# Environmental Conditions
# Appendix II

The unique geology, hydrology and climates of the Deschutes River Subbasin create a diverse mix of habitat conditions for fish and wildlife. These populations are linked to the ecosystems in which they live and their health, individual characteristics and abundance reflect the diversity — and quality — of their environments. Fish populations, for instance, developed complex life histories through time that responded to the subbasin's considerable variation in habitat conditions. Stream flows, water temperatures, substrate characteristics and other combined attributes affected anadromous fish distribution within the subbasin and timing of migration. Wildlife population abundance and distribution also developed in response to habitat conditions. Native grasslands once covered vast areas and supported species such as sage grouse, which once occurred exclusively in this habitat. Loss of grassland habitat greatly reduced such populations. Today subbasin habitat conditions continue to influence fish and wildlife production, distribution and survival. These habitats and their attributes — as well as the aquatic and terrestrial populations they support — are affected by both natural watershed processes and human activities that influence flow, water quality, upland and riparian conditions and instream habitat.

This chapter examines how environmental conditions in the Deschutes watershed affect the subbasin's fish and wildlife populations. Building on the more general review provided in the Overview, the discussion characterizes the environmental conditions within three watershed areas: the Lower Deschutes watershed (below RM 100), Crooked River watershed, and Upper Deschutes watershed (above RM 100). It characterizes the natural watershed environments, such as geology, climate and hydrology, and the focal fish species they support. It looks at historical conditions believed to exist in the watershed at the time of European settlement in the early and mid 1800s and the unique environmental conditions existing today in major drainages of each watershed. In addition, it identifies desired future (potential/optimal) conditions in the year 2050, and examines what future conditions might be expected if no additional future actions are taken.

## 1. Lower Deschutes River Watershed

The lower Deschutes River watershed encompasses the portion of the Deschutes Watershed draining into the 100-mile reach from the Pelton Round Butte Reregulating Dam to the confluence with the Columbia River. The watershed covers approximately 2,680 square miles (1,715,200 acres).

### *1.1. The Lower Watershed Natural Environment*

Below the Reregulating Dam, the Deschutes River enters a narrow, picturesque desert canyon ranging from 700 to 2,000 feet deep. The river's elevation drops from 1,393 feet at the dam to 160 feet at the mouth. Gradient is relatively constant along the reach, with two major drops occurring at Sherars Falls (RM 44), a vertical drop of 15 feet, and Whitehorse Rapids (RM 75), a drop of 35 feet in one mile

The watershed includes approximately 760 miles of perennial streams and 1,440 miles of intermittent streams. Major tributaries entering the Deschutes from the west side include Shitike Creek, White River and Warm Springs River. These streams drain the eastern slopes of the Cascade Mountains. Major tributaries entering the lower Deschutes from the east include Trout, Bakeoven, and Buck Hollow creeks. These tributaries drain the Ochoco Mountains and high Columbia plateau. The lower watershed contains 28 high mountain lakes (including 10 lakes within the Warm Springs reservation), 6 lower elevation lakes and small reservoirs, and numerous man-made or natural small ponds.

### 1.1.1. Geology, Soils and Vegetation

Much of the lower Deschutes watershed is underlain by the Columbia River Basalt group, a series of layered basalt flows that erupted primarily between 17 and 14.5 million years ago (O'Connor et al. 2003). These basalt flows extend from northwestern Oregon, north into Washington and east into Idaho. The Columbia River Basalt has preserved major ridges in the watershed and is between 1,000 and 2,000 feet thick (LDLAC 2002). Younger formations, formed between 15 and 4 million years ago, include the Simtustus, Deschutes and Dalles formations. From Lake Billy Chinook north, the Deschutes River carves through these younger formations, bordered by wide, nearly level basalt ridge tops and cutting a deep V-shaped canyons up to 1,000 feet deep. Large tributaries from the west drain the Cascade Range, while tributaries from the east drain tablelands of the Columbia River Basalt Group and the softer John Day and Clarno Formations. The lower eastside area has the highest average slope and drainage density of the entire Deschutes River watershed (O'Connor et al. 2003). Elevations in the northern watershed range from 11,240 feet at the top of Mount Hood (headwaters of White River) to 160 feet at the river's mouth.

Soils in the watershed were formed in residuum from the weathering of bedrock and in colluvium on sloping uplands and plateaus; material transported by water and deposited as unconsolidated deposits of clay, silt, and gravel; pumice and ash from volcanic activity (Newberry Crater and Mount Mazama); and loess that has been transported by wind from other areas. In some areas, these soils are highly erodible. Erosion potentials due to water or wind range from slight (less than 2.5 tons/acre/year) to severe (5 to 15 tons/acre/year) (LDLAC 2002).

Vegetation in the lower Deschutes watershed ranges from steppe and shrub-steppe in the canyon and plateau areas, to coniferous forests in the Cascade and Ochoco mountains. Indigenous vegetation includes bunch grass, sagebrush, bitterbrush, juniper and ponderosa pine in the lower elevation canyon and plateau areas. At increasing elevations in the western and southeastern portions of the watershed, the coniferous forests transition from pine into Douglas fir and grand fir. Western hemlock and lodgepole pine are common at upper elevations of the eastern Cascades, while western red cedar and Engelmann spruce are common along the stream margins at mid to upper elevations. In some areas, non-indigenous species such as cheatgrass, Kentucky bluegrass and medusa-head wild rye have been introduced through cultivation, livestock grazing and other human activities. Riparian vegetation along the lower Deschutes is dominated by perennial grasses, with communities of sedges, rushes, emergent aquatic plants, birch, hackberry, willow, cottonwood and alder. Low elevation perennial stream corridors are similar, with mixes of vine maple, alder, and cottonwood at higher elevations.

### 1.1.2. Climate

The climate in the lower Deschutes River watershed ranges from transitional in westside tributary headwaters to semiarid in the mainstem canyon and on eastside uplands. While the high slopes of the Cascades often collect more than 100 inches of precipitation each year, much of the watershed lies in the rain shadow of the Cascades and receives little precipitation. Precipitation levels drop significantly from west to east. Annual precipitation in the White River drainage, for instance, ranges from more than 100 inches in the headwaters to 11 inches or less near the river's mouth (Clark 2002). Most precipitation near the Deschutes falls as rain, but there is a substantial snowfall almost every winter at higher elevations.

Drainages on the east side of the Deschutes receive substantially less precipitation. The Bakeoven Creek watershed receives 10 to 12 inches of precipitation annually (Wasco County SWCD 1994). This low rainfall is characteristic of the Intermountain Region, which receives 70-80% of its precipitation between November and March. Two types of events that produce substantial and frequently damaging runoff events in this area are heavy precipitation or rapid snowmelt on frozen soils and violent summer cloudbursts.

Air temperatures within the lower Deschutes watershed range from –10$^{o}$F in the winter to over 100$^{o}$F in the summer. The Dalles, located near the mouth of the Deschutes River, experiences some of the highest temperatures in the state of Oregon.

## *1.2. Historic Environmental Conditions*

Before 1855, the lower Deschutes River displayed many of the same conditions seen today. The river flowed within a constrained channel flanked by deep canyon walls. Few side channels were present. Alder, willow, birch and some cottonwood trees dominated riparian vegetation with shrubs, grasses, sedges, rushes, and other forbs skirting the water's edge. Streamflow in the lower mainstem was generally uniform throughout the year, due to a high contribution of spring fed waters from the Metolius, Crooked (Opal Springs) and Deschutes River (Alder Springs), as well as the Upper Deschutes system. High flow events and associated bedload redistribution occurred, but were infrequent (Hosman et al. 2003). Flows from more runoff-dominated watersheds in the Crooked River and lower basin tributaries were moderated by the larger capacity of fully-vegetated floodplains, which stored and released water throughout the drier summer months and during periods of prolonged winter cold. This stable flow pattern supported healthy riparian communities, and stable streambed and channel configurations. Water temperatures in many reaches also varied less than today due to the moderating effect of upstream springs and seeps associated with sub-irrigated meadows and wetlands (CTWS 1999a).

Westside tributaries to the lower Deschutes River such as the Warm Springs River and Shitike Creek displayed highly complex and favorable riparian and channel conditions for salmonid production (CTWS 1999a). Variable habitat characteristics within constrained and unconstrained stream reaches provided a mix of single channel and multiple channel areas. Beavers created off-channel habitat and wet meadows along unconstrained reaches. Well-developed riparian corridors consisted of deciduous and coniferous trees, shrubs and grasses. Groundwater recharge from wet meadows and beaver complexes stabilized summer and low winter flows and moderated water temperatures. Thus, summer water temperatures were within optimal range for salmonid growth and survival, while cold winter flows were moderated by springs and groundwater discharge from a well developed riparian system. Large woody debris and logjams were also abundant and provided high quality fish hiding and rearing habitat. The Warm Springs River, Shitike Creek and White River delivered abundant coarse sediment to the Deschutes River valley during high flows, perhaps exceeding the gravel volume delivered from upstream (O'Conner et al. 2003a). However, the stream systems may have been more hydrologically stable than today, with well vegetated riparian areas. As today, White River transported large volumes of fine glacial sand and silt from its source on Mount Hood to the Deschutes River.

The eastside tributaries — primarily Buck Hollow, Bakeoven and Trout creeks — flowed through more arid landscapes and contained salmonid habitat that was probably close to marginal under conditions of extended drought (Lichatowich et al. 1998). The drainages received much lower precipitation than the westside drainages and soils were susceptible to erosion (O'Connor et al. 2003a). As a result, they were substantially influenced by climatic conditions. Thunderstorms caused sudden, high flows promoting more dynamic stream channel behavior and characteristics than typically found in other Deschutes tributaries. In streams where natural flows dropped to low levels during summer months, late summer water temperatures became elevated, particularly during low precipitation years. The effects of such natural disturbances were buffered by conditions in the watersheds. Bunch grass plant communities on the uplands, more developed floodplains, and well-vegetated stream corridors slowed runoff and tempered flow and water temperature fluctuations. Beaver complexes and wet meadows promoted sustained groundwater recharge. Beaver complexes also created pools that provided cool water refuge for rearing salmonids and slowed the release of sediments into the stream systems. In-channel large wood and debris dams also provided adult and juvenile cover and rearing habitat. Variable habitat characteristics existed within constrained and unconstrained stream reaches, providing both single channel and multiple channel areas. In lower gradient reaches, stream channels were sinuous and bordered by deciduous vegetation and grasses (CTWS 1999a).

## *1.3. Current Environmental Conditions*

### 1.3.1. Hydrology

The lower Deschutes River displays relatively uniform flows due to the upper system's ability to collect, store and slowly release runoff as groundwater (Gannett et al. 2003). Much of the system's groundwater re-enters the Deschutes River just above the lower Deschutes watershed, creating a substantial base flow in the lower river. During an average year, 91% of the water entering the lower Deschutes River through the Reregulating Dam is from groundwater sources (Gannett et al. 2003). Flows in the lower Deschutes River have exceeded 3,200 cfs 99% of the time, but have only exceeded 9,040 cfs 1% of the time since 1965 (Huntington 1985, O'Connor et al. 2003a). The average annual discharge for the Deschutes River Subbasin is 4.2 million-acre feet, with the lower watershed contributing about 1.2 million-acre feet to this runoff. During peak events, however, runoff from the lower subbasin adds substantially to Deschutes River flow. More than 70% of the peak discharges of both the December 1964 and February 1996 flood flows in the lower Deschutes entered the river downstream of the Pelton Round Butte Complex, an area that represents only 26% of the total Deschutes watershed area (O'Connor et al. 2003).

Streamflows in lower basin tributaries reflect conditions within individual drainages. Westside tributaries, such as the White River, Warm Springs River and Shitike Creek, receive more precipitation than eastside tributaries, including more snow. Flows in these systems peak in the spring and taper off to base flows in August or September. Flows in eastside tributaries Bakeoven, Trout and Buck Hollow creeks are more variable. These streams do not develop large snowpacks, have no glacial influence, and have shallow soils leading to flashier responses to climatic conditions. Streamflows in these systems rise quickly with winter rain or snowmelt and summer rainstorms, contributing to high runoff and flow events. Flows peak in winter and early spring and rapidly diminish to low levels in summer. Stream channel behavior and characteristics are more dynamic than in most other Deschutes tributaries.

Flows have been over appropriated on several streams in the lower Deschutes watershed. Flow conditions in the lower Deschutes and its major tributaries are discussed later in more detail.

### 1.3.2. Water Quality

The Oregon Department of Environmental Quality has listed several reaches within the Lower Deschutes River Watershed that do not meet state standards. This list, called the 303d list, and the water bodies on it are considered to be "water quality limited". Primary parameters of concern are temperature, pH, bacteria and total dissolved oxygen (Table X). Water quality problems may also exist in other areas. Data has been collected from few sites and the list may not accurately reflect the extent of water quality problems in the Deschutes Subbasin. Water quality concerns in each major tributary are addressed in more detail later in this section.

**Table X. Water Quality Limited Streams in Lower Deschutes Subbasin and Trout Subbasin (DEQ 2002 303(d) List).**

| STREAM SEGMENT | RIVERMILE | PARAMETER | REASON for LISTING |
|---|---|---|---|
| **Lower Deschutes Subbasin** | | | |
| Buck Hollow Creek | 0-37.7 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Clear Creek | 0-15.1 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Deschutes River (mouth to White River) | 0-46.4 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Temperature (Sept 1-June 30) | Salmonid Spawning: >55°F |
| | | pH (Summer) | pH >8.5 |
| Deschutes River (White R to Reregulating Dam) | 46.4-99.8 | Temperature (Year Around) | Oregon Bull Trout: >50°F |
| | | Temperature (Sept 1-June 30) | Salmonid Spawning: >55°F |
| | | Dissolved Oxygen (Sept 1-June 30) | Salmonid Spawning: <11 mg/l or<95% saturation |
| | | pH (Winter/Spring/Fall) | pH >8.5 |
| Gate Creek | 0-14.3 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | Excessive surface fines |
| Oak Canyon | 0-6.3 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Rock Creek (mouth to Rock Creek Reservoir) | 0-8.1 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Rock Creek (Reservoir to FS Road 4810) | 8.8-14.1 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Rock Creek (mouth to headwaters) | 0-15.9 | Sedimentation | Excessive surface fines |
| Sixteen Canyon | 0-3.7 | Temperature | Salmonid Rearing: >64°F |
| Tenmile Creek | | Temperature (Summer) | Salmonid Rearing: >64°F |
| Threemile Creek (tributary to White River) | 0-11.3 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Wapinitia Creek | 0-14.4 | Temperature (Summer) | Salmonid Rearing: >64°F |
| White River | 0-12 | Temperature (Summer) | Salmonid Rearing: >64°F |
| Trout Subbasin | | | |
| Auger Creek | 0-6.5 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Big Log Creek | 0-5.5 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Bull Creek | 0-1.8 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Cartwright Creek | 0-4.3 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Dick Creek | 0-2.2 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High cobble embeddedness |
| Dutchman Creek | 0-4.8 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Potlid Creek | 0-5.2 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |
| Tenmile Creek | 0-5.9 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Temperature (Oct 1-June 30) | Salmonid Spawning: >55°F |
| Trout Creek | 0-50.7 | Temperature (Summer) | Salmonid Rearing: >64°F |
| | | Sedimentation | High substrate embeddedness |

## 1.3.3. Land Use and Management

The entire lower Deschutes River watershed is located within the boundary of lands ceded to the United States government by the seven bands of Wasco- and Sahaptin-speaking Indians whose representatives and head men were signatories to the Treaty with the Tribes of Middle Oregon of June 25, 1855. The Warm Springs Tribes are the legal successor to the Indian signatories to the treaty. Tribal reservation and off-reservation lands comprise approximately 21% of the land area of the lower Deschutes

River watershed. Tribal lands are managed primarily for timber production, livestock grazing, and residential uses.

The watershed contains several large parcels of public land. The Forest Service manages 235 square miles in the White River watershed, or 11% of the lower Deschutes River watershed. The Ochoco National Forest manages 27 square miles of land in the headwaters of the Trout Creek drainage. The Forest Service also manages about 23 square miles of the Crooked River National Grasslands in the Trout Creek drainage. The Bureau of Land Management manages about 4% of the watershed, mostly along the lower 20 miles of Deschutes River and along White River. Major land uses on federal lands are timber management, livestock grazing and recreation. The State of Oregon manages approximately 2% of the lower Deschutes River watershed. State lands are managed for recreation, fish and wildlife needs, and livestock grazing.

Private lands make up 62% of the lower watershed, mostly in the middle and lower drainage. These lands are generally managed for agricultural and range use.
Dry land grain production and pasture, principally wheat and barley, are common in the White River watershed. Irrigated farming is generally confined to the valley bottoms along Trout, Buck Hollow, Tygh, Shitike and Badger creeks, and along lower Warm Springs and White rivers. Large tracts of irrigated cropland occur in the Agency Plains area north of Madras and smaller, scattered tracts exist in the Juniper Flat and Wamic areas east of Maupin. Several small irrigated areas border the Deschutes River between North Junction and the Reregulating Dam. Livestock grazing is common in the lower Deschutes River canyon above RM 20 and in tributaries.

The lower Deschutes watershed includes several small communities. Warm Springs (population 3,800) is located along lower Shitike Creek. Maupin (population 500) borders the Deschutes at RM 51 and the mouth of Bakeoven Creek. Other communities in the lower watershed include Tygh Valley, Wamic, Antelope, Pine Hollow, Sidwalter, Simnasho and Pine Grove.

**Wild and Scenic Rivers**

The lower Deschutes River has been designated for protection and enhancement of its scenic, aesthetic, natural, recreation, and fish and wildlife values.

- In 1970, the lower 100 miles of the Deschutes River were designated a component of the Oregon State Scenic Waterways system.

- In 1988, U.S. Congress designated the lower 100 miles of the Deschutes River as a recreational component of the National Wild and Scenic Rivers System.

## *1.4. Focal Fish Species for the Lower Deschutes Watershed*

The lower Deschutes watershed supports several fish species that are the focus of this plan. These focal species include Chinook salmon (spring and fall), rainbow trout (redband and steelhead), bull trout, sockeye and lamprey. This section describes focal species use and distribution in the lower Deschutes watershed, as the fish populations are linked to both natural watershed processes and to human activities that influence water quality, riparian conditions and instream fish habitat.

## 1.4.1. Chinook Salmon

### Spring Chinook

Two separate naturally producing spring Chinook populations are recognized in the lower Deschutes River: one in the Warm Springs River and one in Shitike Creek. Both river systems are located on the Warm Springs Reservation. There is no evidence that wild spring Chinook spawn in either the mainstem lower Deschutes River or tributaries other than the Warm Springs River or Shitike Creek.

### Summer/Fall Chinook

Fall Chinook spawning and rearing is concentrated in the lower Deschutes River. Their historical range may have been similar to that seen today. There are some indications that summer run of Chinook once returned to the lower river, but have since been extirpated. Today, fall Chinook return to the Deschutes River from July through November. They hold in deep pools and runs before spawning in the Deschutes mainstem from October and through December.

## 1.4.2. Redband Trout

### Summer Steelhead

Wild summer steelhead spawn during late winter and early spring in the lower Deschutes River, Warm Springs River system, lower White River, Shitike Creek, Skookum Creek, Wapinitia Creek, Eagle Creek, Nena Creek, the Trout Creek system, the Bakeoven Creek system, the Buck Hollow Creek system and other small tributaries with adequate flow and no barriers to fish migration.

### Resident Redband Trout

Wild rainbow, or redband, trout are present throughout the lower Deschutes River and most tributaries with adequate flow. Redband trout are believed to be less abundant in the Deschutes below Sherars Falls than above (Newton and Nelson 1998), and are believed to be most abundant in the reach from the Reregulating Dam to Maupin (Schroeder and Smith 1989; Zimmerman and Reeves 2000).

## 1.4.3 Bull Trout

Fluvial and resident populations of bull trout reside in Shitike Creek and the Warm Springs River (Brun 2000; Brun and Dotson 2001,2002). Fluvial components of these populations spawn and rear in headwater reaches and sub-adults and adults drop downstream to the Deschutes River to rear before spawning. Headwater areas in Shitike Creek and the Warm Spring River contain cold springs and heavy cover necessary for bull trout spawning and rearing.

## 1.4.4. Pacific Lamprey

Pacific lamprey return to the lower Deschutes and migrate into the Warm Springs River, Beaver Creek and Shitike Creek where they are believed to reproduce naturally (Personal communication with CTWS staff). Most, if not all, lamprey spawning in the lower Deschutes River watershed is assumed to occur within the boundaries of the Warm Spring Reservation.

## 1.5. Focal Wildlife Species in the Lower Deschutes Watershed

Natural grasslands are a historically important wildlife habitat that has almost completely disappeared in the lower Deschutes watershed. Maps of historic habitat show a large area of grassland habitat in the eastern part of the lower basin in Wasco and Sherman counties. One species formerly existing in this habitat, the Columbian sharp-tailed grouse, is no longer present in the subbasin.

[Other information will be added after focal wildlife species/habitats are identified.]

## 1.6. Current Conditions in Major Drainages

This section describes current environmental conditions within the major drainages of the lower Deschutes River below Pelton Dam. These drainages are: the mainstem Deschutes, mouth to the Reregulating Dam (RM 0 to 100); Buck Hollow Creek; White River; Bakeoven Creek; Warm Springs River; Trout Creek; and Shitike Creek.

### 1.6.1. Lower Mainstem Deschutes River, Mouth to Pelton Round Butte Complex (RM 0 to 100); excluding Buck Hollow, Bakeoven, Shitike and Trout Creeks, and the White and Warm Springs Rivers.

The lower Deschutes River flows through a low gradient channel with scattered rapids set in a deep, narrow, arid valley. Stream width averages 263 feet, and varies from 30 to 560 feet, excluding islands. Total water surface area is about 62.1 million square feet at average discharge (Aney et al. 1967). The reach provides important spawning and rearing habitat for fall chinook, summer steelhead and redband trout, and rearing habitat for spring chinook and bull trout. Salmonids also migrate through the reach as they move to and from tributary spawning and rearing grounds. The lower river is part of the federal Wild and Scenic Rivers system and is an Oregon Scenic Waterway.

<u>*Uplands*</u>
The lower Deschutes watershed displays steppe and shrub-steppe habitats in the canyon and plateau areas, and coniferous forests in the Cascade and Ochoco mountains. Lands are in public, Tribal and private ownership. They are generally managed for agriculture, range, timber harvest and recreational uses.

<u>*Riparian Areas*</u>
The lower Deschutes River is confined by canyon walls and shows many aspects of a spring-controlled system. The banks are generally lined with a narrow fringe of trees and other riparian vegetation. The channel is remarkably stable and has not shifted more than 200 feet in the last 90 years, despite impacts from two exceptionally large floods (O’Connor et al. 2003; Curran and O’Connor 2003). The growth of white alder along the river reflects the system’s stability. White alder is the dominant riparian tree along the lower Deschutes and typically lives up to 50 years. They need summer

moisture and can withstand occasional flooding, but cannot tolerate weeks of inundation (Minear 1999).

Some riparian areas along the lower Deschutes River have been degraded through land use actions, such as concentrated recreation, overgrazing, road and railroad construction/maintenance, and localized urban development. These activities reduced habitat complexity along stream margins. Riparian characteristics along some degraded reaches have improved significantly over the last 20 years because of camping and vehicle use restrictions, improved grazing management, and other recovery efforts. Reaches along the smaller Deschutes River tributaries are often sparsely vegetated and lack the woody component of a healthy riparian area.

*Instream Habitat*

A complex aquatic habitat — including large boulders, bedrock irregularities, rooted aquatic macrophytes, overhanging vegetation, and varying water turbulence and depth — provides diverse cover for focal species in the lower Deschutes River. Stream and island margins provide important rearing habitat and escape cover for 0-age fish. Instream habitat complexity is generally lacking in the upper section, except where habitat is associated with river rapids. Side channels associated with islands also provide important spawning and rearing habitat for salmonids. In 1995, 68% of all steelhead spawning between the Reregulating Dam and the mouth of Trout Creek occurred in side channels between islands and channel margins, despite the fact that such side channels comprise less than 10% of the channel length within the reach (Zimmerman and Ratliff 2003; Zimmerman 2000). Other good instream structure, in the form of large boulders and cobble, is associated with old landslides that may have blocked the river flow for short periods. These sites, as described by (O'Connor (2003a) include Trout Creek, White Horse, Buckskin Mary and Box Car rapids. Wood from the riparian zone, mainly dead white alders, accumulates between infrequent high water events and enhances instream habitat. Unlike most streams, large wood from tributaries does not appear to be an important habitat component in the lower Deschutes aquatic ecosystem as infrequent floods large enough to mobilize the wood from tributaries normally deposits that wood out of the wetted channel (Minear 1999). All large wood recruitment to the lower river from the upper subbasin has been blocked for nearly 50 years by the Pelton Round Butte Project.

The lower 46 miles of river substrate contains a high amount of glacial sand and silt that originates from White River, though the Deschutes River is usually capable of transporting this material (Fassnacht et al. 2003). This lower section also periodically receives heavy silt loads from tributaries during high intensity storms on rangeland and adjacent cropland. The fine sediments limit available trout spawning gravel in the lower mainstem as spawning areas often contain a high percentage of glacial sand and silt and are frequently embedded (Huntington 1995). Fine sediments also impact larger gravels used by Chinook salmon. However, the large fish are able to move and clean this substrate during spawning (Huntington 1995).

Spawning gravel for trout and steelhead is limited below White River, but scattered throughout the upper river reach. Because of stable flows, exposed gravel bars are very rare in the lower Deschutes. Mid-channel sand and gravel bars deposited during large floods generally lie only a few inches or feet above the typical annual flow range and rapidly become stabilized by riparian growth until the next significant flow (O'Connor et al. 1999). Some spawning habitat has been lost, especially in the upper portion of this reach, due to cementing of substrates and colonization by mats of rooted macrophytes between infrequent flood events. Important, although limited, habitat for steelhead is found in eastside tributaries Trout, Bakeoven and Buck Hollow creeks. It appears that steelhead use these tributaries at a much greater rate than resident redband trout (Zimmerman and Reeves 2002). Many other short, moderate gradient channels are also used by steelhead for spawning during late winter runoff events. Most reaches in eastside tributaries lack overhanging vegetation. Instream cover is often confined to large gravel, cobble and boulder substrate. High silt/sediment levels (Dry Creek) or gradient and large substrate (Frog Springs Creek) also limit spawning in some tributaries.

*Flows*

The hydrograph for the lower Deschutes River has not changed substantially from pre-European settlement to today (Gorman 2004). The lower river experiences only small seasonal variations in discharge because of large groundwater contributions. According to Gannett et al. (2003), of the approximately 91% of the flow of the Deschutes River at Madras that originates as groundwater, roughly half comes from discharge to the mainstem Deschutes and lower Crooked Rivers within about 16 km of their confluence. The Deschutes River itself gains about 400 cfs from groundwater inflow between Round Butte Dam and Dry Creek at RM 91.8 (about 2.5 miles below Shitike Creek) (Gannett et al. 2001). River level is also controlled by long-term weather patterns and by Pelton Round Butte Project operations. Below the Reregulating Dam, flows average 4,525 cfs, with maximum monthly averages from January through April of 9,000-9,500 cfs. Low flows of 3,000 to 3,800 cfs may occur in any month, though the lowest flows (ranging from 3,015-3,059 cfs) occur in July, August and September. Mean annual flow near the confluence with the Columbia River (Moody gage) averages 5,739 cfs and ranges from 4,290 to 7,380 cfs. Maximum flows generally occur from January through March and minimum flows between July and October. The two largest flood peaks of record occurred in 1964 (instantaneous flow of 67,300 cfs) and in 1996 (instantaneous flow of 70,300 cfs). Water is withdrawn from the lower Deschutes River for limited irrigation, municipal and industrial uses. Flows from tributaries to the lower Deschutes contribute significantly to peak flows in the mainstem Deschutes River (O'Connor et al. 2003a).

*Water Quality*

High stream temperatures are a problem in some reaches. Summer water temperatures in the lower Deschutes below White River exceed the 64°F temperature standard for salmonid rearing and the 55°F temperature standard for salmonid spawning. Between the White River and the Reregulating Dam, water temperatures frequently exceed the state water quality standards for bull trout (50°F) and salmonid spawning (55°F) (Table X). Changes in water temperature can alter growth rates and development of salmonid eggs, fry and juvenile fish.

Dissolved oxygen and pH levels exceed ODEQ standards in some lower river reaches. Dissolved oxygen levels in the Deschutes River from White River to the Reregulating Dam fall below the Oregon Department of Environmental Quality's 90% saturation standard during spawning (September 1 through June 30). Measurements taken by PGE biologists (1998) indicate that ambient dissolved oxygen levels fall to 70-75% of saturation, or approximately 7.5-8.0 milligrams per liter in early morning hours during late-summer and early autumn (Lewis and Raymond 2000). Maximum dissolved oxygen levels during this time were approximately 85% saturation, or around 8.6-8.8 milligrams per liter. State and Tribal dissolved oxygen standards require 11 mg/l or 95% saturation for these waters during spawning. The lowered level of dissolved oxygen could impact the development of incubating fish eggs or later life stage development. Intergravel dissolved oxygen levels may reach lethal levels during Chinook salmon egg incubation. In addition, pH levels for the lower Deschutes River exceed ODEQ's statewide pH standard 23% of the time at the river mouth and 11% of the time at Highway 26 (RM 96) (DEQ 2002 303(d) List).

Water turbidity levels rise in the lower Deschutes due to natural discharge of glacial sediments from White River. Turbidity occasionally affects fish production, particularly since juvenile fishes are sight feeders. Meehan (1982) reported that suspended sediment in excess of 50 NTU at water temperatures above 41°F generally reduces feeding success, growth, and competitive ability. Chronically turbid waters, particularly during the spring, can substantially reduce growth of fish fry. Turbidity can also cause physical discomfort or injury to fish, depending upon the concentration and the duration of exposure. High stream flow, combined with elevated turbidity, interferes with the fishes natural abilities to detect and avoid predators.

ODEQ has issued four NPDES permits for this stretch of the river. The City of Maupin discharges treated effluent from their wastewater treatment plant into the Deschutes River. ODFW has three fish hatcheries, which have permits to discharge to the Deschutes River (Lamb 2004).

### 1.6.2. Buck Hollow Creek

Buck Hollow Creek drains 126,800 acres, with elevations ranging from 680 feet at the mouth to 3,325 feet in the headwaters. The creek extends 36.3 miles from its confluence with tributary Thorn Hollow Creek to where it enters the Deschutes River at RM 43, just below Sherars Falls. The creek supports steelhead and redband trout.

*Uplands*
About 95% of the Buck Hollow Creek watershed is in private ownership. Primary land uses include range (52%), cropland (19%), Conservation Reserve Program (26%), and roads and urban (3%) (CTWS 1999a). There is one surface water right in the watershed, 0.57 cfs for irrigation of 34 acres (LDLAC 2002). Loss of watershed retention through intensive grazing by sheep and cattle at the turn of the century and changes in upland cover due to cultivation have reduced the watershed's ability to buffer high runoff events. Upland conditions are improving due to changes in land management and restoration efforts over the last 15 years.

*Riparian Areas*
Riparian areas along Buck Hollow Creek have been heavily impacted by overgrazing, wild fires and catastrophic flooding for the last century. As a result, some reaches of Buck Hollow Creek and its tributaries have incised into the valley floor. In other areas, lateral scour has produced channels that are wide relative to depth, have little or no bank structure or stability, and have very little shade (ODFW 1992). Some reaches lack riparian trees. Sparsely vegetated stream channels, particularly above Finnegan Canyon, are prone to icing and subsequent erosion during occasional prolonged cold periods. Livestock exclosures and new grazing strategies are improving riparian and floodplain conditions in some reaches.

*Instream Habitat*
Aquatic production in Buck Hollow Creek is limited by the presence of wide, shallow or braided channels that hinder adult fish passage into the upper watershed during low flow conditions. Instream cover is generally lacking, except for small pockets of cobble and boulder (28%). The watershed contains only a small number of scattered pools that provide limited holding and summer rearing habitat. Large woody material is lacking and overhanging vegetation is infrequent. The creek is a gravel-rich system (comprising 46% of the substrate) and sediment from uplands and eroded streambanks appears to be routinely flushed from the system, which prevents severe degradation of salmonid spawning habitat in the system.

*Flows*
Flows in Buck Hollow Creek are heavily influenced by runoff patterns. Average discharge ranges from as high as 95 cfs in April to as low as 2 cfs from July through October. High flows occur during winter rainstorms, snowmelt, and summer thunderstorms. Low flows occur during extended cold winter periods and from mid-summer to late fall. Tributary flows are frequently intermittent during summer and fall months. The creek is subject to flash flooding during rapid snowmelt or during high intensity summer storms.

*Water Quality*
Buck Hollow is included on ODEQ's 2002 303(d) list for not meeting the temperature standard for salmonid rearing (64°F) during summer based on BLM data collected at 3 locations along the creek (Lamb 2004). High summer water temperatures commonly exceed 75°F, except in areas of cool water refugia where seeps and springs enter the channel.

### 1.6.3. White River

White River begins on the White River Glacier on Mount Hood and flows southeast to join the Deschutes River just upstream of Sherar's Falls at RM 47.5. The watershed covers 368 square miles, with elevations ranging from 11,240 feet on Mount Hood to 789 feet at the river mouth. Major tributaries to the White River include Clear, Boulder, Threemile and Tygh creeks. White River Falls, a series of three drops totaling 180 feet, is located two miles above the river's mouth. White River was designated as a National Wild and Scenic River in 1988. The river is designated as recreational, except for a stretch designated as scenic between the mouths of Deep Creek and Threemile Creek.

The lower two miles of White River provide spawning and rearing habitat for resident redband trout and summer steelhead. The drainage contains 217 miles of spawning and rearing habitat for redband trout, which is present in most major creeks and many smaller tributaries. White River Falls prevents anadromous fish access to the rest of the watershed, and isolates populations of redband trout and other resident fish above the falls from those downstream. As a result, areas of upper Rock Creek, Gate, Jordan and Threemile creeks have retained genetic integrity of endemic redband trout (USFS 1995b).

*Uplands*
More than half the White River watershed is in public ownership. The Forest Service is the largest landowner, with Mt Hood National Forest lands extending over higher elevations in the western half of the watershed and including the headwaters of White

River, Clear Creek, Boulder Creek, Gate Creek, Rock Creek, Badger Creek, Threemile Creek, Tygh Creek and Jordan Creek. The White River Wildlife Area, owned by ODFW, covers a narrow band just outside of the National Forest. The Warm Springs Tribes own most land within the reservation boundaries. The Bureau of Land Management owns sections of land, mostly within the White River Canyon.

Many different vegetative zones exist between the river's mouth and its source, a straight-line distance of less than 20 miles. These zones include one of only two Oregon White Oak plant communities east of the Cascades, which transitions into the conifer forest. The watershed supports timber, grazing and farm uses. Forest lands cover about 188,000 acres in the watershed, with current timber practices emphasizing management for "sustainability" of natural resources. Rangelands represent about 90,000 acres and include both public and private lands. Agricultural lands cover about 47,500 acres in the watershed, with about 38,500 acres non-irrigated as the watershed receives less than 20 inches of precipitation annually. Irrigated farmlands comprise 8,640 acres and orchards 350 acres (Lamson and Clark 2003). Approximately 4,490 acres are included in the Conservation Reserve Program or have been converted to pasture grasses (Clark 2004).

*Riparian Areas*

Overall riparian condition in the upper White River watershed is good — with diverse vegetation, some wide floodplains, and scattered wetlands and meadows — though some areas have been degraded through forest practices. Riparian vegetative condition declines in the middle White River watershed, primarily because of forest fire and, in some cases, forest practices and overgrazing. Riparian conditions in the Tygh and Threemile stream systems have been degraded, mainly due to agricultural, range and forest practices. Riparian areas in the lower watershed remain in fairly good condition, except in isolated areas within the narrow basalt canyon where steep walls and flashy flows limit vegetative growth. A band of mature cottonwood borders the river above White River Falls.

*Instream Habitat*

White River carries considerable glacial silts and sands. The river cuts through old mudflows and glacial deposits and is often unstable, particularly in the upper reaches. More than 20 miles of braided channel flow out of the White River Glacier (Lamson and Clark 2003). The fine sand and sediments from the glacier are deposited in slack water areas and affect spawning gravels all the way to the mouth.

Streams that don't drain the glacier contain better instream habitat conditions, though lack of habitat complexity and large wood limits instream habitat condition in Tygh Creek and other drainages. Fine sediment associated with land use practices also reduced instream habitat quality in some reaches.

The White River subbasin contains a number of barriers to fish movement including natural waterfalls, road culverts, dewatered stream reaches, diversion structures and impassable dams at large storage impoundments. Most water diversions in the system are unscreened.

*Flows*

Flows in White River are heavily influenced by snowmelt and glacial runoff. They peak during periods of runoff in winter and spring, and diminish as the summer progresses.

Mean low and high river discharges into the Deschutes River are approximately 100 cfs and 1,500 cfs, respectively (Heller et al. 1983). Naturally low flows in the system are further reduced by spring-fall irrigation diversions and winter-spring reservoir storage. Irrigation water is generally supplied by diversions from White River tributaries. The lowest flow recorded at White River Falls was 66 cfs in January 1979, followed by 68 cfs in September 1977 (Lamson and Clark 2003).

A study conducted by Huntington (1985) indicated that from 1925 through 1963 river flows peaked during April and May. The peak discharge has now shifted to January and February. This shift in runoff timing — also seen in other lower Deschutes tributaries — may reflect changes in precipitation patterns or changes in natural water storage from land use practices (Huntington 1985). The flow pattern change in White River may partially reflect increased timber harvest, which caused snow to melt more rapidly than it did historically under a closed tree canopy. Runoff in other White River drainages — such as Tygh/Jordan Creek, Threemile Creek and the Oak Springs/Maupin area — increased with the introduction of dryland agriculture and other changes (Lamson and Clark 2003). Runoff rates from dryland agriculture are dependent on management techniques, particularly crop rotation and tillage methods.

*Water Quality*
Water temperatures in lower White River and several tributaries often exceed the 64°F standard for salmonid rearing during summer months. Stream reaches on the State's 303(d) list for not meeting water quality standards for stream temperature include Clear Creek (mouth to RM 15.1), Gate Creek (mouth to RM 14.3), Rock Creek (mouth to RM 8.1 and RM 8.8 to 14.1), Threemile Creek (mouth to RM 11.3) and White River (mouth to RM 12).

Turbidity associated with glacial silt and rock flour reduces water quality in the White River system. Suspended sediment loads in the upper White River peak in September and October when White River Glacier experiences rapid melting. Coarse sediment transport (sand and small gravel) in lower White River rises in November and December (59,422 tons/month) as stream flows increase with rainfall (ODFW 1997). Stream reaches on the State's 303(d) list for sediment concerns include Gate Creek (mouth to RM 14.3) and Rock Creek (mouth to RM 15.9).

### 1.6.4. Bakeoven Creek

Bakeoven Creek drains 146 square miles extending from 3,487 feet at Bakeoven Summit to 870 feet at its confluence with the Deschutes River at Maupin, RM 51. Summer steelhead and redband trout spawn and rear throughout the stream system when flows are sufficient to provide access.

*Uplands*
Steppe and shrub steppe cover much of the Bakeoven Creek watershed, which is sharply dissected with deeply entrenched drainage systems. Valleys of Bakeoven Creek and its major tributaries are relatively narrow and confined by steep, high canyon walls with slopes of 30-70% (Wasco County SWCD 1994). Private lands cover about 96% of watershed, with about 83% used as rangeland and 15% as cropland. About 8,512 acres of cropland are currently enrolled in the Conservation Reserve Program. There are no urban areas in the watershed.

The Bakeoven Creek watershed receives 10-12 inches of precipitation each year and about 80% of the precipitation falls during winter. Soils are often highly susceptible to erosion. Human activities have changed the vegetative community and reduced the watershed's ability to buffer high runoff events. Consequently, the watershed responds quickly to snowmelt and precipitation, and displays a reduced ability to capture, store and safely release water over an extended period of time. The system is vulnerable to flash flooding (Wasco County SWCD 1994).

*Riparian Areas*

Bakeoven Creek is confined by a narrow V-shaped canyon in some reaches and unconfined, broader valley areas in other reaches. Riparian vegetation includes dense young groves of white alder, juniper, sagebrush, grass, cheatgrass, and willow. Scattered cottonwood and pine line upper reaches (ODFW 1995). Riparian conditions in the watershed were degraded from overgrazing and catastrophic flooding, but are beginning to recover in some reaches because of new livestock grazing strategies. Conditions are considered poor along 59% of Bakeoven Creek, 49.4% of Deep Creek, and 92.3% of Robin Creek (Wasco County SWCD 1994). The generally wide shallow stream channels with sparse riparian cover are prone to icing and corresponding fish loss during prolonged cold periods.

*Instream Habitat*

The unstable stream channel moves laterally across the valley bottom during high flow events. Intense runoff events have scoured out long reaches of the creek, removed large woody debris, and caused erosion and siltation of pools (CTWS 1999a). During summer flow conditions, the stream channel habitat types include scour pool (13.7%), backwater pools (1.1%), glide (14.5%), riffle (34.8%), rapid (7.9%), cascade (4.8%), step (0.4%) and dry channel (22.6%) (ODFW 1995). Consequently, instream cover is generally lacking, except for the limited quantities of cobble and boulder (28%). Isolated deep pools provide the best over summer habitat for adult and juvenile fish. Fish are often concentrated in these pools with little or no habitat complexity, which exposes them to serious predation.

*Flows*

High peak flows occur during runoff events and low base flows during the summer months. Stream flow is generally perennial in the upper reaches of Bakeoven Creek and in Deep Creek and intermittent in much of the lower main stream. Most tributaries to Bakeoven Creek are now intermittent (Wasco County SWCD 1994). No active surface water irrigation withdrawals remove water from this stream system, though the watershed contains several large irrigation wells.

*Water Quality*

Water quality problem areas in the Bakeoven Creek watershed include Bakeoven Creek (mouth to Deep Creek), Salt Creek, Robin Creek and Deep Creek (Wasco County SWCD 1994). The 64°F salmonid rearing temperature standard in the creek is typically exceeded during summer months, except in areas of cool water refugia. Problems in Bakeoven Creek include turbidity, low dissolved oxygen, nutrients, sedimentation, thermal extremes, streambank erosion, low flow (deceased stream flow) and insufficient stream structure. These problems are associated with surface erosion, elimination of thermal cover, and vegetation removal (Wasco County SWCD 1994).

### 1.6.5. Warm Springs River

The Warm Springs River watershed covers 526 square miles, reaching in elevation from 3,775 feet on the east slope of the Cascades to 1,230 feet at its confluence with the Deschutes River at RM 84. The watershed lies within the Warm Springs Reservation and is managed by the Warm Springs Tribes. The Warm Springs River extends 53 miles in length and provides about 41 miles of anadromous fish habitat, including for spring Chinook. Two major tributaries, Mill Creek and Beaver Creek, also provide anadromous fish habitat.

*Uplands*

Headwaters in the Warm Springs watershed were historically densely forested, but now are a combination of recently harvested clearcuts, new regeneration, and old or second growth forests. Middle and lower parts of the watershed are more arid. The lower Warm Springs has incised a significant canyon that reaches as deep as the Deschutes River canyon where the two rivers join.

The Warm Springs Tribes have rated watershed stability on the Warm Springs drainage based on findings from a Cumulative Impact Analysis of watersheds on the reservation. The analysis assessed watershed stability and capacity to recover from planned management activities. During the analysis, the Tribes compared current conditions with threshold values using cumulative runoff acreage (CRA), which measures the percentage of compacted soil, bare ground and other impacts of management. Most watershed areas have a CRA threshold value of 25%, but those containing highly erosive soils have a threshold value of 20%. The Warm Springs Tribes determined that Coyote Creek had a current CRA value of 29.8% compared to a threshold value of 20%, and Quartz Creek had a current CRA value of 26.6% compared to a threshold value of 20%. Based on these findings they rated watershed stability in the Quartz and Coyote creek drainages as very poor to fair (CTWS 1999b). They are taking action to mitigate conditions in degraded areas.

*Riparian Areas*

There has been a slight to moderate loss of riparian vegetation or vegetative species diversity within the Warm Springs drainage, as well as a loss of proper floodplain function. Many stream reaches remain in good to excellent condition, with overall conditions improving as land management practices improve. The greatest losses of habitat quality have occurred along the lower river, although timber harvest and overgrazing have degraded localized areas in the upper watershed. Channel incision has occurred on the Warm Springs River near Ka-Nee-Ta Resort, on Beaver Creek below Quartz Creek, and in the Quartz and Coyote Creek systems. Channel alterations and stream bank armoring in the Ka-Nee-Ta Resort area has impacted two to three miles of riparian and floodplain lands along lower Warm Springs River.

*Instream Habitat*

The Warm Springs River's boulder/cobble substrate floor creates good rearing habitat for salmonids. Spawning gravel abundance is likely below historic levels as the volume of large wood in the channel has declined due to riparian area degradation, timber harvest and other human activities. Loss of instream wood often reduces spawning gravel availability as large wood plays a critical role in trapping and storing spawning gravel in river and stream ecosystems (Weldon 2004). The fine sediment content in spawning gravels is also a concern. Instream channel structure and complexity has been lost due to flashier flow regimes, channel simplification, and land use management, particularly in the Warm Spring River's lower reaches.

*Flows*

Snowmelt dominates runoff in the Warm Springs River and causes flows to peak in the spring, taper off throughout the summer, and drop to base flows in August or September. The river maintains a mean annual flow of 425 cfs. Recorded flows range from 149 cfs to 24,800 cfs. Only limited amounts of water are used for irrigation (CTWS 1999a).

Flow regimes in the Warm Springs River drainage have changed because of the cumulative effects of watershed management activities and channel incision. The stream system now exhibits earlier peak flows, higher peak flows and lower low flows than it did historically (Huntington 1985).

*Water Quality*

Water temperatures often exceed 70°F through mid to late summer in lower Warm Springs River and are above the suitable range for cold water fish. In addition, the river exhibits excessive sediment loads, primarily due to runoff from several lower Warm Springs tributaries with poor riparian conditions. Two Beaver Creek tributaries, Coyote and Quartz creeks, occasionally contribute significant turbidity to the Warm Springs and Deschutes rivers. Turbidity in Coyote and Quartz creeks averages 32.9 NTU and 35.3 NTU, respectively. A normal measure of turbidity would be less than 5 NTU unless the stream is subject to glacial runoff (CTWS 1999b).

### 1.6.6. Trout Creek

Trout Creek drains 697 square miles and extends about 51 miles in length from its headwaters in the Ochoco Mountains to its confluence with the lower Deschutes River at RM 87, six miles west of the community of Willowdale. Elevations in the drainage range from 5,940 feet to 1,280 feet. The drainage includes 115.5 miles of perennial streams and 41.2 miles of intermittent streams, with about 113 miles currently supporting summer steelhead production. The watershed once supported healthy steelhead and, potentially, spring Chinook salmon runs, but salmonid production in the Trout Creek watershed is now far below historic levels.

*Uplands*

Rangelands dominate the Trout Creek watershed, covering about 86% of the drainage. Forestlands cover about 12% of the watershed and lie primarily in the headwaters of Trout Creek, which drain the forests of the Ochoco Mountain Range. Remaining lands are used for agricultural production (1.5%) and residential/urban uses. Principal industries are livestock, timber production and recreation. Primary population centers within the watershed include Antelope and Ashwood.

Intense grazing at the beginning of the last century changed vegetation patterns throughout the watershed, as well as natural watershed processes and habitat characteristics. Soils in the drainage are often highly susceptible to erosion and the general loss of watershed retention capabilities as a result of overgrazing and other human activities reduced the watershed's ability to buffer high runoff events. Consequently, the watershed responds quickly to snowmelt and precipitation, and displays a reduced ability to capture, store and safely release water over an extended period of time. The system is vulnerable to flash flooding. Rangelands and riparian vegetation are slowly improving because of improved management practices.

*Riparian Areas*

Riparian areas in the Trout Creek watershed have generally been impacted by overgrazing, periodic wild fires and catastrophic flooding for the last century. Today, many streambanks and most riparian areas are in low ecological condition (MDLAC 2001). Currently, about 31% of the riparian areas are in satisfactory condition (Runyon et al. 2002). Increased runoff peaks have overloaded and exceeded the capacity of the natural floodplains in some places. Flood control berms appear to be a key constraint to riparian condition. Willow and alder occupy less than 25% of the stream margin along lower Trout Creek (Runyon et al. 2002). In other areas, riparian condition has been impacted by overgrazing, agricultural practices and other uses. Wide, shallow stream channels with sparse riparian vegetation are prone to icing and corresponding fish loss during prolonged cold periods. Studies suggest that the Mudsprings Creek drainage has the lowest portion (10%) of riparian areas in satisfactory condition in the Trout Creek watershed (Runyon et al. 2002). The upper Trout Creek watershed appears to have the largest proportion of riparian stands in satisfactory condition.

For the last 15 years, Trout Creek has been part of an intensive fish habitat restoration program funded in part by the Oregon Department of Fish and Wildlife and Bonneville Power Administration. Landowners in the watershed have also voluntarily undertaken many projects to improve the watershed's health, with assistance from the Trout Creek Watershed Council and the Jefferson County SWCD. Livestock management and other strategies appear to be effective in enhancing riparian conditions in several parts of the Trout Creek watershed.

*Instream Habitat*

Lower Trout Creek flows slowly through a wide alluvial valley where the stream channel was historically unstable and moved laterally across the valley bottom. This natural channel instability was restricted when most of central and lower Trout Creek was diked following the large flood of December 1964. These dikes have significantly affected channel continuity. Channels were isolated from their floodplains, riparian vegetation removed, side channels cut-off, and some channels straightened. These actions altered stream flow velocities, sediment movement and deposition, and generally reduced bed morphology and diversity of aquatic habitat (WPN 2002a). The Army Corps of Engineers plans to modify the dikes within the next few years to improve geomorphic processes (MDLAC 2001).

The upper watershed above Amity Creek contains the largest amount of high quality fish habitat in the Trout Creek watershed. Instream and overhead cover are lacking in most of the watershed and infrequent, shallow pools and low quantity of woody cover provide much of the fish habitat. Stream cover is generally confined to large gravel, cobble and boulder substrate. Spawning and incubating habitat have been deteriorated by elevated fine sediment inputs that filled interstitial spaces in the stream substrate. Lack of high quality spawning area is a prime factor limiting fish production in the watershed. At low or intermittent flows, fish are vulnerable to harassment and predation. Physical barriers, such as irrigation dams and road culverts restrict fish from volitional movement and using connective habitats during critical periods of their life history (CTWS 1999a).

Significant amounts of channel network in several major tributaries — including Antelope, Mudsprings, and Hay creeks — have been channelized or blocked, limiting instream and overhanging cover in these streams. As a result, several lower Trout Creek tributaries, including the Wilson/Hay Creek complex, are no longer accessible to steelhead. Pony Creek no longer has a functional channel connection to Trout Creek because of past agricultural development. Mud Springs Creek supports steelhead only in the area downstream from the Burlington Northern / Santa Fe Railroad Crossing (CTWS 1999a).

*Flows*

Streamflows in Trout Creek follow seasonal precipitation patterns. They peak in winter and early spring with runoff, and rapidly drop to low levels in summer. Low summer flows in Trout Creek drop further with irrigation diversions. Presently consumptive use of water for irrigation exceeds the estimated volumes of natural stream flow during the summer months in all drainages within the Trout Creek watershed (WPN 2002a). These withdrawals contribute to an inability to meet instream water rights in the areas where they have been established. Analysis by Watershed Professionals Network (2002) found that consumptive water use plus storage exceeds the estimated volume of natural stream flow at the mouth of Trout Creek in the months of June through October in both average (50% exceedance flows) and dry (80% exceedance flows) years. Streamflows in Trout Creek below Amity Creek often average below 1 cfs and sometimes fall to zero during the hot months of August and September (Gorman 2004), During dry years, flows have also fallen below 1 cfs from May through December (WPN 2002a).

Flow fluctuations in Trout Creek are now larger than they were historically. The NRCS estimates that current peak flows in some stream segments are two to three times greater than under presettlement conditions (Jefferson County SWCD 1996). Loss of vegetative cover, decrease in number and size of beaver dams, channel down cutting and channelization, loss of wet meadows and other wetlands appear to be factors responsible for changes in flow patterns, and for moving some reaches of Trout Creek from a perennial to an intermittent flow condition (WPN 2002a).

Mud Springs Creek exhibits an unusually constant hydrograph compared to most other streams in the drainage. Flows in Mud Springs Creek generally vary no more than 10 cfs in any season and provide nearly 10 cfs naturally, suggesting that the system is spring-fed. Outflow from Mud Springs Creek — combined with Agency Plains seasonal irrigation tailwater carried by Mud Springs Creek and Sagebrush Creek, a tributary to Mud Springs Creek — provides most of the summer/fall flow in lower three miles of Trout Creek, with little contribution from the upper watershed (WPN 2002). The Oregon Water Resources Department has operated gaging stations on Mud Springs Creek and Trout Creek below Mud Springs Creek since 1999 and will provide data for analyzing the contribution of this unusual spring dominated tributary (Gorman 2004).

*Water Quality*

Significant portions of the Trout Creek drainage have been identified as water quality limited stream segments. The entire length of Trout Creek and a number of tributaries (Auger, Big Log, Bull Cartwright, Dick, Dutchman and Potlid creeks) are listed as water quality limited because they exceed the criteria for temperature, habitat modification and sedimentation (ODEQ 2002). By late May, water temperatures in Trout Creek often exceed the DEQ 303(d) limit of 64° F. Temperatures often remain above the recommended level through October.

### 1.6.7. Shitike Creek

The Shitike Creek watershed covers 76 square miles, ranging in elevation from 5,280 feet in the Cascades to 1,476 feet at its confluence with the Deschutes River (RM 97). The drainages lies within the Warm Springs Reservation. Lower Shitike Creek flows through the community of Warm Springs. The stream extends about 30 miles and provides about 25.7 miles of anadromous fish habitat.

*Uplands*
The headwaters of Shitike Creek are heavily forested, though the river drops into a more arid environment once it leaves its headwaters. Forest and range management practices have reduced the watershed's ability to capture and slowly release precipitation. The Warm Springs Tribes have rated watershed stability in the drainage as good to very good, with the highest stability in the upper drainage (CTWS 1999b).

*Riparian Areas*
Many reaches of Shitike Creek remain in good to excellent condition, with overall conditions improving as land management practices improve. Stream channels are generally stable with complex riparian vegetative corridors and good species diversity. One of the largest remaining stands of old growth cottonwood in the area frames the lower six miles of Shitike Creek. Areas with the greatest losses of quality habitat are located on Shitike Creek below RM 5 and in intermittent tributaries, though timber harvest and heavy livestock grazing have degraded localized areas in the upper watershed. Floodplain function has declined substantially along parts of Shitike Creek below RM 4.

*Instream Habitat*
Shitike Creek's boulder/cobble substrate creates good spawning and rearing habitat for anadromous and resident fish. Spawning gravel abundance, however, is likely below historic levels as the volume of large wood in the channel — which plays a critical role in trapping and storing spawning gravel — has declined due to riparian area degradation, timber harvest and other human activities (Weldon 2004).There has also been a slight to moderate loss of in-channel habitat complexity in the Shitike Creek drainage because of stream channel simplification associated with urban, industrial and transportation activities, and reduced instream structure and cover. Habitat loss is likely most significant in the lower five miles of Shitike Creek, from the mouth to the Head Works. Since the 1920s and 1930s, this section of Shitike Creek has been straightened and channelized, resulting in the disconnection of the stream from its floodplain, a reduction in channel length (sinuosity), increased channel gradient/velocities, loss of side channels and back water habitat, increased sediment movement (Weldon 2004). This has altered channel bed morphology and reduced fish habitat diversity substantially from natural conditions.

*Flows*
Snowmelt dominated runoff in Shitike Creek causes flows to peak in spring, taper off through summer, and drop to base flows in August or September. The watershed exhibits an altered hydrograph, with earlier peak flows, higher peaks, and lower low flows than occurred under natural conditions. It contributes a mean annual flow of 93.3 cfs to the Deschutes River. Recorded flows in Shitike Creek have ranged from as low as 17 cfs to as high as 4,500 cfs.

<u>*Water Quality*</u>
Water quality is generally considered good in Shitike Creek, though lower reaches exhibit elevated water temperatures exceeding 70°F through mid to late summer. Water quality degradation occurs periodically due to municipal waste spill/discharge or sedimentation associated with forest practices and range or road network runoff. Intermittent tributaries contribute turbidity and sediment loads to Shitike Creek during high intensity storms.

### 1.6.8. Summary of Current Conditions in the Lower Deschutes Watershed

While the lower mainstem is relatively stable, the ecosystem as a whole displays strong environmental gradients that influence the salmonids community (Lichatowich et al. 1998; Zimmerman and Ratliff 2003). Habitat in the lower reaches of the mainstem, for example, is influenced by increasing water temperature, pH and from sediment originating in White River. Tributary habitats differ from the mainstem in several obvious ways (flow, temperature stability), and from each other, with habitat conditions within east side tributaries differing from those within streams entering from the west side (LIchatowich et al. 1998).

The lower Deschutes River continues to recover from the February 1996 flood when island and bank erosion occurred in isolated areas. Damage to the riparian vegetative corridor increased in a downstream progression. However, riparian recovery is occurring in many areas throughout the canyon. The flood mobilized bedload from the mouth of Shitike Creek (RM 97) downstream and likely helped to clean and redistribute spawning gravel within the river. Rooted aquatic vegetation that has been spreading over historic Chinook salmon spawning areas upstream from Shitike Creek did not appear to be impacted by the higher flow (Newton 2004).

Stream habitat conditions have generally been improving on many of this area's streams. This improvement has been generated by a number of stream habitat and watershed habitat restoration programs. Many programs have involved cooperative efforts by private landowners and state and federal resource agencies, and the Warm Springs Tribes. All irrigation withdrawal points on anadromous fish streams have been screened to protect fish loss. Screening is also being installed on some diversions from resident fish streams. Water quality deficiencies, including temperature, DO, pH and turbidity are now regularly monitored.

Upland watershed improvement projects have been emphasized by recently developed agricultural watershed management plans. Implementation of conservation management farming practices and the Conservation Reserve Program have retarded storm run-off and reduced sediment delivery to streams. Aggressive juniper control/removal projects have also resulted in improved vegetative ground cover.

# 2. Crooked River Watershed

The Crooked River watershed is the largest eastside tributary to the Deschutes River. The watershed covers approximately 4,500 square miles (2.9 million acres), stretching west from the Maury and Ochoco mountain ranges to its confluence with the Deschutes River at Lake Billy Chinook (RM 114).

## *2.1 The Crooked Watershed Natural Environment*

The Crooked River flows east to west from its headwaters in the North Fork Crooked River, South Fork Crooked River and Beaver Creek systems. These major tributaries drain the Ochoco Mountains, which are the major range in the basin and a western extension of the Blue Mountains, and the Maury Mountains, a small mountain range to the south of the Ochoco Mountains that is entirely drained by Crooked River tributaries. Watershed elevations range from 7,162 feet on Snow Mountain to 1,945 feet at the river's confluence with the Deschutes in Lake Billy Chinook.

The Crooked River system includes 9,548 miles of stream and rivers and carries an average flow of 1,562 cfs by the time it reaches Lake Billy Chinook. Most of this flow originates from large springs in the lower river canyon near Lake Billy Chinook. Major tributaries to the Crooked River include Ochoco and McKay creeks in the lower watershed and the North Fork, South Fork and Beaver Creek in the upper watershed.

### 2.1.1. Geology, Soils and Vegetation

The Crooked River watershed is underlain by a variety of geologic and topographic characteristics, but the main Ochoco Mountains are formed primarily of the John Day and Clarno formations. These formations are composed of weathered lava flows and poorly consolidated claystone, siltstone, and volcanic ashflow tuff deposited between 55 and 20 million years ago. The John Day and Clarno formations are susceptible to landsliding, and almost all of the landslides in the Deschutes Subbasin are within these units (O'Connor et al 2003).

Three different ecological provinces make up the watershed. These ecological provinces — the John Day province, Mazama province and High Desert province — are based on broad soil/plant relationships determined from a combination of geologic and ecological features. Primary characteristics of the three provinces are identified below based on descriptions presented in the Crooked River Watershed Assessment (Whitman 2002).

- **John Day Ecological Province:** Most of the drainage is located within this ecological province, including the entire upper Crooked River watershed, and most of the lower Crooked River and the Beaver and South Fork watersheds. The John Day province is characterized by extensive geologically eroded, steeply dissected hills of thick, ancient sedimentary materials interspersed with buttes and plateaus capped with basalt or tuffaceous rock.

  Soils within the province are generally finely textured and sticky when wet. They are highly susceptible to precipitation-driven erosion. The dominant land use is the production of livestock and livestock forage. The area was once heavily covered with perennial grasses, but these grasses and the soil qualities they supported have been lost. Soil erosion is currently a problem within much of the province.

- **Mazama Ecological Province:** The southwestern drainage is located in the Mazama ecological province, which is covered by a continuous mantle of pumice and other volcanic material deposits distributed when Mt. Mazama exploded about 6,500 years ago. Communities include Powell Butte, Brothers, Millican, Terrebonne, and the eastern portions of Redmond's urban growth boundary.

  Soils in the Mazama Province have developed in combinations of pumice and volcanic ash overlying basaltic bedrock or ancient soils at a depth from 10 inches to 15 feet. Thick deposits of pumice or pumice overlying loamy soil characterize upland soils. Low lying area soils include deep, coarse, gravelly pumice soils in drainages and draws of the forested uplands, and deep, gravelly loam soils adjacent to marsh areas. The overlying pumice mantle is believed to act as mulch, which aids vegetation. Vegetation is typically sagebrush and bunchgrass. Portions are used for irrigated agriculture.

- **High Desert Ecological Province:** This ecological province is characterized by closed basins surrounded by terraces that were once formed by ancient lakes. Low mountains, isolated buttes, basaltic ridges, and block faulted igneous formations are interspersed. Elevations average between 4,000 and 4,500 feet. The climate in this region is dry and cold, with an average annual precipitation of approximately 10 inches. Extreme hot and cold temperatures are common, with a chance of frost throughout the year. The only community within this province is Hampton.

  Soils in the province range from deep loam to deep clayey soils in basins and from deep sandy to shallow clayey soils on terraces and fans where hardpans are common. The soils surface on most terraces and fans is rocky, likely a result of fractured basalt. Vegetation communities are dominated by shrub-grasslands, and the limited forested areas are dominated by juniper.

### 2.1.2. Climate

The Crooked River Basin lies within the South Central Oregon climatic zone; a semi-arid area of high desert prairie punctuated by small mountain ranges and isolated peaks (CRLAC 2003). Mean and annual air temperatures vary widely in the watershed, with cold nights throughout the year, particularly at higher elevations, and hot daytime temperatures during summer months. The growing season is relatively short, particularly at higher elevations, and frost has been recorded in every month.

Precipitation and snowfall levels fluctuate from year to year, with more rain and snow falling at higher elevations. On average, lower elevation areas receive an average of 8 to 10 inches of precipitation each year and higher elevations receive up to 30 or 40 inches of precipitation, primarily as snow in the winter. The highest monthly precipitation occurs in winter, though the basin also receives good rain and snowfalls in late spring and early summer. Late spring and summer precipitation is often quick and intense and can contribute to localized flooding. These high intensity thunderstorms can add substantially to annual rainfall. The spring-summer peaks become much more pronounced with distance away from the Cascade Mountains (Whitman 2002).

## 2.2. Historic Environment

Early explorers and military expeditions described the Crooked River basin as rich with abundant riparian vegetation and adequate supplies of grass, water and firewood. Forests in the basin were characterized by an open, park-like structure at lower elevations, maintained by frequent ground fires. Large trees were primarily fire-resistant Ponderosa pine at lower elevations, Douglas fir and western larch at middle elevation sites, and true firs at higher elevations. Fires were less frequent on the cooler, higher elevations, but fires that did burn these areas burned a high number of the trees.

On rangelands, early explores found an abundance of bunch grasses (ODFW 1996c). As explained by one early rancher,

> *"This was, certainly, as fine a country then as a stock man could wish to see. The hills were clothed with a mat of bunch grass that seemed inexhaustible. It appeared a veritable paradise for stock* (George Barnes, rancher 1887)."

Western juniper were generally restricted to the rocky outcroppings or moist draw areas naturally resistant to fire. The western edge of the watershed had more juniper than the rest of the basin. Rangeland conditions began to change in roughly the 1870s as livestock grazing became the major land use throughout the entire basin (CRLAC 2003).

Historically, riparian and floodplain areas of the Crooked River watershed had significantly more woody vegetation than now (CRLAC 2003). Floodplains were dominated by bunchgrass and wild rye grass, with very little invasion of juniper and sage communities. The Crooked River had a large floodplain that was described by early settlers as having waist high grasses. Willows were a primary component of riparian species (Ochoco means willow in Pauite) but other common species included cottonwoods, aspen, alder, as well as shrub species such as chokecherry, hawthorn, and dogwood. In some areas, dense vegetation along the Crooked River had to be cut away to facilitate travel (Buckley 1992). Journals of early explorers comment on the abundant grasses and willows. Early pioneers recalled

> *"The valley bottoms were covered with willow and other trees that made travel difficult. Some stream bottoms were covered with wild rye, clover, pea vines, wild flax and meadow grass that was waist high on horseback."*

Another report describing the Crooked River valley noted

> *"The bottom lands of the valley will average from half a mile to mile in width...groves of alder and cottonwood, with dense thickets of willow, exist on its banks... the plains back of the hills are...clothed with a carpet of luxuriant bunch grass* (Buckley 1992)."

Floodplain and riparian vegetation played an important role in reducing erosions. Over the years, some areas of fine-grained valley alluvium were likely incised by gullies that eroded headward up the stream channel network. A study of Camp Creek in the upper Crooked River basin identified several periods of prehistoric incision followed by aggradations that may have corresponded to subtle climatic shifts (O'Connor et al. 2003).

Natural flows in the streams of the Crooked River displayed characteristics of the semiarid climate, with low precipitation producing low runoff. Generally, there were also more springs and watercourses in the basin. Beaver and beaver dams were plentiful and instrumental in maintaining a high water table under most stream valleys. Camp Creek, for example, was a wet meadow with abundant grass, willow and aspen. Consequently, many streams that are currently intermittent were perennial. Trout Creek in the Paulina/Beaver Creek drainage provided a source of food (salmon/trout) to locals in the late 1800's through the turn of the century (Whitman 2002). There was more riparian vegetation, including sedges, grasses, and woody species, and stream channels were well connected to broad valley bottom floodplains. Early settlers reported that the "*Crooked River was as clear as a mountain stream."* The Crooked River 'flooded' practically annually, with a meandering channel that took up the entire valley floor. In 1887, the Prineville School was located "*on the banks of the Crooked River*" at the corner of 2nd and Deer Street (ODFW 1996c). Today this location is nearly one-fifth of a mile from the active channel of the Crooked River.

Rivers and streams were abundant with native fish including rainbow trout, summer steelhead and Chinook salmon (Crook County Historical Society 1981). Ogden's' journals of his expeditions up the Crooked River in 1826 described the excellent quality of beaver habitat and noted that the mainstem and all tributaries he observed were lined with willows and aspen, and grass as tall as 7 feet (Ogden 1950). One entry from Steen's military unit, dispatched in July 1860 to survey a route from Harney Lake to Eugene City, described the Crooked River as a *"Good running stream 30 ft wide 1 ft deep in middle. Good rocky bottom. Plenty of fish"*. Ogden's journal also notes the presence of an Indian fish weir below the junctions of the North and South forks that was apparently used for capturing anadromous fish (ODFW 1996c). Other journals mention good trout and salmon populations in Ochoco and Beaver creek watersheds.

## *2.3. Current Environment*

### 2.3.1. Hydrology

The semiarid climate of the Crooked River watershed produces low runoff during most of the year and many streams in the drainage have low or intermittent flow conditions during summer months. Approximately two-thirds of the total annual precipitation comes as snow from October through April. Runoff varies dramatically on an annual and seasonal basis, with snowmelt and summer rainstorms contributing to high runoff and flow events. Before construction of Prineville Reservoir, the mean March flow of the Crooked River near Prineville was 100 times the mean August flow (O'Connor et al. 2003).

Most flow in the Crooked River is collected from spring releases, snowmelt and rain in the South Fork, North Fork, Beaver Creek and other tributary drainages in the Ochoco Mountains. Tributaries originating to the south do not contribute as much water, but can be influenced heavily by high intensity storm events such as summer thunderstorms. Below the City of Prineville, there are no known springs of significant size until RM 15, where large springs augment the flow to the confluence. The watershed includes 32 fifth-field watersheds, with an average area of 99,761 acres (Dedrick 2004). The system discharges an average of 1,131,000-acre feet annually into the Deschutes River at Lake Billy Chinook (Whitman 2002).

Two major impoundments, Bowman Dam on the Crooked River (completed in 1960) and Ochoco Dam on Ochoco Creek (completed in 1921), regulate flow patterns in the Crooked River and restrict fish movement. Both facilities were built for irrigation and flood control. The dams were constructed without fish passage facilities and now isolate fish populations in lower stream reaches from habitat areas in the upper watersheds. Other smaller, public, reservoirs in the basin include Allen Creek Reservoir, Antelope Flat Reservoir, Walton Lake, Haystack Reservoir, and Reynolds Pond.

By 1912 diversion of water was so extensive that the riverbed of the mainstem Lower Crooked River near RM 35, where no springs provided water, was frequently dry. Lower reaches of most of the smaller tributaries were also dry in late summer and early fall; only the North Fork and uppermost tributaries contained water at this time of year (ODFW 1996c). Today, there are approximately 750 surface water rights in the Crooked River watershed, excluding reservoir rights, representing 4,000 cfs. The lower Crooked River drainage has the largest number of water rights and largest allocation of surface water. Surface water rights allocated to the lower watershed total 3,566 cfs. Reservoir rights total 227,861 acre feet in the Crooked River watershed, with 167,823 acre feet of these rights allocated to the upper watershed (OWRD 1999).

### 2.3.2. Water Quality

The ODEQ 303(d) list of water quality limited streams includes several reaches within the Crooked River Watershed that do not meet water quality standards (Table X). Most streams are included on the list because they exceed the state's temperature standard. Portions of the Crooked River are also listed for not meeting water quality standards for pH, bacteria and total dissolved gas (Table X). In addition, since streams are only included on the 303(d) list where data has been collected and submitted to ODEQ, there may be additional water quality problems beyond what is indicated by the 303(d) list. Water quality concerns in each major tributary are addressed in more detail later in this section and will discuss issues beyond just the 303(d) listings.

### 2.3.3. Land Use and Management

More than 90% of the Crooked River watershed supports agriculture, range or forest land uses. Public lands cover almost 59% of the watershed and are generally forested or grasslands. These include Bureau of Land Management lands, covering 35.2% of the watershed (1,023,215 acres) and Forest Service lands, covering 22.8% of the watershed (463,587 acres in the Ochoco National Forest, 172,136 acres in the Deschutes National Forest, 27,365 acres in the Crooked River National Grasslands, and 75 acres in the Malheur National Forest). In addition, the State of Oregon owns 1% of the watershed (26,650 acres) (USFS 1999-01). The remaining 41% of the watershed (1,193,570 acres) is privately owned. Land use and water utilization on private lands is primarily for livestock grazing, timber harvest, and irrigation. Most irrigated agriculture occurs near the City of Prineville. Other substantial blocks of irrigated cropland lie in the upper watershed along Crooked River and some of the larger tributaries.

**Table X. Stream reaches in the Crooked River Watershed that exceed Oregon's Water Quality Criteria, as listed in 2002. All exceedances are for the 64°F summer criteria unless noted otherwise.**

| Watershed | Streams |
|---|---|
| Lower Crooked River | Crooked River to Baldwin Dam (RM 0-51) - *also bacteria (summer) and pH (all year)*<br>Crooked River: Baldwin Dam to Prineville Reservoir (51-70)– *total dissolved gas only*<br>Harvey Creek (0-1.4)<br>Little McKay Creek (0-6.7) – *also 55˚F October 1 – June 30*<br>Marks Creek (0-17.1) – *also 55˚F October 1 – June 30*<br>McKay Creek (0-14.7)<br>McKay Creek (14.7-19.5) –*55˚F October 1 – June 30*<br>Mill Creek (0-11.5) – *also 55 F October 1 – June 30*<br>Mill Creek, East Fork (0-7.6)<br>Mill Creek, West Fork (0-4.9)<br>Ochoco Creek (0-36.4) |
| Upper Crooked River | Allen Creek (Mile 0-10.1)<br>Bear Creek (0-34.3) – *also 55˚F October 1 – June 30*<br>*Cow Creek (0-7.2)*<br>Crazy Creek (0-3.5)<br>Crooked River: Prineville Reservoir to N.F.Crooked R. (82.6-109.2), *also pH (all year)*<br>Crooked River, North Fork (0-44.7)<br>Deep Creek (0-10.6)<br>Deer Creek above private reservoir to headwaters (0.9-4)<br>Double Corral Creek (0-5.4)<br>Fox Canyon Creek (0-6.8) – *also 55˚F October 1 – June 30*<br>Fox Creek (0-4.9)<br>Gray Creek (0-6.7)<br>Happy Camp Creek (0-6.7)<br>Horse Heaven Creek (0-14)<br>Howard Creek (0-9.5)<br>Indian Creek (0-9.1)<br>Jackson Creek (0-5.9) – *also 55˚F October 1 – June 30*<br>Klootchman Creek (1-5.3)<br>Little Horse Heaven Creek (0-2.9)<br>Little Summit Creek (0-10) – *also 55˚F October 1 – June 30*<br>Lookout Creek (0-1.5)<br>Lytle Creek (0-4.2)<br>Peterson Creek (0-10.7)<br>Porter Creek (0-4.5) – *also 55˚F October 1 – June 30*<br>Shotgun Creek (0-5.9)<br>Wickiup Creek (0-8.6)<br>Wildcat Creek (0-4.3) – *also 55˚F October 1 – June 30* |
| Beaver Creek/South Fork Crooked | Beaver Creek, South Fork (Mile 0-26.4) – *also 55˚F October 1 – June 30*<br>Beaverdam Creek (0-10.8)<br>Dippingvat Creek (0-7.7) – *also 55˚F October 1 – June 30*<br>Dry Paulina Creek (0-13.1) – *also 55˚F October 1 – June 30*<br>Powell Creek (0-12.7)<br>Roba Creek (0-7.2) – *also 55˚F October 1 – June 30*<br>*South Fork Crooked River (0-18)* ) – *also 55˚F October 1 – June 30*<br>Sugar Creek (0-11.5)<br>Wolf Creek (0-17.l) – *also 55˚F October 1 – June 30*<br>Wolf Creek, North Fork (0-10.3) |

Lands in the Crooked River watershed extend over seven Oregon Counties, with about 64% of the watershed in Crook County. Other counties cover smaller parts of the watershed, including Deschutes County (26%), Lake County (3.4%), Jefferson County (1.9%), Wheeler County (1.9%), Harney County (1.5%), and Grant County (1.3%). The City of Prineville, located along the Crooked River, is the principal community in the basin and the county seat for Crook County. The watershed also contains the towns and communities of Terrebonne, Powell Butte, Paulina, Post, Suplee, Alfalfa, Millican, Brothers, and Hampton (Whitman 2002).

**Wild and Scenic Rivers**

Several river reaches in the Crooked River Watershed have been designated as Wild and Scenic Rivers under the Oregon Omnibus Wild and Scenic Rivers Act of 1988.

- *North Fork Crooked River* — Total of 34.2 river miles, from mouth to headwaters, except private lands in Big Summit Prairie.
- *Lower Crooked River, Chimney Rock Section* — Total of 8 river miles, from Bowman Dam to State Scenic Highway. 27, mile-marker 12.
- *Lower Crooked River* — Total of 9.8 river miles from the National Grasslands Boundary to Opal Springs (RMs 8 to 17.8).

## 2.4. Focal Fish Species for the Crooked River Watershed

Before construction of dams and water diversions, the Crooked River supported spring Chinook, summer steelhead, redband trout, bull trout, mountain whitefish, Pacific lamprey and many non-game fish populations. Frey (1942) reported observing abundant lamprey larvae in the Crooked River at the Cove Hydroelectric Plant (inundated by Lake Billy Chinook) in and on the sand in the canal. He also reported that "scrap fish" including lamprey were abundant in the middle warmwater portions of the Crooked River (Nielson 1950). The drainage may have also supported other anadromous species, such as coho salmon, but presence of such species is not documented in any historical accounts. Opal Springs Dam, a small hydroelectric dam on the Crooked River about one mile above Lake Billy Chinook, was constructed in 1921 was a partial barrier to migratory fish. Ochoco and Bowman Dams, completed in 1921, and 1961, respectively, were constructed without fish passage facilities and blocked anadromous fish runs into the Ochoco Creek and upper Crooked River basins. Round Butte Dam was completed on the Deschutes River just downstream of the confluence with the Crooked River in 1964. Fish passage facilities were constructed, but they were not effective and fish passage was terminated in 1968, eliminating spring Chinook and summer steelhead from the lower Crooked River (ODFW 1996c).

Today, spring Chinook, fall/summer Chinook, summer steelhead and lamprey are not present in the Crooked River, though the watershed continues to support several resident indigenous fish populations. Anadromous runs may return to the Crooked River if current efforts to provide passage at the Pelton Round Butte Project are successful. If introduction of these species occurs, passage would be sought over Opal Springs Dam and other smaller mainstem and tributary passage barriers in the Crooked River basin downstream from Bowman Dam. Anadromous fish passage at Ochoco and Bowman dams may not be pursued because of their height and fluctuating pools.

### 2.4.1. Chinook

Historical abundance and distribution of Chinook salmon in the Crooked River watershed is largely unknown (ODFW 1996c). The watershed may have supported runs of spring and summer Chinook, with summer Chinook returning to the mainstem Crooked River below McKay Creek and spring Chinook moving further through the system to habitat in Ochoco Creek and the upper mainstem and tributaries (ODFW 1996c). Spring Chinook were reported in the watershed into the 1940's, though by this time the run would have been severely impacted by habitat degradation. Spring Chinook may have resided in the Crooked River until completion of Ochoco and Bowman dams in 1921 and 1961, respectively.

### 2.4.2. Redband Trout

#### Summer Steelhead

Summer steelhead were historically present throughout much of the Crooked River basin with the exception of the North Fork Crooked River above Lower Falls, an impassable barrier. With planned passage at the Pelton Round Butte Project (Ratliff et al. 2001), steelhead will have access into tributaries and the mainstem downstream of Ochoco and Bowman dams.

#### Resident Redband Trout

Redband trout, a subspecies of rainbow trout adapted to the arid conditions east of the Cascade Mountains, are present throughout the Crooked River watershed, except in Reynolds Pond, Walton Lake and possibly Antelope Flat Reservoir. Most of the best remaining habitat in the watershed is on Ochoco National Forest lands. Redband trout are the only native game fish left in the upper basin and reside primarily in headwaters of smaller tributaries (ODFW 1996c).

### 2.4.3. Bull Trout

Bull trout were historically found and caught by anglers in the lower Crooked River. Bull trout spawning in the basin was no documented, but bull trout used the lower Crooked River for juvenile rearing and adult holding areas (Ratliff et al. 1996). Bull trout were caught as recently as the early 1980's up to the City of Prineville (ODFW 1996c; Walt Carter 1992, personal communication). Today, bull trout in the Crooked River basin are confined to Lake Billy Chinook and in the lower Crooked River up to Opal Springs Dam, an impassable barrier since 1982.

### 2.4.4. Pacific Lamprey

Pacific Lamprey were also present in the river, but very little is known about their life history, abundance or distribution. Completion of the Pelton Round Butte Project ended production of lamprey in the Crooked River system.

## *2.5. Focal Wildlife Species of the Crooked River Watershed*

The amount of riparian and herbaceous wetland, which provided important historic wildlife habitat, has declined drastically in the Crooked River watershed. Oxbow sloughs, willow swamps, and permanent ponds formed by river and stream meanders created this habitat and have been almost entirely lost. A wildlife species thought to have existed in this habitat, but no longer present in the subbasin, is the Columbian white-tailed deer.

[Other information will be added on focal wildlife species/habitats.]

## 2.6. Current Conditions In Major Drainages

This section describes the current condition of the environment in the Crooked River watershed. It discusses watershed characteristics in several different areas:

- Crooked River, Lower section (mouth to RM 34)
- Crooked River, Prineville Valley section (RM 34-57)
- McKay Creek
- Ochoco Creek
- Crooked River, Chimney Rock sections (RM 57-70)
- Crooked River, Prineville Reservoir Reach (RM 70-85.9)
- Bear Creek
- Sanford Creek
- Crooked River, above Prineville Reservoir
- North Fork Crooked River
- Camp Creek
- Beaver Creek
- South Fork Crooked River

### 2.6.1. Crooked River, Lower Section (RM 6-34)

*Uplands*
This section of the Crooked River generally flows through a narrow basalt canyon. Adjacent lands are about 47% publicly owned, with a mixture of BLM and USFS ownership. Lands adjacent to river above Highway 97 are mostly privately owned, with the exception of Smith Rock State Park (RM 23 to 26). Private lands are primarily managed for agricultural and range uses. In 1988, the lower river from the National Grassland boundary below Highway 97 downstream 9.8 miles to Lake Billy Chinook was included in the federal Wild and Scenic River system.

*Riparian Areas*
The lower Crooked River canyon below Highway 97 displays a remote and relatively undisturbed character, with a near pristine riparian condition. Riparian vegetation in the reach includes willow, alder, cottonwood, aspen, birch, dogwood, chokecherry, and rose. Riparian vegetation has been degraded along the reach from Highway 97 to Prineville.

*Instream Habitat*
This section of the Crooked River contains a variety of instream habitat, with changes occurring near where Highway 97 crosses the river canyon at RM 18. Instream conditions and complexity in the river downstream of Highway 97 are good and the river canyon contains a mixture of high gradient boulder reaches and long slow glides. Upstream of Highway 97, the river corridor displays a mixture of boulder-strewn riffles and long glides with a low gradient (0.2 to 1.0%). Parts of the channel have been simplified and/or isolated from their floodplain

*Flows*
Flows in the Crooked River drop at RM 28 where the North Unit Irrigation District withdraws an average of 70 cfs with a pump and flume system and diverts water to

Haystack Reservoir for delivery in the Culver-Madras area. A minimum flow of 10 cfs is bypassed below the pumps. Instream Flow Incremental Methodology (IIFIM) study results (1992) indicate that higher flows would be required to obtain optimal production of adult and spawning redband trout (ODFW 1996c).

Springs begin to augment flows in the reach below Highway 97 and contribute significantly to constant water flow, cooler water temperatures, and water quality. The volume of flow contributed from springs increases as the river flows north, with Opal Springs discharging up to 240 cfs, and the river averaging over 1,550 cfs at Lake Billy Chinook. With the addition of spring inflow, water quality and temperatures improve substantially for supporting coldwater fish species (ODFW 1996c). Opal Springs Dam has been a migration barrier to redband and bull trout, and mountain whitefish, except during infrequent periods of high flow, since it was renovated and retrofitted in 1982 (ODFW 1996c)

*Water Quality*
Water quality problems (increased temperature and sediment) reduce habitat quality in the Crooked River from RM 34 to the Highway 97 bridge. Summer water temperatures in the reach exceed state water quality standards. This reach also suffers from high pH (year round) and high bacteria (summer), which exceeds state standards, and high BOD and low dissolved oxygen. Water quality improves below Highway 97 with additional flow from spring releases.

### 2.6.2. Crooked River, Prineville Valley Section (RM 34-57)

*Uplands*
The Prineville section of the Crooked River flows through a wide floodplain with little confinement by geological formations. Most land adjacent to the river in this section is privately owned. Land use and water utilization on private lands through the valley is for livestock grazing and irrigation for crop production. Major crops include alfalfa, mint, wheat, and potatoes. The section also flows through the City of Prineville urban growth boundary where lands support residential, industrial and commercial uses.

*Riparian Areas*
Poor riparian condition reduces fish production in the Prineville Valley section of the Crooked River (ODFW 1996c). The river channel has been altered or simplified at several locations throughout the Prineville Valley reach. Soils in the reach are naturally susceptible to erosion and reduction of riparian vegetation through land use actions has worsened the riparian condition.

*Instream Habitat*
The Crooked River meanders through the Prineville Valley with little confinement and has a low gradient of 0.1 to 0.2%. Channel alterations, active bank erosion and low gradient contribute to a generally poor instream habitat. The general lack of instream habitat complexity and a substrate with a high sediment load further degrades habitat in this reach. Key habitat for spawning and incubation, fry colonization, and adult holding has been lost due to reduced flows, loss of habitat structure and degraded water quality. IFIM study results (1992)suggest higher flows are needed for optimal production of adult and spawning redband trout in this river section (ODFW 1996c).

*Flows*
Streamflow withdrawals and associated water quality problems limit fish production in this section of the Crooked River (ODFW 1996c). The Crooked River Feed Canal (RM 57) diverts 160 to 180 cfs during the irrigation season. Fish were trapped in this canal until 2001 when Ochoco Irrigation District, in cooperation with the BOR, replaced the old screening system at the canal with a state of the art screening facility (Marx 2004). Other diversions — all unscreened and partial or complete barriers to fish migration— include the Rice Baldwin Ditch at RM 57, the People's Irrigation Ditch near RM 50, and several smaller diversions between the City of Prineville and RM 18. These diversions remove most of the remaining flow and leave the Crooked River below Prineville with very low flows during the summer. Some irrigation return water from Ochoco and McKay creeks augments flows, though other irrigation diversions downstream continue to withdraw water from the Crooked River.

*Water Quality*
Water diversions and point and non-point discharge in the urban area affect water quality in this reach of the Crooked River. Sections within this reach of the Crooked River are included on the 303(d) list for not meeting water quality standards for fecal coliform bacteria, summer water temperatures and pH. Summer stream temperatures rise as high as 80°F below the City of Prineville because of low flows and low shade. The lower Crooked River has also been identified as having the potential for limitations related to dissolved oxygen, total dissolved gas and nutrients (ODEQ 1998). Water quality for the entire lower Crooked River was reported to be moderate to severe for water quality, fish, and aquatic life (ODEQ 1988).

The only NPDES permit in the Crooked River Watershed belongs to the City of Prineville for their sewage treatment facility. The sewage treatment plant is only allowed to discharge to the Crooked River (RM 47) during the winter months, and the quality and amount of the discharge is regulated by flow in the Crooked River. If flows are less than 15 cfs, no discharge is allowed. During the summer months, the sewage is land applied to the golf course in Prineville (Lamb 2004).

### 2.6.5. McKay Creek

McKay Creek joins the Crooked River at RM 45.2. The creek and its tributaries, including Allen and Little McKay creeks, provide more than 50 miles of stream habitat and drain about 103 square miles.

*Uplands*
Upper reaches of McKay Creek and its tributaries flow through public forestlands that are used for livestock grazing, timber harvest, and recreation. Land use and water utilization on private lands along McKay Creek is primarily for livestock grazing, timber harvest, and irrigation for crop production.

*Riparian Areas*
Many riparian sections along McKay Creek are in a degraded condition. Up to 65% of the creek has been channelized or altered. A large portion (15%) of the riparian area is characterized as unvegetated and the riparian recruitment situation is inadequate for just under 90% of stream reaches in the drainage (Walter 2000).

*Instream Habitat*
Results from a stream sensitivity assessment indicate that 74% of McKay Creek shows high channel sensitivity (19% moderate and 7% low). Channel condition was found to be better in Little McKay Creek, with no areas rated as having high sensitivity and 44% having low sensitivity (Walter 2000). Shade along McKay Creek is typically 0-30% and pools average less than 10% of the channel.

*Flows*
McKay Creek flow reflects watershed management and alterations, as well as seasonal water withdrawal for irrigation. Peak stream flows associated with snowmelt are generally earlier and of greater magnitude that historical stream discharge. The stream from the Allen Creek confluence to the mouth at Crooked River is frequently intermittent or dry during the irrigation season. Between Allen Creek and Little McKay Creek, the flow is seasonally reduced to low levels by irrigation withdrawals.

*Water Quality*
Portions of both McKay Creek and Little McKay Creek are included on the 303(d) list for exceeding both the rearing (64$^{o}$F) and spawning (55$^{o}$F) criteria. Recorded water temperatures have reached 75$^{o}$F on both creeks. Water quality conditions for McKay and Allen creeks are considered moderate to severe for water quality, fish, and aquatic life (ODFW 1996c, ODEQ 1988).

### 2.6.4. Ochoco Creek

Ochoco Creek joins the Crooked River at RM 45.5. The drainage comprises about 150 miles of stream and drains an area of 360 square miles (230,400 acres). Its two major tributaries, Mill Creek and Marks Creek, meet Ochoco Creek at RM 14 and RM 20, respectively.

*Uplands*
Headwaters and tributaries of Ochoco Creek begin on the forested hills of the Ochoco National Forest, and flow through narrow valleys and steep v-sided canyons. The lower drainage is generally a broad valley in private ownership, with agricultural lands primarily used for livestock and hay production. Elevations range from 5,500 feet in the headwaters to 2,800 feet at the mouth. Land ownership in the drainage is approximately 48% USFS, 1% BLM and 51% private. The City of Prineville is the only community in the Drainage. Ochoco Dam impounds the creek at RM 11, forming Ochoco Reservoir.

*Riparian Areas*
Ochoco Creek and tributaries flow through a variety of plant communities, ranging from relatively level wet meadows to narrow forested canyons. Assessments conducted in 2000 on Ochoco Creek and tributaries Mill and Marks creeks, using OWEB methodology, showed that the riparian recruitment situation was inadequate for roughly two-thirds of stream reaches on Ochoco Creek. Rating for tributaries Marks and Mill creeks were even worse (Watershed Professionals 1999). The assessments showed that riparian recruitment was generally inadequate along Mill Creek, West Fork Mill Creek, Marks Creek and Ochoco Creek (Whitman 2002).

Earlier habitat surveys by USFS and ODFW personnel on upper Ochoco Creek (1979) and on Marks and Mill creeks (1977) showed that the stream reaches with the best riparian conditions were upper reaches of Canyon and Ochoco creeks (ODFW 1996c). The riparian corridor along lower Ochoco Creek has been damaged by livestock grazing, channel simplification, urban development in the Prineville area, and agricultural practices. Tributaries Canyon, Fisher and Judy creeks had been impacted by past mining activity. ODFW survey results for Marks Creek indicated that overgrazing, irrigation structures, and stream channelization had adverse impacts on fish habitat, streamside cover, and bank condition. Up to 80% of the banks were eroding. Average shade was 10-30% on Ochoco Forest lands and 0-20% on private lands. A small livestock exclosure on Marks Creek had contributed to riparian vegetation and streambank recovery in the past 12 years (ODFW 1996c).

*Instream Habitat*
Habitat complexity has been reduced along lower Ochoco Creek through stream channelization and berming. Several reaches are isolated from their floodplains and large wood is in low abundance. Assessments conducted on Ochoco Creek in 2000 for the Crooked River Watershed Council indicated that channel sensitivity was high for 84% of the Ochoco Creek. Channel sensitivity for Mill and Marks creeks was rated as high for the entire channels (Walters 2000).

*Flows*
Most flow in Ochoco, Marks and Mill creeks below the Ochoco National Forest is diverted for irrigation. There are more than 100 cfs of out-of-stream water rights for appropriation on Ochoco Creek alone, although the creek was withdrawn for further water appropriation in 1915 because of over-appropriation. As a result, Ochoco and Mill creeks are frequently dry above Ochoco Reservoir in July, August and September.

Flows in lower Ochoco Creek respond to water storage and releases from Ochoco Dam. These operations reverse the natural seasonal flow pattern in lower Ochoco Creek. High flows occur during the irrigation season (April to mid-October) and low flows occur while water is stored for the next irrigation season.

*Water Quality*
Portions of Mill Creek, West Fork Mill Creek, East Fork Mill Creek, Marks Creek and Ochoco Creek are included on the 3030(d) list for exceeding water temperature criterion for salmonid rearing (64°F). Water temperatures have been recorded as high as 78°F on Mill Creek and 80°F on the West Fork of Mill Creek (ODFW 1996c). The spawning criterion (55°F) has also been exceeded in Marks Creek and Mill Creek. In addition, elevated mercury levels have been documented in fish collected in Ochoco Creek and Ochoco Reservoir, likely from inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek. A two-year-old fish collected from Ochoco Reservoir had mercury levels exceeding 0.5 mg/l, approaching the state legal limit of 1.0 mg/l. Older age fish typically have greater levels of bioaccumulated mercury, suggesting that 3 to 4 year old fish may reach or exceed the state health standard (ODFW 1996c).

### 2.6.3. Crooked River, Chimney Rock Section (RM 57-70)

*Uplands*
The Crooked River below Bowman Dam is tightly constrained by low, but steep hills.

Most land adjacent to this river section is administered by the BLM. Uplands draining into the section are primarily used for livestock grazing and recreation. The reach extending from RM 70 to RM 62 is part of the federal Wild and Scenic River system.

*Riparian Areas*
Riparian vegetation conditions in the upper reach remain in fair to good condition. However, tailrace discharges from the dam that improve flows for fish in the 12-mile reach below the dam may limit riparian vegetation growth. The regulated flows are the reverse of natural flows, which are typically high in late winter and low in summer and early fall. These reverse flows of the lower Crooked River in the Chimney Rock section appear to limit growth of streamside vegetation during the growing season.

*Instream Habitat*
Channel conditions in the upper reach remain stable, though flow regulations limit the ability of the stream channel to rejuvenate through landform developing processes such as large floods. Peak flows that used to occur every 2.5 years (about 4,000 cfs) now occur about every 50 years on average, which has a significant effect on channel morphology (Whitman 2002; McSwain 1999; ODFW 1996). The reach contains limited spawning habitat quality and quantity. In addition, instream habitat complexity is provided by coarse substrate as large wood is lacking.

*Flows*
Operations at Bowman Dam changed the timing of peak flows as well as their size in the Crooked River. Before dam construction and operation, 75% of the average flow of the Crooked River occurred in the months of March, April, and May (McSwain 1999). Today, flows below Bowman Dam are regulated by the Bureau of Reclamation and managed by the Ochoco Irrigation District. The cold-water releases substantially improve water quantity and fish habitat in this reach (ODFW 1996c), and have created a "tailrace fishery". Flows are typically 200-250 cfs during the summer irrigation season and 30-75 cfs during the winter storage season. Before the closure of Bowman Dam in 1960, average peak discharges typically ranged from 3,000-7,000 cfs (OWRD 1998). Since construction of the reservoir, flows have ranged from as low as 10 cfs during winter months, the minimum flow required by the project, to as high as 3000 cfs (OWRD 1998). The goal of the flood control operation is to limit the outflow from the reservoir so as not to exceed 3,000 cfs. Flows have been reduced to 0 cfs for up to two hours annually during inspections of the gate and stilling basin by Bureau personnel, causing some stranding and mortality of fish and aquatic insects (ODFW 1996c).

IFIM study results (1992) indicated that optimal fish production in the Chimney Rock segment occurs with flows of approximately 75-150 cfs for fry and juvenile redband trout, while optimal production for spawning and adult redband trout occurs at flows exceeding 200 cfs (Hardin 1993). Uncontracted storage in Prineville Reservoir of 80,360 acre feet may be available to meet instream flow requirements for fish and other aquatic resources, contingent upon Congressional reauthorization of the project, for retention in the reservoir and release into the Crooked River (Marx 2004).

*Water Quality*
Cold-water reservoir releases strongly influence water temperatures in the reach, where summer water temperatures average 47$^{o}$F to 50$^{o}$F, with a high of 54$^{o}$F; while winter temperatures average 37$^{o}$F to 40$^{o}$F, with a low of 32$^{o}$F. Water discharged from the

reservoir rarely exceeds 54°F. A 1989 survey (Stuart) found an abundant population of redband trout in the Crooked River immediately below Bowman Dam where the discharge of cold water from the hypolimnion of the reservoir supplies cold water to the river. The flows, however, are frequently turbid due to sediments suspended in the water at Prineville Reservoir. Water in the Crooked River is generally turbid throughout the lower basin downstream to RM 16 where sufficient spring inflow contributes to good water clarity and cooler temperatures (ODFW 1996c).

Variable discharges at the dam, however, have created problems and issues somewhat unique to the lower Crooked River. Nitrogen super saturation occurs when water is spilled over Bowman Dam or high volumes are released through the outlet structure (ODFW 1996c). In a high water event during April 1989, gas bubble disease was observed in over 85% of the rainbow trout captured during electrofishing surveys in the Crooked River from Bowman Dam downstream to Prineville. A saturometer recorded nitrogen super saturation levels in the water — entrained as water is discharged into the stilling basin — as high as 109% two weeks after the water had been discharged at this level. One month later, saturation levels were still at 108%, recorded at 0.5, 3, and 5 miles below Bowman Dam. These levels cause mortality in egg and fry stages and cause serious fin erosion and disease in older age classes. Modification of the dam's discharge tube, spillway and stilling basin is recommended to eliminate this problem during high water discharge (ODFW 1996c). This reach of the Crooked River is included on the state 303(d) list for exceeding criterion for total dissolved gas.

### 2.6.6. Crooked River, Prineville Reservoir Reach (RM 70 to RM 85.9)

This reach of the Crooked River extends from above Bowman Dam to the upper end of Prineville Reservoir. It comprises approximately 16 miles of the mainstem Crooked River and several hundred miles of tributary streams, including Bear Creek and Sanford Creek. Prineville Reservoir lies approximately 17 miles south of the City of Prineville. The reservoir has a maximum surface area of 3,030 acres and a present storage capacity of 155,000 acre-feet. Maximum depth is 230 feet with an average annual drawdown of 25 to 30 feet. The elevation at full pool is 3,235 feet above mean sea level.

*Uplands*
Headwater tributaries drain the north and south slopes of the Maury Mountains and pass through a mixture of private, USFS and BLM lands before reaching Prineville Reservoir. The area surrounding the reservoir is characterized by rolling hills and flat plateaus bisected by broad stream valleys. Vegetation consists primarily of western juniper intermixed with big sagebrush, bitterbrush, rabbitbrush and a variety of other shrub, grass and forb species. Grasses include native species of Idaho fescue, bluebunch wheatgrass, and wildrye. Exotic species include crested wheatgrass and cheatgrass.

*Riparian Areas*
There are 36 miles of shoreline along Prineville Reservoir, of which 34.5 are in public ownership and administered by the BOR. Habitat along Prineville Reservoir is characterized by a lack of shoreline vegetation, an expansive mud flat substrate in the upper end, and a boulder and cobble strewn substrate in the lower end (ODFW 1996c). Erodible soils are present along more than 90% of the reservoir shoreline (ODFW 1996c), and water level fluctuations hinder the growth of a stable riparian community

along the reservoir edge. Tributary streambanks are often also highly erodible and lack adequate riparian cover.

*Instream Habitat*
Severe drawdown in some years — such as in 1991 and 1992 — limits food production and living space for all fish species. Additional habitat limitations for fish include low to moderate concentrations of nutrients in the water, high suspended sediments which limit photosynthesis, annual water level fluctuations, very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production and too warm for optimal trout production (ODFW 1996c).

*Flows*
Irrigation and flood control functions drive dam operations. Irrigation water is released from April 15 to October 15, and the reservoir level is lowered accordingly. The reservoir must be at or below 93,000 acre-feet from November 15 to February 15 for flood control purposes. If the reservoir exceeds that level, water is released to lower the level to 93,000 acre-feet. After February 15, most inflow is stored for irrigation needs. During drought years, when water levels are below 93,000 acre feet during the storage period, a majority of the inflow is stored to bring the reservoir up to the minimum flood control level. In addition to irrigation and flood control releases, minimum flows of 10 cfs are authorized for fish and wildlife purposes in the Crooked River below the reservoir. Since 1990, the BOR has released 30 to 75 cfs in the Crooked River during winter, depending on flood and snowpack conditions, to improve river flows. Presently, 70,300 acre-feet of space in the reservoir are allocated, with the remaining 82,700 acre-feet of active space still unallocated. During drought years, OID and NUID have requested and received non-contracted water on a one-year basis to meet irrigation needs (ODFW 1996c).

*Water Quality*
Prineville Reservoir has been severely impacted by high quantities of suspended sediments, or turbidity, since the early 1970's. This turbidity is a result of erosion occurring on the mainstem Crooked River, Camp Creek, Eagle Creek and Bear Creek, and shoreline erosion of the reservoir itself from wave action from wind and boats. Erodible soils along the reservoir shoreline contribute to turbidity when waves loosen soil on the shoreline (ODFW 1996c). The watersheds upstream of the reservoir are formed from highly erodible soils, including montmorillinite clay; and upland and riparian areas are in poor condition. These factors result in increased erosion rates. Eroding streambanks from timber harvest, roading, and improper livestock grazing contribute large quantities of sediment to the reservoir during the spring run-off period. As a result, the reservoir is muddy during the spring months and often late into the summer. When washed into the reservoir, the montmorillinite clay stays in suspension for several years, increasing reservoir turbidity and preventing sunlight penetration into the water column. The lack of light penetration ultimately reduces potential primary food production in the reservoir (i.e. zooplankton), which adversely affects fish production.

### 2.6.7. Bear Creek

Bear Creek begins above Antelope Flat Reservoir on the south side of the Maury Mountains and empties into Prineville Reservoir. Bear Creek and tributaries drain approximately 260 square miles, or 10% of the basin upstream of Prineville Reservoir.

*Uplands*
The Bear Creek watershed contains a mixture of private, USFS, and BLM lands. Bear Creek and most of its tributaries in the Maury Mountains flow through a variety of plant communities, including wet meadows and forested communities. Lower portions of tributary streams and the mainstem flow through wider valleys with sagebrush and juniper communities in uplands, and irrigated meadows and hay fields along Bear Creek.

*Riparian Areas*
Limited habitat surveys indicate that much of Bear Creek is unshaded, with streamside vegetation primarily grasses, sedges, and an occasional willow. The Bear Creek drainage is composed of highly erodible soils and eroded cutbanks occur along much of the creek. Loss of historic riparian tree and shrub vegetation has reduced vertical habitat complexity and has resulted in channel down-cutting with the corresponding loss of water storage capacity of the floodplain and riparian area.

*Instream Habitat*
Much of the Bear Creek channel has incised into the fine valley soils, with a corresponding drop of former floodplain water table. The stream generally lacks any large woody debris or appreciable instream habitat complexity. The substrate is predominantly fine sediment with widely scattered patches of marginal quality spawning gravel. Physical and water quality barriers limit trout production and movement.

*Flows*
Flows decline to low levels during summer months, creating fragmented or isolated trout populations. Several water diversions remain unscreened.

*Water Quality*
Bear Creek is included on the 303(d) list for exceeding both the state's rearing (64$^{o}$F) and spawning (55$^{o}$F) temperature criteria. The creek also often carries a great sediment load per volume of flow, although overall discharge is far less than the Crooked River.

### 2.6.8. Sanford Creek

The Sanford Creek basin covers an area of approximately 20 square miles and joins the Crooked River at Prineville Reservoir.

*Uplands*
Sanford Creek flows from public forests on the northwest corner of the Maury Mountains and through a mixture of BLM and private lands before emptying into the upper Prineville Reservoir. Most of the drainage is privately owned. Much of Sanford Creek flows through sagebrush and juniper lands. Highly erodible soils cover most of the drainage.

*Riparian Areas*
Most of the creek is unshaded, with streamside vegetation consisting primarily of grasses, sedges, and an occasional willow. Eroded cutbanks occur along much of Sanford Creek.

*Instream Habitat*
Stream habitat conditions in Sanford Creek are similar to those in Bear Creek. The stream channel is generally incised into the fine soils of the stream's floodplain. The

channel lacks instream habitat complexity, summer flows are very low, and the substrate in predominantly composed of fine sediment.

*Flows*
Low flows during summer months limit trout production and movement. Several water diversions remain unscreened.

*Water Quality*
High summer water temperatures and high turbidity limit trout production. Water quality barriers also hinder fish movement and create fragmented or isolated trout populations.

### 2.6.9. Crooked River, above Prineville Reservoir (RM 85.9)

The upper Crooked River drainage above Prineville Reservoir collects flow from the upper mainstem Crooked River and the North Fork Crooked River, Camp Creek, South Fork Crooked River, and Beaver Creek drainages.

*Uplands*
Generally, land in the upper basin is equally split among federal and private ownership. Small tributaries to the mainstem drain public forest lands and flow through a variety of plant communities, including wet meadows and forested areas. Lower reaches of tributary streams and the mainstem Crooked River flow through wider valleys with sagebrush and juniper communities in the uplands, and irrigated meadows and hay fields along the stream bottoms. Land use and water utilization on private lands is primarily for livestock grazing, timber harvest, and irrigation, while public lands are used for livestock grazing, timber harvest, and recreation.

*Riparian Areas*
Habitat surveys indicate that much of the mainstem river and tributaries have open canopies providing little to no shade (ODFW 1996c). Habitat surveys conducted by USFS (1998) in the upper Crooked River drainage found that the loss of riparian tree and shrub species had reduced vertical habitat complexity and reduced water storage capacity of riparian areas.

*Instream Habitat*
The mainstem Crooked River has a low gradient with long, slow moving shallow pools and long glides. Many stream reaches have been disconnected from adjacent floodplains. Severely eroded cutbanks with very little riparian vegetation occur along much of the river, and several portions have been channelized. The river has a substrate of fine sediments in pools and glides with occasional riffles of cobbles and boulders. Spawning gravel is very limited (ODFW 1996c).

*Flows*
Most of the upper Crooked River is characterized by low summer flows. Summer flows range from 1 to 7 cfs with numerous temporary irrigation dams, mostly earth and gravel, diverting much of the flow throughout private lands. During drought years, the mainstem Crooked River has a very low flow or becomes intermittent during the summer months, making it unsuitable for salmonid production.

*Water Quality*
The Crooked River from Prineville Reservoir to the confluence with the North Fork Crooked River is included on the ODEQ 303(d) list for summer temperatures (64°F), pH, flow modifications. Streams water temperatures often exceed 70°F and have been recorded as high as 83°F. The reach has also been identified as having the potential for limitations related to bacteria, dissolved oxygen and nutrients (ODEQ 1988). Water quality conditions in many streams in the upper basin are moderate to severe for fish and aquatic life (ODEQ 1988). Erosion from this reach of the mainstem Crooked River — and from Camp, Eagle, Lost and Conant creeks and other tributaries — contributes to turbidity and sediment loads in Prineville Reservoir (ODFW 1996c).

### 2.6.10. North Fork Crooked River and tributaries

The North Fork Crooked River begins in the Ochoco Mountains, 75 miles east of Prineville, and joins the Crooked River at RM 109.2. The drainage covers 340 square miles, or 13% of the upper basin. The North Fork and tributaries comprise 250 miles of river and tributaries including Deep, Gray, Indian, Stump, Elliot, Johnson, Committee, Allen, Fox, Crosswhite, Brush, Lookout, Shady, Beetle, Yellowjacket, Ross, and Peterson creeks.

*Uplands*
Headwaters of the North Fork Crooked River and tributaries generally drain mixed conifer forests. The North Fork originates in the forest meadows of Williams Prairie in the Ochoco Mountains. Approximately 75% of the North Fork Crooked River basin lies on USFS, 12% on BLM, and 13% on private lands, the latter on or near the Big Summit Prairie and along the lower North Fork Crooked River. Ownership of lands along the North Fork Crooked River is 26% USFS, 23% BLM, and 51% private (Whitman 2002).

*Riparian Areas*
The North Fork and tributaries are formed by spring releases, rain and snowmelt. In the high elevation areas, the streams flow through rolling broad valleys or steep v-sided canyons. Below the mouth of Deep Creek, the North Fork enters a steep, rugged canyon (500 feet depth) with basalt flows and rimrock formations that create large, deep pools.

Habitat surveys conducted by the Forest Service (1995) in the North Fork watershed showed that riparian habitat has been simplified and that present riparian vegetation was dominated by exotic species, such as tufted hairgrass and timothy (Whitman 2002). Surveys conducted previously by ODFW in 1972 and 1978 also indicated riparian area degradation and showed that the river was generally open with 10% or less shade, with most shade from old growth ponderosa pine or fir, and sheer rock canyon walls (ODFW 1996c, Ferry et al. 1979). Stream survey results for the North Fork Crooked River basin above the mouth of Deep Creek in 1994 also indicated that most streams had low shade and very low large woody debris, although cutbanks were relatively minimal (ODFW 1996c, Johnson et al. 1994).

*Instream Habitat*
Instream habitat in much of the lower North Fork Crooked River drainage is in a degraded condition. Stream reaches have little habitat complexity, and habitat diversity is limited by a general lack of large wood and overhanging cover. North Fork Falls,

located on the North Fork approximately 8.5 miles upstream from its confluence with the mainstem Crooked River, limits movement of redband trout in and out of most of the North Fork drainage. The falls also historically limited steelhead access to potential habitat in the upper drainage.

*Flows*
Most streams in the North Fork Crooked River drainage have late summer flows of less than 2 cfs, although Deep Creek, a major tributary below Big Summit Prairie, and the North Fork Crooked River below the confluence of Deep Creek have generally greater flows of 5 to 10 cfs. Flow measurements for the North Fork Crooked River just above Deep Creek averaged from 2 to 6 cfs from July to October, while springtime flows ranged as high as 1,500 cfs (ODFW 1996c).

Over 200 cfs of out-of-stream water rights have been appropriated from the North Fork Crooked River and tributaries, including Gray, Indian, Stump, Elliot, Johnson, Committee, Allen, Fox, Crosswhite, Brush, Lookout, Shady, Beetle, Yellowjacket, Ross, and Peterson creeks (ODFW 1996c). The small impoundments and irrigation diversions have altered much of the flow and isolated some populations of rainbow trout in the upper North Fork Crooked River. In the northeast corner of Big Summit Prairie, Allen Creek Reservoir and its associated irrigation distribution system, and Peterson Reservoir, have isolated populations of redband trout in tributaries of the North Fork Crooked River from the mainstem, since construction of the impoundments in the 1940-50's (ODFW 1996c).

*Water Quality*
Several reaches in the North Fork watershed are included on the 303(d) list for exceeding state water temperature standards for salmonid rearing, including the North Fork (RM 0-44.7) and Deep, Fox, Gray, and Peterson creeks. Headwater streams are generally located in mixed conifer forests and have cool water, however, as these streams approach Gray Prairie, Big Summit Prairie, and Little Summit Prairie, the impacts of water withdrawal and livestock grazing reduce flows and significantly raise water temperature (ODFW 1996c). Several reaches in the watershed are also listed for flow and habitat modifications (ODEQ 1998).

In addition, inactive mercury (cinnabar) mines located at the headwaters of Johnson Creek may adversely impact water quality. Elevated mercury levels have been documented in fish collected in Johnson Creek (ODFW 1996c; Bruce Anderson, USFS Hydrologist, personal communication).

## 2.6.11. Camp Creek

*Uplands*
Camp Creek begins in the arid Price Valley of the Maury Mountains and joins the Crooked River at RM --. Soils in the drainage are highly erodible and the drainage has been impacted by overgrazing and other watershed changes.

*Riparian Areas*
The creek was historically a wet meadow with abundant grass, willow, and aspen. This condition changed due to overgrazing, beaver removal and other activities, which incised

the stream channel and transformed the riparian areas into severely eroded streambanks. Today, Camp Creek remains below its historic condition. While riparian density, instream channel conditions and perennial flows have improved significantly in some reaches since the 1960s with improved land management, riparian vegetation composition in low gradient reaches has not returned to historic conditions.

*Instream Habitat*
Reaches of the stream channel have incised into the valley floor, with ongoing bank erosion. Lack of instream habitat complexity, low flows, and high sediment loading all contribute to poor instream habitat in Camp Creek. The stream no longer supports a resident trout population.

*Flows*
Flows in Camp Creek decline significantly due to irrigation withdrawal and are extremely low or intermittent during summer months (ODFW 1996c).

*Water Quality*
Summer water temperatures increase dramatically with flow withdrawals (ODFW 1996c).

### 2.6.12. Beaver Creek

Beaver Creek and tributaries comprise several hundred miles of river and tributaries and drain an area of about 540 square miles, or 22% of the upper Crooked River basin. Tributaries to Beaver Creek include South Fork Beaver Creek, Paulina, Sugar, Wolf, Dippingvat, Roba, Widow, Dobson, Freeman, and Tamarack creeks. Beaver Creek joins the Crooked River at RM ---.

*Uplands*
Beaver Creek collects flow from springs and snowmelt fed streams on the Ochoco National Forest, and from intermittent streams on plateaus of moderate elevation. The creeks and tributaries flow through a variety of plant communities, including wet meadows, forests, arid sagebrush and juniper lands, and irrigated pasture hay fields. Some springs in the drainage are hot. Temperatures of springs near Paulina and Suplee range from 70 to 112 $^{o}$F. Beaver Creek and lower elevation tributaries run through valley bottoms with irrigated alfalfa and grass fields.

*Riparian Areas*
Limited habitat surveys suggest that much of Beaver Creek and its tributaries are unshaded, with streamside vegetation of primarily grasses, some sedges, and an occasional willow or cottonwood. Surveys by ODFW found poor riparian conditions in the Beaver Creek drainage (ODFW 1996c).

*Instream Habitat*
Beaver Creek has a low gradient and a high pool:riffle ratio characterized by long slow moving shallow pools with long glides. Much of the river has a substrate of fine sediments in pools and glides, with occasional riffles of cobbles and boulders. Spawning gravel is very limited in much of Beaver Creek (ODFW 1996c).

*Flows*
Summer flows on the mainstem and lower tributaries range from 0 to 5 cfs with numerous irrigation dams diverting much of the flow throughout the private lands. The

diversions create low instream flows and several create fish passage barriers to potential upstream habitat.

*Water Quality*
Low instream flows and corresponding high summer water temperatures are the primary limiting factors affecting fish production in the mainstem Beaver Creek (ODFW 1996c). Several streams in the Beaver Creek drainage are on the state 303(d) list, including South Fork Beaver, Dippingvat, Sugar, Dry Paulina, Roba and Wolf creeks. Sedimentation also causes water quality problems in the drainage.

### 2.6.13. South Fork Crooked River

The South Fork Crooked River drainage includes about 36 miles of river and numerous miles of tributaries, draining about 800 square miles or 32% of the upper Crooked River basin before joining the Crooked River at RM---. The South Fork Crooked River is formed by the outflow of several springs, including some hot springs. One major tributary, Twelvemile Creek, flows into the South Fork Crooked River at RM 19.5. Many streams in the basin are unnamed and intermittent or ephemeral. More than one-third of this drainage does not contribute runoff in most years.

*Uplands*
Headwaters of the South Fork Crooked River begin as springs and ponds in the high desert northwest of Brothers, Oregon. The river flows through a mixture of narrow, steep rimrock canyons and areas of wider rimrock canyons and irrigated hay meadows.

*Riparian Areas*
Habitat surveys in 1975 and 1977 found that the South Fork Crooked River canopy is generally open with little to no shade, with streamside vegetation of primarily grasses, some sedges, and an occasional willow (ODFW 1996c).

*Instream Habitat*
The South Fork Crooked River has a relatively high pool:riffle ratio ranging from 50:50 to 80:20 characterized by long slow moving pools with long glides. Much of the river has a substrate of fine sediments, occasional riffles of cobbles and boulders, and spawning gravel is very limited.

*Flows*
Summer flows ranged from 2 to 9 cfs, with numerous irrigation dams diverting much of the flow throughout the private lands.

*Water Quality*
The South Fork Crooked River (RM 0-18) is included on the state 303(d) list for exceeding summer rearing temperature (64°F) and spawning temperature (55˚F from October 1 to June 30. Sedimentation causes water quality problems in some areas.

### 2.6.14. Summary of Current Conditions in the Crooked River Watershed

Streams of the Crooked River watershed exhibit characteristics of a watershed that is not safely capturing, storing and releasing water (Whitman 2002). Much of the Crooked River drainage is dominated by soils vulnerable to erosion due to steep slopes, high clay content and poor vegetative cover. As a result of overgrazing, beaver removal, timber harvest, fire suppression and other actions, watershed function has changed and impacted watershed hydrology. Loss of native vegetation in riparian areas throughout much of the watershed has increased erosion and reduced the storage capacity of drainages — resulting in larger peak and lower low flow events (Whitman 2002).

An extensive reservoir and irrigation system also affects the natural hydrology of the Crooked River watershed. This system alters the timing and intensity of flows in much of the lower basin, impairing the ability of native vegetation to remain established or re-colonize denuded areas (CRLAC 2003). Prineville (1961) and Ochoco (1921) reservoirs play a large role in controlling floodwaters in the Lower Crooked River Watershed. Operations at Bowman Dam have changed the size and timing of peak flows in the Crooked River. Before closure by Bowman Dam, 75% of the average flow of the Crooked River occurred in March, April, and May. Today this natural seasonal flow pattern is reversed, with high flows during the irrigation season when water is released, and lower flows while water is stored for the next irrigation season. Streamflows have also been altered in Ochoco Creek below the Ochoco Dam, as well as in other parts of the watershed where public and private reservoirs have been created for water storage (Whitman 2002). Surface water rights are overallocated for the entire watershed and water withdrawals impact flows and water quality conditions for fish and other aquatic species during certain times of the year.

Channel modification, particularly along Ochoco Creek and McKay Creek through the greater Prineville urban area, and almost the entire length of the Crooked River has resulted in a stream system disconnected from its floodplain and essentially designed as a water transport system (ODFW 1996c). This channel straightening, along with degraded vegetation conditions in riparian and upland areas, and the erodible soils present throughout much of the drainage, contribute to the now characteristic flashiness of flows within the watershed (Whitman 2002). The intensity of floods, such as the 1964 flood, has been exacerbated by stream channel incision, loss of riparian area, and general loss of contact with historic floodplains. The Post/Paulina area is particularly impacted by floods due to landscape condition. Rapid snow melt, or a rain on snow event, sends water rushing from degraded headwater tributary streams to lower Beaver Creek and the upper Crooked River where flooding can occur because of much faster runoff — as opposed to historic conditions where the uplands and floodplain associated with small tributaries were in good condition and peak flows and peak flow duration were moderated.

In the lower watershed, changes in the timing and size of peak and channel maintenance flow events have restricted channel-forming processes in the Crooked River and Ochoco Creek. Controlled releases have also limited the amount of sediment available in streams throughout the Lower Crooked River watershed. Natural wetland and riparian areas, particularly within the Prineville urban area, have been filled, removed or relocated, altering the storage and transport of water through this area of the basin and increasing the flashiness of flow events. Roads in the basin generally follow stream courses; many riparian areas are degraded by the presence of roads and road crossings (CRLAC 2003).

Some of these conditions are being improved through voluntary actions. Voluntary involvement by private landowners in riparian improvements has increased since the 1960s. Actions have been taken to reduce livestock impacts to riparian areas — including riparian fencing to exclude cattle, the creation of riparian pastures and modified grazing schedules, and off-stream water developments to encourage livestock use of upland areas.  These management changes have resulted in increased vegetation in riparian zones, however, the composition and extent of the riparian community has not been restored.  Particularly at lower elevations, riparian communities in the basin are dominated by non-native grasses or herbaceous vegetation that lacks the root stability of the woody vegetation or sedge communities that existed historically CRLAC 2003).

# 3. Upper Deschutes Watershed

The upper Deschutes River watershed encompasses the portion of the Deschutes Subbasin from the Pelton Round Butte Project upstream 132 miles to its headwaters in the Cascade Mountain Range.

## *3.1. Upper Deschutes Natural Environment*

Covering an area of approximately 1,547,639 acres, the upper Deschutes River watershed extends east to the Crooked River drainage, south to the Klamath drainage, west to the crest of the Cascade Range and north to the Pelton Reregulating Dam (RM 100). It consists primarily of a long, wide plain ranging in elevation from 1,945 feet where the Deschutes River enters Lake Billy Chinook to 4,300 feet in the south. The highest point in the watershed is South Sister Mountain, elevation 10,358 feet, located along the watershed's western boundary in the Cascade Mountains.

From its source at Little Lava Lake, the Deschutes River flows approximately 132 miles before reaching Lake Billy Chinook. It gathers flow from springs in the upper watershed and from Snow, Cultus, and Deer creeks and Cultus and Quinn rivers above Crane Prairie Dam; and Browns, Davis and Sheep Springs creeks between Crane Prairie and Wickiup reservoirs. Below the reservoirs (RM 226), the Deschutes collects flow from three major tributaries, Fall River (RM 205), Spring River (RM 190) and the Little Deschutes River (RM 193) before reaching the City of Bend. Between Bend and the Reregulating Dam, the Deschutes River picks up Tumalo Creek (RM 160), Squaw Creek (RM 123), Crooked River (114), and the Metolius River (RM 112). The upper basin also contains more than 400 high elevation lakes including Odell, Crescent, Davis, Cultus, Little Cultus, Lava, Little Lava, South Twin, North Twin, Hosmer, Elk, Sparks, East, and Paulina lakes (ODFW 1996a).

### 3.1.1. Geology, Soils and Vegetation

The upper Deschutes watershed covers a mosaic of landforms and topography created through at least 35 million years of glacial and volcanic activity (Yake, 2003). The watershed falls within two major geologic provinces, the Cascade Range and the Basin and Range provinces. The oldest rock in the upper basin, a basalt, is part of the John Day formation and is believed to be about 12 million years old (Yake 2003). Layering this rock are deposits made 10 to 6 million years ago when lava, sediments and ash were shed by the emerging Cascade Range and from volcanic areas in the eastern portion of the basin. These layers – the Deschutes and Dalles formations – were deposited at a time when the basin was changing rapidly, particularly in the upper basin. The formations are topped by basalt flows from local sources that range from about 6 to 4 million years old and cover large parts of the uplands (O'Connor et al. 2003).

Parent soils in the watershed are primarily composed of ash, cinders, and pumice deposited from past volcanic eruptions. Pumice and ash tephras were expelled during the eruption of Mt. Mazama. This material remains in 0.5 to 1.0 meter depths on a gradient north to south and is the primary soil material holding the roots of vegetation in the area (Yake 2003; USFS 1997c). Below these deposits lie hard basalts, adesites, tuffs, breccias, glacial till and outwash gravels that were deposited during past volcanic eruptions. Because of the relatively recent volcanic activity, soils in the watershed have not had time to develop and mature (UDLAC 2003). The volcanic ash soils covering most of the watershed are light in color and have low fertility levels. They contain minor amounts of hard rock material and have little structural development — making them very sensitive to lateral soil movement or displacement.

The springs that provide most of the water for the Deschutes River were formed by past volcanic lava flows and the sedimentation from explosive volcanic events and glacial activity (Gannett et al. 2003). The highly permeable volcanic rocks allow rain and melting snow to easily sink into the ground and trickle downward to the water table.

Residual and non-forested soils cover a much smaller part of the watershed. These soils are generally found in areas of rocky mountain peaks, wet meadows, canyon walls, barren flats and scabs, cinder cones and lava flows. They are composed of older or weathered ash and residual material and have a thicker, darker surface and slightly better cohesion than the other volcanic ash soils in the watershed. The soils are reddish in color and textures range from gravely to stony fine sandy loam or clay loam. They are highly susceptible to detrimental soil compaction (Yake 2003; Crown Pacific FEIS 1998). Detailed information on soil types found in the Upper Deschutes Soil Survey is available at the USDA Agricultural Services Center (Deschutes SWCD office) in Redmond.

Vegetative communities vary over the upper Deschutes landscape. Mountain hemlock, alpine, and subalpine plant communities cover much of the high elevation areas and other areas where high precipitation occurs. Mixed conifer and ponderosa pine communities are common at middle elevations. In semiarid, lower elevation areas along the eastern edge of the basin, dominant species include sagebrush, juniper, and sparse ponderosa pine communities. Lodgepole pine occurs over a wide range of site conditions and elevations.

The upper watershed also displays a variety of riparian vegetations and conditions. Above Bend, riparian areas along the upper Deschutes River support stands of lodgepole pine and ponderosa pine, with understories of spiraea, snowberry, alder and willows, and herbaceous layers of forbs and sedges. Several large willow/sedge meadows are scattered along the reaches, as are lodgepole (wet) habitat (USFS 1996d). About 1,850 acres of meadow and 5,070 acres of lodgepole (wet) habitat exist along the Deschutes River above Bend (Yake 2003). Riparian vegetation condition along the brood floodplains of the Little Deschutes River include dense willow communities interspersed with wet meadows. Many remaining wet meadows and forested wetlands are associated with the high groundwater table in the La Pine area. Below Bend, the river corridor reflects the more arid, high desert climate. Deciduous vegetation consisting of alders and willows dominate riparian areas along river benches and islands.

### 3.1.2. Climate

The climate in the upper Deschutes watershed is considered continental. Lying in the rain shadow of the Cascade Mountains, the area receives much less precipitation than the western side of the Cascades. Storms approaching from the Pacific Ocean rise as they reach the mountains and release most of their moisture on the western slopes of the Cascades, creating a much drier climate on the eastern slopes. Most precipitation that reaches the watershed falls as snow between November and March. Mean annual precipitation varies widely, ranging from 140 inches in higher elevations down to 10 inches in the Deschutes Valley and the eastern part of the watershed (ODFW 1996a).

Temperatures in the watershed are characterized by moderate days and cool nights. Bend averages about 10 days per year with temperatures above 90°F. Low winter temperatures average between 20 and 30°F. Extreme temperatures can range from 100°F to minus 30°F.

## *3.2. Historic Environment*

Historically, stable flows in the upper Deschutes River's supported lush riparian zones. Springs and seeps frequently occurred along the stream banks between the present sites of Wickiup Dam and the City of Bend. Below Bend, the tightly confined canyon of the Deschutes River exhibited many of the conditions seen today. Deciduous vegetation consisting of alders and willows dominated riparian areas along benches and islands. Juniper, scattered pine and various grasses and forb species armed the stable riverbanks created by a very uniform flow regime. The large springs in the lower reaches maintained relatively cool and stable year-round temperatures that provided ideal conditions for salmonid growth and survival.

Historic vegetation patterns in forested areas were shaped by frequent fire activity. Most stands were open in appearance and dominated by ponderosa pine. Journal notes by the Williamson, Abbott railroad survey crew in 1853 reflect these conditions. In the survey, Abbott wrote:

> *"We found yellow pine still abundant, forming by far the most constant feature in the vegetation of our route from Pit River to the Columbia. Near or distant, trees of this kind were always in sight; and in the arid and really desert regions of the interior basin we made whole days marches in forests of yellow pine, of which the absolute monotony was unbroken either by other forms of vegetation, or the stillness by the flutter of a bird, or the hum of an insect. The volcanic soil, as light and dry as ashes, into which the feet of our horses sank to the fetlock, produces almost nothing but an apparent unending succession of large trees of P. Ponderosa (Yake 2003; USFS 1998d)."*

Open stands of large trees also covered much of the Little Deschutes drainage. In 1843, Lieutenant John Fremont's expedition crossed through the Little Deschutes River drainage near the present community of Crescent. He wrote in his journal:

> *"The great beauty of the country in summer constantly suggested itself to our imaginations… the rich soil and excellent water surrounded by noble forests made a picture that would delight… these (ponderosa) pines are remarkable for the red color of their boles… all day we traveled over pumice stone; beautiful firs but no grass here (Gray 1986)."*

Other early surveyors also described vegetation conditions during their surveys. Notes from the Cascade Reserve Forest Survey of 1903 identify vegetation included mountain hemlock, huckleberry, laurel, manzanita, willow, and alder (Yake 2003).

In the Metolius watershed, the area of riparian vegetation probably resembled that seen today. Tall stands of ponderosa pine armored the stream corridor, along with a well-developed growth of deciduous vegetation consisting of chokecherry, red-osier dogwood, alder, willow and possibly cottonwood. The stream channel was very stable and constrained over most of its length, except for a few locations were braiding occurred. Water quality was excellent, with low contributions of fine sediment and cool summer streamflows (CTWS 1999a). There was also more large wood in the streams. Trees falling into the stable spring fed streams and rivers slowly developed floating island habitat, supporting first forb and graminoid plant associations and eventually shrubs. These islands were cover for aquatic wildlife, amphibians, and birds, and provided structural diversity in riparian areas for many other species (USFS 1996b).

The Squaw Creek watershed also displayed higher quality habitat conditions before the late 1800s when flow allocations for irrigation began. Higher summer flows created deeper pools for fish use during summer months and riparian vegetation, such as willows and cottonwood, provided cover for off-channel and pool habitat. The broad floodplain of Indian Ford Creek allowed safe refuge from flooding and may have been an important rearing habitat for redband trout. Water temperatures in Squaw Creek reflected the higher summer flows and healthy riparian areas. Before the late 1800s, water temperatures in the lower reaches of Squaw Creek were probably near ODEQ standard for temperature. Houslet (1998) found that if average summer flows were not diverted, the average maximum water temperature for August would be near 66.5°F above Alder Springs.

## *3.3. Current Environment*

### 3.3.1. Hydrology

Water storage and releases drastically alter the natural flow regime of the Deschutes River. Two water projects, Crane Prairie Reservoir (1922) and Wickiup Dam (1945), regulate flows in the upper Deschutes River. Flows are also influenced by storage and release of flows from Crescent Lake in the upper Little Deschutes River.

Water storage projects at Wickiup Dam, Crane Prairie and in the Little Deschutes River — and water diversions for irrigation — have replaced the stable natural flows in the Deschutes River above Bend with flows as low as 20 cfs below Wickiup Dam in the winter when the reservoirs are being filled, and as high as 2,000 cfs during the height of the summer irrigation season when water is being released from the reservoirs. Presently, the maximum is about 1,600 cfs (Gorman 2004). Flows released out of Wickiup increase downstream with groundwater and runoff contributions from Fall river (90-160 cfs), Spring River (180-210 cfs) and the Little Deschutes River (5-3,500 cfs) above the City of Bend, and from Tumalo and Squaw creeks and springs below Bend.

Nearly all water released from Wickiup Reservoir during the irrigation season is diverted into six major canals. River flow below the diversion points during the summer is very low. Until recently, summer flows dropped to about 30 cfs. However, recent instream transfers and conservation work have brought that minimum up to 35 cfs (UDLAC 2003). The irrigation canals, mostly unlined and dug through highly porous soils, leak a substantial amount of water. Some estimates have put the overall transmission losses at 50% (UDLAC 2003). Several irrigation districts are working on lining and piping projects to conserve water. North Unit Irrigation District, for example, has lined the first twelve miles of its canals to prevent seepage so that irrigators can use the saved water on their farms.

In 1983, the Oregon Department of Fish and Wildlife received three instream water rights for the Deschutes River from Wickiup Dam downstream to North Canal Dam. These rights are 300 cfs from Wickiup Dam to the Little Deschutes River; 400 cfs from the Little Deschutes River to Spring River; and 660 cfs from Spring River to North Canal Dam. These instream water rights have a priority date of November 3, 1983 and are junior to existing water rights. These instream water rights are currently not being met on a year-round basis.

### 3.3.2. Water Quality

Water quality problems exist in several reaches of the Deschutes River and tributaries, including seasonal temperature extremes (i.e. high summer temperatures and winter icing), high erosion rates, low dissolved oxygen and other problems (Table x).

**Table x. Stream reaches in the Upper Deschutes Watershed that exceed Oregon's Water Quality Criteria, as listed in 2002. [replace with table similar to other two]**

| Stream Segment | Temp | pH | Dissolved Oxygen | Chlorophyll *a* | Bacteria | Habitat Modification | Flow Modification |
|---|---|---|---|---|---|---|---|
| Deschutes River (Lake Billy Chinook) | | summer | | spring/ summer/fall | | | |
| Deschutes River (Lake Billy Chinook to Steelhead Falls) | | summer | | | | | |
| Deschutes River (Steelhead Falls to North Unit Main Canal) | summer | summer | | | | | annual* |
| Deschutes River (North Unit Main Canal to Central Oregon Canal) | | summer | | | | | |
| Deschutes River (Central Oregon Canal to Wickiup Reservoir) | | | annual | | | annual | Annual |
| Deschutes River (Wickiup Reservoir to Crane Prairie Reservoir) | summer | | | | | | |
| Lake Creek, North Fork (mouth to Suttle Lake) | summer | | | | | | |
| Lake Creek, South Fork (mouth to Suttle Lake) | summer | | | | | | |
| Odell Lake | | summer | | | | | |
| Squaw Creek (Alder Springs to Maxwell Ditch) | summer | | | | | | Annual |
| Tumalo Creek (mouth to Columbia Southern Canal) | | | | | | | Annual |
| Crescent Creek (mouth to Crescent Lake) | summer | | | | | | |
| Little Deschutes River (mouth to Hemlock Creek) | summer | | | | | | |
| Paulina Creek (mouth to Paulina Lake) | summer | | | | | | |
| Willow Creek | summer | | | | | | |

### 3.3.3. Land Use and Management

Approximately 75% of the Upper Deschutes Watershed is in public ownership. The primary land manager in the watershed is the Forest Service, which manages about 66% of the watershed [need to add Little Deschutes]. Other public lands in the watershed are managed by the Bureau of Indian Affairs (0.01%), Bureau of Land Management (8.60%), and state agencies (0.55%).

Privately-owned lands cover about 25% of the upper watershed (Yake 2003). Private owners manage most of the land adjacent to the Deschutes and Little Deschutes rivers, and over half of the lands adjacent to Tumalo and Squaw creeks. Private land use varies throughout the watershed. Most lands around the La Pine area are used as grazed timberland and for subirrigated agriculture. Cropland and pasture irrigated with Deschutes River water extend from the Bend area to the Lower Bridge-Terrebonne area. Forage, cereals and seed crops are the dominant crops grown on irrigated lands, with irrigated pasture and alfalfa accounting for most of the consumptive use of water (UDLAC 2003). Subdivision of large farms and ranches into “hobby” farms has resulted in an increase in livestock numbers. Livestock include llamas, horses, beef and breeding cattle, poultry, sheep, goats and a few dairy cows.

**Wild and Scenic Rivers**

A total of 147.3 miles of stream within the Upper Deschutes Watershed were included in the Wild and Scenic Rivers program in 1988. The river segments are to be managed “to protect river values and the management plan shall be coordinated with resource management planning for affected adjacent Federal lands (USFS 1996a)”. Designated river reaches include:

- Deschutes River from Wickiup Dam to the north boundary of Sunriver (RM 226.7 to RM 186.2), recreational.
- Deschutes River from the north boundary of Sunriver to Lava Island Camp (RM 186.2 to RM 175), scenic
- Deschutes River from Lava Island Camp to the Bend Urban Growth Boundary (RM 175 to RM 172), recreational.
- Little Deschutes River from headwaters to Hemlock Creek (RM 97 to RM 84), scenic?.
- Crescent Creek, a tributary to the Little Deschutes River, from Crescent Lake Dam to Country Road 61 crossing (RM 84-97), recreational.
- Big Marsh Creek, a tributary to Crescent Creek, from headwaters to its confluence with Crescent Creek, recreational.

Several segments of the Deschutes River have also been designated as State Scenic Waterways. State Scenic Waterway designations for this section of the Deschutes River include; Little Lava Lake to Crane Prairie Reservoir (RM 253 to RM 230), the stream gauge below Wickiup Dam to General Patch Bridge (RM 226.6 to RM 199), Harper

Bridge to the Central Oregon Irrigation District diversion (RM 192.6 to RM 171), Sawyer Park to Tumalo State Park (RM -- to RM 159), and from Deschutes Market Road bridge to Lake Billy Chinook (RM 134.5 to RM 120, excluding the Cline Falls hydroelectric facility). State Scenic Waterway designations include the river and the riparian areas extending one-quarter mile on either side of the river. Sections in the Upper Deschutes Watershed are designated as either Community River Areas in recognition of close private development, or Recreational River Areas, which have easy access to the river.

## *3.4. Focal Fish Species of the Upper Deschutes Watershed*

Before construction of the Pelton Round Butte Project in the 1960s, the Deschutes River (up to Big Falls), Squaw Creek and the Metolius River supported runs of spring and fall Chinook, summer steelhead and Pacific lamprey. Anadromous fish passage was terminated in 1968 with the failure of fish passage facilities at the Pelton Round Butte Project, eliminating salmon and steelhead runs from the Upper Deschutes River watershed and also ended upstream migrations of lampreys and redband and bull trout.

Today, the Upper Deschutes Watershed supports healthy resident indigenous fish populations. Currently Portland General Electric and Warm Springs Power Enterprises are pursuing efforts to reintroduce anadromous fish upstream of Round Butte Dam. The intent of the plan is to restore sockeye and spring Chinook salmon and summer steelhead to their historical range in the upper Deschutes drainage.

### 3.4.1. Chinook

Historically, spring Chinook returned to the upper Deschutes River (up to Steelhead Falls or Big Falls) and to Squaw Creek and the Metolius River. The Metolius River was the major spring Chinook spawning and rearing area in the upper Deschutes watershed. Reports of early explorers (1855 and 1874) note that salmon in the Metolius River were very abundant (Nehlsen 1995; Davidson 1953). The last good Chinook run (149 spawning salmon and 200 redds observed) was reported in the Metolius and tributaries in 1953, after which the run began to decline (Nehlsen 1995). Spring Chinook were last documented in the Metolius by spawning ground counts in 1967 (ODFW 1996a). Spring Chinook were observed in the Deschutes River at the Steelhead Falls fish ladder trap in 1953. In Squaw Creek, records of spawning salmon and redds in Squaw Creek from 1951-1960 showed a high count of 30 in 1951 and 0 by 1960 (Nehlsen 1995). Accounts of spring Chinook abundance are not available before 1950.

Today, a small landlocked Chinook population may exist in Lake Billy Chinook. However, ODFW receives only infrequent reports of their presence and has captured only one individual in recent years (Marx 2004).

### 3.4.2. Redband Trout

#### Summer Steelhead

Historically, Big Falls was likely the upstream limit of anadromous fish migration, as steelhead are believed to have negotiated Steelhead Falls in high winter or early spring flows (Nehlsen 1995). The length of this migration period increased in 1922 after the fishway was constructed, which allowed them to move upstream through the fish ladder for a period of years. It was determined that a minimum flow of about 300 cfs in the

Deschutes River at Bend was required to assure adequate efficiency of the fishway. After 1930, such flows were available only in November through April, possibly hampering summer and fall migrating fish in their attempts to move above Steelhead Falls. Fishways were constructed at Big Falls and Cline Falls in the 1920's, but no steelhead were ever observed attempting to pass either falls (Nehlsen 1995; Mathisen 1985a). Summer steelhead were trapped in the Steelhead Falls fishway in 1953, 1954 and 1955. Eighteen fish were recovered at the falls during those years (Nehlsen 1995).

Squaw Creek was historically a primary spawning area for summer steelhead in the Upper Deschutes Basin. In 1952 and 1953, Montgomery estimated that a minimum of 582 steelhead used Squaw Creek in 1952 (461 counted) and 1,000 spawned in the creek in 1953 (619 counted) (Nehlsen 1995). By this time, steelhead use had already declined because of irrigation diversions and other uses. Steelhead were also documented in the Metolius River, but in very small numbers. Elders from the Warm Springs Tribe of Warm Springs do not believe they were indigenous to the Metolius (ODFW 1996a; Terry Luther, personal communication, 1993).

#### Resident Redband Trout

Historically, redband trout were found throughout the Upper Deschutes watershed in waters connected to the Deschutes River. Presently, they are found in the mainstem Deschutes River from Lake Billy Chinook upstream to the headwaters, the Little Deschutes River, Crescent Creek, Squaw Creek, Tumalo Creek, and Odell Creek.

### 3.4.3. Pacific Lamprey

Pacific lamprey probably occurred in the Deschutes River above the Pelton Round Butte Project, however, very little is known about their life history or abundance in the watershed.

### 3.4.4. Sockeye

Sockeye salmon once migrated up the Metolius River and into the Lake Creek-Suttle Lake complex to spawn. The run was suppressed by the 1930's due to passage problems at artificial dams on Lake Creek near the outlet of Suttle Lake. The last sizable run of sockeye in the Metolius was 227 adults reported in 1955, though most of these adults were likely hatchery returns from the Oregon Fish Commission's Metolius Hatchery on Spring Creek (Nehlsen 1995). The native run of sockeye in Suttle Lake and Link Creek was reported extinct by 1940 (Frey 1942).

### 3.4.5. Bull Trout

Bull trout were historically found throughout most of the Deschutes River subbasin. There are many historical photos of large bull trout or "Dolly Varden" as they were called from both the Upper Deschutes River near Bend and from the Metolius River basin. Bull trout were extirpated from the Deschutes River mainstem in the 1950's due primarily to flow manipulations and dams with no upstream fish passage (Buchanan et al. 1997). Today, they are found in Odell Lake, occasionally in Odell Creek and Davis Lake, Squaw Creek below Alder Springs, the Metolius River and tributaries, Crooked River downstream of Opal Springs Dam and in the Deschutes River from Lake Billy Chinook upstream to Big Falls (Marx 2004).

## *3.5. Focal Wildlife Species of the Upper Deschutes Watershed*

Ponderosa pine and lodgepole pine woodlands are a wildlife habitat in the upper watershed that has been fragmented. Maps of historic and current wildlife habitat show that these woodland habitats — pure ponderosa pine or lodgepole pine forests or mixed forests — existed historically in large areas in the southern subbasin south of Bend. These habitats have been reduced and fragmented apparently due to suburban development and encroachment by other conifer forest types. A wildlife species that occurs in this habitat, and that is thought to have declined since historic times, is the white-headed woodpecker. Mule deer are also an important species that utilize this habitat.

[Additional information will be added once focal wildlife species/habitats are identified.]

## *3.6. Current Conditions in Major Drainages*

This section describes current environmental conditions within the major reaches and drainages of the upper Deschutes River from the Pelton Round Butte Project to the headwaters. These include:

- the Deschutes River, Pelton Round Butte Project
- Willow Creek
- Metolius River
- Deschutes River, Lake Billy Chinook to Bend
- Squaw Creek
- Tumalo Creek
- Deschutes River, Bend to Benham Falls
- Deschutes River, Benham Falls to Wickiup Dam
- Spring River
- Little Deschutes River
- Fall River
- Deschutes River above Wickiup Dam.

### 3.6.1. Deschutes River, the Pelton Round Butte Project (RM 100-120)

The Pelton Round Butte Project spans a 20-mile reach of the Deschutes River. The project consists of three dams and their associated reservoirs. The Reregulating Dam (RM 100.1) sits at the downstream end of the Project. Above this small reservoir, Pelton Dam forms Lake Simtustus. Round Butte Dam, immediately above Lake Simtustus, creates Lake Billy Chinook, which inundates the lower reaches of the Crooked and Metolius rivers, as well as a considerable stretch of the Deschutes.

**Reregulating Reservoir —** The Reregulating Reservoir extends about 2.5 miles between the Reregulating Dam and Pelton Dam. The small reservoir has a maximum pool elevation of 1,435 feet and fluctuates approximately 20 feet in elevation daily to maintain steady outflow into the Deschutes River while electricity is generated (PGE 1999). Because of large water level fluctuations, fish production is minimal and no public use is allowed at this reservoir. Fish routinely enter the reservoir through the Pelton Dam turbines and pass the Reregulating Dam into the lower river.

**Lake Simtustus —** Lake Simtustus extends about 7 miles above Pelton Dam to the base of Round Butte Dam. Two small tributaries enter Lake Simtustus. Seekseequa Creek, a seasonally dry stream, joins the lake from the west and Willow Creek joins the lake from the east. Lake Simtustus is a narrow reservoir confined between 800-foot high walls of the Deschutes River canyon. The reservoir has a normal maximum surface elevation of 1,580 feet above sea level, approximately 18 miles of shoreline, and 540 surface acres (PGE 1999). Because of the steep canyon walls, only about 12% of the reservoir is less than 10 feet deep. The lake fluctuates little in elevation year-round and the shoreline supports dense growths of alders, shrubs and grasses.

**Lake Billy Chinook —** Lake Billy Chinook extends about 9 miles up the Deschutes River canyon, 7 miles up the Crooked River canyon and 13 miles up the Metolius River canyon. The reservoir has a maximum depth of 400 feet and a surface area of 4,000 acres. Over 60% of the reservoir is more than 100 feet deep and only 6% is less than 10 feet deep. In a typical year, the reservoir is drawn down about 10 feet from November until February or March, and refilled in April and May (PGE 1999).

Fish habitat in Lake Billy Chinook is characterized by steep shoreline topography, boulder, cobble and sand substrate, and generally good water quality. The steep topography and coarse substrate around the reservoir limit the growth of emergent vegetation. Habitat in the reservoir is well-suited for kokanee, which rears in the reservoir and moves into the Metolius River to spawn. Habitat conditions improve considerably in the transition zones at the mouths of all three rivers. This habitat is particularly well-suited for resident salmonids. The three areas provide habitat for an abundance of rainbow and brown trout. The Metolius River Arm also provides good habitat for juvenile and subadult bull trout (PGE 1999).

### 3.6.2. Willow Creek

Willow Creek and tributaries drain about 180 square miles. The creek begins on forested slopes of the Ochoco Mountains and flows west 34 miles to join the Deschutes River in Lake Simtustus (RM 105). The drainage supports redband trout.

*Upland Conditions*
From its mountainous headwaters, Willow Creek flows through private range and agricultural lands, and through the Crooked River National Grasslands and the City of Madras. Land use in the watershed is 10% forest, 65% rangeland, and 25% cropland. About 70% of the cropland is irrigated for crops including grass seed, alfalfa, seed potatoes, carrot seed, grains, flower seed, hay, nursery crops, herbs, mint, sugar beets, onion seed, and garlic. Non-irrigated crops include hay, small grains, CRP, and pasture. Sixty percent of the cropland (15,000 acres) is classified as Highly Erodible Land (MDLAC 2001). Public lands on the Crooked River National Grasslands are used for livestock grazing and recreation.

*Riparian Conditions*
Habitat surveys conducted by ODFW in July 1980 showed that Willow Creek and many of its upper tributaries were in poor to very poor habitat condition. Stream shade

averaged 17%, with less than 20% shade on public lands and 12% shade on private lands (ODFW 1996c). Riparian conditions in some reaches are improving through better land management and habitat restoration. Conditions improve below the City of Madras, where the creek flows through a narrow basalt canyon to its confluence with the Deschutes River. Livestock use and human access are limited in this lower reach.

*Instream Conditions*
Lower Willow Creek flows through a rough, narrow canyon and has good instream habitat, including spawning gravels and deep pools. The stream has been channelized through the town of Madras and is dry, or nearly dry in this reach from summer through fall. Upstream from Madras the stream is again confined within a rimrock canyon and generally lacks instream wood. However, considerable structural diversity is maintained from large rocks and boulders. Upstream of the Crooked River Grasslands some reaches have been channelized and the stream is incised in some areas with active bank erosion. Instream habitat complexity is generally lacking and the substrate has a high fine sediment content.

*Flows*
Flows in Willow Creek are typically highest from February to May with heavy rains or snowmelt, and lowest during summer. Low summer flows drop further in upper and middle reaches where they are diverted for irrigation. Streamflow above the town site of Grizzly between October 1967 and December 1978 averaged 1.51 cfs, with long periods of no flow. A high flow of 52 cfs occurred in April 1978. Flows are typically highest from February through May (MDLAC 2001).

ODFW's habitat surveys have shown that flows were moderate in forested upper reaches, ranging from 0.5 to 3 cfs, but became intermittent to nonexistent when the stream entered irrigated farmlands. Streamflows were also intermittent to nonexistent in the middle section of Willow Creek, with the exception of the Crooked River National Grasslands, where flows ranged from 0.5 to 3 cfs. Streamflow below the Grasslands once again became intermittent to nonexistent when adjacent to irrigated agricultural lands (ODFW 1996c).

Streamflow is most consistent in the canyon below Madras downstream to Lake Simtustus where access and livestock utilization are minimal. Habitat conditions improve below RM 4.5 where spring releases increased flows in Willow Creek downstream to the mouth. ODFW surveys indicate that together 12 small springs add an estimated 22.7 cfs at an average temperature of $68^{o}$F. The streamflow at the mouth of Willow Creek was estimated at 27 cfs (ODFW 1996c).

*Water Quality*
Stream temperatures range from $51^{o}$ to $88^{o}$F (ODFW 1996). Stream temperatures in Willow Creek exceed the state water quality standard of $58^{o}$F. Water quality conditions for Willow Creek were reported to be moderate to severe for water quality, fish, and aquatic life (ODEQ 1988).

### 3.6.3. Metolius River

The Metolius River is one of the largest spring-fed streams in Oregon. The river originates from three springs and flows 29 miles to its mouth in Lake Billy Chinook. The drainage covers 315 square miles and contains 110 miles of perennial streams, 324 miles of intermittent streams, 42 lakes and 121 ponds. Major tributaries to the Metolius include Lake, Spring, Jack, Canyon, Abbot, Candle and Jefferson creeks and the Whitewater River.

*Upland Conditions*
Land ownership in the Metolius River drainage is approximately 60% federal (Deschutes National Forest), and 40% private and Tribal land. Primarily land uses include recreation, timber, farming and residential. A 28.6-mile reach of the Metolius is designated as Wild and Scenic. Fisheries, scenery, hydrology, geology, recreation, wildlife, and ecological values in the designated stretch are classified as “Outstandingly Remarkable” in the Metolius Wild and Scenic River Plan (USFS 1996b).

*Riparian Conditions*
The stable flows within the Metolius River promote a healthy riparian corridor along the stream and undercut banks. Good riparian growth also exists along most of the river’s tributaries. There are few wetlands along the Metolius, but several tributaries have extensive marshy areas, particularly in the Lake Creek area.

*Instream Conditions*
Healthy riparian vegetation and undercut banks along the Metolius create good fish habitat. Stream channels are generally stable with functional floodplains and habitats created by beaver activity, including ponds and wetlands. High quality spawning gravel suitable for redband trout is most abundant above Gorge Campground.

The Metolius River has a relatively uniform gradient, which increases from 25 ft per mile between the headwaters and Lower Bridge, to 44 ft per mile in the lower reaches. Pool, riffle, and glide characteristics are not as well defined as those of similarly sized rivers because of the river’s spring-fed nature, the lack of flood events, and the relatively uniform gradient within a volcanic bed. Low supplies of large wood limit fish habitat in the Metolius River. Habitat enhancement projects initiated since the early 1980s have increased fish cover in the river, particularly above Camp Sherman Bridge. In addition, the USFS and Warm Springs Tribes now manage the Metolius River corridor to increase the amount of wood entering the stream (USFS 1995a; CTWS 1992).

The cool spring-fed tributaries to the lower Metolius River — Jack, Canyon, Candle and Jefferson creeks and Whitewater River, which drains Mt. Jefferson — contain abundant spawning gravel, undercut banks, side channels and wood that form high quality bull trout rearing habitat (Ratliff et al. 1996). The tributaries also support few fish species that compete with bull trout, probably because of the cold water (USFS 1995a).

*Flows*
The Metolius originates from spring releases of 100 to 110 cfs and runs bankfull at all times. Average flows at the river’s mouth range from 1,653 cfs in June to 1,360 cfs in October. Flows for a 69-year period from 1913, and 1922 to 1989 measured just above the river’s confluence with Lake Billy Chinook averaged 1,493 cubic feet per second (USGS 1990). The lowest discharge (1,080 cfs) occurred in February 1932 and the highest discharge (7,530 cfs) occurred in December 1964 (USGS 1989).

*Water Quality*
Water quality is generally excellent throughout the Metolius system due to spring sources in the tributaries and in the mainstem. Water testing has shown low dissolved

solids, low alkalinity, and low conductivity. Phosphorus levels have measured higher than the recommended DEQ maximum. The tributaries generally have low conductivity and nutrients, compared to the Metolius River water.

Water temperatures in the Metolius generally do not exceed 50°F (measured at Bridge 99) during the summer. The cool flows are preferred by bull trout, but limit growth of redband trout, which prefer temperatures of 55-65°F. Unlike most rivers, summer temperatures in the Metolius River generally get colder with distance downstream because tributaries entering the lower river are cooler than those near the headwaters. The headwater spring has summer temperatures of about 48°F, while Spring Creek enters the Metolius at about 44°F. The river's cool, stable flows create a unique habitat for fish. Fish in the river experience less disease and parasite problems than typically found in warmer rivers. Still, water temperatures in the lower Metolius River can exceed the temperature standard for bull trout (50°F) during certain seasons of the year. Lake Creek is also listed for exceeding summer temperature criterion.

### 3.6.4. Deschutes River, Lake Billy Chinook (RM 120) to Bend (RM 164.8)

The Deschutes River extends 44.8 miles between Lake Billy Chinook and the City of Bend at North Canal Dam. The reach includes 120 miles of perennial streams, and tributaries Squaw Creek and Tumalo Creek. Several falls exist within the reach, including Steelhead, Big, Odin, Cline and Awbrey falls. Big Falls (RM 132) was historically considered the upstream limit of anadromous fish passage. A significant amount of flow from the Deschutes River is diverted for irrigation at the upper end of this reach.

*Upland Conditions*
Land ownership in the reach is approximately 61% private, 34% federal, 3% state and 2% county. Land uses include farming, rural residential development, municipal and recreation. The area includes the fast growing communities of Bend and Redmond.

The Deschutes corridor changes dramatically below Bend, leaving the forested landscape and entering a high desert landscape where upland vegetative communities are dominated by juniper and sparse ponderosa pine communities. The well-defined basalt canyon varies in width from a few hundred yards to one-half mile. The canyon gradually deepens to about 700 feet and becomes narrower near Lake Billy Chinook.

*Riparian Conditions*
The riparian area in canyon sections is narrow and dominated by woody species, such as alder, red-osier dogwood, willow, chokecherry, rose and by sedge, rush and various grasses. Few areas are broad enough to support extensive willow or sedge growth. Riparian vegetation is thicker when springs emerge from the canyon walls.

*Instream Conditions*
ODFW habitat surveys (1993) describe habitat conditions within five sections of this reach. The survey was completed during the summer low flow period. Findings from this survey, as described in ODFW's Upper Deschutes River Watershed Fish Management Plan (1996), are summarized below:

**Steelhead Falls to Long Butte, 25 river miles —** The reach of the Deschutes River from Steelhead Falls to Long Butte is constrained by steep (80%) and moderate v-shaped hill slopes (15%). Average width of the active channel was 109 feet with a wetted width of 62 feet. Gradient averaged 0.6%. Streambank stability was excellent and protected by non-erodible substrate and vegetation. Instream wood material was lacking to absent. Habitat area was 29% pool, 37% riffle, and 19% glide. Pools through the section averaged 8.6 feet in depth. Streambed substrate was classified as 28% cobble, 23% boulder, 18% bedrock, and gravel 16%. Sand and silt substrate made up the balance. Special cases through the section include Awbrey, Cline, Steelhead and Big falls. An additional 24 steps or falls were identified.

**Long Butte upstream 1.3 miles — T**he river valley became more open in this section. The active channel averaged 96 feet with a wetted width averaging 47 feet. Gradient averaged 0.5%. Streambank stability was excellent and provided almost solely by streambank vegetation. Wood material was lacking. Habitat distribution was classified as 61% riffle and 38% glide. No pool area was identified. Substrate was classified as 48% cobble, 24% gravel, 13% sand, and 11% boulder, with silt and bedrock comprising the balance.

**Upstream end of Long Butte section to Tumalo, 1.3 river miles —** This river section is constrained by steep, v-shaped hill slopes. No actively eroding areas were identified and non-erodible streambank and vegetation provided stability. The active channel width averaged 87 feet with a wetted surface width of 47 feet. Gradient through the section was 0.4%. Habitat distribution was 70% pool, 17% riffle, and 11% rapids. Substrate included 34% boulder, 28% cobble, 13% sand and 11% for each gravel and bedrock. Wood material contribution was insignificant through the section.

**Tumalo to upstream end of Tumalo State Park, 3.5 river miles —** Above Tumalo, valley width increases with the river constrained by terraces. The entire length of streambank was stabilized by vegetation. Active channel width averaged 125 feet, with a wetted width of 54 feet and depth of 0.49 feet. Gradient was 0.3%. Glide habitat comprised 49% of the total area with riffles 38% and pools 12%. Substrate was classified as 40% cobble, 28% gravel, 14% boulder, and 10% silt. Sand and bedrock made up the remaining substrate.

**Tumalo State Park to North Canal Dam, 5.8 river miles —** Steep V-shaped hill slopes contain most of the channel between Tumalo State Park and North Canal Dam. Active channel width averaged 85 feet, with a wetted width of 47 feet. Depth averaged 3 feet. Section gradient was 1.2%. Streambanks were stabilized by non-erodible substrate and vegetation, and no eroding streambanks were identified. Habitat distribution included 32% pool, 22% glide, 25% riffle, with the balance composed of cascades, step/falls, and rapids. Substrate through the section was 34% boulder, 25% cobble, 15% bedrock, 14% gravel, 9% sand, and 4% silt.

Survey results showed that good spawning habitat in the Deschutes between Steelhead Falls and Bend is not abundant, though there is good spawning habitat in the Foley Waters area just upstream of Steelhead Falls (ODFW 1996a). Biologists determined that spawning is most likely confined to small pockets of gravel in the mainstem and in the lower two miles of Squaw Creek and in Tumalo Creek. They determined that carefully selected placement of gravel and rearing habitat throughout the mainstem should greatly increase available brown and redband trout spawning habitat — though improved summer flows would be needed to realize any benefit (ODFW 1996a).

<u>*Flows*</u>
Before irrigation began in the late 1800s and early 1900s, flows in the Deschutes River at Bend normally ranged from 1,500 to 1,600 cfs during summer months. Flows occasionally dropped to 1,100 to 1,200 cfs in mid-winter, but only for a few days. By the 1920s, following irrigation development in Deschutes and Jefferson counties, nearly the entire flow at the North Canal Dam at Bend was diverted during the irrigation season. Today on average, 90% of the water in the Deschutes is diverted near RM 164 during the high withdrawal months of June through September (Yake 2003). Inflow from two tributaries, Tumalo and Squaw creeks, and from springs beginning near Steelhead Falls, add streamflow to the Deschutes River below Bend. Still, flows between Bend and Lower Bridge reach as low as 30 to 35 cfs in hot summer months during the irrigation season (although historical short-term flows to 1 cfs have been recorded).

<u>*Water Quality*</u>
The reach of the Deschutes above Steelhead Falls is included on the state 303(d) list for exceeding water temperature criterion for salmonid spawning (September 1 through June 30) and for salmonid rearing. The highest recorded water temperature for the reach was 81$^{o}$F in 1994 (ODFW 1996a). The reach is also listed for exceeding state pH standards. Increases in water temperature and pH have been attributed to a combination of higher ambient air temperatures, low flows, lack of riparian vegetation, agricultural return flow, and excessive growth of aquatic vegetation (primarily algae) during the summer (BOR 1997). Low flows are believed to be the main cause of increased water temperatures and to contribute to nutrient concerns (UDLAC 2002).

### 3.6.5. Squaw Creek

Squaw Creek begins on the Bend Glacier of Broken Top Mountain, flows 39 miles in a northeasterly direction through the City of Sisters, and enters the Deschutes River at RM 123.1, about five miles below Steelhead Falls and a few miles above Lake Billy Chinook. Elevations range from more than 9,000 feet in the headwaters to about 2,100 feet at the mouth of Squaw Creek.

Squaw Creek was once the primary spawning area for steelhead in the upper Deschutes watershed. The drainage also supported populations of spring Chinook and redband trout. Steelhead and resident redband trout migrated up Squaw Creek to the lower falls near the wilderness boundary. They also migrated up Indian Ford Creek to the Black Butte Ranch area and into lower Snow Creek. Spring Chinook were likely confined to a smaller area of the drainage. There are no historic records of bull trout or lampreys in Squaw Creek, but it is likely that both bull trout and lampreys frequented the stream historically. Today, Squaw Creek continues to provide important habitat for native redband tout and brown trout in the lower 15-mile reach, primarily due to springs that provide water during low flow periods. Trout production occurs mainly in those stream reaches having ample summer flows and lower water temperatures. Bull trout have been observed in the lower stream reach in recent years. Introduced brown trout and brook trout are also present in Squaw Creek (Lewis 2003; Hubler 2000).

<u>*Upland Conditions*</u>
Squaw Creek watershed covers 230 square miles. It drains the glacial flanks and forests of Broken Top and the Three Sisters in the Cascade Mountains, and then

sagebrush steppe before reaching the Deschutes River at RM 123. It also flows through the City of Sisters and through lower valley farm and ranch lands.

*Riparian Conditions*

Riparian areas along upper Squaw Creek are generally in good shape, though some areas show damage from timber harvest and recreation use. The most severe riparian condition is within the stream section beginning just south of Sisters and extending downstream for eleven miles. This section was further degraded after the 1964 flood. In an attempt to repair damage and reduce future risks from flooding, the reach was cleared of debris and the channel was straightened and widened by up to 150 feet. Downstream of Sisters, Squaw Creek has a broad riparian area comprised of floodplains, willow stands, and cottonwood bottom lands. In some areas, riparian communities are limited by geology, or have been altered from grazing and channelization.

*Instream Conditions*

Riparian floodplains along Squaw Creek once served as a dynamic system of gravel bar deposits and pool formation while floods covered vulnerable areas. These bottomlands also may have been some of the most productive habitats for steelhead and salmon spawning and rearing. Alterations to these riparian communities from overgrazing and channelization have reduced habitat quality for the native redband trout and other species ODFW 1996a). In particular, channel simplification has reduced channel complexity and stability from RM 18.8 to 23.5. Large wood volume is low or absent from the channel below RM 25. Seven irrigation diversions, all unscreened, also impact fish passage during low stream flows.

*Flows*

Streamflow in Squaw Creek is notoriously “flashy”, fluctuating from extreme high flows to low flows that at times go subsurface. Glacial runoff maintains a consistent level of flow in Squaw Creek, which is augmented by rain and snowmelt in late spring. Fall and winter flows of 70 cfs rise to 200 cfs or more as snow melts in June. Rain and snow flood events can often cause flows to rise above 1,000 cfs. Flows in Squaw Creek are lowest during October and March, providing a mean and record flow of 60 and 63 cfs, respectively (Curtis 1994). Releases from springs supplement flows in some reaches below the town of Sisters and near the mouth of Squaw Creek. Alder Springs (RM 2) provides an important refuge for bull trout, redband trout and other fish populations.

Natural flow pattern in Squaw Creek remains generally undisturbed from the headwaters to about RM 23.5, where a series of irrigation diversions remove most water from the stream. The stream is largely dry near the town of Sisters in summer months, although recent projects have put some water back in this stream section. Between Sisters and RM 17, flows gradually improve with spring releases and return flow. Springs near Camp Polk Road (RM 17) contribute about 7 cfs to flows in Squaw Creek. Indian Ford Creek, which joins Squaw Creek at RM 20, also dries up due to irrigation diversions and natural seepage. Water lost in this tributary system may resurface as springs in lower Squaw Creek. Alder Springs contributes about 20 cfs to the stream. At the mouth, nearly 100 cfs discharges to the Deschutes because of spring inflow (UDLAC 2003).

*Water Quality*

Water quality in Squaw Creek differs significantly from the nearby Metolius River. The Oregon Department of Environmental Quality rated Squaw Creek as severely impacted by turbidity, low dissolved oxygen, nutrients, streambank erosion, decreased stream flow, and insufficient stream structure. Most of these factors can be linked to reduced flow from irrigation and domestic water use, or channel alterations from the 1964 flood and subsequent channel modifications.

The stream exhibits high water temperatures during summer months. High water temperatures particularly limit fish production in reach between RM 1.5 and 25. Below water diversions near the City of Sisters, water temperatures in Squaw Creek can rise to over 70°F. In 1994, ODFW measured water temperatures in Squaw Creek at RM 6.0 from April 15 to October 1. Results showed a mean temperature of 62.1°F, a minimum temperature of 42.8°F and a maximum temperature of 86°F. The warmer water temperatures result in lower dissolved oxygen as the stream flows through the dry canyon section (ODFW 1996a). Black Butte Ranch (on Indian Ford Creek) has an NPDES permit for discharge of the treated effluent from their wastewater treatment plant into Indian Creek. They are not allowed to discharge in the summer (Lamb 2004).

### 3.6.6. Tumalo Creek

Tumalo Creek and tributary Bridge Creek originate as springs and as snowmelt from Tumalo and Broken Top mountains, approximately 20 miles west of Bend. It enters the Deschutes River at RM 160.2 just north of the City of Bend. The mainstem of Tumalo Creek is approximately 16 miles long. Four tributaries — North Fork, South Fork, Middle Fork and Bridge Creek — contribute 20 additional stream miles to the basin.

*Upland Conditions*
Tumalo Creek flows from subalpine park-like vegetation near Broken Top through areas of Douglas fir dominant –mixed conifer forest, manzanita dominant shrubland, ponderosa pine forest and woodland, and finally western juniper woodland before joining the Deschutes River (Yake 2003). Land ownership in the drainage is 67% federal (Forest Service), 24% private, 8% city (Bend), 1% county (Deschutes) and >1% state (Parks). Primary land uses in the basin are recreation, timber, farming, residential, mining, and water withdrawal. Bridge Creek, a major tributary to Tumalo Creek, is a principal source of water for the City of Bend, which maintains a diversion facility in Tumalo Creek (RM 15). Approximately 2.6 miles of Tumalo Creek flows through Shevlin Park, owned and operated by Bend Metro Park and Recreation District.

*Riparian Conditions*
Riparian conditions remain good along much of Tumalo Creek and its tributaries. Areas along three miles of Tumalo Creek and one mile of Bridge Creek burned in 1979 during the Bridge Creek Fire. Salvage operations following the fire removed large amounts of large woody debris from the stream and streambanks.

*Instream Conditions*
While the system contains good spawning gravel, fish production in lower Tumalo Creek is limited by lack of pool habitat and a limited supply of large wood. Instream habitat diversity is also restricted in reaches burned by the Bridge Creek Fire. Fish movement barriers include the Tumalo Feed Canal diversion (RM 2.5) and Tumalo Falls (RM 15.4).

*Flows*
Tumalo Creek flows drop below the Tumalo Feed Canal, an irrigation diversion point at RM 2.5, during the irrigation season. Since 1992, a minimum flow of 2.5 cfs has been

maintained in the creek below the feed canal. This minimum was increased to 5.8 cfs in 2001 when an instream water right was placed on the creek from the Tumalo Feed Canal to the mouth. The water savings has been largely due to conservation efforts by the Tumalo Irrigation District. The only significant diversion from Tumalo Creek above the feed canal is the City of Bend. Low summer flows in Tumalo Creek below RM 2.5 continue to restrict fish movement.

*Water Quality*
Naturally cold water temperatures in upper Tumalo Creek limit salmonid production. In the lower reach below RM 2.5, summer water temperatures rise to levels that restrict salmonid production during the irrigation season.

### 3.6.7. Deschutes River, Bend (RM 164.8) to Benham Falls (RM 181)

Benham Falls, a high gradient natural cascade, separates the Deschutes River into two logical sections, with low gradient above the falls and high gradient below. Below Benham Falls, the Deschutes courses through lava formations that result in falls and copious whitewater. Rainbow trout are the dominant fish species in the reach.

*Upland Conditions*
Much of this reach of the Deschutes flows through ponderosa pine forests on the west side and lava flows on the east. The lower end of this reach of the Deschutes River flows through City of Bend urban growth boundary.

*Riparian Conditions*
Lava flows, boulders, and rubble armor a considerable portion of the streambed and banks from the erosive action of high irrigation flows. On the east side, relatively undisturbed patches of ponderosa pine, alder and aspen dominate riparian vegetation in areas that escaped lava flow. Vegetation along the west side of the Deschutes shows signs of disturbance from recreational use, particularly from Benham Falls to Lava Island Falls (Yake 2003). Riparian conditions along the Deschutes River through the City of Bend have been disturbed by industrial, residential and commercial uses.

*Instream Conditions*
Four major falls comprise about 13% of the Deschutes from Meadow Camp (RM 173) to Benham Falls. Benham, Dillon and Lava Island falls may hinder upstream fish movement at certain flows. The higher flows in this section provide deeper pools and considerable turbulence, both of which provide fish cover. Still, high stream gradient and high flows and water velocities in this reach limit spawning and rearing of trout. High flows carry gravel and woody material to the stream margins where they become stranded as flows drop during winter months. Thus, both spawning gravels and large woody structure are limited in the reach. Aquatic organisms, including fish, are trapped inside channels and backwaters as flows are rapidly curtailed in the fall (ODFW 1996a).

Three dams within the City of Bend's urban growth boundary have no fish passage facilities (Yake 2003). The North Canal Dam (RM 164.8) and Pacific Power and Light Dam (RM 166) are complete barriers to upstream fish movement. The Colorado Street Dam is a partial barrier to upstream fish movement.

*Flows*
The Deschutes River between Benham Falls and Bend displays a more stable flow regime compared to the upper section of the Deschutes below Wickiup Reservoir. Inflow from the Little Deschutes River, Fall River, Spring River, and various springs maintain a more adequate winter flow. Some instream flow is lost in the several subterranean lava tubes that are present in the reach. For the water years October 1955 to September 1982, the mean monthly flow at Benham Falls ranged from 731 cfs in October to 2,426 cfs in July (USGS 1990). The higher winter flows help reduce the "icing" problems experienced in the reach from Wickiup Dam to Fall River. Still, the magnitude of flow variation in the reach adversely affects the aquatic ecosystem.

*Water Quality*
The river reach between Bend and Benham Falls is included on the state 303(d) list of exceeding water quality criteria for temperature, dissolved oxygen, chlorophyll *a,* turbidity and pH. Water temperatures in the Deschutes River from Bend to Benham Falls exceed the temperature criterion for salmonid fish spawning between September 1 and June 30. Above RM 168.2, the reach is also listed for exceeding dissolved oxygen criterion for spawning, cold water dissolved oxygen criterion, chlorophyll *a* criterion, and state sediment and turbidity standards. Below RM 168.2, this reach of the Deschutes River is listed exceeding the state pH standard (Yake 2003).

### 3.6.8. Spring River

Spring River originates from a spring source and is approximately one mile long, joining the Deschutes River from the west at RM 191.

*Upland Conditions*
Spring River, because of its extremely short length and spring water source, has a much abbreviated watershed. Uplands are primarily forested.

*Riparian Conditions*
Streambank ownership is approximately 20% federal (Forest Service) and 80% private. Vegetation along the river corridor is predominantly pine forest along with sedges, forbs, willow and alder. Public access is very limited, especially from the bank, though the river is accessible by boat from the Deschutes River during favorable flow conditions.

*Instream Conditions*
Habitat observations suggest that there is a lack of trout cover in Spring River, both hiding for adult fish and juvenile rearing. What cover exists is primarily in the upper quarter-mile and comprised of a few logs and overhanging vegetation (ODFW 1996a). Spawning gravel is limited.

*Flows*
While there is no stream flow gauging station on Spring River, state personnel periodically measure flows. These records show flows at the mouth ranging from 299 cfs in April 1907 to 118 cfs in November 1925. The most recent flow measurement at the mouth was 124 cfs in January 1995. Spring River has a flat gradient and water depth is influenced by fluctuating water levels in the Deschutes River. Water depth in Spring River drops when the irrigation season ends and Deschutes River flows are reduced to enable storage in upstream reservoirs (ODFW 1996a).

*Water Quality*
Naturally cold water temperatures limit salmonid growth in Spring River. There are no extensive water temperature records for Spring River, but a maximum temperature of 48°F was recorded in 1970 (OSGC 1970).

### 3.6.9. Little Deschutes River

The Little Deschutes River begins near Mule Peak in Klamath County and drains approximately 1,020 square miles, flowing approximately 97 miles north to its confluence with the Deschutes River at RM 192.5. Crescent Creek is the largest tributary to the Little Deschutes.

*Upland Conditions*
Lands along the lower Little Deschutes River from the mouth to the Gilchrist Mill Pond (RM 63) are primarily privately owned. These lands are generally used for residential development, livestock grazing, and timber management. The drainage also contains the communities of La Pine and Gilchrist. Undeveloped lands dominate the section above RM 58.2, with public ownership of lands along the Little Deschutes River increasing above the Gilchrist Mill Pond. Almost equal amounts of private and public lands exist below Highway 58 and mostly federal forestland above Highway 58.

*Riparian Conditions*
Heavily eroding streambanks and degraded riparian areas are common in the first 38 stream miles due to overgrazing and urban development along the stream corridor. Many stream sections from RM 44.6 to RM 63 also show the impacts of overgrazing (ODFW 1996a). Riparian condition along the upper Little Deschutes River is generally good. Livestock grazing only occurs along one stretch of this river section, which lies just above the Gilchrist Mill Pond area and exhibits a degraded riparian condition. Conditions improve above this stretch. Riparian vegetation transitions from a willow and sitka sedge community to the bog blueberry and sitka sedge community that is more common at higher elevations. Riparian cover is also lacking along sections of Crescent Creek with heavy livestock use.

*Instream Conditions*
Spawning habitat is lacking in the lower Little Deschutes, but becomes more available upstream. ODFW surveys (1989-90) between the mouth of the Little Deschutes and RM 63 found a river gradient of 0.17%, and habitat type distribution at 86.4% glide, 10.8% primary channel pool, 1.0% side channel, and only 0.9% riffle. The surveys noted an increase to 17% riffle habitat from RM 61 to RM 63. Stream channel substrate from RM 0-63 was sand (81%), gravel (14%), hard pan (4%), cobble (1%) and small boulders (1%). The area had some of the best spawning habitat in the Little Deschutes due to low silt content within the gravels (ODFW 1996a).

Habitat conditions in the Little Deschutes River improve above Gilchrist Mill Pond (RM 63). Between RM 63 and 80, there are numerous side channels and backwater areas throughout the section. Large wood and instream complexity is lacking, but overhanging vegetation and undercut streambanks provide good cover for fish. Spawning habitat is abundant, with many tailouts and riffles containing good quality gravel. Above RM 80, habitat distribution is mainly glide with pool habitat secondary. Spawning habitat in this reach is lacking, especially in low gradient areas. Riffle habitat dominates in higher gradient areas. Dominate fish cover transitions from overhanging banks and aquatic vegetation in the lower areas to predominately wood moving upstream.

*Flows*
Flows in the Little Deschutes River are mostly unregulated except for minor storage and release effects of water from Crescent Lake, which serves as an irrigation storage reservoir. Releases from Crescent Lake during the irrigation season boost flow in the Little Deschutes. Average summer flows exceed natural flows, but are lower than high flows that would occur naturally during the months of April, May and June. Flow regulation has little effect on winter flows in the Little Deschutes River. The average flow was 385 cfs between 1924 and 1987. Flows typically drop to their lowest levels in October, with an average flow of 85 cfs between 1923 and 1995. Flow monitoring in the lower Little Deschutes recorded an all time low of 5.5 cfs in 1994.

Flow fluctuations in Crescent Creek from irrigation demands are the greatest factor limiting fish production, especially upstream of Big Marsh Creek. Flows are often low from September to April during reservoir storage and high during the rest of the year.

*Water Quality*
Several segments of the Little Deschutes River are listed as water quality limited streams on the 303(d) list. These reaches include: Little Deschutes for temperature (both spawning and rearing) from Crescent Creek to Hemlock Creek (RM 54.1-78) and for dissolve oxygen (both spawning and rearing) from mouth to Crescent Creek; Crescent Creek for summer temperature (mouth to RM 26.1) and Paulina Creek (RM 0-13.2). The lower portion of the Little Deschutes was not included for temperature because the data submitted to DEQ was collected in a drought year (Lamb 2004). Streams where data was only collected in a drought year were listed as “potential concern” rather than actually included on the list. The Little Deschutes River from the mouth to Crescent Creek is also listed as needing data for bacteria, flow modification, habitat modification, nutrients and sediments (ODEQ 1988). In addition, Crown Pacific holds an industrial NPDES permit for discharge of cooling water and process wastewater into the Little Deschutes at the town of Gilchrist (Lamb 2004).

### 3.6.10. Fall River

Fall River originates from a spring and flows east to the Deschutes River, entering the river from the west at RM 204.5. The river stretches 8.15 miles long and drains a small watershed of 45.1 square miles. The river provides important habitat for redband trout.

*Upland Conditions*
Streambank ownership is approximately 59% federal (Forest Service), 38% private, and 3% state (State Parks and ODFW Fall River Hatchery). Ponderosa pine and bitterbrush cover much of the uplands area (Yake 2003).

*Riparian Conditions*
From its headwaters, Fall River flows in a very gentle gradient. The dominant vegetation along the stream is lodgepole pine, with scattered willow and bog birch. A variety of grasses and forbs line most of the river.

*Instream Conditions*
Stream surveys by ODFW and Forest Service (1989 and 1991) showed that Fall River contained limited amounts of large wood, instream cover and pool habitat to support local trout populations. Spawning gravel was also limited and often embedded with fine sediment. River substrate was largely sedimented alluvial gravels, sand, pumice, and basalt outcrops. A 1967 Oregon State Game Commission stream survey of Fall River classified a total of 7,071 square yards of spawning gravel of which 2,990 square yards was rated as good and the remainder marginal (ODFW 1996a; Griggs 1967).

Lower Fall River up to the falls (RM 2.0) remains an important spawning area for Deschutes River brown trout. Several habitat enhancement projects have been implemented to increase spawning gravel and wood material content below the falls.

*Flows*
Fed by springs, the river exhibits a very stable flow regime. The historical mean flow from 1938-1989 was 148 cfs. The maximum discharge was 254 cfs in 1965 and the minimum was 67 cfs in 1969 (USGS 1989).

*Water Quality*
Daily water temperatures recorded at the Fall River hatchery for the years 1990-94 showed an annual average daily temperature of 45°F, with a range of 34-60°F. There are no known water quality limitations in Fall River. Fall River hatchery has a NPDES permit for discharges of hatchery water to Fall River.

### 3.6.11. Deschutes River, Benham Falls (RM 181) to Wickiup Dam

The Deschutes River below Wickiup Dam shows the effects of water storage and releases since 1949. While natural flows remained stable throughout the year, regulated flows change drastically; altering channel morphology, water quality and fish production in the river below the dam. This river section from Wickiup Dam to Benham Falls exhibits distinct stream morphology, with a lower gradient compared to the river below Benham Falls.

*Uplands*
The headwaters of the upper Deschutes River generally collect flow from public forestlands managed by the Forest Service for recreation and timber harvest. Much of this area lies above 4,500 feet in elevation.

*Riparian Areas*
Riparian areas below Wickiup Dam are dominated by ponderosa and lodgepole pine forests, willow thickets and sedge meadows. Several reaches within this section show damages from past and present land use. Riparian condition has been reduced by flow fluctuations, harvesting or thinning of lodgepole pine, overgrazing, and recreational use (USFS 1996d). In addition, the section contains the community of Sunriver and residential lands south to La Pine, which have seen tremendous growth during the past 30 years. Much of the land along the Deschutes between General Patch Bridge and Harpers Bridge, where 96% of the riparian land is privately owned, has been altered by private development (Yake 2003).

Nearly 15% of the banks along the Deschutes from Benham Falls to Wickiup Dam are currently bare and badly eroding (ODFW 1996a; Century Testing Laboratories

Incorporated 1978). A 1978 streambank erosion survey estimated that bank erosion in the reach generally range from zero to two inches per year, but jumps to eight inches per year at many locations (Yake 2003). This erosion appears to have started subsequent to the operation of Wickiup Dam and may have resulted from changes in the timing of high and low stages. A comparison of 1943 and 1991 photographs reveals that the Deschutes River between Wickiup Dam and Benham Falls widened an average of 20% during the 48-year period (ODFW 1996a; USFS 1994).

*Instream Habitat*

Downstream of Wickiup Dam, the Deschutes River is generally a meandering stream (with the exception of Pringle Falls at RM 217), with gradient averaging less than 1% until it reaches Benham Falls. Sloughs and oxbows are found throughout the section. River substrate is generally silt, sand, and pumice with an underlayer of clay and siltstone. Alluvial gravel is found mixed with these substrates, and dominates the substrate in some riffle and higher water velocity areas.

The aquatic environment in this section has been degraded, primarily due to extreme seasonal flow fluctuations caused by irrigation releases and storage in the reservoirs. The reach has little habitat complexity and lacks large wood, boulders and pool habitat. High flows push much of the large woody debris to the stream margins where it becomes unavailable once flows recede. Many aquatic organisms must semiannually redistribute themselves, and find themselves in winter pools that lack adequate cover (ODFW 1996a). Low winter flows also leave the limited spawning gravel along the stream margins as unavailable or barely usable by spawning fish (ODFW 1996a). Further production is lost because small fish and aquatic invertebrates become stranded in pools and side channels when flow recedes and they soon perish.

Low winter flows expose streambanks to "frost heave", with loosened soil washing downstream when flows increase in the river during the beginning of irrigation season. At a flow of 30 cfs, about 50% of the stream channel is exposed to frost action cycles (USFS 1994). When the river is at the minimum flow of 20 cfs below Wickiup Dam, even more of the channel is exposed.

Fish habitat improves progressively in the Deschutes River with flow supplementation from Fall, Little Deschutes, and Spring Rivers — though there is still high turbidity, flow fluctuations and icing in the reach above Sunriver. Below Sunriver, higher low flow and banks armored with boulders and rubble reduce frost heave and subsequent erosion. Spawning gravels are limited, but Fall and Spring rivers provide about one mile of high quality spawning habitat. Lava formations in the reach create pools that support larger fish during low flows and provide rubble, cobble and boulder substrate that are important winter habitat for juvenile trout.

*Flows*

While natural flows historically remained very stable year-round, the regulated flows below Wickiup rise and plunge dramatically through a year (Yake 2003). Before development of Crane Prairie (1922) and Wickiup (1942), natural flows rarely dipped below 500 cfs in the low flow months of winter, and occasionally rose to around 1,400 cfs during the peak runoff period in May or June (USFS 1994). Today, water storage creates low flows during the fall, winter and spring, and water releases for irrigation cause sustained high summer flows — opposite of the natural streamflow regime. Since 1946, the managed flows have created the equivalent of a 25-year flood event sustained for the six-month irrigation season (USFS 1996d). Flows currently are managed to vary between 20 cfs in winter to under 1,600 cfs during high irrigation demand in summer months (Gorman 2004). The minimum flow of 20 cfs represents a 95% reduction from natural unregulated flows (USFS 1996d).

Flows in the Deschutes River improve with releases from Fall River (90-160 cfs), the Little Deschutes River (140-350 cfs) and Spring River and nearby springs (180 to 210 cfs) (USFS 1996d). Nevertheless, flow manipulations still cause extreme variation in water levels and flows in the reach. For the years 1963-82, the maximum discharge was 2,591 cfs and the minimum 487 cfs (River Task Force 1986) at the Benham Falls gauge. The average discharge for a 70-year period (1907-13, 1925-87) had been 1,418 cfs (USGS 1989).

<u>Water Quality</u>
Water quality in the Deschutes River declines below the reservoir. The river reach is included on the state 303(d) list of exceeding water quality criteria for temperature, dissolved oxygen, chlorophyll and turbidity. Temperatures from Benham Falls to Sunriver exceed the temperature criterion for salmonid fish spawning between September 1 and June 30. The reach from Benham Falls to Wickiup Dam is listed for exceeding dissolved oxygen criterion for spawning, and the reach upstream to RM 189.4 (below Sunriver) is also listed for exceeding the cold water criterion. The reach upstream to just below Sunriver is also listed for exceeding chlorophyll *a* levels from June 1 to September 30. In addition, the upper Deschutes River below Wickiup Dam experiences higher than normal turbidity levels during water releases from spring through summer. Turbidity levels increase as much as 30 times after spring water releases for irrigation (Yake 2003; Forest Service Turbidity Monitoring Study 1991-1993 data). This turbidity is caused as water releases from Wickiup send a rush of high flows down a channel that had been dewatered for most of the winter. The gush of water erodes exposed streambanks that typically experience repeated freezing and thawing during the winter, creating high levels of turbidity.

### 3.6.12. Deschutes River, Wickiup Reservoir to Headwaters

The eight-mile reach of the Deschutes River above Crane Prairie is the only reach of a total 252 miles where the flow regime remains unaltered by dams. Except for overgrazing, recreation sites and transportation impacts — the section remains relatively natural (ODFW 1996a). Consequently, the Deschutes River from its headwaters to Crane Prairie Reservoir was designated as a State Scenic Waterway in 1988. In addition, the Crane Prairie Osprey Management Area, covering 10,600 acres, was established in 1970. The reservoir also supports many other water-associated birds such as bald eagles, blue herons, cormorants, mergansers, kingfishers, ducks, geese, and swans.

<u>Uplands</u>
The headwaters of the upper Deschutes River collect flow from public forestlands managed by the Forest Service for recreation and timber harvest. Crane Prairie was a natural meadow in which the Deschutes River, Cultus River, Rock Creek, Cold Creek, Quinn River, Deer Creek, and Cultus Creek converged. The Deschutes River originates approximately 8.4 river miles north of Crane Prairie in Little Lava Lake, a spring-fed body of water. Portions of the watershed have an extensive road network that provides

access to most streams, lakes and associated recreation sites. There has been limited timber harvest and grazing in the area.

The area surrounding Odell Lake is also forested. Plant communities upslope of Odell Lake are primarily mountain hemlock or mountain hemlock/lodgepole pine. The watershed includes several recreation sites.

*Riparian Areas*

The stream channel is bordered by lodgepole pine forests and riparian meadows. Grasses include Kentucky bluegrass, blue-joint reed grass, tufted hairgrass, and blue wildrye. Lupine, false hellebore and a variety of rushes and sedges are also present (USFS 1989). Mountain alder and spruce are found along with lodgepole pine (ODFW 1996a).

The riparian condition around the Odell Lake watershed is generally excellent, except for localized recreation sites where human influences have altered the form and function of riparian and floodplain areas (USFS and BLM 1999).

*Instream Habitat*

Much of the spawning gravel in the headwaters occurred in the area now inundated by Wickiup Dam and the reservoirs, and is no longer available. The best trout spawning and rearing habitat is now found in the Deschutes River above Crane Prairie and is used by redband trout, brook trout, whitefish, and kokanee. Of the approximately 13.5 total miles of tributary habitat available in the Cultus and Deer Creeks and Cultus, Quinn, and Deschutes rivers, over three quarters of it is in the Deschutes River (ODFW 1996). Other tributaries to Crane Prairie Reservoir provide varying amounts of trout spawning and rearing habitat for both reservoir and resident fish populations. According to 1989 Forest Service stream surveys, much of the available spawning gravel in these tributaries is embedded with naturally occurring fine sediment. Other factors, including low or non-existent stream flows during the summer and fall in Cultus and Deer creeks, render these streams unusable for fall spawning species such as brook trout, whitefish, and kokanee (ODFW 1996a).

Trapper Creek is the only tributary to Odell Lake with a known spawning population of bull trout. Juvenile bull trout rear in Trapper Creek, Hemlock Creek, and Odell Creek, and probably several other tributary streams intermittently (USFWS 2002b). A 1996 USFS habitat survey found 35% of the total habitat units in Trapper Creek had bull trout-size spawning gravels; however, spawning habitat was limited by other factors, including water depth and velocity (USFWS 2002b). Low levels of large wood also limit bull trout production in Trapper Creek. The 1996 survey found only five side channels for rearing, constituting only 5% of the total habitat area in the 0.8-mile reach of Trapper Creek below a 7.5-foot waterfall (USFWS 2002b). Bull trout may also occupy Maklaks Creek, which originates as springs and seeps on Maklaks Mountain and flows 0.43 miles to its confluence with Odell Creek. Water quality appears suitable for bull trout ranging from 40.1$^{o}$F at the source to 41.9$^{o}$F at the Odell Creek confluence.

*Flows*

The Deschutes River flows about 8.4 miles from Little Lava Lake to Crane Prairie Reservoir. The spring-fed flows are very stable with minimal daily, monthly, and even annual fluctuations in water flows and temperatures (Mathisen 1990). Unlike most streams in Oregon, flow in this reach of the Deschutes is lowest in the winter and peaks in August to early September (ODFW 1996a).

Odell Lake is a natural lake in the Cascade Mountains. The lake covers 3,600 acres and has an average depth of 40 meters. Trapper Creek is the only tributary of Odell Lake that responds to runoff events (USFWS 2002b). Most of the basin exhibits fixed drainage patterns fed by spring releases. Davis Lake, a shallower natural lake (20 feet maximum depth), has no surface outlet, however, many seeps in the lava flow allow water into Wickiup reservoir (USFWS 2002b).

*Water Quality*

Generally, water quality in the Deschutes River above Crane Prairie remains good, though problems do exist. The State of Oregon has listed Odell Lake and parts of Odell Creek as water quality limited for pH and of concern for chlorophyll *a*. Monitoring by USFS and ODEQ personnel during 2001 found summer pH levels consistently exceeding the upper limit of 8.5 standard established by ODEQ (USFWS 2002b). Odell Creek is also listed for exceeding state water temperature standards for spawning and rearing. Summer water temperatures in Odell Creek generally exceed 70°F, as a result of the discharge of warm surface water from Odell Lake (USFWS 2002b). In addition, Lava Lake is on the 303(d) list for exceeding the cool water dissolved oxygen criterion. Cold water temperatures may also limit trout rearing potential in the Cultus River, Snow Creek and other tributaries and some lakes.

Water quality in the Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir deteriorates during mid-summer because of warm water releases out of Crane Prairie. Algae released with the flow discolors the water and triggers algae blooms in Wickiup Reservoir (ODFW 1996a).