addition to their intrinsic value and importance as a sport fishing resource, the native fishes in the Lower Sprague-Lower Williamson subbasin function as keystone species and are indicators of watershed condition (Mills et al. 1993). Watershed protection, enhancement and restoration actions are often focused on possible benefits to fish, because managing for fish habitat would be expected to benefit aquatic ecosystems generally.

This chapter provides an overview regarding the current status of fisheries and aquatic habitat within the assessment area. It also provides known information about historical fisheries conditions.

Historical evidence suggests that fish populations in the Lower Sprague-Lower Williamson subbasin were dramatically different from those which exist today (Buettner and Scoppettone 1990). A variety of factors contributed to changes. Before the construction of Copco Dam on the Klamath River in 1917, anadromous Chinook salmon and steelhead trout utilized the Lower Sprague-Lower Williamson subbasin and its tributaries as spawning and rearing habitat (Fortune et al. 1966, Hamilton et al. 2005). Helen Crume Smith, born in 1934, remembers "people gathering there at the river, and here were these people and here were these fish, about twice as tall as me. Those salmon, those were the last run of the salmon, of the ones that were left after the dams. This had to be 1937 or 1938, and I've got people that say it couldn't be. But I say, I remember 'em. And my granddad called them salmon, and who am I to dispute his word." Lost River, shortnose and Klamath largescale suckers had previously used the waters of the Lower Sprague-Lower Williamson subbasin as well (Buettner and Scoppettone 1990). Construction of Chiloquin Dam on the main-stem Sprague River was competed in 1918. Although no formal research has investigated fish passage over Chiloquin Dam, there are indications that the dam interrupts normal fish passage (U.S. House of Representatives 2001, Battelle 2005).

The introduction of non-native fish species has also altered the fishery in the subbasin. Stocking programs, intentional introductions by sport fishers and accidental introductions are all possible sources of non-native fish. Competition and hybridization between native and introduced fish species can limit the reproductive potential of native fish and create interspecies competition for resources (Tyus and Saunders 2000). Efforts to reduce the interaction between native and non-native fish species are under way by the Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service, National Park Service and U.S. Forest Service, with the intent of sustaining native fish populations.

Fish habitat conditions have also changed over the years. Aerial photographs show dramatic changes over the years in the condition of the streams and riparian corridors, as discussed in the riparian areas and channel characteristics chapters. The loss of stream-side riparian zones has led to changes in fish habitat due to streambank destabilization and loss of vegetation cover (Armour et al. 1994), Sheffield et al. 1997, Platts 1991). In general, salmonid species such as bull trout and rainbow trout require slow-moving backwaters for rearing fry, in-stream cover and very cold water (USFWS 2005, Behnke 2002). Loss or alteration of stream-side vegetation can lead to increased stream width (Platts 1991). Wider stream channels, in turn, allow for increased solar radiation gain, which increases water temperatures (Quin et al. 1997, Platts 1991).

Further changes in fish habitat conditions will be discussed later in the chapter. However, changes in fish habitat characteristics are not well documented for the entire assessment area. Most available information regarding fish habitat characteristics is for tributaries in the Fremont-Winema National Forest. Little habitat information has been obtained for the main stem of the Sprague River and Williamson River. Data gaps will be identified as appropriate.

FISH SPECIES

This section will present a short summary of what is known about native fish species in the Lower Sprague-Lower Williamson subbasin. Because this Assessment will provide a foundation for future enhancement and restoration projects, a brief summary of native anadromous species will be presented in light of potential reintroduction or reestablishment of salmon and steelhead.

Bull Trout (*Salvelinus confluentus*)

Because of the listing of bull trout under the Endangered Species Act in 1999, a large portion of the available data pertains to headwater tributaries where current bull trout populations are found. There is no critical bull trout stream habitat designated by the U.S. Fish and Wildlife Service within the assessment area. The assessment area does not include the headwater reaches of either the Williamson or Sprague rivers, because the Upper Sprague River Watershed Assessment and the Upper Williamson River Watershed Assessment were already completed for those areas. Bull trout are especially important because of their status as a Federally Threatened Species, but they will not be addressed further in this document because they are not currently located within the assessment area.

Redband Trout (*Oncorhynchus mykiss newberrii*)

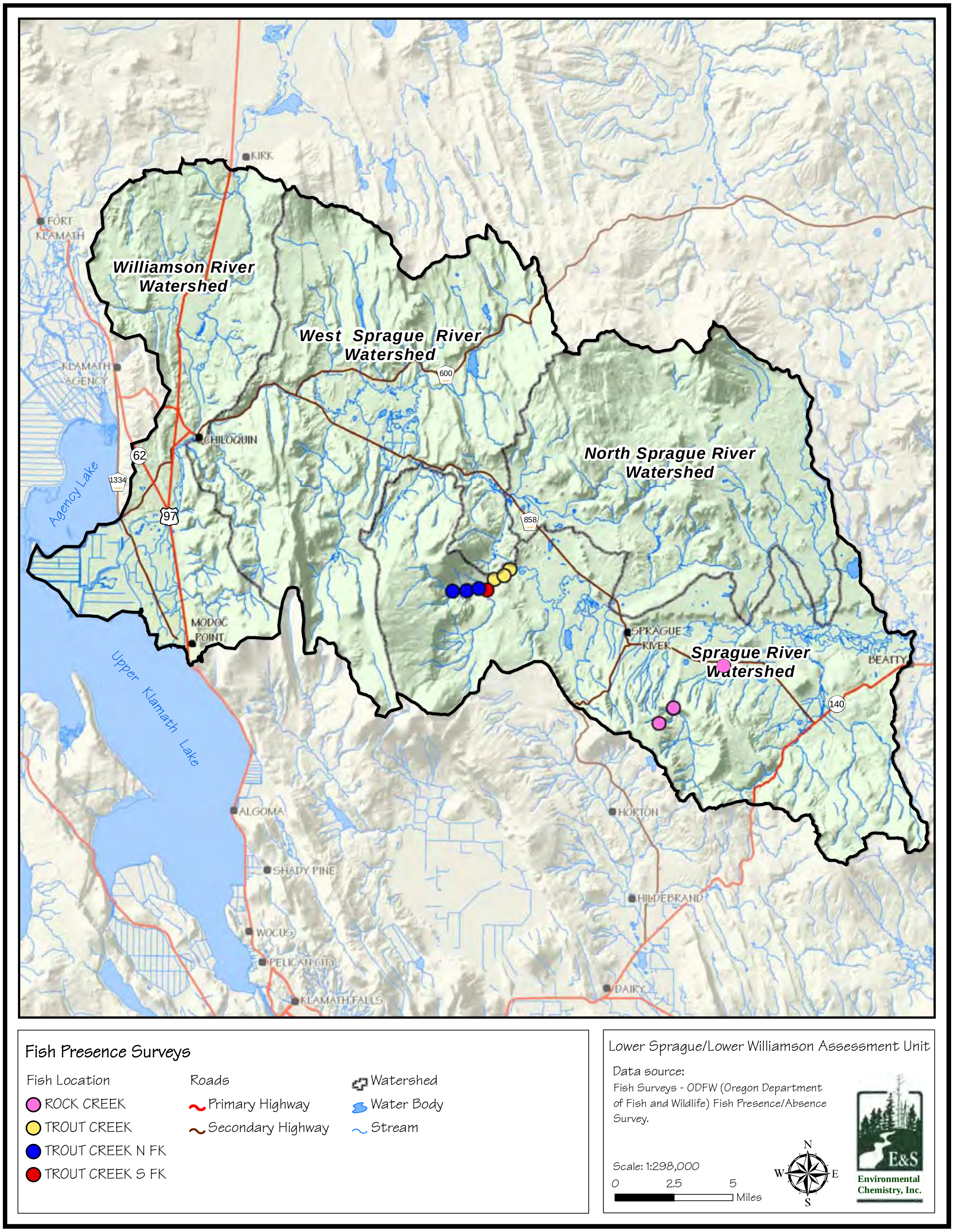
Habitat Requirements and Life History

Other than bull trout, redband trout are the only native salmonid species currently found in the Sprague River basin (Weyerhaeuser 1995). Redband trout are considered the same species as coastal rainbow trout by some fishery scientists (Currens 1997), although Behnke (1992) has distinguished several substantial redband groups as separate subspecies (*newberrii*). Redband trout populations in the Lower Sprague-Lower Williamson subbasin are believed to be important to the diversity of the overall population of redband trout and represent a keystone species (Behnke 1992).

Redband trout found in the Lower Sprague-Lower Williamson subbasin exhibit two life strategies. One strategy is the adfluvial form, where adults rear in larger lakes, attaining larger body sizes and higher fecundity, and migrate upstream to spawn. The second form is the fluvial form, which spends its entire life in smaller tributaries and rivers (Benhke 2002). Both forms of redband trout spawn in the headwater streams where they can find appropriate cold-water temperature for egg incubation and juvenile rearing (Behnke 2002). Spawning in the spring is initiated by an increase in stream temperature. Eggs hatch within 30 to 40 days, and fish remain in shallow waters with good cover through the winter (Weyerhaeuser 1996). Juveniles will move to deeper and faster moving waters, seeking larger pools before reaching maturity, after about two years. Adult redband trout thrive when water temperatures are between 55 º F and 65º F (12 º C to 18º C) (Hokanson et al. 1977). Growth rates have been observed to slow in water above 68 º F (20 º C) (Hokanson et al. 1977). Rodnick et al. (2004) showed that large (0.8 to 3.0 pound) redband trout in southeastern Oregon were more susceptible to the negative effects of elevated stream temperatures than smaller redband trout. Redband trout, like other salmonids, are typically found closely associated with riparian cover, such as overhanging vegetation, undercut banks and large woody debris (Fausch and Northcote 1992, Theurer et al. 1985). (See Table 11-3.)

Distribution, Abundance and Productivity

Resident and migratory redband trout exist throughout the main stem of the Sprague and Williamson rivers. The U.S. Fish and Wildlife Service conducted screwtrap surveys for juvenile fish throughout the Lower Sprague-Lower Williamson subbasin during the fall of 2005. In 2006, juvenile redband trout was the primary species captured in the lower Williamson River above the confluence with the Sprague River and was the secondary species caught in the Sprague River. Redband trout was the primary species of juvenile fish captured at all locations in the Sprague River in 2007. The presence of juvenile fish peaks in late spring and in late fall, when moderate water temperatures exist (Murphy and Parrish 2008).



Map 11-1 Location of fish presence surveys by the Oregon Department of Fish and Wildlife in the Lower Sprague-Lower Williamson subbasin
(Data Source: ODFW 2004a)

Table 11-1 Fish presence in the Lower Sprague-Lower Williamson subbasin based on a 1991 survey of the Sprague River Watershed by the Oregon Department of Fish and Wildlife
(Data Source: ODFW 2004a)

Stream	Fish Species		Number of Individuals
	Common Name	Scientific Name	
Trout Creek	Rainbow Trout	*Oncorhynchus mykiss*	14
	Brook Trout	*Salvelinus fontinalis*	1
	Dace	*Rhinichthys* spp.	3
	Redside Shiner	*Richardsonius balteatus*	6
North Fork Trout Creek	Rainbow Trout	*Oncorhynchus mykiss*	12
	Brook Trout	*Salvelinus fontinalis*	1
	Unknown Salmonid		3
South Fork Trout Creek	Rainbow Trout	*Oncorhynchus mykiss*	1
Rock Creek	Dace	*Rhinichthys* spp.	1
	Redside Shiner	*Richardsonius balteatus*	1
	Sucker	*Catostomus* spp.	1
	Tui Chub	*Gila bicolor*	1

Resident and migratory redband trout also exist in Trout Creek and other tributaries of the Sprague and Williamson rivers (Table 11-1). ODFW has conducted only limited fish presence surveys within the Lower Sprague-Lower Williamson subbasin (Map 11-1). ODFW (2004a) indicates the presence of redband trout in the North Fork, South Fork and main stem of Trout Creek. A quantitative evaluation to determine the upper and lower limits of this species has not been made.

Anadromous Salmonids

Before construction of the Copco Dam on the Klamath River in 1917 (Fortune et al. 1966), Chinook salmon and steelhead (anadromous rainbow trout) utilized the Williamson River, whereas only steelhead utilized the Sprague River for spawning and rearing habitat (Hamilton et al. 2005) (Map 11-2). There is some difference in opinions about which fish were endemic to which rivers. Information in this section is based on Hamilton et al. (2005). Chinook salmon and steelhead trout can exhibit a wide diversity of life histories, and their exact historical distributions within the drainages of the Sprague and Williamson rivers is unknown, so only a brief description of their spawning and rearing habitat requirements will be presented here.

Chinook Salmon (*Oncorynchus tshawytscha*)

Chinook salmon are the largest of the Pacific salmon species, reaching average body weights of 10 to 25 pounds, with individuals recorded as large as 90-plus pounds (Behnke 2002). Chinook salmon typically spawn in middle-sized to large rivers (Quinn 2005) and require cool water temperatures for higher spawning success (generally around 41º F to 55º F (5º C to 13º C) (Richter and Kolmes 2005). They require large gravel substrate with well oxygenated water (Quinn 2005). McCullough et al. (2001) recommend that temperatures stay below 54º F (12º C) for proper egg incubation and fry development. A temperature range of 54º F to 68º F (12º C to 20º C) has been recorded for rearing and growth of Chinook juveniles (Richter and Kolmes 2005). Juvenile Chinooks express two life strategies, ocean-type or stream-type. Ocean-type individuals migrate downstream immediately or shortly after emerging from an egg. Stream-type individuals typically spend one full year in the river before migrating downstream (Quinn 2005).

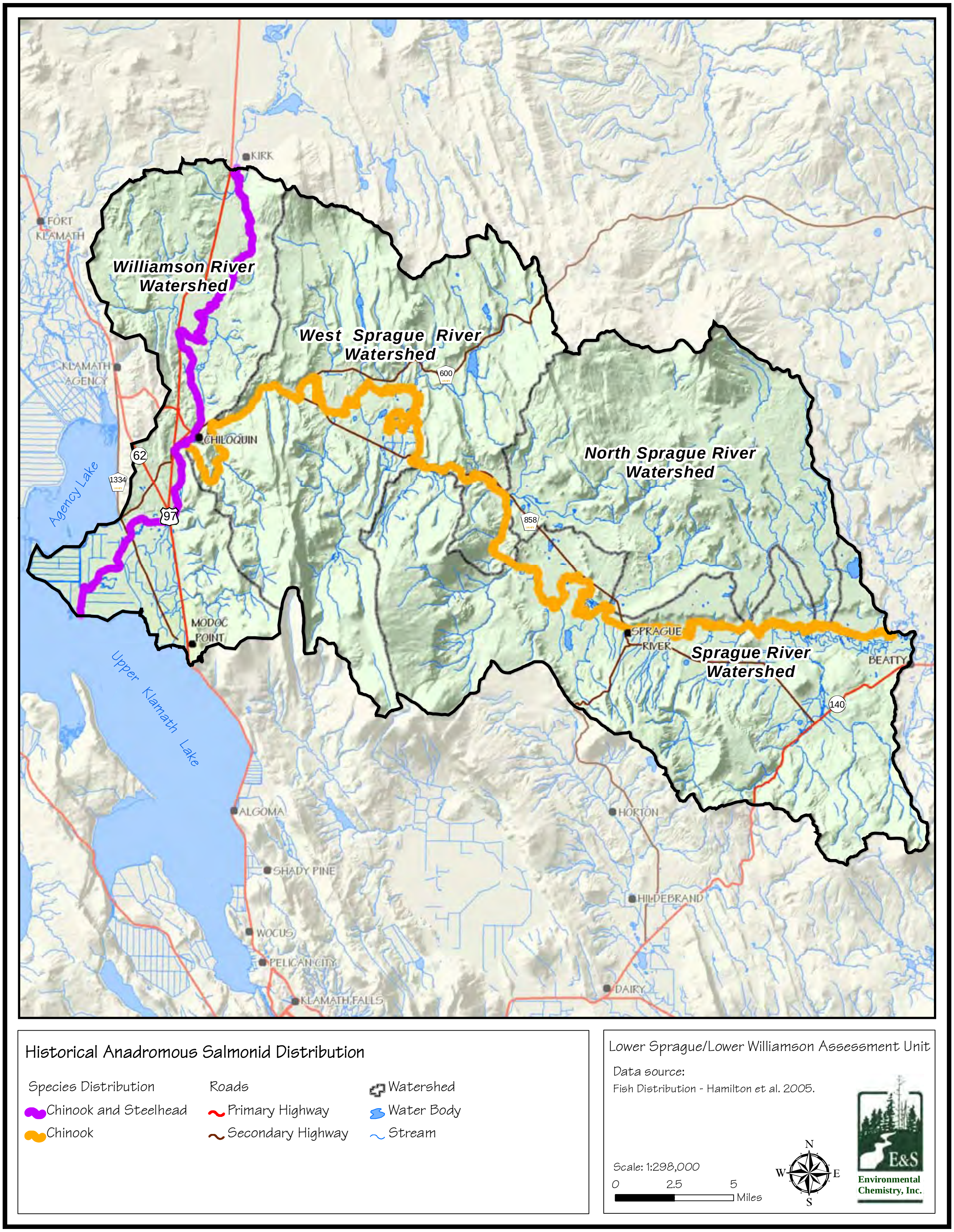
Steelhead (Rainbow) Trout (*Oncorhynchus mykiss*)

Steelhead are defined as a coast rainbow trout that spend a portion of their life in freshwater and saltwater. Steelhead usually weigh between 2 and 12 pounds, but individuals have been recorded at over 30 pounds. Like most trout, they spawn in headwater streams requiring small to medium-sized gravel and well-oxygenated waters (Quinn 2005). Bell (1991) reported that daily temperature range should be
50º F to 54º F (10º C to 12º C) for spawning steelhead. McCullough et al. (2001) recommend a constant incubation and fry development temperature between 52º F and 54º F (11º C and 12 º C) for steelhead. A temperature range of 57º F to 60 º F (14º C to 15º C) has been described as optimal range for growth of juvenile steelhead (Hicks 2002). Steelhead generally spend one to three years in freshwater streams and then migrate to the ocean, where they can spend one to three years before returning to their natal stream to spawn (Quinn 2005).

Sucker Species

Three native species of suckers exist in the Lower Sprague-Lower Williamson subbasin: the shortnose sucker (*Chasmistes brevirostris*), the Lost River sucker (*Deltistis laxatus*) and the Klamath largescale sucker (*Catostomus snyderi*). Both shortnose suckers and Lost River suckers are federally listed as endangered. Klamath largescale suckers are recognized as a species of concern, and are listed by the State of Oregon as not rare or apparently endangered, but with cause for long-term concern (ORNHIC 2005). All three sucker species are long-lived, iteroparous (spawn multiple times) and often migrate up large streams to spawn (Table 11-2) (Cooperman and Markle 2003). Opinions vary among researchers on the exact dates and seasons for migration.

Klamath largescale suckers are primarily river residents; whereas both shortnose and Lost River suckers can be found in the river outside of the spawning season. Twelve sites where suckers spawn in the Sprague and Williamson rivers have been documented. Because sucker larvae will drift downstream to suitable foraging habitat after emergence (Cooperman and Markle 2003), the presence of larvae in this reach suggests that suckers are spawning at or above Beatty Gap (Ellsworth et al. 2007). However, most of the information available on spawning suckers above the Beatty Gap is provided by Klamath largescale suckers. During spawning, they have been observed on five occasions in the Sprague River above Beatty Gap and in the Lower Sycan watershed (USFS 2005). U.S. Geological Survey has monitored larval sucker emigration in the Sprague River from 2004 through 2006 and has collected larval suckers as early as March in the Sprague River near Beatty (Ellsworth et al. 2007). Peak larval emigration occurred during April and May (M. Buettner, pers. comm. 2006). U.S. Fish and Wildlife Service has also monitored juvenile sucker emigration from 2006 to the present (2009) in the Sprague River and has tracked juvenile sucker presence peaking in June and lasting all year. Juvenile sucker sampling in the Williamson River above its confluence with the Sprague River indicated no juvenile presence in 2006 (Murphy and Parrish 2008).



Map 11-2 Historical distribution of anadromous salmon and steelhead in the Lower Sprague-Lower Williamson subbasin
(Data Source: Hamilton et al. 2005)

Figure 11-1 and Figure 11-2 summarize the size differences between male and female suckers in the Williamson and Sprague rivers. The data shows that females are slightly larger than the males for both shortnose and Lost River suckers (BOR 2007).

Table 11-2 Life stage periodicity for key species in the Lower Sprague-Lower Williamson subbasin

Data Source: ODEQ 2002)

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Redband trout	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning	X	X	X	X	X	X						
	Incubation	X	X	X	X	X	X						
	Fry		X	X	X	X	X	X					
	Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
	Migration												
Klamath largescale sucker	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning		X	X	X	X							
	Incubation		X	X	X	X							
	Fry		X	X	X	X	X	X					
	Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
	Migration												
Lost River sucker	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning		X	X	X	X	X						
	Incubation		X	X	X	X	X						
	Larval		X	X	X	X	X	X					
	Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
	Migration	X	X	X	X	X	X						
Shortnose sucker	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning				X	X	X	X					
	Larval				X	X	X	X					
	Fry				X	X	X	X	X				
	Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
	Migration												

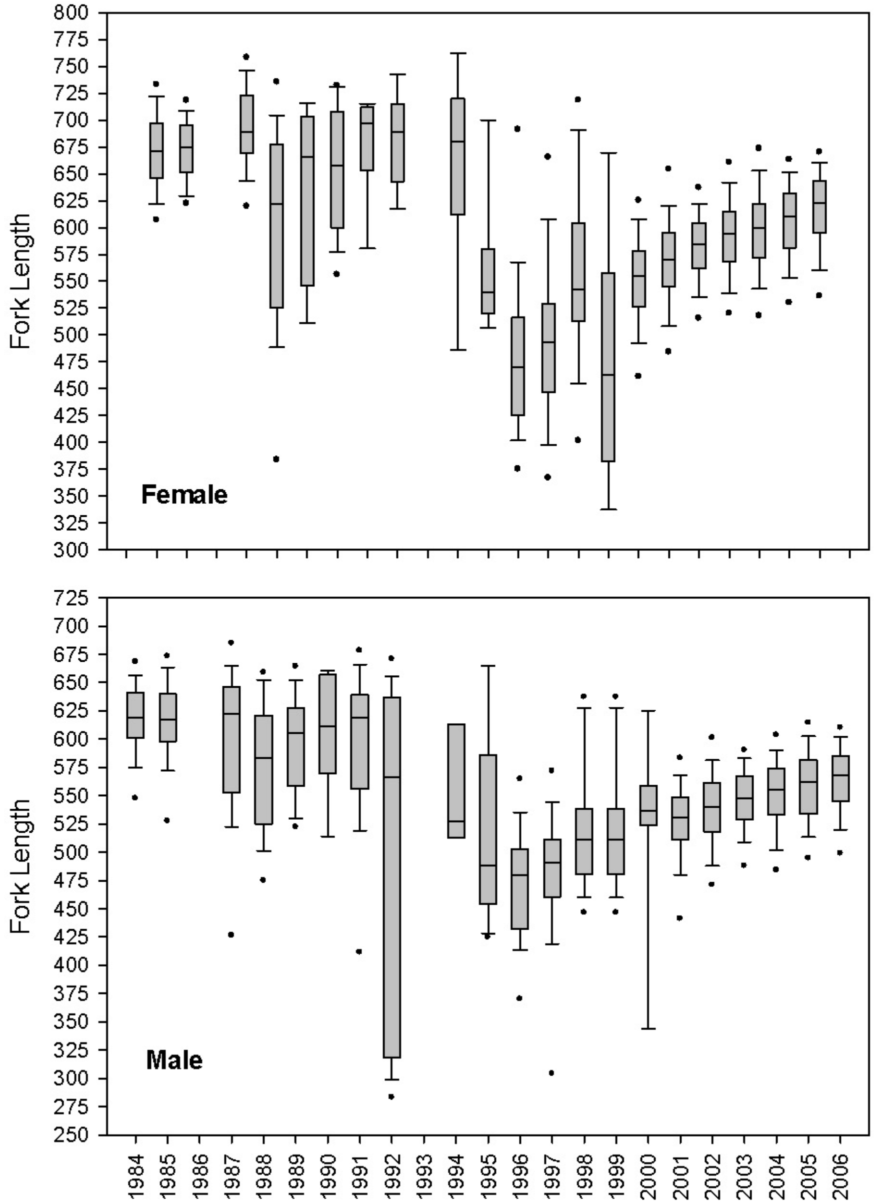


Figure 11-1 Size distribution comparison of Lost River suckers collected in the Sprague and Williamson rivers between 1984 and 2006

(Data Source: Janney and Shively 2007, extracted from BOR 2007)

Note: Lower and upper boundaries of a box correspond to the 25th and 75th percentile of the size distribution. The horizontal line dividing a box corresponds to the median size, the lower and upper whiskers represent the 10th and 90th percentiles, and the diamonds show the 5th and 95th percentile.

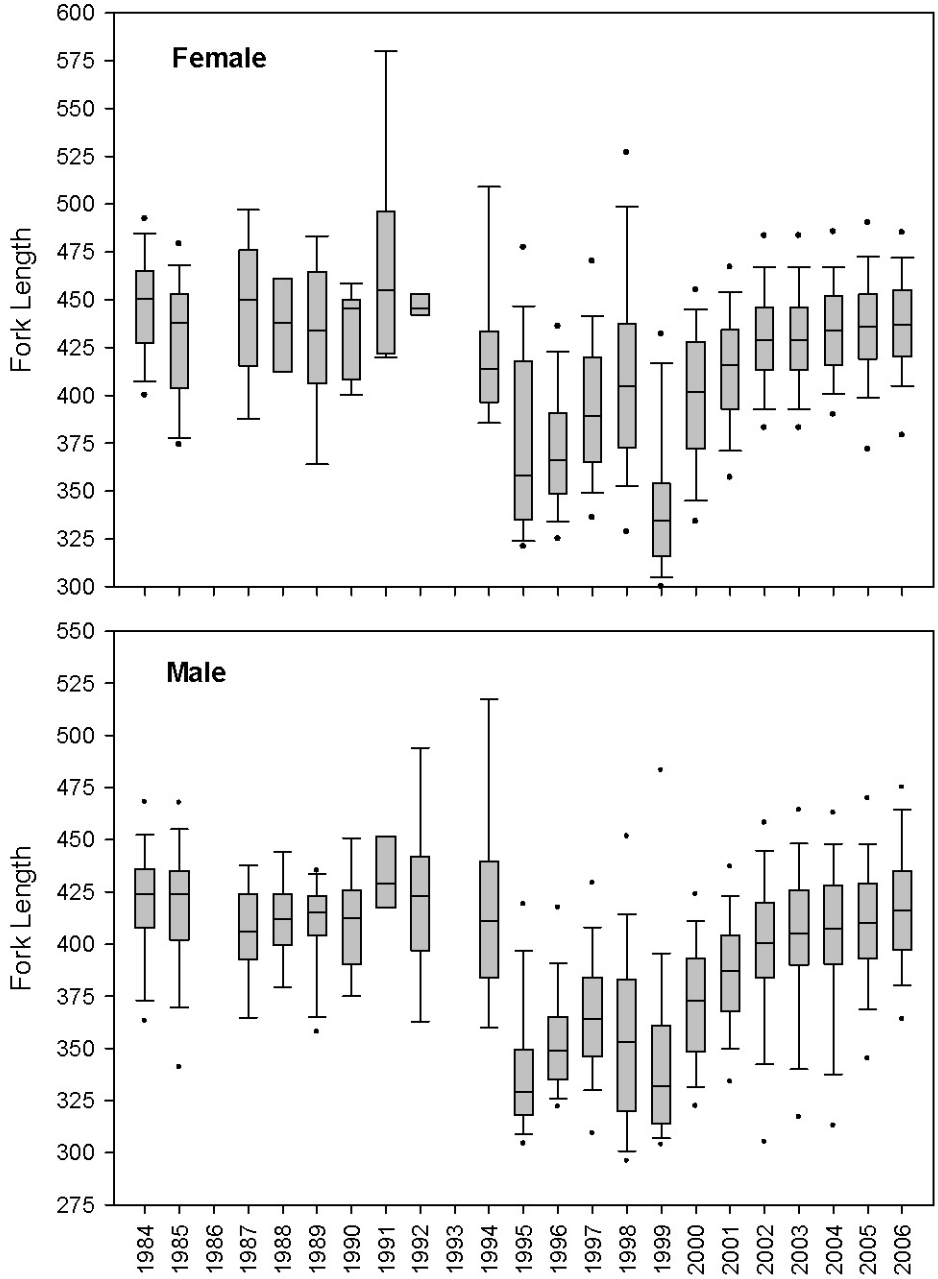


Figure 11-2 Size distribution comparison of shortnose suckers collected in the Sprague and Williamson rivers between 1984 and 2006
(Data Source: Janney and Shively 2007; extracted from BOR 2007)

Note: Lower and upper boundaries of a box correspond to the 25th and 75th percentile of the size distribution. The horizontal line dividing a box corresponds to the median size, the lower and upper whiskers represent the 10th and 90th percentiles, and the diamonds show the 5th and 95th percentiles.

Other Fish Species

Brook trout (*Salvelinus fontinalis*) are widely distributed, but not native to the Lower Sprague-Lower Williamson subbasin. Brook trout occur mainly in cool, well-oxygenated water in small to medium-sized rivers and lakes. They feed primarily on benthic invertebrates, insects and small fish. Life span for brook trout typically extends for seven years, although 15-year-old introduced brook trout have been reported in California (Froese and Pauly 2006).

Brown trout (*Salmo trutta*) prefer cold spring-fed streams, similar to bull trout. Brown trout feed on small fish and insects. Sexual maturity is reached after three years, and spawning occurs in the fall (October through November). Fry typically emerge in March (USFS 2006)

Miller Lake lamprey (*Lampetra minima*) are the world's smallest predatory lamprey, reaching 3 to 6 inches in length. Like Pacific lamprey, adults are parasitic, while the larval form (ammocoetes) are filter feeders. They are endemic to the Lower Sprague-Lower Williamson subbasin and were believed to be extinct until rediscovered in 1992 in the upper Williamson River (ODFW 2004b). They are federally listed as a species of concern because of their limited geographic distribution and evolutionary uniqueness, although the population is currently considered stable and not immediately threatened (ODFW 2004b).

Pit-Klamath brook lamprey (*Lampetra lethophaga*) are nonmigratory lampreys that are native to the Lower Sprague-Lower Williamson subbasin. They inhabit riffles and runs in stream that are low in suspended sediment. Ammocoetes occur in proximity to weed beds and sandbars. Unlike the Pacific lamprey, these fish are nonparasitic (Froese and Pauly 2006).

Klamath river lamprey (*Lampetra similis*) are nonmigratory lamprey native to the Klamath River and Upper Klamath Lake. They are a parasitic species that inhabit large rivers, impoundments and lakes (Froese and Pauly 2008).

Tui chub (*Gila bicolor*) are native fish that inhabit lake and vegetated mud- or sand-bottom pools of small creeks to large rivers. There are many subspecies of tui chub that occur throughout its range in Washington, Oregon, Idaho, Nevada and California. *Gila bicolor bicolor* is the subspecies found in the Klamath Basin (Froese and Pauly 2006).

Blue chub (*Gila coerulea*) are native fish that inhabit rocky pools of creeks and small to large rivers, and rocky shores of lakes and impoundments. The primary range of this species is the Klamath and Lost river systems in Oregon and California (Froese and Pauly 2008).

Fathead minnow (*Pimephales promelas*) are found in the Lower Sprague-Lower Williamson subbasin. These fish inhabit muddy pools of headwaters, creeks and small rivers and are also found in ponds and lakes. They tolerate unsuitable conditions including turbid, hot, poorly oxygenated and intermittent streams. They feed on detritus and algae. Fathead minnows can be an important forage species for co-existing larger fish (Froese and Pauley 2008).

Brown bullhead (*Ameiurus nebulosus*) are not commonly found in the Lower Sprague-Lower Williamson subbasin. These bottom-dwelling fish were introduced to the subbasin. They utilize a wide variety of food sources including benthic invertebrates, insects, algae, small fish and fish eggs. Brown bullhead are able to withstand low dissolved oxygen concentrations and temperatures up to

89° F. As defense against adverse environmental conditions, brown bullhead have been observed to bury themselves in the mud (Froese and Pauly 2006).

Speckled dace (*Rhinichthys osculus*) are native fish found in a wide variety of stream habitats, including riffles, runs and pools of headwater creeks and medium-sized rivers. Speckled dace can be an important forage species for co-existing larger fish (Froese and Pauly 2006).

Other fish that have been found in the Lower Sprague-Lower Williamson subbasin include bluegill, brown bullhead, largemouth bass, marbled sculpin, yellow perch and slender sculpin.

The above list of fish includes both native and non-native species. The following fishes are native to this subbasin: Miller Lake lamprey, Pit-Klamath brook lamprey, Klamath river lamprey, Tui chub, blue chub, speckled dace, marbled sculpin and slender sculpin. The non-native fish species inhabiting this subbasin include: brook trout, brown trout, brown bullhead, fathead minnow, bluegill and brown bullhead. Two additional fish species within this subbasin, largemouth bass and yellow perch, are considered invasive. A non-native species is one that would not naturally occur within the local river drainages. The non-native species will use similar resources as the native species, but not necessarily outcompete the native species. In contrast, an invasive species will outcompete the native species, thereby causing damage to the native fish populations through a reduction in available resources and sometimes due to predation of the native fish species.

AQUATIC HABITAT

Introduction

The characteristics that define habitat suitability differ from species to species and from habitat to habitat. In general, parameters of habitat suitability reflect the needs of a species for food, water, cover, reproduction, and social interactions (Young and Sanzone 2002). Such needs are fulfilled through aspects of the physical, chemical and biological environment, including water temperature, dissolved oxygen, flow velocity, substrate type, and the presence of predator, prey and competitor species.

Appropriate habitat conditions in upland streams (headwater reaches) would include adequate shading of the stream channel, an abundance of large woody debris (LWD) and deep pools, intact riparian vegetation that includes large-diameter trees, adequate in-stream gravel conditions, an absence of passage barriers and the availability of off-channel refugia. In lowland locations (main-stem reaches), additional important habitat conditions would include stream sinuosity, connection to freshwater wetlands, floodplain functionality, deep channels and serviceable riparian vegetation (WPN 1999). The importance of springs and inflow from coldwater tributaries is not completely known for the Lower Sprague-Lower Williamson subbasin, but research indicates that they provide important seasonal thermal refugias during summer peaks in temperature (Ebersole et al. 2001, Torgersen et al. 1999, Matthews and Berg 1997).

There is a large gap in the information available for aquatic habitats in the Lower Sprague-Lower Williamson subbasin. Available information primarily focuses on headwater reaches within the areas managed by the U.S. Forest Service. ODFW has conducted stream surveys on the North Fork and main stem of Trout Creek (Map 11-4).

Distribution and abundance of fish varies with habitat conditions. Many fish utilize different locations of a stream network for different parts of their life cycle. Habitat requirements differ somewhat from species to species. Nevertheless, healthy populations of native trout species are generally associated with the following habitat characteristics:

- Cool, clean, well-oxygenated water;
- Unobstructed access to spawning grounds;
- Clean, stable spawning gravel;
- Winter off-channel refuge habitat for juveniles;
- Complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- Deep pools;
- Stream channels with an abundant supply of LWD;
- Abundant food supply;
- Adequate summer stream flows;
- Diverse, well-established riparian plant communities (Quinn 2005, Biosystems 2003, Behnke 2002, WPN 1999).

The habitat requirements for rainbow trout are summarized in Table 11-3 (NRCS 2000).

The data for the surveyed reaches in the Lower Sprague-Lower Williamson subbasin are limited and a few years old. Streams are dynamic, and channel features may change dramatically from year to year, depending on climatic conditions. Thus, conditions today may vary considerably from those that prevailed in the early 1990s. Also, the effects of restoration work performed in the past decade, particularly road repair, streambank stabilization and increased riparian vegetation, are not reflected in the survey data presented here.

Table 11-3 Summary of rainbow trout habitat requirements (Data Source: NRCS 2000)

Habitat Component	Habitat Requirements
General	• Cold creeks, rivers, cool lakes; include oceans and estuaries for steelhead • Complex array of in-stream wood, boulders, undercut banks • Provisions for fish passage to the extent possible throughout the watershed
Food	*Aquatic food items:* • Larval and adult insects (mayflies, stoneflies, caddis flies), worms, crayfish, plankton, snails, leeches • Small fishes, fish eggs *Terrestrial food items:* • Grasshoppers, ants, beetles
Spawning Habitat	• Riffles in tributaries of rivers and inlet or outlet streams of lakes
Cover	• Undercut banks, overhanging riparian vegetation, turbulent or deep water, aquatic weed beds, submerged or semi-submerged logs, boulders, rock piles, or root masses
Interspersion	• Stream habitat: Complex of cool, clean water; undercut banks with overhanging riparian vegetation; slow-flowing shallow to deep pools; riffles in high-velocity water; gravel substrate of one-inch to three-inch diameter gravels or pebbles; aquatic weed beds; and submerged or semi-submerged logs, rock piles, and root masses that provide shelter • Lake habitat: Complex of moderately deep to deep, cool water, shallows, vegetation, and unimpeded access to inlet or outlet streams

Potential Barriers to Fish Passage

The available information suggests that there are major concerns with fish passage. Many fish species migrate seasonally within the stream network. However, the ability of fish to move up and down the stream system has been impeded by roads and culverts in some locations. The degree of impedance is not known. Migration may also be inhibited by low-flow conditions and elevated water temperatures (Behnke 2002). Unscreened diversion may pose an additional hazard to migrating and rearing fish.

For the tributaries of the Lower Sprague and Lower Williamson rivers, there are potential barriers to fish passage in the form of culverts (Map 11-3). These potential barriers are largely in the form of road/stream crossings.

At most crossings, the stream is routed through a culvert. Culverts may block passage of juvenile and in some cases adult migratory fish. The extent of blockage is a complex function of several factors, including fish species, life stage, velocity of water in the culvert, the height that a fish must jump to reach the lower end of the culvert from the stream immediately below the culvert, and the depth and length of the pool below the culvert from which the fish must jump (Biosystems 2003). Some of these conditions vary with season and with weather and flow conditions. Some species can jump higher than others. Adult fish can often make a jump that would prevent juvenile fish passage.

For such reasons, a culvert may be passable under some conditions, but be impassable under other conditions.

In order to determine which of the culverts shown in Map 11-3 actually constitute barriers to fish passage, it would be necessary to survey the culverts in the field and make a series of measurements at each. ODFW has conducted such surveys at the locations in Map 11-3. The U.S. Forest Service also conducts culvert assessments. In 2007, a culvert on the North Fork of Trout Creek and one on the South Fork of Trout Creek were replaced by the U.S. Forest Service. The new culverts are adequately sized to allow for fish passage and to contain high-flow runoff events.

In addition to the road/stream crossing issues, the Chiloquin Dam posed a large barrier for fish passage (Map 11-3). Although the dam was equipped with a fish ladder, the ladder was not designed appropriately to allow adequate fish passage. The Chiloquin Dam was removed in the summer of 2008. This dam removal will potentially restore fish passage on the lower main stem of the Sprague River.

Before it was removed along with Chiloquin Dam, the fish ladder was a good research site. In particular, suckers entering the fish ladder were captured, studied and released by the Klamath Tribes, U.S. Geological Survey (USGS) and other agencies. Some of this data is presented in Figures 11-3, 11-4 and 11-5. Studies of the Lost River and shortnose suckers have been conducted to determine their habitat requirements, including minimum and maximum conditions and migration patterns. A subsample of the passive integrated transponder (PIT)-tagged suckers are radio tagged, and then their movements are tracked. Figures 11-3 and 11-5 show the movement of radio-tagged suckers in relation to the water temperature in the Lower Williamson and Lower Sprague rivers. Figure 11-4 illustrates the number of suckers caught in the Chiloquin Dam fish ladder during the 2000 through 2006 spawning seasons. Over this seven-season period, there was an increase in the number of shortnose and Lost River suckers located in the Chiloquin Dam fish ladder. There was a particularly high number of Lost River suckers during the 2006 season.

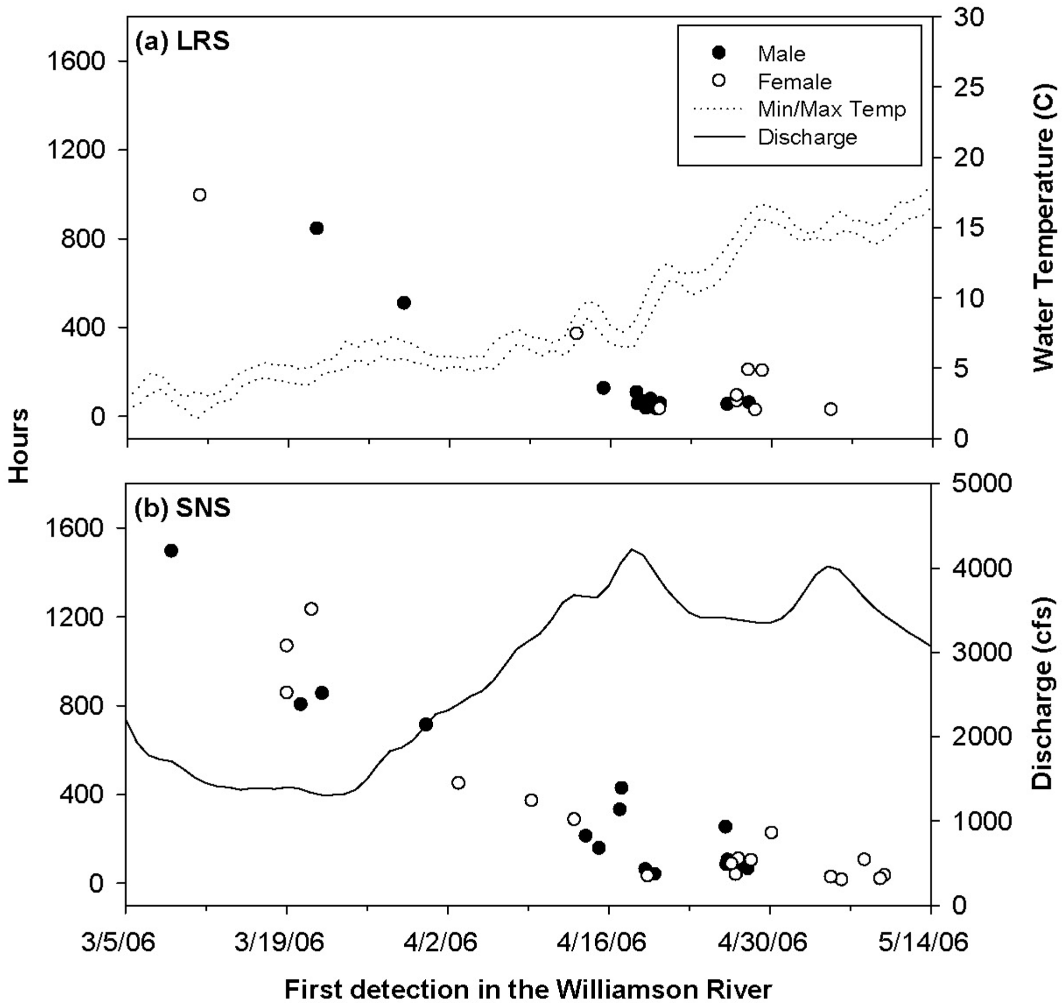


Figure 11-3 Time elapsed (h) between first detection of an individual radio-tagged (a) Lost River sucker (LRS) and (b) shortnose sucker (SNS) at the Lake Remote Station (rkm 0) near the mouth of the Williamson River and when it crossed the Williamson River fish weir moving upstream in 2006. Daily minimum and maximum water temperature for the Williamson River taken at the weir (a) and discharge as measured for the Williamson River at USGS gage 11502500 (b) are also shown

(Data Source: Extracted from Ellsworth et al. 2007)

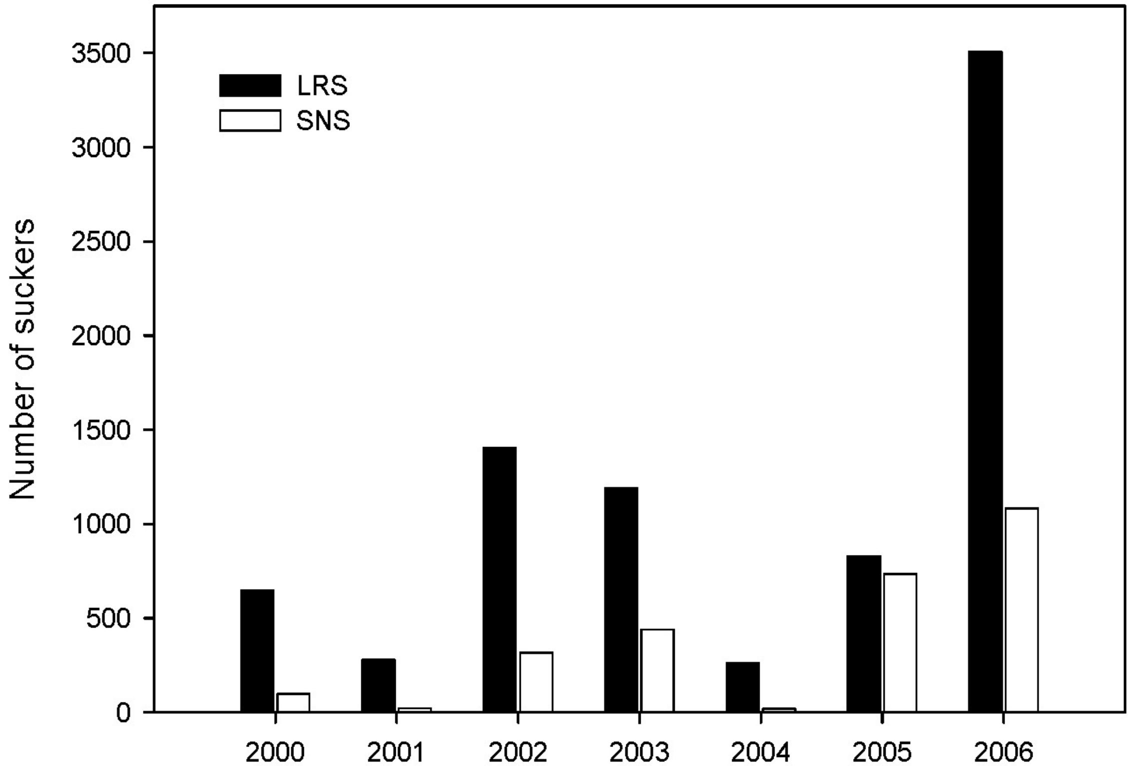


Figure 11-4 The bars represent the total number of Lost River suckers (LRS) and shortnose sucker (SNS) sampled in the Chiloquin Dam fish ladder during spawning seasons from 2000 through 2006.
(Data Source: Janney et al. 2006)

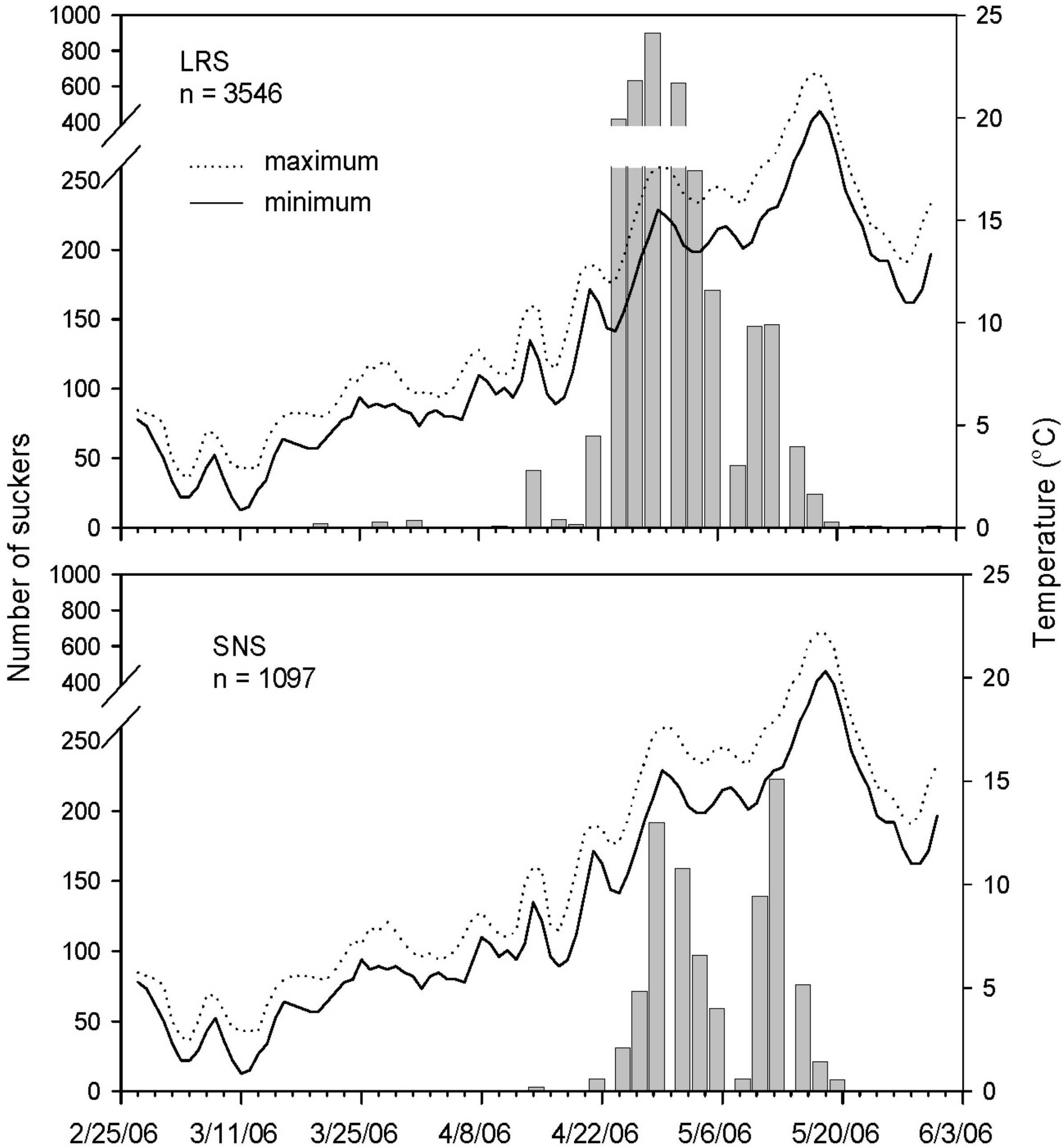


Figure 11-5 This is the summary of Lost River sucker (LRS) and shortnose sucker (SNS) catch and daily minimum and maximum water temperature (solid and dotted lines, respectively) at the Sprague River Dam fish ladder near Chiloquin, Oregon. The catch data include recaptures.
(Data Source: Janney et al. 2006)

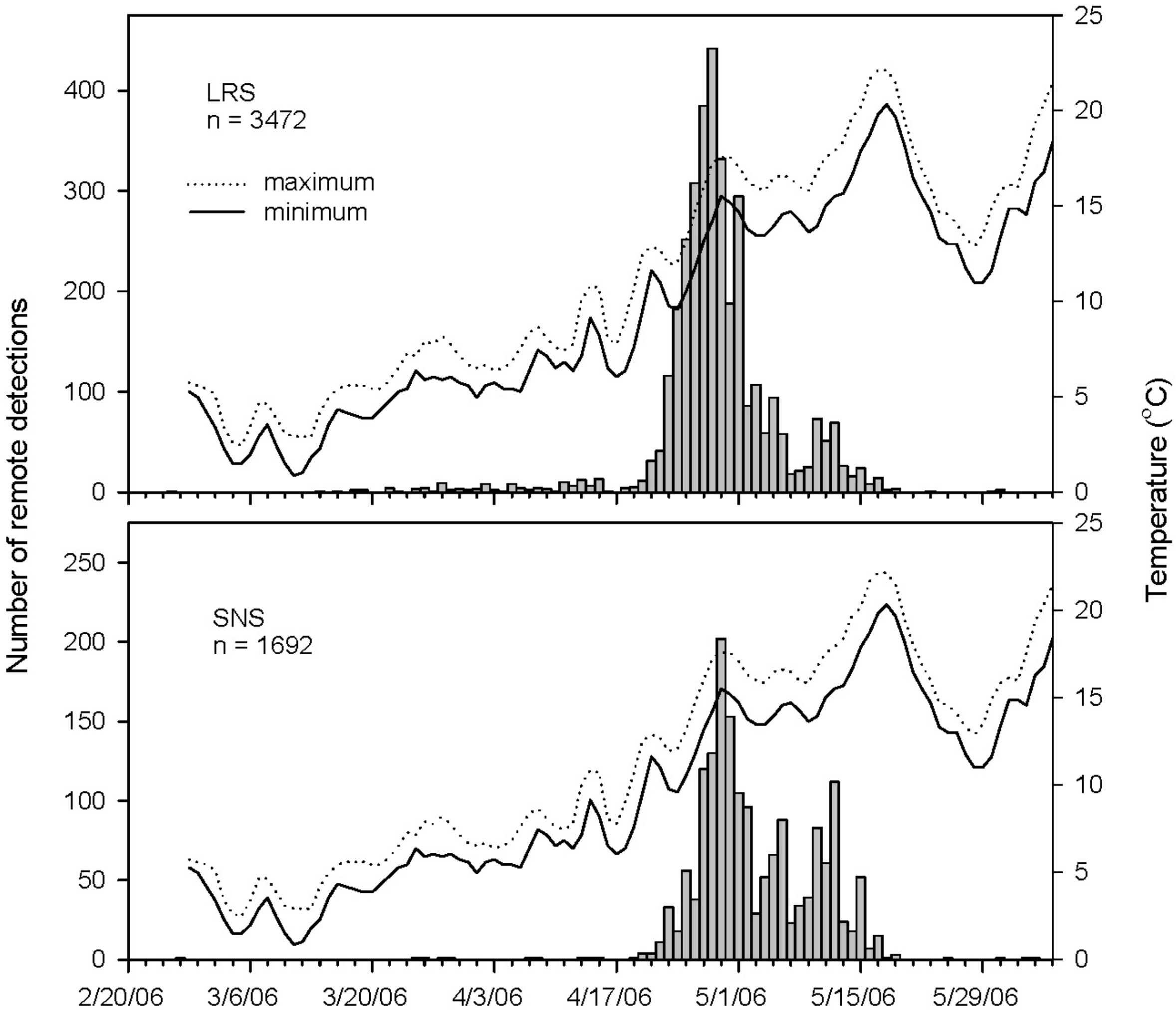
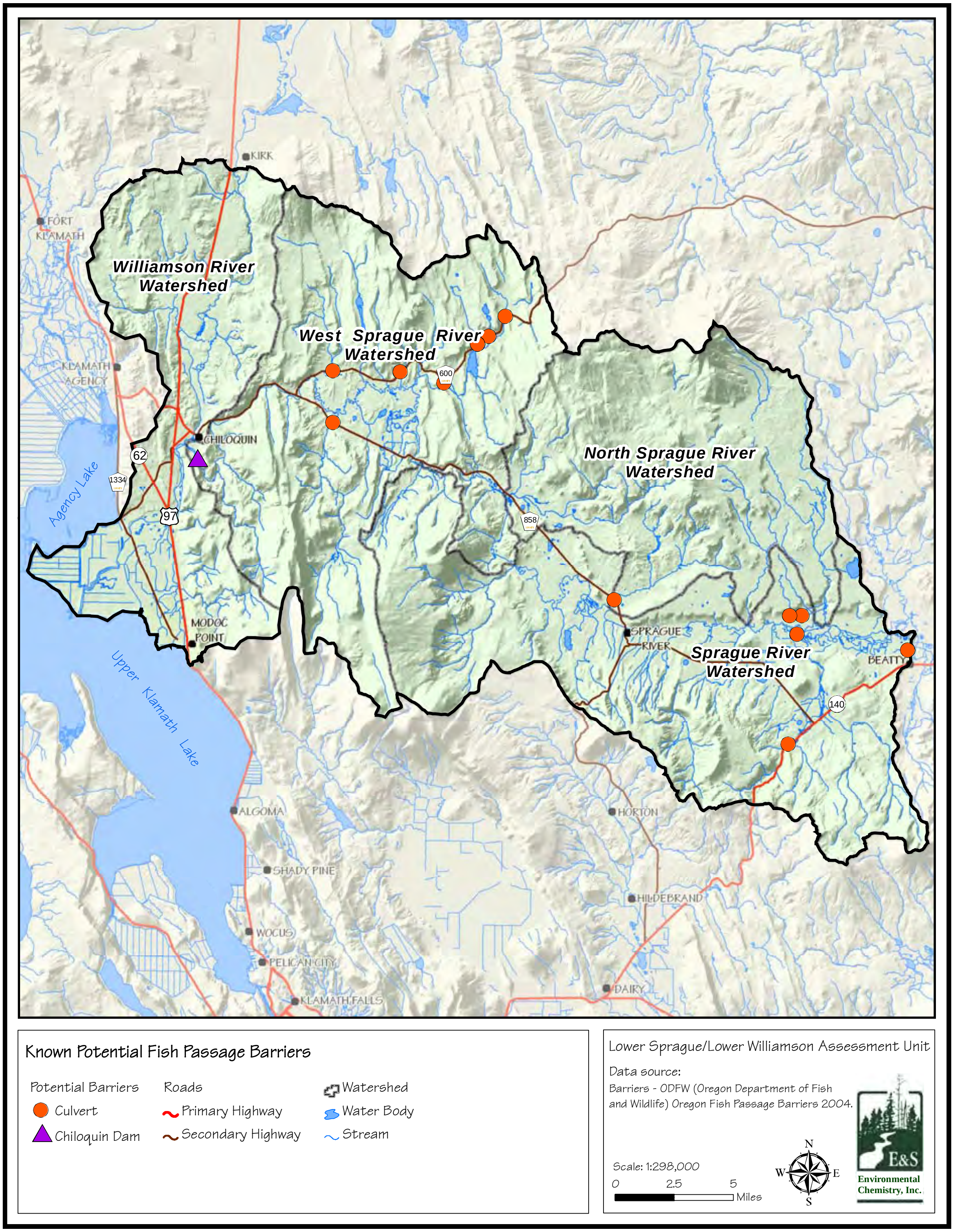


Figure 11-6 This is a summary of the first remote detection of individual LRS and SNS on the downstream antenna at the Sprague River Dam fish ladder near Chiloquin, Oregon, and daily minimum and maximum water temperature (solid and dotted lines, respectively). Note the change in scale on the left Y axis

(Data Source: Janney et al. 2006)



Map 11-3 Known potential fish passage barriers in the Lower Sprague-Lower Williamson subbasin
(Data Source: ODFW 2004b)

In-Stream and Riparian Habitat

Analysis of ODFW Survey Data

To access current in-stream habitat conditions within the Lower Sprague-Lower Williamson subbasin, fish habitat survey data collected according to the ODFW protocols have been compiled. To interpret the habitat survey data, ODFW has established statewide benchmark values as guidelines for an initial evaluation of habitat quality (Table 11-4). The benchmarks rate habitat characteristics as "good," "fair," or "poor." The use of the numerical standards in these benchmarks should take into consideration the potential of the riparian-wetland areas and associated stream types. Different stream types located in different positions in the watershed produce varied habitat characteristics. For stream reaches that have the potential to produce the desired benchmarks, the numbers can be used directly. If not, an interdisciplinary team uses knowledge and experience to understand the physical function as well as appropriate desired habitat characteristics. The benchmarks and fish habitat assessment are designed to look at combinations of habitat characteristics rather than to single out an individual numerical standard. This approach is meant to help identify patterns within these characteristics that can then be interpreted in a broader watershed context.

Aquatic habitat is created and maintained when the physical processes are functioning. Streams and their associated riparian areas are shaped by watershed processes through adjustments to handle the water and sediment load delivered by the watershed. Proper functioning condition (PFC) is a state of resiliency that will allow a riparian-wetland area to hold together during frequent events, such as the 5-, 10- and 20-year events, with a high degree of reliability. This resiliency allows an area to then produce, over time, desired values such as fish habitat or neotropical migratory bird habitat. This happens through the interaction of soil/landform, vegetation and water. Healthy riparian-wetland areas are typically characterized by vigorous and diverse riparian plant communities that have the root structure and mass necessary to resist the erosive forces of water and sediments, or in forested reaches that provide for the recruitment of large woody material to the stream channel to accomplish the same thing. If a riparian-wetland area is lacking in these critical attributes, it will not be resilient to normal variations in water and sediment loads, and aquatic habitat will likely be negatively impacted.

Recovery of aquatic habitat starts with recovery of physical function—acquiring the right element or elements to dissipate energy (adequate landform, vegetation or large woody material), which puts the physical process into working order and provides the foundation to create and maintain the necessary combination of habitat characteristics. Once the stream reach has "fair" or "poor" habitat quality characteristics and has the potential for recovery, understanding the physical functions and trend over time can help develop adaptive management and monitoring scenarios that take advantage of droughts and floods. Trend over time is the tie between current conditions and desired habitat.

To obtain a complete picture of riparian-wetland health, including both physical and biological sides, one must have information on both physical status, provided through PFC assessment, and biological habitat quality, provided through habitat assessments or inventories. Neither will provide a complete picture when analyzed in isolation. As stated earlier, an interdisciplinary team must make interpretations on both types of assessments based on the potential of each site, helping to determine linkages between desired conditions and the stream reach or watershed processes that produce the desired conditions.

ODFW has surveyed five reaches on North Fork Trout Creek and two reaches on Trout Creek (Map 11-4). This survey encompassed approximately four miles of stream. It is important to note that only a very small percentage of the overall stream habitat in the subbasin has been surveyed by ODFW for habitat conditions. Furthermore, the streams that were surveyed are clustered in one location within the subbasin. Thus, stream habitat conditions summarized here represent very little of the overall habitat and may or may not be similar to conditions in reaches that were not surveyed. The condition of in-stream habitat is dynamic, and although watershed-scale assessments can provide information useful for prioritizing restoration activities, all sites should be field-verified before specific restoration actions are planned.

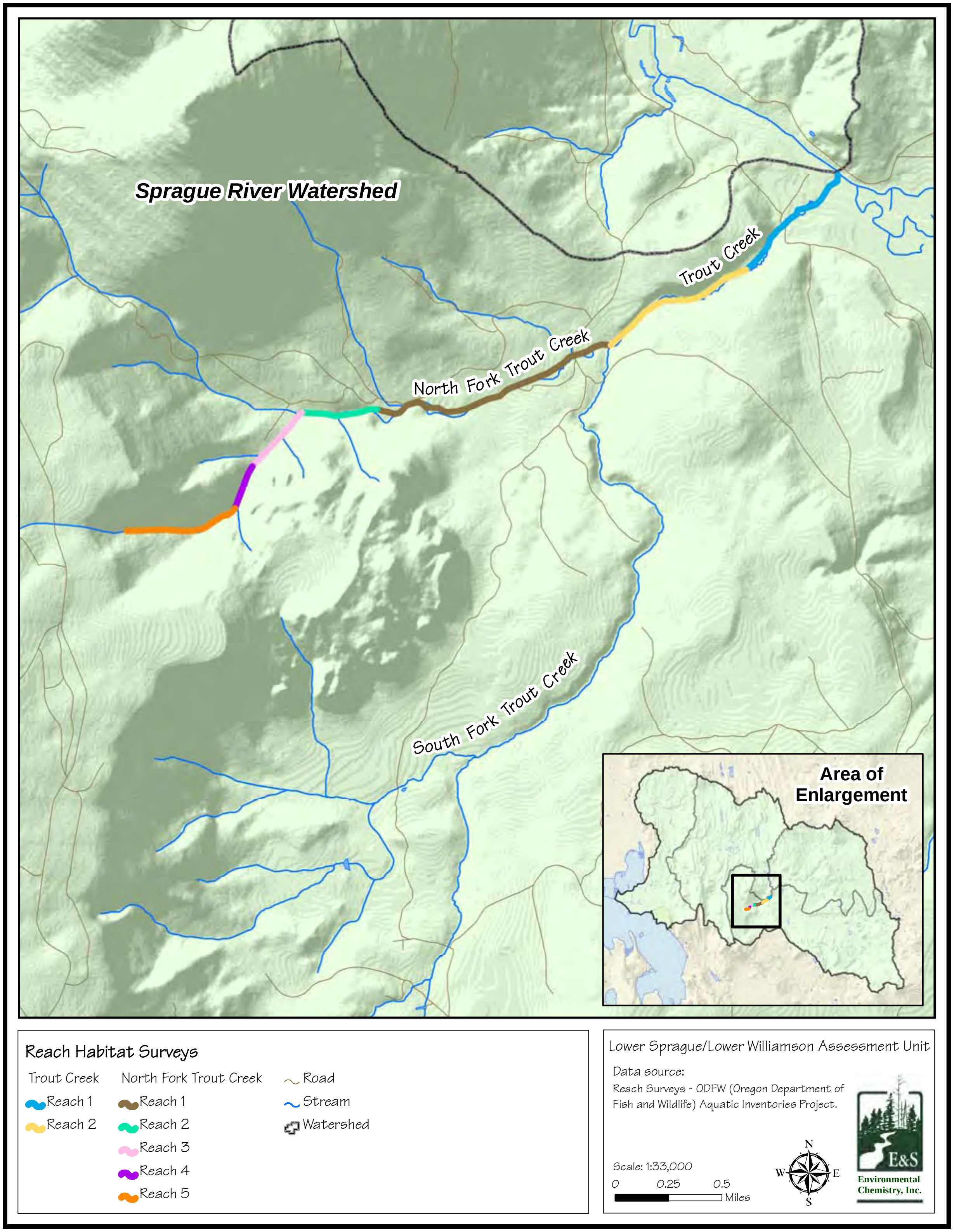
Table 11-4 summarizes important measures of stream habitat for pools, riffles and LWD, following OWEB guidelines and ODFW benchmarks. For the stream reaches surveyed within the Trout Creek drainage, reach ratings are shown for each of the summarized stream habitat characteristics (Tables 11-5 through 11-8).

For pools and pool characteristics, North Fork Trout Creek received primarily poor ratings, whereas Trout Creek rated fair to good. Overall, for gravel in riffles and width-to-depth ratio, the reaches rated primarily good. For silt and organics, the reaches rated mostly poor. Stream shading was rated from poor to good with a range of percent shade from 17 to 88. There was a large amount of variation within the degree of shading from one reach to the next.

Table 11-4 Stream habitat survey benchmarks
(Data Source: WPN 1999)

Habitat Characteristic	Measurements Used for Rating Habitat Quality	Benchmark Values		
		Good	Fair	Poor
Pools	**Percent area in pools:** percentage of the creek area that has pools	> 35	10 - 35	< 10
	Residual pool depth: depth of the pool (m), from the bottom of the pool to the bottom of the streambed below the pool	> 0.5	0.2 - 0.5	< 0.2
	Pool frequency: channel widths between pools	5 - 8	other	> 20
Riffles	**Width-to-depth ratio:** width of the active stream channel divided by the depth at that width	< 10	10 - 30	> 30
	Percent gravel in the riffles: percentage of creek substrate in the riffle sections of the stream that are gravel	> 35	15 - 35	< 15
	Percent sediments in the riffles: percentage of creek substrate in the riffle sections of the stream that are sediments (silt, sand and organics)	< 8	8 - 15	> 15
Riparian	**Dominant riparian species:** hardwoods or conifers	large diameter conifers	medium diameter conifers & hardwoods	small diameter hardwoods
	Percent of the creek that is shaded	> 50	40 – 50	< 40
Large Woody Material in the Creek	**Number of wood pieces**[1] per 100 m (328 ft) of stream length	> 20	10 - 20	< 10
	Volume of wood (cubic meters) per 100 m of stream length	> 30	20 - 30	< 20

[1] Minimum size is 6-inch diameter by 10-foot length or a root wad that has a diameter of 6 inches or more.



Map 11-4 Stream reaches surveyed by ODFW within the Lower Sprague-Lower Williamson subbasin
(Data Source: ODFW 2004a)

Table 11-5 Pool habitat conditions in a portion of the Lower Sprague-Lower Williamson subbasin, based on ODFW survey data for a portion of the Sprague River watershed (Data Source: ODFW 2004a)

Stream	Reach	Percent Pools	Rating	Residual Pool Depth (m)	Rating	Pool Frequency (Channel Widths/ Pool)	Rating
North Fork Trout Creek	1	4.7	Poor	0.1	Poor	54.3	Poor
	2	8.5	Poor	0.2	Fair	31.6	Poor
	3	8.1	Poor	0.1	Poor	5.4	Good
	4	4.6	Poor	0.2	Fair	3.8	Fair
	5	0	Poor	0	Poor	0	Fair
Trout Creek	1	88.8	Good	0.2	Fair	7.1	Good
	2	18.9	Fair	0.2	Fair	13.4	Fair

Table 11-6 Riffle habitat conditions in portion of the Lower Sprague-Lower Williamson subbasin, based on ODFW survey data for a portion of the Sprague River watershed (Data Source: ODFW 2004a)

Stream	Reach	Gravel in Riffles (% area)	Rating	Width-to-Depth Ratio	Rating	Silt-Sand-Organics (% area)	Rating
North Fork Trout Creek	1	40	Good	5	Good	53	Poor
	2	20	Fair	5	Good	75	Poor
	3	20	Fair	8	Good	64	Poor
	4	25	Fair	8	Good	59	Poor
	5	0	Poor	11	Fair	0	Good
Trout Creek	1	28	Fair	9	Good	54	Poor
	2	13	Poor	10	Fair	45	Poor

Table 11-7 Stream shade and riparian vegetation condition in a portion of the Lower Sprague-Lower Williamson subbasin, based on ODFW survey data for a portion of the Sprague River watershed
(Data Source: ODFW 2004a)

Stream	Reach	Shade (Average %)	Rating	Dominant Riparian Vegetation [1]	Sub-Dominant Riparian Vegetation [2]	Rating (Dominant Veg.)
North Fork Trout Creek	1	32	Poor	G	C50	Poor
	2	48	Fair	G	M50	Poor
	3	45	Fair	G	M50	Poor
	4	74	Good	G	C50	Poor
	5	88	Good	G	C50	Poor
Trout Creek	1	18	Poor	G	S	Poor
	2	24	Poor	G	C50	Poor

[1] G - Annual grasses, herbs and forbs
[2] C50 - Coniferous dominated (canopy more than 70% conifer); mature timber; developing understory of trees and shrubs
M50 - Mixed conifer/deciduous (approx. 50/50); mature timber; developing understory of trees and shrubs
S - Shrubs (willow, salmonberry, some alder)

Table 11-8 Summary of stream survey ratings in the Lower Sprague-Lower Williamson subbasin, based on ODFW survey data for the Sprague River watershed
(Data Source: ODFW 2004a)

Stream	Reach	Stream Miles	Gradient (%)	Average Condition Rating			
				Pools	Riffles	LWD	Riparian
North Fork Trout Creek	1	1.2	1.5	Poor	Fair	Poor	Poor
	2	0.4	2.4	Poor	Fair	Fair	Fair
	3	0.3	2.1	Fair	Fair	Fair	Fair
	4	0.2	2.7	Fair	Fair	Fair	Fair
	5	0.5	17.1	Poor	Fair	Fair	Fair
Trout Creek	1	0.6	0.5	Good	Fair	Poor	Poor
	2	0.7	1.4	Fair	Poor	Poor	Poor

DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies. This information in this Assessment should be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data is determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly divergent from the source information may result in errors or inaccuracies. This data is presented at the watershed scale, and may not be detailed enough for the farm or ranch planning scale.

DATA GAP

It is important to note that while the stream surveys discussed in this chapter may adequately reflect the Trout Creek drainage, it is not possible to extrapolate these generalities to other stream reaches within the subbasin. A large data gap for this subbasin is the lack of stream habitat survey data.

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CHAPTER 12. TERRESTRIAL WILDLIFE SPECIES AND HABITAT

INTRODUCTION

The Lower Sprague-Lower Williamson subbasin is noteworthy from a wildlife perspective because it contains a high diversity of species and because it is home to species that are considered rare or deserving of special conservation status. Both of these factors are due, at least in part, to the location of this subbasin at the intersection of five different ecological regions, or ecoregions.

In particular, riparian areas and wetlands in the subbasin support a high diversity of wildlife species. Healthy riparian areas and wetlands can provide healthy habitats for wildlife. Key issues that limit wildlife diversity include a reduction in vegetation complexity (multiple vegetation layers, including large trees), scarcity of snags and downed logs, and increasing abundance of noxious invasive plants.

Overall biotic condition is reflected in the condition, health and viability of populations of all native species within the watershed. Characterizing and monitoring all species is not possible from a practical standpoint. Resource managers therefore focus attention on species whose presence or absence reflects the health of the ecosystem; on special status species, including those listed as Threatened or Endangered; and on game species.

Because the Lower Sprague-Lower Williamson subbasin lies near the intersection of five different ecoregions, it is not surprising that the area supports a wealth of animal diversity. It is estimated that over 200 species of vertebrates occur in, or have been extirpated from, the assessment area. Table 12-1 summarizes the number of species closely associated with major habitat types in the assessment area.

Table 12-1 Comparison of vertebrate species richness among 12 habitat types in the Lower Sprague-Lower Williamson subbasin
(Data Sources: O'Neil et al. 2001, NHI 2000)

Habitat Type	Vertebrate Class				Total
	Amphibians	Reptiles	Birds	Mammals	
Agriculture, Pasture and Mixed Environs	12	10	103	46	171
Dwarf Shrub-steppe	5	16	32	19	72
Eastside (Interior) Mixed Conifer Forest	8	10	51	39	108
Herbaceous Wetlands	13	4	90	24	131
Lodgepole Pine Forest and Woodlands	7	11	33	21	72
Montane Coniferous Wetlands	9	1	19	27	56
Montane Mixed Conifer Forest	21	3	45	37	106
Open Water	9	2	69	11	91
Ponderosa Pine and Eastside White Oak Forest and Woodlands	11	19	44	27	101
Shrub-steppe	8	18	49	32	107
Urban and Mixed Environs	15	14	57	40	126
Western Juniper and Mountain Mahogany Woodlands	5	14	31	13	63

FORESTS AND WOODLANDS

Wildlife Diversity and Function

The composition and structure of forests and woodlands in the Lower Sprague-Lower Williamson subbasin are highly variable as a result of variations in topography, climate, elevation and patterns of natural disturbance. "Generalist" species of wildlife can be found throughout many forest types in the assessment area, whereas "indicator" species have a narrow ecological tolerance for certain types or successional stages. For example, white-headed woodpecker is only associated with open-canopy Ponderosa pine, whereas American robin is found in virtually every forest type of the assessment area. However, the distribution and abundance of most species is influenced more by vegetation structure than by generalized vegetation type.

In a review of wildlife-habitat associations in forests east of the Cascades (eastside) in Oregon and Washington, Sallabanks et al. (2001) reported that snags are an important element for 33 percent of vertebrate species inhabiting eastside forests, and downed logs are used by 29 percent of forest wildlife species. Eastside late successional forests (or old-growth forests) have fewer closely associated wildlife species (4) than westside old-growth forests (75) (Sallabanks et al. 2001). In contrast, many species dwelling in eastside forests are closely associated with early successional stages (Sallabanks et al. 2001).

Management Issues

The increasing severity of forest health problems in eastern Oregon results from a number of interacting causes. These causes include drought, insect reproduction cycles, and the effects of past logging practices and fire suppression. Changes to vegetation structure and composition caused by these stressors will affect wildlife communities in a variety of ways, but the response of wildlife assemblages to forest health problems has not been well researched. It is known that some species are well adapted to forests with high volumes of dead wood (e.g., black-backed woodpecker) and are likely to thrive in stands dying from insect outbreaks or disease. In addition, much of the wildlife diversity in the assessment area is associated with early-seral conditions and semi-open canopy forests (Sallabanks et al. 2001), which are less common now than under the natural fire regime. In recent years, forest management by both the U.S. Forest Service and private timber companies has been modified to focus more heavily on improving wildlife habitat.

SHRUBLANDS AND WESTERN JUNIPER WOODLANDS

Shrub-steppe and western juniper woodlands provide habitat for a variety of wildlife species. These arid habitats share many common qualities, but there are some important structural differences. A lack of trees is a defining characteristic of the shrub-steppe vegetation type. This lack of trees results in fewer vegetation layers and associated habitat strata, and a corresponding decrease in wildlife diversity, compared to ponderosa pine or mixed conifer forest. The presence of scattered trees in an open-canopy juniper woodland provides an additional structural element that functions as thermal cover for land animals and roosting habitat for birds.

Wildlife Diversity and Function

There are 107 vertebrate species present in the assessment area that are considered to be associated with shrub-steppe habitats and 63 species associated with western juniper woodlands (Table 12-1). There is considerable overlap in the species composition of these two arid habitat types. Some species are unique to arid shrublands and juniper woodlands, including striped whipsnake (*Masticophis taeniatus)* and Great Basin pocket mouse (*Perognathus merriami).* There are stages to juniper woodland succession. There is the presence of scattered trees, with a shrub and grass understory, which later develops into dense woodland, with a closed canopy and little or no understory. Each stage provides habitat for a different suite of wildlife.

Two taxonomic groups are particularly noteworthy for their ecological importance in arid shrublands and juniper woodlands: (1) reptiles and (2) ground squirrels of the genus *Spermophilus*. Of the 28 native reptile species in Oregon, 21 occur in shrub-steppe habitats (Vander Haegen et al. 2001). This habitat type provides for a greater diversity of reptiles than any other habitat type in the state. Because of their successful adaptation to the environmental extremes that are characteristic of shrub-steppe communities, reptiles can occur in high densities and contribute significantly to the overall biomass available to other trophic levels (Vander Haegen et al. 2001).

Although considered a pest by many ranchers, ground squirrels (e.g., *Spermophilus beldingi, S. lateralis, S. townsendii*), serve several important ecological roles. Ground squirrels provide an important prey base for many snakes, raptors and mammalian carnivores. Furthermore, burrows that are excavated by ground squirrels provide a crucial refuge for a large number of other wildlife species. Finally, soil mixing that results from the burrowing activity of ground squirrels (as well as the badgers pursuing them) improves aeration and water infiltration (Vander Haegen et al. 2001). However, sheet runoff during spring melt can result in sediment deposition to streams from ground squirrel deposits (C. Sokol, pers. comm. November 2005).

Management Issues

In some cases, irrigated grazing pastures result in benefits to certain species by providing additional vegetation for a longer period during the year. In other cases, over-grazing can diminish habitat quality for wildlife that depend upon the vegetation structure of shrubs or feed upon the associated plant species. Research conducted in eastern Oregon by Irwin et al. (1994) has demonstrated that plots exposed to grazing by livestock and elk have, on average, 75 percent less shrub cover than was estimated on plots excluded from grazing. Also, soil disturbance can foster the establishment of cheatgrass and other noxious weeds, decreasing the availability of native plants that wildlife use for cover and forage (Vander Haegen et al. 2001). The wildlife species richness in annual grasslands (such as stands of cheatgrass) is estimated to be only 55 percent of that in native shrub-steppe habitats (Vander Haegen et al. 2001).

It should be noted, however, that some shrub-steppe species do benefit from at least three components of agricultural operations. First, buildings and farm structures are used as shelter by many species of wildlife. Second, edges, fencerows and odd areas are used as feeding sites, nesting habitat and movement corridors by many species. Finally, irrigated fields and reservoirs developed for farms increase water availability, an important life requisite for all wildlife and a limiting factor for many species in arid habitat types. Most non-native animal species that inhabit the assessment area (e.g., bullfrog (*Rana catesbeiana*), European starling (*Sturnus vulgaris*), English sparrow (*Passer domesticus*), and Virginia opossum (*Didelphis virginiana*)) are strongly associated with disturbed habitats.

Open woodland of western juniper has been an important habitat for wildlife through at least the Holocene epoch. Indeed, the American robin and other fruit eaters are the primary agents of seed dispersal for western juniper (Bedell et al. 1993). However, the expansion of dense stands of juniper into shrub and grassland communities (particularly those habitats formerly dominated by sagebrush represents an important threat to wildlife associated with shrub-steppe vegetation. The Prineville District of the Bureau of Land Management (BLM) estimates that open juniper woodlands support 146 species of wildlife; but species richness declines to 71 species when canopy closure excludes shrubs and grasses (Bedell et al. 1993).

RIPARIAN AREAS AND WETLANDS

Wildlife Diversity and Function

Riparian areas and wetlands are characterized by a suite of physical and ecological attributes that foster a high degree of animal diversity. The proximity to water, nutrient deposition via stream or slope, and vegetation heterogeneity all combine to create a variety of ecological niches that wildlife communities are able to exploit. Of the over 200 vertebrate species estimated to occur in the assessment area, 56 species are associated with montane coniferous wetlands, and 131 are associated with herbaceous wetlands (Table 12-1). Riparian areas and wetlands provide the following primary habitat functions:

- Food and water—Riparian areas and wetlands offer an abundance and variety of food for wildlife. The well-developed vertical stratification that is typical of riparian areas in forests offers feeding habitat for understory and canopy foragers. Only a small number of wildlife species can satisfy their entire requirement for water from what is available in their food. Therefore, a large number of upland species regularly visit streams and wetlands to drink.
- Resting/thermal/hiding cover—Vegetation density and complexity of landforms offer many species of wildlife cover from predators and climatic extremes, allowing them to conserve energy. The abundance of downed logs in forested riparian areas provides an important refuge for many amphibians, reptiles and small mammals.
- Breeding and rearing areas—Habitat elements essential to reproduction are often among the most limiting factors to population abundance and long-term persistence. Aquatic habitats, tree cavities, large trees and shrubs are some examples of habitat elements essential for a number of species, including waterfowl and wading birds, to breed. These features tend to be aggregated in riparian areas and wetlands to a greater extent than in surrounding forests and rangelands.

Management Issues

Human land uses tend to be concentrated near streams, wetlands and on floodplains because of the resources found in these habitats, including water supply, productive sites for crops and transportation routes. Riparian areas and wetlands are vulnerable to natural and human-made disturbances because of their susceptibility to upslope and upstream events.

Forestry practices can have a number of impacts on streamside and wetland environments. Clearcut harvesting in riparian areas can lead to increased air and stream temperatures (Fowler et al. 1988, Brown and Krygier 1970) and promote overland transport of sediment into streams under some conditions (Beschta 1978). Research has indicated a number of serious effects on fish, amphibian and small mammal populations as a consequence of these actions (Bunnell et al. 1997). The most serious impacts to forested riparian areas and wetlands are now limited by state forest protection rules for private lands and by BLM and Fremont-Winema National Forest resource management plans for federal lands. Forestry practices can also be used for positive effect such as improving riparian buffers, retaining corridors for habitat connectivity and reforestation following fires.

While proper grazing can provide habitat benefits, uncontrolled grazing in riparian areas and wetlands can eliminate desirable native plants and alter the habitat structure to which wildlife are adapted (Oakley et al. 1985). Heavy grazing in riparian areas and wetlands can also lead to changes in channel morphology and lowered water tables (Oakley et al. 1985). Increasingly, however, managed grazing programs and riparian or wetland exclusion fences are serving to minimize and eliminate these problems.

BIG GAME

Four species classified by the Oregon Department of Fish and Wildlife (ODFW) as big game mammals regularly occur in the Upper Sprague River subbasin: Rocky Mountain mule deer (*Odocoileus hemionus hemionus),* Rocky Mountain elk *(Cervus elaphus nelsoni*), black bear (*Ursus americanus),* and cougar *(Puma concolor).* Pronghorn antelope (*Antilocapra americana*) migrate through the watershed, but there is not a significant population breeding in the assessment area.

Mule Deer

Rocky Mountain mule deer occupy a variety of habitat types, including sagebrush steppe, juniper woodland and semi-open conifer forest. Population densities have fluctuated greatly since Euro-American settlement. Pioneers arriving in eastern Oregon during the early nineteenth century reported a paucity of deer (Verts and Carraway 1998). However, 50 to 75 years later, miners found deer to be abundant (Verts and Carraway 1998). During the 1960s the total statewide population ranged between 510,000 and 570,000 deer (Verts and Carraway 1998). In 2004, the state mule deer population was estimated to be 247,350 (ODFW 2005). In the assessment area, the causes of recent mule deer population declines are believed to be increased closed forest cover and a corresponding decrease in foraging habitat, greater mortality due to predators, encroachment by developments, and increased roadkill (T. Collom pers. comm., 2006). Population estimates specific to the assessment area are not available, but the population in the Interstate Wildlife Unit was believed to be about 7,400 mule deer during spring 2005, much lower than the ODFW management objective for the unit of 14,000 deer (T. Collom, pers. comm. 2006).

ODFW has established two Wildlife Management Units (WMUs) for mule deer. These units include the area north of the Sprague River from Beatty to the Upper Klamath Lake (defined as Sprague WMU) and the south side of Sprague River (defined as the Klamath Falls WMU). The number of mule deer tags issued is adjusted annually dependent on the overwinter survival, recruitment, previous year's harvest and buck-to-doe ratios. In 2008, 600 tags were issued on the Sprague WMU, and 850 on the Klamath Falls WMU. Rifle hunting for mule deer is through a controlled hunt, where hunters must apply for limited tag numbers. Archery hunting is general hunting season, where tags can be purchased over the counter, with no limit on them. The rifle season is a 12-day period at the beginning of October (exact dates vary each year), and the archery season is August 30 to September 28 each year (T. Collom, pers. comm. 2008).

Elk

Elk require landscapes composed of forested cover and forage-producing openings such as prairies, clearcuts or hayfields. Local forestry and agricultural practices can lead to improved or diminished habitat conditions for elk, depending upon the resulting changes to vegetation patterns (ODFW 2003). Elk strongly avoid humans (except in certain areas where they have become habituated to human presence), so hunters, snowmobiles, and other forest recreation can greatly increase elk movement, decrease foraging time and lower survival rates (ODFW 2003). Chronic wasting disease (CWD) is a serious threat to wild elk populations in certain Rocky Mountain and Midwestern states, but the disease has never been detected in Oregon herds since ODFW began surveillance testing in 1996 (ODFW 2003).

ODFW has established general rifle and archery hunts for elk that allow one animal to be harvested per tag. There is also a controlled hunt for either sex in a portion of the Interstate Wildlife Unit, an ODFW hunting unit within the region. ODFW does not conduct systematic surveys for elk, but records observations of the species during annual mule deer surveys (T. Collom, pers. comm. 2006). Population estimates specific to the assessment area are not available, but the Interstate Wildlife Unit is believed to contain approximately 300 elk (T. Collom, pers. comm. 2006).

Black Bear

Black bears are habitat generalists, using many types of forested habitats. Bears tend to shift their activities according to seasonal food availability. Brushy clearcuts are often preferred because of the berry and fruit-producing shrubs that are common in these areas (Verts and Carraway 1998). In eastern Oregon, many black bears are coated in shades of brown, causing a number of mistaken reports of grizzly bears (*Ursus arctos*) each year (ODFW 2005). The last grizzly bear documented in Oregon was killed in Wallowa County on September 14, 1931 (Verts and Carraway 1998).

Open general hunting season in eastern Oregon for black bears is from August through November. Hunters are limited to one bear per tag. There is also a controlled spring hunt for black bears in some ODFW management units, but in 2005 no spring hunts were allowed in the assessment area. ODFW does not conduct regular surveys because of the difficulty of detecting bears. Instead, the department relies on voluntary cooperation by hunters to submit samples of teeth and reproductive tracts from harvested animals for purposes of population analysis. Black bear populations are believed to be increasing across the state. A total of 308 black bears were harvested from ODFW management units east of the Cascade crest in 2003 (most recent data available) (ODFW 2005).

Cougar

Optimum cougar habitat east of the Cascades is characterized by a mosaic of mixed conifer forest, juniper woodland and riparian areas (Verts and Carraway 1998). Steep terrain is usually preferred over more gentle topography. The density of cougar populations is largely determined by the abundance of major prey species, especially deer and elk.

Since 1994, ODFW has allowed unlimited tags for a year-round, statewide cougar hunting season (ODFW 2005). ODFW has established a system of cougar hunting zones with quotas, and hunting is closed in a zone for the remainder of the year when the harvest quota is attained (ODFW 2005). ODFW does not conduct annual surveys for cougars, but does require hunters to have animals they have taken be inspected by ODFW staff so that they may record sex and age data. Based on this information, increased animal damage reports and road-related cougar mortalities, ODFW believes cougar populations have significantly expanded since 1980 (ODFW 2005). Harvests during 2001 to 2003 in the southeastern Cascades cougar hunting zone has averaged 16.3 cougars taken per year (minimum = 12 cougars, maximum = 21 cougars).

THREATENED, ENDANGERED AND SENSITIVE ANIMAL SPECIES

Table 12-3 lists species with special conservation status that may be likely to occur in the Lower Sprague-Lower Williamson subbasin. A short description of each species is provided below.

Table 12-4 lists the federally threatened and candidate species located on Fremont-Winema National Forest lands. No endangered wildlife species occur within this National Forest. The only threatened wildlife species known to occur within this National Forest is the northern spotted owl.

Invertebrates

California Floater (mussel) (*Anodonta californiensis*)—This freshwater mussel species can be found in large and medium-sized rivers in pool areas. The mussel does not migrate (NatureServe 2007).

Oregon Floater (mussel) (*Anodonta oregonensis*)—This species has thin fragile shells compared to most other native mussels, enabling them to inhabit silt because they can "float" on semi-liquid substrates. These species can thrive in small nutrient-rich water bodies that are subject to oxygen and temperature stress in the summer. Mussel die-offs can occur during stressful periods, and the buildup of gases in the shell cavity of decaying animals may float the light shells to the water's surface. Their thin shells and inflated shape allows them to inhabit silt found in the deeper areas of lakes and reservoirs. Small rocky streams, favored by other western species such as western pearl-shells and western ridged mussels, are difficult environments for Oregon floaters, because their thin shells are prone to damage in such habitats. They depend on attachment to fish gills at the larval stage for nurturing, protection, growth and dispersion.

Western Pearlshell (mussel) (*Margaritifera falcata*—The spatial distribution of mussels at large scales (across reaches) is associated with dissolved oxygen and shear stress. Mussel distribution at small scales is associated with wetted width, canopy, abundance of small gravel substrate and distance from the stream bank. Mussels are found in locations having reduced shear stress, turbulence , and gradient and increased wetted width, abundance of small gravel, dissolved oxygen and conductivity. Optimum water depth is 0.2 meter to 0.6 meter, and optimum current velocity is 0.23 meters per second to 0.30 meters per second. Mussels prefer substrates where boulders increased bed roughness, allowing small gravel and sand to create a stable, heterogeneous substrate. Because Western pearlshell relies on salmon and trout for hosts, its absence or scarcity could be related to historic extirpation of anadromous salmonids and the subsequent introduction of unsuitable hosts such as non-native bass. Declines in some European populations of this species have been linked to trout host densities that drop below a critical threshold.

Western Ridged Mussel (mussel) (*Gonidea angulata*)—These mussels are widespread with multiple age-classes. Mussel shells have been found in prehistoric Indian middens located on the Sprague River, indicating that the species were present and accessible for harvest circa. 2000 years b.p. Western ridged mussel's fish host preferences are unknown, although this species is likely to be less host-specific than Western pearlshell and, therefore, less vulnerable to changes in fish assemblages.

Cascades Apatanian Caddisfly (*Apatania tavala*)—Larvae are aquatic and would be subject to being carried by stream currents, whereas adults are capable of flight. This caddisfly appears to be confined to elevations between 4,000 feet and 6,000 feet. Larvae have been found in streams from one-half to several meters in width and on coarse gravel and cobble substrates in areas of low to moderate current. They were not found in areas of fast current or in pools of slow currents where silt covered the underside and sides of cobbles. They were also found in stream channels having varying degrees of shading and at road openings, but not in stream reaches in recent clearcuts (NatureServe 2007).

Schuh's Homoplectran Caddisfly (*Homoplectra schuhi*)—This caddisfly is only known from two collections, one which is near Keno River, Klamath County (somewhat south of the assessment area). Aquatic larvae are carried by stream current or crawling, whereas adults are capable of flight. Habitat is described as a spring seepage area (NatureServe 2007).

A Caddisfly (*Moselyana comosa*)—This caddisfly is locally abundant between 3,000 feet and 6,000 feet in Klamath and surrounding counties (NatureServe 2007).

Montane Peaclam (*Pisidium ultramontanum*)—This peaclam occurs in herbaceous wetlands on the roots of *Salicornia*. The montane peaclam seems to occur in marshes that have persisted in (geologic) time in areas of the coast that are characterized by sandy beaches and flats (NatureServe 2007).

Mardon Skipper (butterfly) (*Polites mardon*)—The mardon skipper inhabits generally grassy openings in subalpine coniferous forests in mountain regions. Adults oviposit on Idaho fescue in southern Oregon and nectar on clovers (NatureServe 2007).

Amphibians

Western Toad (*Bufo boreas*)—Adult toads are primarily terrestrial, spending most of their time in underground burrows or buried under forest litter. Breeding occurs in marshes, stock ponds and high-elevation lakes. The reasons for declining western toad populations are unclear, but increased atmospheric UV-B radiation and a fungus normally found in fish have been implicated (Marshall et al. 1996). Western toads are present in the assessment area (Nussbaum et al. 1983).

Oregon Spotted Frog (*Rana pretiosa*)—The Oregon spotted frog is a highly aquatic species associated with emergent vegetation and floating algae in lakes, marshes and river side channels. The species has completely disappeared from large areas of its previous geographic range. Predation by non-native bullfrogs and fish are believed to be the primary causes of population decline (Marshall et al. 1996). Spotted frogs have been previously documented in the Upper Sprague River (Nussbaum et al. 1983), but it is unknown whether the species is still present.

Reptiles

Northwestern Pond Turtle (*Clemmys marorata marmorate*)—The northerwestern pond turtle inhabits creeks and medium-sized rivers with moderate gradients and pools. Specific habitat features include benthic areas, where the turtles burrow in or use soil and fallen logs or debris. This turtle is an opportunistic feeder and exhibits carnivorous, invertivorous and piscivorous tendencies. It migrates locally and also hibernates/aestivates (NatureServe 2007).

Birds

Tricolored Blackbird (*Agelaius tricolor*)—This gregarious bird breeds in freshwater marshes of cattails, tule, bulrushes and sedges. Nests are located in vegetation of marshes or thickets or sometimes on the ground. Historically, this bird was strongly tied to emergent marshes; in recent decades much nesting has shifted to non-native vegetation. During the nonbreeding season, this blackbird inhabits open cultivated lands and pastures (NatureServe 2007).

Black-Throated Sparrow (*Amphisphiz bilineata*)—This sparrow typically inhabits sagebrush scrub areas with less than 25 percent of vegetative cover. Their nests are located in the brush (usually rabbitbrush or sagebrush), are well concealed, and are near the ground. Foraging flocks may follow local topography, particularly washes, eating seeds and insects (NatureServe 2007).

Bufflehead (*Bucephala albeola*)—The migratory bufflehead migrates mostly at night, traveling north in the early spring and south in the late fall. This bird feeds on aquatic insects, snails, amphipods, small fishes and some aquatic plants. Within riparian areas, the bufflehead uses standing snags or hollow trees. It breeds in tree cavities in mixed coniferous-deciduous woodland near lakes and ponds, usually nesting in natural tree cavities or abandoned flicker holes. Females often nest in the same site in successive years (NatureServe 2007).

Barrow's Goldeneye (*Bucephala islandica*)—In summer, Barrow's goldeneye is usually found in small, scattered groups, and in winter is often seen in large flocks. This bird usually nests near a lake or pond surrounded by dense vegetation but may nest in wooded or open country. It usually nests in a natural tree cavity, abandoned woodpecker hole, rock cavity or streambank. It particularly favors riparian areas along a large river with a low gradient, for breeding and foraging (NatureServe 2007).

American Peregrine Falcon (*Falco peregrinus anatum*)—These migratory birds favor bare rock/talus/scree, cliffs, and shrubland/chapparal habitats. They feed along herbaceous wetlands and river mouths (NatureServe 2007).

Yellow-Breasted Chat (*Icteria virens*)—These long-distance migratory chats breed in forested wetlands with second growth, shrubby old pastures, thickets, bushy areas, scrub, woodland undergrowth and fence rows, including low, wet places near streams, pond edges, or swamps; thickets with few tall trees; early successional stages of forest regeneration; and commonly in sites close to human habitation. They nest in bushes, brier tangles, vines,and low trees, generally in dense vegetation less than 2 meters above the ground.

Mountain Quail (*Oreortyx pictus*)—These quail only migrate locally at higher elevations, about 20 to 40 miles. They inhabit brushy mountainsides, coniferous forest, forest and meadow edges, dense undergrowth, and sagebrush and juniper. They favor areas with tall, dense shrubs, close to water, and move to areas with suitable mast crops in fall. Nests are on the ground in a shallow scrape lined with plant material, usually under protective cover of a tree, shrub or fallen branches within a few hundred meters of water (NatureServe 2007).

Flammulated Owl (*Otus flammeolus*)—This long-distance migratory bird arrives in the assessment area in late May, for breeding. Breeding usually occurs in open conifer forests containing pine, with some brush or saplings (typical of the physiognomy of pre-European settlement ponderosa pine forests). This owl shows a strong preference for ponderosa and Jeffery pine, exhibiting mature growth with open canopy, andavoids dense young stands (NatureServe 2007).

Black-backed Woodpecker (*Picoides arcticus*)—In Oregon, the home range sizes for three individuals of this species were found to be 72, 124 and 328 hectares. Small home range size was associated with abundant mature or old-growth timber. This woodpecker is highly responsive to forest fire and other processes, such as spruce budworm outbreaks, that result in high concentrations of wood-boring insects invading dead trees. It usually inhabits forests or forested riparian areas with lodgepole pine or Douglas-fir. The woodpecker usually nests in a hole excavated in a hard snag, partially dead tree or live tree with dead heartwood, and occasionally in a stump, fence post or utility pole (NatureServe 2007).

Western Bluebird (*Sialia mexicana*)—This bluebird inhabits open woodlands, farmlands, orchards, savanna, riparian woodlands and burned woodlands. The western bluebird nests in natural tree cavities or abandoned woodpecker holes, usually 1.5 meter to 12 meters above the ground and uses bird boxes. This bluebird may be limited by nest site availability (NatureServe 2007).

Great Gray Owl (*Strix nedulosa*)—This owl inhabits dense coniferous and hardwood forest, especially pine, spruce, paper birch and poplar, and is also found in second growth, especially near water, and forages in wet meadows. Nests are made in the top of large broken-off tree trunks, in old nests of other large birds (e.g., hawk nest), or in debris platforms from dwarf mistletoe; frequently near bogs or clearings. Nests are frequently reused often by the same pair in successive years.

Northern Spotted Owl (*Strix occidentalis caurina*)—Typical habitat characteristics include: moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; a high incidence of large trees with large cavities, broken tops, and other indications of decadence; numerous large snags; heavy accumulations of logs and other woody debris on the forest floor; and considerable open space within and beneath the canopy. Generally these conditions are found in old-growth (at least 150 to 200 years old), but sometimes they occur in younger forests that include patches of older growth. In Oregon, conifer forests begin to develop conditions suitable for spotted owls about 80 to 120 years after clearcutting. Nests are located on broken tree tops, on cliff ledges, in natural tree cavities, or in trees on stick platforms, often the abandoned nest of a hawk or mammal, and sometimes in a cave.

Northern Goshawk (*Accipiter gentilis*)—The northern goshawk is a large, aggressive hawk that usually nests and rears young in late successional forests with relatively open understories. However, goshawks also nest in aspen stands in shrub-steppe environments. The species is believed to be sensitive to the loss of mature and old-growth forests (Marshall et al. 2003). Goshawks have been known to nest in the assessment area.

Bald Eagle (*Haliaeetus leucocephalus*)—Usually associated with large bodies of water such as estuaries, lakes and large rivers, bald eagles nest in large trees or snags, usually within one mile of water (Anthony and Isaacs 1989). Eagle surveys have been conducted every year in Oregon since 1978 (Marshall et al. 2003). Surveys indicate that nesting pairs have increased from a low of 56 to a recent estimate of 393 pairs (Isaacs and Anthony 2001). Bald eagles are known to have recently nested at multiple sites along the Sprague and Williamson rivers (ORNHIC 2007).

Yellow Rail (*Coturnicops noveboracensis*)—The yellow rail is a rare, secretive bird that nests in flooded wetlands dominated by sedges. There were no reported sightings of yellow rails in Oregon from 1926 until 1983 (Marshall et al. 2003). Since then, the species has been observed only rarely in Oregon. Most sightings are from Klamath and Lake counties. Yellow rails have been recently observed at Sycan Marsh and several sites in the Sprague River valley (Marshall et al. 2003). Threats to the species include agricultural practices that lead to wetland loss (e.g., ditching and diking) and intensive grazing that reduces vegetation cover (Marshall et al. 2003).

Greater Sandhill Crane (*Grus canadensis tabida*)—Sandhill cranes forage in wet meadows and agricultural fields. Floating nests are constructed in marshes. Sandhill cranes that breed in the Sprague River valley migrate in winter to northern California. (Marshall et al. 2003). Predation by coyotes occasionally causes significant loss of nests and juveniles (Marshall et al. 2003). Wetland conversion to agricultural fields also reduces habitat availability (Marshall et al. 2003).

Upland Sandpiper (*Bartramia longicauda*)—Upland sandpiper nesting sites are usually located in montane meadows surrounded by ponderosa or lodgepole pine forests (Marshall et al. 2003). The upland sandpiper is one of the rarest breeding birds in the western United States.

Lewis's Woodpecker (*Melanerpes lewis*)—Associated with open canopy woodlands, especially ponderosa pine-Oregon white oak communities, Lewis's woodpeckers nest in tree cavities excavated by other woodpecker species. Once common on the east side of the Cascades and in portions of western Oregon, Lewis's woodpecker populations have declined dramatically since the 1940s. Factors causing population declines are thought to be the loss of oak woodland and savanna habitat, as well as nest site competition from European starlings (Marshall et al. 2003).

White-headed Woodpecker (*Picoides albolarvatus*)—The white-headed woodpecker is strongly associated with open-canopy ponderosa pine woodlands, but is occasionally found in mixed conifer forests. White-headed woodpeckers prefer stands composed of large-diameter trees. Nests are excavated in large snags, usually with a diameter at breast height greater than 25 inches (Marshall et al. 2003). Logging of old-growth ponderosa pine forests and fire suppression are reported to have reduced habitat availability for the species.

White-Faced Ibis (*Plegadis chihi*)—White-faced ibis is a colonial species that uses wetlands and flooded agricultural fields. The species was decimated by over-hunting during the nineteenth century, but has recovered and is expanding its geographic range. White-faced ibis may still be at risk from cattle grazing on nesting sites and pesticide use on agricultural lands, particularly on wintering grounds in Mexico (Marshall et al. 2003).

Olive-sided Flycatcher (*Contopus cooperi*)—The olive-sided flycatcher occurs mostly in open canopy conifer forest or near forest edges. Prominent trees and snags are an important habitat element. It has been estimated that Oregon populations decreased 5.1 percent from 1966 to 1996 (Marshall et al. 2003). The principal threat to olive-sided flycatcher populations is believed to be habitat loss in South American wintering areas, although fire suppression and loss of late successional forests in the western United States may be contributing to declines (Marshall et al. 2003).

Willow Flycatcher (*Empidonax traillii adastus*)—In eastern Oregon, willow flycatchers occur almost exclusively in shrubby riparian areas. The principal threat to the species is believed to be degradation of riparian habitat due to over-grazing and altered hydrological regimes (Marshall et al. 2003). Nest parasitism by brown-headed cowbirds may contribute to lower population recruitment (Marshall et al. 2003).

Purple Martin (*Progne subis*)—The purple martin is a colonial nester that uses snags and human-made nest boxes. The species is most frequently found near large rivers, lakes and estuaries. Purple martins are extremely rare east of the Cascades in Oregon, but have been observed along Alder

Creek near the Sprague River (ORNHIC 2007). Reasons given for population declines are the reduction of large snags on managed forest lands and nest site competition from European starlings (Marshall et al. 2003).

Mammals

Myotis Bat Species (*Myotis evotis, M. thysanodes, M. volans, M. yumanensis*)—Although all five of these *Myotis* species exhibit differences in behavior, diet and reproduction, all of these bats are primarily associated with conifer forests and are often captured at the same sites. *Myotis* bats use a variety of natural structures (caves, rock crevices and tree cavities) and human-made structures (mines, abandoned barns and bridges) for roosting and maternity colonies. They are thought to be at risk because of the loss of old-growth forests, human disturbance at roosts and hibernation sites, and pesticide use (Marshall et al. 1996). All five of these *Myotis* species have been captured within the assessment area (ORNHIC 2007).

Silver-Haired Bat (*Lasionycteris noctivagans*)—Associated with conifer forests, including western juniper woodlands, silver-haired bats usually roost in tree cavities and under peeling bark, but will use caves and mines if available. The species strongly prefers late successional forests to younger stands (Perkins and Cross 1988) and therefore is thought to be vulnerable to the loss of old-growth forest. Silver-haired bats have been captured at several springs and stock ponds in the assessment area (ORNHIC 2007).

Pallid Bat (*Antrozous pallidus*)—In central and southeastern Oregon, the pallid bat inhabits shrublands and western juniper woodlands. Day roosts used by the species include caves, mine shafts, rock crevices and tree cavities. Pallid bat populations have declined, mainly because of human disturbance at roosts and limited habitat (Marshall et al. 1996). Pallid bats have been observed in the assessment area (ORNHIC 2007).

Townsend's Big-Eared Bat (*Corynorhinus townsendii*)—Though a relatively sedentary bat, in Oregon individuals moved up to 24 kilometers from hibernation sites to foraging areas. Activity usually begins well into the night, late relative to other bats, though activity before darkness has been observed in some areas. These bats inhabit cave or other cool rock areas, particularly associated with conifer forests and riparian areas. These bats are invertivores (NatureServe 2007).

American Marten (*Martes americana*)—American martens are extremely rare throughout Oregon. Most observations have been at high elevations in the Cascades and Blue mountains. Martens use a variety of forest habitats including lodgepole pine forests, mixed conifer forests and western juniper woodlands. The species prefers late successional forests that have an abundance of large trees, snags and downed logs (Marshall et al. 1996). The loss of old-growth forest is thought to be the primary cause for the decline in American marten populations (Marshall et al. 1996).

Western Gray Squirrel (*Sciurus griseus*)—This arboreal and terrestrial species inhabits fairly open oak and pine-oak forests (NatureServe 2007). This forest type, while indicative of some portions of the Winema-Fremont National Forest, is not found within the assessment area.

California Wolverine (*Gulo gulo luteues*)—No sitings of California wolverine have been reported for Klamath County. This carnivore inhabits chiefly subalpine forest and alpine fellfields, alpine meadows, and forests of lodgepole pine and red fir (NatureServe 2007).

Fisher (*Martes pennanti*)—Fishers inhabit upland and lowland forests, including coniferous, mixed and deciduous forests. They occur primarily in dense coniferous or mixed forests, including early successional forest with dense overhead cover. Fishers commonly use hardwood stands in summer but prefer coniferous or mixed forests in winter. They generally avoid areas with little forest cover or significant human disturbance; rather, they prefer large areas of contiguous interior forest. They may prefer riparian areas (NatureServe 2007).

Canada Lynx (*Lynx canadensis*)—Canada lynx live deep in coniferous forests near rocky areas, bogs and swamps. Lynx are territorial and solitary. The home ranges of females may overlap, and a male's and a female's range may overlap, but males' ranges are separate (NatureServe 2007). While the assessment area is part of the southernmost portion of the Canada lynx's range, the lynx may not be found locally (Trish Roninger, pers. comm.).

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Table 12-2 Animal species likely to occur within the Lower Sprague-Lower Williamson subbasin
(Data Sources: O'Neil et al. 2001; ORNHIC 2004; Philip Milburn, ODFW, pers. comm. October 2007; Trish Roninger, USFWS, pers. comm. December 2007)

Common Name	Scientific Name
Amphibian Species	
Long-Toed Salamander	*Ambystoma macrodactylum**
Western Toad	*Bufo boreas**
Bullfrog	*Lithobates catesbeianus**
Pacific Chorus (Tree) Frog	*Pseudacris regilla**
Oregon Spotted Frog	*Rana pretiosa*
Rough-Skinned Newt	*Taricha granulose*
Reptile Species	
Rubber Boa	*Charina bottae**
Northwestern Pond Turtle	*Clemmys marmorata marmorata**
Western Rattlesnake	*Crotalus oreganus**
Western Skink	*Eumeces skiltonianus**
Night Snake	*Hypsiglena torquata**
Striped Whipsnake	*Masticophis taeniatus**
Desert Horned Lizard	*Phrynosoma platyrhinos*
Gopher Snake	*Pituophis catenifer**
Sagebrush Lizard	*Sceloporus graciosus**
Western Fence Lizard	*Sceloporus occidentalis**
Western Terrestrial Garter Snake	*Thamnophis elegans**
Common Garter Snake	*Thamnophis sirtalis**
Bird Species	
Cooper"s Hawk	*Accipiter cooperii**
Northern Goshawk	***Accipiter gentilis****
Sharp-Shinned Hawk	*Accipiter striatus**
Spotted Sandpiper	*Actitis macularia**
Clark's Grebe	*Aechmophorus clarkia**
Western Grebe	*Aechmophorus occidentalis**
Northern Saw-Whet Owl	*Aegolius acadicus**
Red-Winged Blackbird	*Agelaius phoeniceus**
Tricolored Blackbird	*Agelaius tricolor**
Wood Duck	*Aix sponsa**
Grasshopper Sparrow	*Ammodramus savannarum*
Northern Pintail	*Anas acuta**
American Wigeon	*Anas americana**
Green-Winged Teal	*Anas carolinensis**
Northern Shoveler	*Anas clypeata**
Cinnamon Teal	*Anas cyanoptera**
Blue-Winged Teal	*Anas discors**
Mallard	*Anas platyrhynchos**
Gadwall	*Anas strepera**
Greater White-Fronted Goose	*Anser albifrons**
American Pipit	*Anthus rubescens**

Common Name	Scientific Name
Golden Eagle	*Aquila chrysaetos**
Great Egret	*Ardea alba**
Great Blue Heron	*Ardea herodias**
Short-Eared Owl	*Asio flammeus**
Long-Eared Owl	*Asio otus**
Lesser Scaup	*Aythya affinis**
Redhead	*Aythya americana**
Ring-Necked Duck	*Aythya collaris**
Greater Scaup	*Aythya marila**
Canvasback	*Aythya valisineria**
Cedar Waxwing	*Bombycilla cedrorum**
American Bittern	*Botaurus lentiginosus**
Canada Goose	*Branta canadensis**
Great Horned Owl	*Bubo virginianus**
Bufflehead	*Bucephala albeola**
Common Goldeneye	*Bucephala clangula**
Barrow's Goldeneye	*Bucephala islandica**
Red-Tailed Hawk	*Buteo jamaicensis**
Rough-Legged Hawk	*Buteo lagopus**
Ferruginous Hawk	*Buteo regalis**
Green Heron	*Butorides virescens**
Dunlin	*Calidris alpine**
Western Sandpiper	*Calidris mauri*
California Quail	*Callipepla californica**
American Goldfinch	*Carduelis tristis**
Cassin's Finch	*Carpodacus cassinii**
House Finch	*Carpodacus mexicanus**
Turkey Vulture	*Cathartes aura**
Hermit Thrush	*Catharus guttatus**
Brown Creeper	*Certhia americana**
Semipalmated Plover	*Charadrius semipalmatus**
Killdeer	*Charadrius vociferous**
Snow Goose	*Chen caerulescens**
Ross's Goose	*Chen rossii**
Black Tern	*Chlidonias niger*
Lark Sparrow	*Chondestes grammacus**
American Dipper	*Cinclus mexicanus**
Northern Harrier	*Circus cyaneus**
Rock Dove	*Columba livia**
Olive-Sided Flycatcher	*Contopus cooperi**
Common Raven	*Corvus corax**
Yellow Rail	*Coturnicops noveboracensis*
Trumpeter Swan	*Cygnus buccinators**
Tundra Swan	*Cygnus columbianus**
Dark-Eyed Junco	*Dark-eyed junco**
Blue Grouse	*Dendragapus obscurus**
Yellow-Rumped Warbler	*Dendroica coronata**
Black-Throated Gray Warbler	*Dendroica nigrescens**
Townsend's Warbler	*Dendroica townsendi**

Common Name	Scientific Name
Pileated Woodpecker	***Dryocopus pileatus****
Hammond's Flycatcher	*Empidonax hammondii**
Willow Flycatcher	*Empidonax traillii adastus**
Horned Lark	*Eremophila alpestris**
Merlin	*Falco columbarius**
Prairie Falcon	*Falco mexicanus**
American Peregrine Falcon	*Falco peregrinus anatum**
American Kestrel	*Falco sparverius**
American Coot	*Fulica americana**
Common Snipe	*Gallinago gallinago**
Common Yellowthroat	*Geothlypis trichas**
Northern Pygmy-Owl	*Glaucidium californicum**
Greater Sandhill Crane	*Grus canadensis tabida**
Sandhill Crane	*Grus canadensis**
Pinyon Jay	*Gymnorhinus cyanocephalus**
Bald Eagle	*Haliaeetus leucocephalus**
Black-Necked Stilt	*Himantopus mexicanus**
Barn Swallow	*Hirundo rustica**
Yellow-Breasted Chat	*Icteria virens**
Northern Shrike	*Lanius excubitor*
Loggerhead Shrike	*Lanius ludovicianus**
Herring Gull	*Larus argentatus*
California Gull	*Larus californicus**
Bonaparte's Gull	*Larus philadelphia*
Franklin's Gull	*Larus pipixcan**
Long-Billed Dowitcher	*Limnodromus scolopaceus**
Marbled Godwit	*Limosa fedoa**
Hooded Merganser	*Lophodytes cucullatus**
Red Crossbill	*Loxia curvirostra**
Belted Kingfisher	*Megaceryle alcyon**
Western Screech-Owl	*Megascops kennicottii**
Lewis's Woodpecker	*Melanerpes lewis**
Song Sparrow	*Melospiza melodia**
Common Merganser	*Mergus merganser**
Brown-Headed Cowbird	*Molothrus ater**
Townsend's Solitaire	*Myadestes townsendi**
Long-Billed Curlew	*Numenius americanus**
Black-Crowned Night-Heron	*Nycticorax nycticorax**
Macgillivray's Warbler	*Oporornis tolmiei**
Mountain Quail	*Oreortyx pictus**
Flammulated Owl	*Otus flammeolus**
Ruddy Duck	*Oxyura jamaicensis**
Osprey	*Pandion haliaetus**
House Sparrow	*Passer domesticus**
Savannah Sparrow	*Passerculus sandwichensis**
Fox Sparrow	*Passerella iliaca**
Gray Jay	*Perisoreus canadensis**
Cliff Swallow	*Petrochelidon pyrrhonota**
Double-Crested Cormorant	*Phalacrocorax auritus**

Common Name	Scientific Name
Red-Necked Phalarope	*Phalaropus lobatus*
Wilson's Phalarope	*Phalaropus tricolor**
Ring-Necked Pheasant	*Phasianus colchicus**
Black-Headed Grosbeak	*Pheucticus melanocephalus**
Black-Billed Magpie	*Pica hudsonia**
White-Headed Woodpecker	*Picoides albolarvatus**
Black-Backed Woodpecker	*Picoides arcticus**
American Three-Toed Woodpecker	***Picoides dorsalis****
Pine Grosbeak	*Pinicola enucleator**
Green-Tailed Towhee	*Pipilo chlorurus**
White-Faced Ibis	*Plegadis chihi**
Black-Bellied Plover	*Pluvialis squatarola*
Vesper Sparrow	*Pooecetes gramineus**
Sora	*Porzana carolina**
Virginia Rail	*Rallus limicola**
American Avocet	*Recurvirostra americana**
Ruby-Crowned Kinglet	*Regulus calendula**
Golden-Crowned Kinglet	*Regulus satrapa**
Bank Swallow	*Riparia riparia**
Mountain Bluebird	*Sialia currucoides**
Western Bluebird	*Sialia Mexicana**
Red-Breasted Nuthatch	*Sitta canadensis**
Brewer's Sparrow	*Spizella breweri breweri**
Chipping Sparrow	*Spizella passerine**
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis**
Forster's Tern	*Sterna forsteri**
Common Tern	*Sterna hirundo*
Great Gray Owl	*Strix nebulosa**
Northern Spotted Owl	***Strix occidentalis caurina****
Barred Owl	*Strix varia**
Western Meadowlark	*Sturnella neglecta**
European Starling	*Sturnus vulgaris**
Lesser Yellowlegs	*Tringa flavipes*
Greater Yellowlegs	*Tringa melanoleuca**
Willet	*Tringa semipalmata**
Solitary Sandpiper	*Tringa solitaria*
American Robin	*Turdus migratorius**
Barn Owl	*Tyto alba**
Orange-Crowned Warbler	*Vermivora celata**
Nashville Warbler	*Vermivora ruficapilla*
Wilson's Warbler	*Wilsonia pusilla**
Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus**
Mourning Dove	*Zenaida macroura**
White-Crowned Sparrow	*Zonotrichia leucophrys**
<u>Mammal Species</u>	
Pronghorn Antelope	*Antilocapra americana**
Pallid Bat	*Antrozous pallidus**
Coyote	*Canis latrans**

Common Name	Scientific Name
American Beaver	*Castor canadensis**
Rocky Mountain Elk	*Cervus canadensis nelsoni**
Townsend's Big-Eared Bat	*Corynorhinus townsendii**
Ord's Kangaroo Rat	*Dipodomys ordii*
Big Brown Bat	*Galleria mellonella**
Northern Flying Squirrel	*Glaucomys sabrinus**
Silver-Haired Bat	*Lasionycteris noctivagans**
Sagebrush Vole	*Lemmiscus curtatus**
Snowshoe Hare	*Lepus americanus**
Black-Tailed Jackrabbit	*Lepus californicus**
Northern River Otter	*Lontra canadensis**
Canada Lynx	***Lynx canadensis***
Yellow-Bellied Marmot	*Marmota flaviventris**
American Marten	***Martes americana***
Montane Vole	*Microtus montanus**
House Mouse	*Mus musculus**
Western Red-Backed Vole	*Myodes californicus**
California Myotis	*Myotis californicus**
Little Brown Myotis	*Myotis lucifugus**
Long-Legged Myotis	*Myotis volans**
Yuma Myotis	*Myotis yumanensis**
Bushy-Tailed Woodrat	*Neotoma cinerea**
Dusky Footed Woodrat	*Neotoma*
Mule Deer	*Odocoileus hemionus**
Northern Grasshopper Mouse	*Onychomys leucogaster**
Great Basin Pocket Mouse	*Perognathus merriami**
Deer Mouse	*Peromyscus maniculatus**
Raccoon	*Procyon lotor**
Purple Martin	*Progne subis**
Cougar	*Puma concolor**
Norway Rat	*Rattus norvegicus*
Western Harvest Mouse	*Reithrodontomys megalotis**
Western Gray Squirrel	*Sciurus griseus**
Water Shrew	*Sorex palustris**
Trowbridge's Shrew	*Sorex trowbridgii*
Vagrant Shrew	*Sorex vagrans**
California Ground Squirrel	*Spermophilus beecheyi**
Belding's Ground Squirrel	*Spermophilus beldingi**
Golden-Mantled Ground Squirrel	*Spermophilus lateralis**
Yellow-Pine Chipmunk	*Tamias amoenus**
Least Chipmunk	*Tamias minimus**
Douglas' Squirrel	*Tamiasciurus douglasii**
Northern Pocket Gopher	*Thomomys talpoides**
Black Bear	*Ursus americanus**
Western Jumping Mouse	*Zapus*

In bold: Management indicator species that use old-growth communities as stated in the "Land and Resource Management Plan" for the Winema National Forest (USFS 1990).
*Confirmed by Philip Milburn, ODFW Klamath District Wildlife Biologist, as present.
List was reviewed and edited by Trish Roninger, U.S. Fish and Wildlife Service (2007).

Table 12-3 Terrestrial wildlife species with special conservation status likely to occur in the Lower Sprague-Lower Williamson subbasin
(Data Sources: ORNHIC 2004; Philip Milburn, ODFW, pers. comm. October 2007; Trish Roninger, USFWS, pers. comm. December 2007)

Class	Common Name	Scientific Name	Federal Status	State Status
Amphibians				
	Western Toad	*Bufo boreas**	--	SV
	Oregon Spotted Frog	*Rana pretiosa*	C	SC
Reptiles	Northwestern Pond Turtle	*Emys marmorata marmorata**	SOC	SC
Birds	Northern Goshawk	*Accipiter gentilis**	SOC	SC
	Tricolored Blackbird	*Agelaius tricolor**	SOC	SP
	Black-Throated Sparrow	*Amphispiza bilineata**	--	SP
	Upland Sandpiper	*Bartramia longicauda*	SOC	SC
	Bufflehead	*Bucephala albeola**	--	SU
	Barrow's Goldeneye	*Bucephala islandica**	--	SU
	Olive-Sided Flycatcher	*Contopus cooperi**	SOC	SV
	Yellow Rail	*Coturnicops noveboracensis*	SOC	SC
	Willow Flycatcher	*Empidonax traillii adastus**	SOC	SU
	American Peregrine Falcon	*Falco peregrinus anatum**	--	LE
	Greater Sandhill Crane	*Grus canadensis tabida**	--	SV
	Bald Eagle	*Haliaeetus leucocephalus**	SOC	LT
	Yellow-Breasted Chat	*Icteria virens**	SOC	
	Lewis's Woodpecker	*Melanerpes lewis**	SOC	SC
	Mountain Quail	*Oreortyx pictus**	SOC	
	Flammulated Owl	*Otus flammeolus**	--	SC
	White-Headed Woodpecker	*Picoides albolarvatus**	SOC	SC
	Black-Backed Woodpecker	*Picoides arcticus**	--	SC
	American Three-Toed Woodpecker	*Picoides dorsalis**	--	SC
	White-Faced Ibis	*Plegadis chihi**	SOC	--
	Purple Martin	*Progne subis**	SOC	SC
	Western Bluebird	*Sialia Mexicana**	--	SV
	Great Gray Owl	*Strix nebulosa**	--	SV
	Northern Spotted Owl	*Strix occidentalis caurina**	LT	LT
Mammals	Pallid Bat	*Antrozous pallidus**	SOC	SV
	Townsend's Big-Eared Bat	*Corynorhinus townsendii**	SOC	SC
	California Wolverine	*Gulo gulo luteus*	SOC	LT
	Silver-Haired Bat	*Lasionycteris noctivagans**	SOC	SU
	American Marten	*Martes americana**	--	SV
	Fisher	*Martes pennanti*	C	SC
	Long-Eared Myotis	*Myotis evotis**	SOC	SU
	Fringed Myotis	*Myotis thysanodes**	SOC	SV
	Long-Legged Myotis	*Myotis volans**	SOC	SU
	Yuma Myotis	*Myotis yumanensis**	SOC	--
	Western Gray Squirrel	*Sciurus griseus**	--	SU
Invertebrates	California Floater (Mussel)	*Anodonta californiensis*	SOC	--

Class	Common Name	Scientific Name	Federal Status	State Status
	Cascades Apatanian Caddisfly	*Apatania tavala*	SOC	--
	Schuh's Homoplectran Caddisfly	*Homoplectra schuhi*	SOC	--
	A Caddisfly	*Moselyana comosa*	SOC	--
	Montane Peaclam	*Pisidium ultramontanum*	SOC	--
	Mardon Skipper (Butterfly)	*Polites mardon*	C	--

[1] Federal Status: LT=Listed ESA Threatened; C=Candidate for Listing; SOC=Species of Concern
[2] State Status: LE=Listed State Endangered; LT=Listed State Threatened; SC= Sensitive-critical; SP=Species at Edge of Range or Naturally Rare; SV=Sensitive-vulnerable; SU=Sensitive-undetermined.
* Confirmed by Philip Milburn, ODFW Klamath District Wildlife Biologist, as present.

Table 12-4 Terrestrial wildlife species with special conservation status occurring in the Fremont-Winema National Forest
(Data Sources: USFS 2004; Trish Roninger, pers. comm. 2007)

Class	Common Name	Scientific Name	Federal Status[1]
Birds	Northern Spotted Owl	*Strix occidentalis caurina*	T
Mammals	Pacific Fisher	*Martes pennanti pacifica*	C
	Canada Lynx	*Lynx canadensis*	T
Amphibians	Oregon Spotted Frog	*Rana pretiosa*	C
Invertebrates	Mardon Skipper Butterfly	*Polites mardon*	C

[1] T=Threatened; C=Candidate

DATA, METHODS AND LIMITATIONS

Much of the information presented in this chapter originated from a Washington Department of Fish and Wildlife and Northwest Habitat Institute project published in "Matrixes for Wildlife-Habitat Relationships in Oregon and Washington" (O'Neil et al. 2001). This project identified 32 wildlife-habitat types in Oregon and Washington. Wildlife species known to be associated with each of these wildlife-habitat types are presented in these matrices. This information was developed to synthesize and disseminate the current state of knowledge about amphibians, birds, mammals and reptiles, and their terrestrial, freshwater and marine habitats in Oregon and Washington (O'Neil et al. 2001).

The Oregon Natural Heritage Information Center's (ORNHIC) "Rare, Threatened, and Endangered Species in Oregon" (ORHNIC 2004) was also used to create the data tables presented here.

Table 12-1
Habitat types occurring in the Lower Sprague River subbasin were determined through Geographic Information System (GIS) analysis of habitat data created by the Northwest Habitat Institute (2000). Wildlife-habitat matrices were then consulted to determine the number of amphibians, reptiles, birds and mammals that are likely to be related to the habitat types that were determined to be found in the Lower Sprague-Lower Williamson subbasin (O'Neil et al. 2001).

Table 12-2
This table lists the common and scientific name of each species indicated in Table 12-1. The geographic distribution of these wildlife-habitat relationships spans Washington and Oregon. As a result, it is possible that although the matrix indicates that a particular species is closely associated with a certain habitat type, it may occur elsewhere in Washington or Oregon and not in the Lower Sprague River subbasin. Species that are known to occur in the Lower Sprague River subbasin are indicated with an asterisk, as verified by Oregon Department of Fish and Wildlife (ODFW) personnel (Philip Milburn, ODFW, pers. comm. October 2007) and U.S. Fish and Wildlife Service (USFWS) personnel (Trish Roninger, USFWS, pers. comm. December 2007).

Species that appear on the ORNHIC list of rare, threatened and endangered species in Oregon that were not included in the list generated through the wildlife-habitat matrices are also included in this table.

Forest management indicator species (bolded) were found in the "Land and Resource Management Plan" for the Winema National Forest (USFS 1990).

Table 12-3
This table lists species of special state and federal conservation status that appear on the ORNHIC list of rare, threatened and endangered species in Oregon. This list was generated by querying for species that are known to occur in Klamath County. Species that are known to occur in the Lower Sprague River subbasin are indicated with an asterisk, as verified by ODFW personnel (Philip Milburn, ODFW, October 2007, pers. comm.) and US Fish and Wildlife Service (USFWS) personnel (Trish Roninger, USFWS, December 2007, pers. comm.).

Table 12-4
Federally listed wildlife species found in the Winema National Forest were obtained from information posted to the Winema National Forest website (USFS 2004).

The information presented here is adequate at the watershed scale. It may not be detailed enough for use at the individual farm and ranch planning scale.

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CHAPTER 13. WATERSHED FUNCTION SUMMARY

Throughout this document, certain principles have been emphasized, principles that have emerged from the watershed assessment process itself. These principles include:

- The conviction that scientific understanding must be joined with social and economic understanding to produce lasting solutions that have solid community support.
- The insight that overall watershed condition and function—in both riparian areas and in the uplands—are the result of dynamic interactions between soil, water and vegetation.
- The importance of basing restoration, management planning and even regulatory actions on site-specific analysis, rather than just on generalized judgments about conditions at the watershed scale.
- The importance of focusing on "trend over time," which allows resource managers to determine whether fundamental processes are in place that will produce a stable—but dynamic— landscape over the long term.

Although conditions have clearly changed from pre-settlement times, the goal is to try to determine whether, and to what extent, watershed function has been compromised. Return to pre-settlement condition is not necessarily possible, or even desirable. Ultimately, the goals of future natural resources management actions and watershed restoration should focus on improving and restoring stable but dynamic function to the extent that is practical. This can be achieved in incremental steps over a longer term to obtain a balance of healthy watershed conditions and needs of other beneficial uses.

GENERAL GEOGRAPHIC CHARACTERISTICS

The Lower Sprague-Lower Williamson subbasin covers 599.6 square miles and drains a varied landscape, from steep-sloped reaches to low gradient floodplains. Within the assessment area lie a variety of aquatic features including perennial, intermittent and ephemeral streams, constructed ditches, lakes and marshes. Only 23 percent of the streams in the subbasin are perennial. Most streams are intermittent or ephemeral. The major streams within the watershed flow generally from east to west and north to south. The Lower Sprague River continues from Beatty Gap west to its confluence with the Williamson River. The Lower Williamson River continues south from Kirk Reef and then southwest from the Sprague River confluence until it reaches its delta at Upper Klamath Lake. Elevations within the watershed range from 4,143 feet at the Williamson River Delta to approximately 7,268 feet at Swan Lake Point.

Average annual precipitation ranges from 12 to 16 inches in the valleys, 16 to 25 inches in nearby hills, and 30 to 40 inches at higher elevations. About 41 percent to 46 percent of the precipitation in the survey area occurs in winter. Snowfall accounts for 30 percent of the annual precipitation in the valleys and as much as 50 percent in the mountains.

Prior to the settlement of European Americans in the late nineteenth century, human activity in the Lower Sprague River and Lower Williamson River watersheds consisted primarily of seasonal subsistence hunting and gathering by Native Americans. Native Americans may have used fire

Suppression of fire in the late nineteenth and early twentieth centuries had a significant effect on flora, fauna and the hydrology of the assessment area.

In the late nineteenth century, the nature of human dependence upon the area's natural resources began to change. The Bureau of Indian Affairs promoted intensive livestock grazing—including horses, mules, sheep and cattle—as early as the 1870s. About the same time, European settlers began to arrive in greater numbers, establishing livestock and hay operations and sawmills and box companies. Many of the negative effects on riparian vegetation and stream channel function can be traced to the late 1800s through the mid-1900s.

GEOLOGIC PROCESSES

Although erosion is a natural process, an increase in the amount of erosion due to human activities can compromise stream function because an abundance of fine sediment can fill the spaces in streambed gravel and reduce the habitat quality for fish. Soils within the assessment area are typically high in phosphorous. Streambank erosion is an important concern in some areas within this subbasin, due in part to concerns about phosphorous loading in downstream habitats. There appears to be limited data available on active bank erosion within the assessment area.

Roads are another potential source of excessive sedimentation. There are approximately 2,300 miles of roads in the Lower Sprague-Lower Williamson subbasin, at an average road density of 3.8 miles of road per square mile. Approximately 31 percent of the stream miles in the Lower Sprague River subbasin are within 200 feet of a road.

HYDROLOGY AND WATER USE

The available data indicate that changes in vegetation and soil conditions in the Lower Sprague-Lower Williamson subbasin—including forest structure, the prevalence of fire, riparian vegetation conditions and juniper ecology—may have reduced the capacity for the watershed to retain and safely release available precipitation.

Water is currently withdrawn from both the Lower Sprague and Lower Williamson rivers for a variety of beneficial uses. Water is used for irrigating crops or forage for livestock, and for domestic use. Most diversions are for irrigation. It is difficult to establish the precise effect of diversions on stream flow because of the return and reuse of tailwater, and the complicated interaction of groundwater and surface water.

Where favorable permeable zones for fracture are intersected by streams, groundwater is discharged by large springs. There are some data suggesting that development of irrigation wells to substandard specifications may be negatively affecting flow from springs (Bruce Topham, pers. comm.). In some cases, groundwater pumped for irrigation may supplement surface flows.

Water is a limited resource within the watershed. The water is currently over-allocated between beneficial uses. Eventually, if it has not already, the landscape will reach a carrying capacity for the amount of water available in the system.

TERRESTRIAL VEGETATION

At the time of European settlement, the Lower Sprague-Lower Williamson subbasin consisted of a mosaic of coniferous forests, marshes, shrublands and grasslands. Ponderosa pine and lodgepole pine coexisted in the pumice region in the northern reaches of the Williamson River watershed, the West Sprague River watershed and the North Sprague River watershed. Outside of the pumice region, ponderosa pine forests graded into ponderosa pine dominant mixed conifer forests (*Abies concolor* and *Abies lasciocarpa* becoming more abundant*)* at their upper limits. At the forests lower elevational limits, they abutted with sagebrush shrublands or western juniper-sagebrush woodland. Riparian shrublands were exhibited in a band following rivers, streams and shorelines of lakes. At the mouth of the Williamson River, where the entire subbasin drained into Upper Klamath Lake, a 12-square-mile delta rich in sediments sustained a vast network of marshes.

As a result of tree harvesting and a dramatically altered fire regime, climax species such as white fir and grand fir were able to grow in much greater densities as compared with pre-settlement conditions. Stream function has been affected because of the reduction in the availability of large wood. Fire suppression also led to increased fuel loadings and more widespread mixed-species (ponderosa pine dominant) stands. Although data from other regions indicate that changes in stand composition and structure increase susceptibility to insect outbreak, historical records have shown that severe insect outbreaks occurred before significant timber harvest began. Throughout the twentieth century, the range and density of juniper increased dramatically, due to fire suppression and reduction in fine fuels.

Site-specific assessments of the uplands by the Working Landscapes Alliance (WLA) indicated opportunities for land managers who may not have streams or wetlands to contribute to the overall functionality of the watershed. Juniper- dominated sites that were assessed were found to be functioning at risk or nonfunctioning hydrologically. As part of the loss of hydrologic function have come losses in plant vigor and productivity and in plant community diversity.

Noxious weeds are a concern both in the upland and riparian areas. Landowners have been working to control and limit the spread of noxious weeds.

RIPARIAN AREAS

The straightening and diking of significant reaches of the Sprague River and some of its tributaries constituted substantial modifications to riparian and wetland areas. Removal of native riparian vegetation increased bank erosion. These actions reduced or eliminated the ability of certain key stream segments to dissipate the high energies of peak flows by spreading these flows out over a floodplain, or by accessing secondary high flow channels. These actions also reduced the viability of in-stream fish habitat by simplifying streambed topography and flow dynamics.

The data gathered for the watershed as a whole have indicated some general changes in riparian condition, including erosion of channels both outward and downward, local lowering of the water table, disconnection of stream channels from their floodplains, shifts in vegetation communities and changes in certain key fish habitat features.

As a result of the involvement of the National Riparian Service Team (NRST) and the WLA, considerable attention was devoted to riparian areas during this Assessment. The involvement of the

NRST and the WLA has allowed the large-scale data to be supplemented in this Assessment with information gathered during specific site visits on public and private lands.

Some key findings emerged from specific site assessments conducted during the 2007 field season. First, there was wide variability with regard to riparian conditions and function across the watershed, and even within a particular site. Second, there was evidence at most sites that major changes had taken place in the early part of the last century, and that riparian conditions and functions have been gradually improving since that early disturbance. Third, there was clear evidence at each site of the potential for substantial and rapid recovery of vegetation conditions with relatively minor shifts in management. And finally, it gradually became clear over the course of the field season that in riparian areas where vegetation conditions and hydrologic function had declined, forage production for livestock had also declined. This fact was considered to be of critical importance, because strategies could be developed that would simultaneously contribute to the functionality of the riparian area, as well as to the economic viability of the agricultural operation.

WETLANDS

According to available data (National Wetland Inventory), wetlands cover about 28,140 acres (7.3 percent) of the Lower Sprague-Lower Williamson subbasin. The largest amount of wetland area is located in the valley reaches of the Lower Sprague River.

Wetland conditions have changed since pre-settlement times as a result of draining, diking, grazing, forestry and irrigation. Some of the former willow and woody vegetation has been replaced in many lowland areas by wetland/sedge/wet pasture and meadow/grass/pasture vegetation types.

The engineered flood control projects implemented by the U.S. Army Corps of Engineers during the 1950s caused significant changes in wetlands in the assessment area. In particular, the main stem of the Lower Sprague River was diked, straightened and isolated from its floodplain. As part of this same effort, wetland and riparian vegetation—including native willows, sedges and rushes—were removed.

CHANNEL CHARACTERISTICS

Channel conditions include the cross-sectional profile, the longitudinal profile, the ratio of width to depth, the connection of the channel to its floodplain, the sinuosity (or meandering pattern) and vegetation conditions. Each of these components is directly related to how the channel is functioning in terms of its ability to dissipate the energy of high flows. Each is also related to the quality of habitat for fish, because proper function with regard to these conditions results in the development of key habitat features for native species. Modifications of channel characteristics can result either from intentional reconfiguration of channel form to serve other purposes (dikes, reservoirs, dams, etc.) or from a gradual erosive process stemming from management of riparian areas.

The most intensive channel modifications in the assessment area, resulting from federal flood control projects, have already been discussed.

There are stream channels throughout the Lower Sprague-Lower Williamson subbasin that have experienced substantial channel modification, and some of this modification has been associated with excessive erosion. Such changes to the channel morphology are associated with a variety of activities, including over-grazing, beaver trapping, removal of riparian vegetation, land clearing, wildfires and loss of wetlands.

WATER QUALITY

Water quality is directly associated with the viability of habitat for aquatic organisms, as well as other beneficial uses. At the screening level of this Assessment, water quality in the major streams of the Lower Sprague-Lower Williamson subbasin would be considered impaired with respect to Oregon Department of Environmental Quality (ODEQ) statewide water quality standards for temperature, pH, phosphorus, bacteria and possibly dissolved oxygen. ODEQ has conducted extensive analyses on water quality parameters within the assessment area.

Most streams listed by the state as water quality limited are listed for temperature. Reduced streamside vegetation, reduced wetlands and channel widening may contribute to elevated stream temperatures. Groundwater pumping and flood-irrigated pastures may contribute to late-season lowering of water temperatures if return flows are subsurface. However, if return flows are on the surface, then they can contribute to increased water temperatures.

The streams and groundwater of the Lower Sprague-Lower Williamson subbasin are relatively high in dissolved phosphorus, due in part to erosion of soils and volcanic bedrock that are naturally high in phosphorous.

AQUATIC SPECIES AND HABITAT

The major focus of habitat quality issues within the Lower Sprague-Lower Williamson subbasin concerns native fish species. In particular, the influence of habitat quality on Klamath largescale sucker (Federal Species of Concern), Lost River Sucker, shortnose sucker (the latter two are Federally listed Endangered Species), redband trout and two currently extinct species of anadromous salmonids—chinook salmon and steelhead trout. Historical evidence suggests that fish populations in the Lower Sprague-Lower Williamson subbasin were different from those which exist today.

A variety of factors have contributed to the changes that have occurred. The construction of Chiloquin Dam interrupted normal passage, and the introduction of non-native fish species resulted in competition and hybridization. The loss in stream-side riparian zones may have led to changes in fish habitat due to changes in channel form and flow dynamics, alteration of vegetation cover and increases in stream temperature.

TERRESTRIAL WILDLIFE AND HABITAT

The Lower Sprague-Lower Williamson subbasin is noteworthy from a wildlife perspective because it contains a high diversity of species and because it is home to many species that have been classified as rare or deserving of special conservation status. Both of these factors are due, at least in part, to the location of this subbasin at the intersection of five different ecological regions. It is estimated that over 200 species of vertebrates occur in, or have been extirpated from, the assessment area.

Key issues that limit wildlife diversity include a reduction in vegetation complexity (multiple vegetation layers, including large trees), scarcity of snags and downed logs, and increasing abundance of noxious invasive plants.

In some cases, irrigated pastures result in benefits to certain species by providing additional vegetation for a longer period during the year. In other cases, grazing can diminish habitat quality for wildlife that depend upon the vegetation structure of shrubs or feed upon the associated plant species.

CONCLUSION

The Lower Sprague-Lower Williamson subbasin has experienced significant changes over the last century. Some of these changes have been positive, and others have been negative. And, in some cases, whether a given change is positive or negative has changed based on a better understanding of how the natural systems in the area function.

Healthy rivers, streams, riparian zones, wetlands, forests and uplands are critical to maintaining the economic, social and ecological benefits that residents receive from the watersheds within the subbasin. Although there is growing agreement concerning the benefits provided by watershed functions, there is considerable disagreement about the current condition of the natural resources, appropriate use of these resources, treatments and tools that can be used to restore and maintain healthy ecosystems, and prioritization of ecological and economic concerns.

Disagreement over the management and use of natural resources has recently led to litigation and regulatory actions, which sometimes exclude those most affected by management decisions. Increasingly, collaborative approaches are attempting to build capacity in local communities to confront complex natural resource problems in an integrated fashion.

The assessment process has indicated that local landscapes can be highly responsive to relatively modest shifts in management. Riparian areas and stream channels, in particular, have proven to respond in ways that result in short-term and long-term benefits for both the human and nonhuman inhabitants of the watersheds. In some cases, more intensive or costly projects may be needed to affect some watershed conditions. Overall, it is important to make progress by employing good management practices, changing practices when needed and working together across ownership boundaries.

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CHAPTER 14. RESTORATION ACCOMPLISHMENTS

It is sometimes assumed that watershed assessments are necessary because there are ecological problems that no one is doing anything about. This is certainly not the case in the Lower Sprague-Lower Williamson subbasin, where many management changes and restoration projects have already been implemented. Yes, there is more work left to do, but progress is already being made. This chapter summarizes some of the restoration and management work that has been done in the Lower Sprague-Lower Williamson subbasin in recent years. This work has, in most cases, been done collaboratively through partnerships involving private landowners, government agencies, advocacy organizations, community groups and everyday citizens. It is especially important to acknowledge the significant amount of work done by private landowners, which is oftentimes difficult to document or quantify.

PRIVATE LANDOWNERS

After conducting personal interviews with landowners of the Lower Sprague-Lower Williamson subbasin for this Assessment, there is no doubt that support for restoration efforts has increased among landowners over the last 15 years. With the help of local restoration and watershed education groups such as the Klamath Watershed Partnership, Water for Life Foundation, The Nature Conservancy, Klamath Basin Rangeland Trust, and Oregon State University Klamath Basin Research and Extension Center, landowners are able to find answers, advice, and direction quickly on how they can proceed with habitat restoration projects on their properties.

Measuring the exact number of projects is difficult because the sources of funding and monitoring are so diverse. There is, therefore, a data gap for which further research is needed to summarize projects by private landowners that are funded both independently and with financial assistance from local, state, and federal agencies and organizations.

It is known that many landowners are doing projects without any local, state or federal assistance. Cliff Rabe has conducted rotational grazing and noxious weed control for the past 20 years with private funds (Cliff Rabe, pers. comm. 2008). Bruce Topham has managed cattle grazing to avoid sensitive riparian areas along Whiskey Creek and springs, and has conducted extensive noxious weed control (Bruce Topham, pers. comm. 2006). There are many other examples of private projects that were completed with private funding and labor.

For example, erosion control to repair head cuts has been conducted at Dam's Meadow by the Bartell family with private funds and some assistance from the U.S. Fish and Wildlife Service (USFWS). The erosion was controlled in a straightforward manner using wool bales to stabilize the stream channel and hold water later in the season to allow vegetation to reestablish (Edward Bartell, pers. comm. 2006).

The Natural Resources Conservation Service (NRCS) estimates that over 200 projects on private lands in the assessment area have been reported to NRCS, Oregon Watershed

Enhancement Board, USFWS Klamath Falls Office, USFS Resource Advisory Committee, or the Klamath Watershed Council between 2000 and 2006 in the Lower Sprague-Lower Williamson subbasin. This number does not include those projects that are not reported to one of the above agencies, or those that are reported but for which permission has not been granted by the landowner for inclusion in these statistics. Many landowners have multiple projects and multiple funding sources for these projects, making estimates even more difficult.

Projects include but are not limited to riparian fencing, upland juniper removal, reconnecting river to floodplain, remeandering, wetland restoration, wetland fencing, riparian stabilization, willow planting, in-stream fish passage improvements, improved road crossings, improved irrigation water management, sprinkler installation, fish screens, new head gates and noxious weed treatments.

KLAMATH WATERSHED PARTNERSHIP

The Klamath Watershed Council (KWC) serves the entire Upper Klamath Basin from the Headwaters of the Klamath River to the California border. The Klamath Basin Ecosystem Foundation (KBEF) aims to protect, conserve and restore the natural resources of the Klamath Basin and to promote long-term sustainability of the region's economy. KBEF is made up of members representing the diversity of culture and lifestyle in the Upper Klamath Basin. In 2008 these two organizations merged to form the Klamath Watershed Partnership.

Sprague River Working Group

There are eight working groups within the Klamath Watershed Partnership that are primarily composed of landowners and community members. The Sprague River Working Group is the most active, with nearly 30 to 40 participants at each of its monthly meetings. These meetings are designed to encourage sharing among landowners concerning progress on agricultural lands and management strategies; inform landowners of opportunities from local, state, and federal agencies and organizations; and educate landowners on current issues such as endangered species and policy changes.

The Sprague River Working Group has helped members to better understand the process of obtaining restoration support on their properties, and as a result, the number of projects taking place in the basin has increased dramatically.

As part of the Lower Sprague-Lower Williamson River Assessment Field Season in 2006 and 2007, Klamath Watershed Partnership worked with the landowners, the National Riparian Service Team (NRST) and the Working Landscapes Alliance (WLA) to perform a site-specific assessment of riparian and upland conditions. The recommendations from this assessment focused on enhancing streamside forage and vegetation conditions by managing livestock access to riparian areas.

USDA AND KSWCD RESTORATION PROJECTS

The United States Department of Agriculture (USDA) agencies, NRCS and the Farm Service Agency (FSA) have performed environmental restoration work in the Lower Sprague-Lower Williamson subbasin in partnership with the Klamath Soil and Water Conservation District (KSWCD). A variety of federal programs are available to assist farmers and ranchers with conservation efforts. Such programs may provide cost-share and/or land leasing funds to accomplish certain tasks. The major programs are described briefly below.

Active Restoration Programs and Projects

The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with federal, state, and Tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation (CCC). CRP is administered by the FSA and the KSWCD, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

Goals of the CRP are to reduce soil erosion, protect the ability of the United States to produce food and fiber, reduce sedimentation in streams and lakes, improve water quality, establish wildlife habitat, and enhance forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as native grasses, wildlife plantings, trees, filterstrips or riparian buffers. Farmers receive an annual rental payment for the term of the multiyear contract. Cost sharing is provided to establish the vegetative cover practices (NRCS 2006).

An offspring of the CRP, the Conservation Reserve Enhancement Program (CREP) is a voluntary program for agricultural landowners. Unique state and federal partnerships allow landowners to receive incentive payments for implementing specific conservation practices. Through the CREP, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers on eligible land (NRCS 2006). Within the subbasin, there are currently portions of eight properties enrolled as CREP riparian buffer projects. The acreage these encompass is approximately 432 acres (J. Outlaw, pers. comm. 2008)

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program administered through the NRCS that was re-authorized in the 2002 Farm Bill. The program supports production agriculture and environmental quality as compatible goals.

Through EQIP, farmers and ranchers may receive financial and technical help, in the form of cost share, with structural and management conservation practices on agricultural land. NRCS administers EQIP based on locally identified natural resource needs consistent with national EQIP priorities. Local Working Groups (LWGs) convened by the Soil and Water Conservation Districts provide advice to NRCS about local priorities within their area. With this advice, NRCS evaluates applications for funding EQIP contracts consistent with these local priorities as well as national priorities.

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-share to implement selected conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are typically carried out according to a conservation plan, developed in conjunction with the producer, that identifies the appropriate conservation practice or practices to address landowner- and agency-identified resource concerns. The practices are subject to NRCS technical standards adapted for local conditions (NRCS 2006).

The Wetlands Reserve Program (WRP) is a voluntary program that provides technical and financial assistance to eligible landowners to restore, enhance and protect wetlands. Landowners have the option of enrolling eligible lands through permanent easements, 30-year easements and restoration cost-share agreements.

The Oregon WRP is focused on addressing the following issues on private and public lands: restoration of the functional role of wetlands in agricultural ecosystems; development of habitat for migratory birds; restoration and preservation of ancient crop areas for traditional, cultural practices and subsistence; and restoration and connectivity of aquatic and riparian habitat for endangered species.

In Oregon, projects have been funded from the coastal estuaries to the mountain meadows. Through WRP, significant investment has been made in the Klamath Basin. The goal of this investment is to restore wetland hydrology and help aid riparian and wetland function in this area (NRCS 2006). Within the subbasin, there were eight properties enrolled as WRP projects between 2000 and 2008. The acreage these encompass is approximately 7,700 acres (J. Outlaw, pers. comm. 2008).

THE NATURE CONSERVANCY

The Nature Conservancy (TNC) is working to restore the Williamson River Delta. In the 1950s, a 7,500-acre property that encompasses the Williamson River Delta was diked and drained for agricultural use, particularly to raise seed potatoes and alfalfa. As a result, the Williamson River in this reach was redirected and channelized. Since 1997, TNC has restored the course of the Williamson River and broken down the dike barriers. The breeching of the dikes has restored the delta area to hydrologic influences of Upper Klamath Lake. In time, wetland vegetation and hydrologic functions should restore the Williamson River Delta to its former function as a delta and lake fringe marsh.

Craig Bienz, TNC, believes that the primary issues in the Upper Klamath Basin appear to be with water quality and water quantity. TNC uses an approach that quantifies the extent of various threats and develops strategies to abate those threats, which it calls "Conservation by Design." TNC continually monitors its management, which then allows for making changes to better meet the conservation objectives, a process known by some as adaptive management.

USFWS (KLAMATH FALLS OFFICE) PROJECTS

The USFWS Klamath Falls Office is involved in a variety of restoration projects in the Lower Sprague-Lower Williamson subbasin, including restoration of river function by reconnecting the river to the floodplain by breaching levees, remeandering, and in-stream work; fence construction for livestock management; streambank stabilization to reduce sedimentation and erosion; restoration of wetlands; habitat restoration for native species; irrigation tailwater return systems; off-stream livestock watering; and planting of vegetation for stream shading and erosion control. Funding for restoration has been available through programs such as Partners for Wildlife, the Hatfield Restoration Program, Jobs-in-the-Woods and the Bureau of Reclamation Restoration Program. Since 1994, over 200 projects involving nearly 14,000 individuals have been undertaken in the Williamson River and Sprague River watersheds by the USFWS Klamath Falls Office. Many of these projects are on private lands and include the help and support of the farmers and ranchers of the community. Active USFWS projects in the Lower Sprague-Lower Williamson subbasin are presented in Table 14-1 (Sue Mattenberger, pers. comm. 2008).

Table 14-1 Active habitat enhancement projects through USFWS (Data Source: S. Mattenberger, USFWS, pers. comm. 2008)

Watershed Name	Project Description	Funding Year	# of Projects
Sprague River below Beatty	Channel Restoration	FY1996	1
	Channel Restoration	FY2001	1
	Channel Restoration	FY2003	3
	Channel Restoration	FY2004	2
	Channel Restoration	FY2005	2
	Channel Restoration	FY2006	1
	Channel Restoration	FY2007	2
	Channel Restoration	FY2008	1
	Riparian Restoration, Fencing	FY1995	4
	Riparian Restoration, Fencing	FY2001	6
	Riparian Restoration, Fencing	FY2002	1
	Riparian Restoration, Fencing	FY2003	1
	Riparian Restoration, Fencing	FY2004	1
	Riparian Restoration, Fencing	FY2005	2
	Riparian Restoration, Fencing	FY2006	4
	Riparian Restoration, Fencing	FY2007	2
	Riparian Restoration, Fencing	FY2008	4
	Wetland Restoration	FY1996	1
	Wetland Restoration	FY1999	1
	Wetland Restoration	FY2001	2
	Wetland Restoration	FY2002	1
	Wetland Restoration	FY2003	4
	Wetland Restoration	FY2004	1
	Wetland Restoration	FY2005	1
	Wetland Restoration	FY2007	3
	Wetland Restoration	FY2008	2
	Fish Passage	FY2002	1
	Fish Passage	FY2003	1
	Fish Passage	FY2007	1
	Spring Enhancement	FY2001	2
	Spring Enhancement	FY2004	1
	Dam Removal	FY2006	1
	Upland	FY1998	1
	Upland	FY2001	1
Williamson River below Kirk	Channel Restoration	FY2001	1
	Riparian Restoration, Fencing	FY2000	2
	Riparian Restoration, Fencing	FY2001	1

Watershed Name	Project Description	Funding Year	# of Projects
	Riparian Restoration, Fencing	FY2001	4
	Riparian Restoration, Fencing	FY2002	2
	Wetland Restoration	FY2000	1
	Wetland Restoration	FY2008	1
Total			**75**

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CHAPTER 15. RECOMMENDATIONS AND DATA GAPS

BACKGROUND

As has been emphasized throughout this document, specific restoration actions must be based on site-specific analysis of relevant parameters. The following generalized recommendations are intended to assist the prioritization process, but they are not meant to imply that a given recommended action is appropriate for all, or even most, sites.

Prime locations for restoration should be selected based on the importance of various limiting factors, probability of success, proximity to core habitat areas, landowner willingness and ability to participate, and cost/benefit tradeoffs. Restoration activity should be focused in areas that are the most likely to respond to management actions. To the extent possible, restoration should be coordinated among the landowners and other stakeholders in the subbasin to take advantage of possibilities to leverage multiple efforts for greater benefit. It is particularly important to develop an effective and affordable long-term monitoring program, so that the effectiveness of various restoration actions can be evaluated and documented.

RECOMMENDATIONS

Aquatic Species and Habitats

Restoration activities for aquatic species should be concentrated in areas with the best potential for success of coldwater species. Coldwater species such as redband trout exhibit high levels of sensitivity to habitat degradation and are great indicator species. Therefore, efforts should be focused on projects that help to establish or maintain their populations as well as recreate connectivity between populations.

Management actions to improve fish habitat should focus on preserving and recreating riparian corridors. Properly functioning riparian corridors will help bank stabilization, prevent erosion and substrate embedment, improve large woody debris recruitment potential and reduce stream temperatures. Other important activities should include identifying and removing fish passage barriers, and restoring properly functioning wetlands and floodplains. Actions such as these will benefit all native species of fish in the Lower Sprague and Lower Williamson rivers.

Action recommendations include the following:

- Encourage restoration of stream connectivity by eliminating barriers and obstacles to fish passage. Restoration and enhancement projects should focus on physical barriers that, when removed or repaired, create access to the greatest amount of high-quality fish habitat.
- Identify stream reaches that may serve as "oases" or refugia for fish during the summer months, such as at the mouth of small or medium-sized tributaries and coldwater springs. Protect or enhance these streams and spring riparian buffers and develop proper functionality.

- Encourage community participation in fish monitoring activities. Raise awareness about potential problems associated with introducing non-native fish species into rivers and streams.
- Work cooperatively with landowners to improve fish habitat conditions. Develop BMPs for agriculture and cattle grazing. Establish inexpensive passive restoration and enhancement projects to restore properly functioning conditions in riparian corridors.
- Provide landowners and appropriate entities with additional resources to assist in restoration and enhancement projects (e.g., find grant funding, help with project planning).

Channel Characteristics

Substantial changes to channel conditions occurred as a result of federal flood control efforts in the 1950s. Some of the effects of these actions, such as eradication of riparian vegetation, are easily reversible, and have been reversed in places. Other effects, such as channelization and diking, are more problematic because certain land uses now depend upon those modifications. Also, because flood control efforts involved substantial engineering and earth-moving, reversing the effects of these actions can be very costly. Nevertheless, opportunities to mitigate the negative hydrologic and biological effects of these modifications should be investigated.

While the Watershed Assessment can help to guide general restoration planning, site-specific field condition evaluations are needed for individual project scoping. It is recommended that a field-based analysis of channel conditions be conducted in advance of any detailed restoration project planning. One such analysis is currently being conducted by the Klamath Tribes Natural Resource Department. Members of the Working Landscapes Alliance can assist with site-specific plans.

At this time limited data are available on channel characteristics within the assessment area, particularly at the large scale of the assessment area. Many site-specific assessments of channel characteristics have been conducted on different stream reaches within the subbasin. However, no comprehensive study of the channel characteristics within the assessment area has been located.

Action recommendations include the following:

- Increase overall understanding of channel morphology conditions through more detailed field-based analyses.
- Investigate feasibility of restoring channel function.
- Where appropriate, improve pools and riffles while increasing in-stream large woody material by placing large wood and/or boulders in streams with channel types that are responsive to restoration activities and have an active channel less than 30 feet wide.
- Continue landowner visits based on Proper Functioning Condition (PFC), as well as programs to increase understanding of the importance of appropriate channel function, including the role of vegetation management on channel function.
- Establish and manage riparian pastures for both optimum channel stability and forage production; investigate options for timing and stocking of pastured livestock; and where appropriate, manage access to sensitive riparian areas with off-site watering and/or riparian fencing.

Geologic Processes

Erosion problems in the watershed can be addressed in some areas by riparian planting efforts and especially by efforts to control sediment inputs from roads and streambanks. Emphasis should be placed on road repair and decommissioning in roaded areas that are in proximity to the stream channel and on steep slopes, and also on riparian enhancement subbasin-wide. Erosion control efforts in upland portions of the watershed should be especially focused on areas subject to recent or ongoing land-disturbing activities.

Roads should be considered for closure and/or stabilization if they are presently causing, or are likely to cause, serious future erosion, are near fish-bearing streams, have excessively high maintenance costs or are determined to be unneeded. Stabilization of closed roads can include measures such as water bar installation, removal of fill material, culvert removal, and planting of native grasses and other plants.

Action recommendations include the following:

- Identify in greater detail areas of excessive streambank and gully erosion.
- Implement management changes or native vegetation plantings in riparian zones that are experiencing excessive erosion.
- Decommission roads that are no longer needed, especially those near streams, on steep slopes, and where road maintenance has been difficult.

Hydrology and Water Use

In the uplands, the ability of the watershed to capture, store and safely release available precipitation has been reduced as a result of changes in stocking levels, stand structure, increased canopy closure and vegetation composition. Optimizing the capture of available precipitation will result in significant benefits with respect to all beneficial uses, including irrigation, fish habitat and water quality. Measures that can be taken to improve the capture of available precipitation are discussed in the following section (Terrestrial Vegetation).

There is much uncertainty regarding the impact of diversions and water uses on habitat and hydrologic function. The state and transition of riparian and wetland communities are dynamic in time and space. The dynamic process has confused the interpretation of mechanisms that may result in changes in ecological function. Consequently, efforts to enhance function or productivity may fail. Moreover, the ability to “restore” an historic community state may not be achievable due to broader environmental changes. Until the science behind riparian and wetland state and transition mechanisms is better defined, much time, effort and funding may produce few positive results.

Some uncertainty is due to the ongoing adjudication process. But there are also unanswered questions regarding the impact of groundwater pumping, the role of irrigated pastures in groundwater storage, and the effect of irrigation development on total annual flows. While it is assumed that reducing unnecessary applications of diverted water would provide benefits to all users, it is critical that the above questions be resolved, so it will be clearer what potential there is for improvement.

Riparian Area

One of the most effective measures to enhance the overall health of the Lower Sprague-Lower Williamson River subbasin would be improvement of riparian health and associated in-stream habitat conditions. Efforts should be directed toward restoration of native riparian vegetation, especially native sedges, rushes, woody shrubs and trees. Restoration activities need to be assessed on a site-specific basis, with the landowner's management objectives in mind.

PFC site assessments are an excellent way to initiate the restoration process and to determine what type of restoration, if any, is necessary. Private landowners should be provided with the assistance to develop riparian restoration plans that can be effectively implemented within the constraints of their operating resources.

Some benefits of these riparian enhancement efforts will be seen almost immediately, while some may not be seen for several years. Still others will be manifested over a period of decades or longer. The vegetation type and overall conditions present in a specific area should be verified on the ground before planning any restoration activity.

High priority should be placed on preserving areas that currently are functioning well and providing acceptable habitat for riparian-dependent species. Such areas should be managed to further promote the development of desirable features, including densely rooted riparian plants, sediment capture, water storage capacity, large conifers and cottonwoods where appropriate, downed logs, snags and high species diversity.

Action recommendations include the following:

- Work with landowners, the community and other entities to develop a local PFC or site assessment team.
- Work with landowners, the community and other entities to secure funds to coordinate data collection, prioritization of projects and identification of priority surveys areas.
- Continue to work cooperatively with landowners, the community and other entities to conduct PFC site assessments of important riparian areas.
- Assist in implementation of land use practices that enhance or protect riparian areas, while maintaining the landowner's management objectives.
- Work with NRCS and other agencies to help identify sites within prioritized reaches where restoration is needed. Protect riparian areas by providing stock water systems, riparian fencing and shade trees outside of the stream channel and riparian zones, which would complement other management practices. Fence riparian areas as appropriate.
- Work with the Army Corp of Engineers to identify dikes where removal would increase floodplain access and improve stream function. Investigate the need to remove dikes along the streams.
- Identify sites where planting native riparian trees, shrubs and understory vegetation in areas with poor or fair riparian area conditions would be beneficial in accelerating recovery, where sites have potential for them. Work with landowners who know areas where these species were removed in the 1950s and 60s.

- Manage forested riparian zones for uneven-aged stands with large diameter trees and younger understory trees to allow establishment of shade-intolerant riparian species to establish.
- Maintain areas with good native riparian vegetation, noting that non-native species such as canary reedgrass may currently play a critical role for maintaining function.
- Where appropriate, establish buffers of native trees and/or shrubs, depending upon local conditions. If sites do not have potential for woody vegetation, manage for establishment of sedge/rush communities to aid in channel narrowing and reduction of width-to-depth ratios.
- Identify riparian zones dominated by xeric species and non-native plants and work to reestablish a higher water table that will support riparian/wetland species.

Terrestrial Vegetation

The uplands of the Lower Sprague-Lower Williamson subbasin, which consist primarily of ancient volcanic landforms (strato volcanoes, cinder and lava cones, basalt flows and deposits of welded tuff), wind-deposited volcanic ash and pumice, and ancient lake (lacustrine) sediments, make up the vast majority of the basin. These landforms, now expressed as mountains and hills and their associated side-slopes and alluvial fans, and the tablelands, tilted lava lands, lake terraces and ancient beaches have given rise, over time, to a wide array of soils with vastly different capabilities. These soils vary in the kinds and amounts of vegetation they produce, in the way they process precipitation and in the way they respond to treatment (management).

Much of this information is available to landowners, land managers and planners and can be found in the NRCS and Forest Service Soil Survey publications developed under the National Cooperative Soil Survey Program. It is strongly recommended that these locally prepared reports be referred to in the early stages of planning and in the application of any land treatment. However, site specifics must be checked in order to verify the soil survey reports.

Significant changes in plant community composition and plant density have occurred since the arrival of Europeans in the area. Future decisions regarding land use and treatment need to promote the capture of precipitation where it falls, the storage of that moisture in the soil for plant use and other forms of biological activity, and the eventual safe release of that moisture to deep percolation for groundwater recharge and lateral flow that maintains springs, seeps and streams.

Historic timber management has resulted in a loss of late and early seral stage forests and overstocking of current mid-seral stage woodlands. Suppression of fire has led to an overabundance of understory growth. Management to protect and develop late successional forest habitat, including the use of prescribed fire where appropriate, will promote the health and diversity of terrestrial ecosystems. Such habitat should be fostered, where possible, in large blocks rather than small patches. This process should be accompanied by thinning to reduce overstocking. Increased prevalence of late successional forest habitat will benefit a large number of species that utilize such habitat for their prosperity or survival.

Every effort should be made to curtail the spread of noxious and exotic plants and eradicate isolated patches of noxious weeds before they spread. Management actions could include cleaning large silvicultural and agricultural machinery of weed seeds and propagules to prevent unintentional dispersal of the plants. Such preventive actions would likely be more successful than attempted treatments after a particular invasive species has invaded.

It will be important to reintroduce frequent, low intensity fire as an important component of forest management in the ponderosa pine lands. Fire provides an essential function in riparian and wetland communities by recycling nutrients and preventing lodgepole pine encroachment. Fire is also important in the control and reduction of encroachment of juniper into shrub and grassland habitat.

Action recommendations include the following:

- Manage upland vegetation to maximize capture and safe release of available precipitation.
- Restore fire frequency and intensity to enhance ecological processes.
- Eradicate invasive, non-native plants.
- Reduce lodgepole pine encroachment into riparian and wetland communities.
- Reduce juniper encroachment into grasslands and riparian shrublands.
- Monitor the spread and extent of noxious weeds and invasive plants.

Terrestrial Wildlife

Much of the wildlife diversity in the assessment area is associated with early seral conditions and semi-open canopy forests, which are less common now than under the natural fire regime. Efforts to enhance watershed function through upland restoration will help sustain biological diversity and terrestrial wildlife.

Open woodland of western juniper has been an important habitat for wildlife in the Lower Sprague-Lower Williamson subbasin. However, the expansion of dense stands of juniper into shrub and grassland communities represents an important threat to wildlife associated with shrub-steppe vegetation. A return to a more normal (historically speaking) fire regime will contribute to restoration of shrub and grassland communities.

Local forestry and agricultural practices can lead to improved or diminished habitat conditions for elk, depending upon the resulting changes to vegetation patterns. Forest management that promotes late seral stage woodland with open areas can lead to improved elk habitat.

Action recommendations include the following:

- Promote the development of late seral ponderosa pine forest.
- Manage woodlands for creation of snags and large downed wood, especially near streams.
- Reduce fuels loading by implementing forest thinning operations.
- Create periodic openings in dense mid-seral stage forests.
- Manage for increased plant species diversity, especially in wetlands and riparian areas.
- Control invasive non-native plants.

Water Quality

In 1998, the Oregon Department of Water Quality (ODEQ) listed the Sprague and Williamson rivers as water quality limited for temperature, pH, and dissolved oxygen. Therefore, activities to improve and restore riparian conditions will have beneficial effects on water quality by increasing the amount of stream shading, increasing bank stability, decreasing erosion and preventing stream widening. Properly functioning riparian conditions will increase the potential for large woody debris deposition and increase sediment loading along streambanks, thereby decreasing in-channel substrate embedment and increasing pool and stream channel depth.

Furthermore, it is suggested that the decrease in properly functioning riparian corridors has lead to an increase in phosphorus loading. Increased erosion of naturally high-phosphorus soils and irrigation returns may be contributing to elevated phosphorus concentrations in subbasin streams and Upper Klamath Lake. Such an effect contributes to eutrophication. Therefore, efforts to restore properly functioning riparian corridors and control erosion will have beneficial effects on several aspects of water quality.

Action recommendations include the following:

- Continue monitoring and incorporation of existing projects within the subbasin to help increase our understanding and management practices. In addition, expand monitoring efforts to include more tributaries and main-stem sites to increase our ability to understand and manage the subbasin.
- Investigate the feasibility of constructing tailwater reuse systems or designing tailwater treatment wetland ponds for irrigation returns.
- Support projects that restore proper stream function by developing and/or reestablishing floodplains and wetlands.
- Increase shade and stream depth by managing to restore properly functioning riparian corridors.
- Develop livestock grazing practices (e.g., rotation grazing and seasonal grazing) that limit stream access during critical growing seasons for riparian vegetations. In addition, provide stock water systems and shade trees outside of the stream channel and riparian zones to limit cattle congregation along stream edges. Fence riparian areas to limit or exclude cattle from foraging along critical riparian corridor areas.
- Manage for robust riparian communities. Develop management strategies that maintain and create properly functioning riparian corridors.

Wetlands

There are many opportunities for wetland enhancement and restoration within the assessment area. It may be necessary to reconnect streamside wetlands and springs that have been hydrologically isolated from the stream system through non-natural processes. These areas, once reconnected, may provide rearing habitat and off-channel refugia for fish and other aquatic organisms during high flow periods. They also may provide important moderating controls on hydrology by helping to decrease peak flows and increase low flows.

Wetland restoration often involves engineering efforts to restore previously altered hydrological conditions. Such projects are often large, complex and expensive. However, there is also a great need for many smaller wetland restoration projects to restore hydrological connections to small, off-channel, low-lying areas. The cumulative benefits in terms of water retention and habitat enhancement can be substantial if many such projects are undertaken.

Action recommendations include the following:

- Encourage practices that limit adverse effects on existing wetlands, such as off-channel watering, hardened crossings, livestock exclusion (part or all of the year), and that provide stream shade.
- Increase awareness of wetland functions and benefits.
- Reconnect to the stream system, where practical, streamside wetlands, floodplains, and other areas having hydric soils.
- Reestablish beaver populations where appropriate, giving consideration to agricultural needs.

Restoration Projects

It is important to recognize the many activities that have been conducted on public and private lands to restore watershed and habitat conditions. These projects sometimes succeed and sometimes fail. It is important to learn from the successes, but also to learn from the failures, so they are not repeated.

Action recommendations include the following:

- Monitor restoration projects and best management practices.
- Determine which are succeeding and which are failing and, if possible, why.
- Conduct baseline monitoring, as well as post-project monitoring.

DATA GAPS

A number of data gaps were identified in the process of conducting this assessment. In the following sections, data gaps are described.

Aquatic Species and Habitats

- Locations of fish passage barriers (in particular, culverts). Identification and removal of fish passage barriers would provide fish access to upstream areas, potentially increasing the amount of available habitat. Fish passage barrier removal is one of the most effective means of improving conditions for fish populations. Field inventories of potential barriers, such as culverts, would be required. The U.S. Forest Service has inventoried some culverts on its lands, but not all potential barriers have been assessed for fish passage.
- Stream surveys. Stream surveys are extremely limited within this subbasin. Conducting additional stream surveys on stream reaches for which surveys have not been conducted would provide valuable baseline data for the condition and improvement potentials of the stream reaches.

Channel Characteristics

- Channel modifications. The major channel modifications that are a result of federal flood control efforts should be inventoried.

Geologic Processes

- *Detailed soils information.* Detailed soils maps in SSURGO format should be available for approximately 95 percent of the watershed (all except Fremont National Forest) in a seamless coverage by 2011. At that time, analysis on the erosion risks and hazards can be re-run on this detailed soils information.
- *Streambank erosion.* A survey of streambank erosion along reaches of Sprague River, Williamson River and larger tributaries should be conducted. This survey should include causes and explanation of excessive amounts of streambank erosion, particularly in terms of riparian-wetland functions.

Riparian Vegetation

- *Refinement of riparian vegetation information.* More information on riparian plant community species composition would be helpful in identifying areas of high quality riparian vegetation. Additional field verification and refinement of the air photo and LiDAR-based analyses of riparian vegetation could greatly improve the understanding of riparian vegetation in the Lower Sprague-Lower Williamson subbasin. Half-meter aerial photos from the summer of 2005 are expected to become publicly available from the State of Oregon in 2007 and may provide a high enough level of resolution to further classify riparian plant communities.

Roads

- *Detailed road and culvert condition information, including mapped locations of problem culverts and road segments.* Detailed road and culvert information would help prioritize actions to reduce erosion and sediment contribution to the stream system. Although the U.S. Forest Service maintains limited information on road conditions in this subbasin, data are incomplete in many parts of the subbasin. Data on roads outside of federally managed public lands are very limited.

Stream Channels

- *Channel modifications.* There are stream channels throughout the Lower Sprague-Lower Williamson subbasin that have experienced substantial channel modification due to federal flood control measures and other activities, as well as gullying, stream incisement, and channel widening. Unfortunately, few data exist regarding the specific locations of channel modifications and historical channel disturbances. A geomorphological study is currently being conducted for parts of the assessment area, but that information was not available for inclusion in this Assessment.

Weeds

- *Information regarding distribution and trends of establishment for noxious and exotic weed species.* The development of a noxious weed database that allows analysis and characterization of the status of noxious and exotic weeds would be useful. Information regarding the location of weeds could be gathered in the field during routine weed eradication efforts or obtained directly from landowners, and the information could be analyzed on a periodic basis to determine trends and spatial patterns of noxious weed populations in the subbasin.

Wetlands

- *Historical wetland distribution.* Information regarding the historical location of wetlands would be useful for planning riparian and wetland restoration activities. Historical wetlands could be mapped by identifying hydric soils from SSURGO and U.S. Forest Service soils maps. The NRCS is conducting soils inventories that will be useful to assess historical hydric soils.