7.0 Wildlife

The Little Deschutes River Subbasin supports a variety of resident and migratory wildlife species, including songbirds, waterfowl, reptiles, amphibians and mammals. The purpose of the Wildlife assessment is to summarize what is known about wildlife populations, the condition of their habitats, and actions that can be taken to enhance or restore those habitats. The assessment focuses primarily on species of special concern and mule dear migration patterns. Where feasible, this chapter identifies opportunities for voluntary actions that can be taken to restore and protect wildlife populations and habitat.

7.1 Critical Questions

Species of Special Concern

1. What are the wildlife Species of Special Concern?
2. What critical habitat or special habitat designations are in this area?
3. What are the restrictions or limiting factors in population growth or stability?

Wildlife Species

1. What are the primary bird, mammal, reptiles and amphibians of interest in the watershed?
2. Is the population growth or stability of these species being impacted by increased human development?

7.2 Species of Special Concern

Species of Special Concern include Threatened and Endangered species listed under the Endangered Species Act (ESA) as well as those considered or under review for listing. These species are regulated through the U.S. Fish and Wildlife Service. Species of Special Concern also include those listed by the State of Oregon, the BLM, and the Deschutes National Forest (DNF). State listed species are regulated through the Oregon Fish and Wildlife Commission. Specific habitat and location data are available to land management agencies from Oregon State University's Oregon National Heritage Program (ONHP). ONHP has established a series of databases to tracks rare plants, animals, and plant communities throughout Oregon. General information on species is available through their web site, but specific location data are not provided to the public to avoid harm to the species. Two primary sources were used for specific information; 1) The *Joint Aquatic and Terrestrial Programmatic Biological Assessment April 2001- April 2003* was conducted on federal lands including BLM lands and 2) the Big Marsh Watershed Analysis (Deschutes National Forest, 1997). The species with Federal or State status documented as occurring in the Little Deschutes River Subbasin are listed in Table 7-1.

Table 7-1: Proposed, Endangered, Threatened or Sensitive wildlife species known or potentially occurring in the Little Deschutes River Subbasin (ONHP, 2001).

Species	Status Federal, State*	Presence in Subbasin
Canada Lynx	LT, -	Not Documented, Habitat Available
Pacific Fisher	Soc, SC	Present
California Wolverine	Soc, CT	Present
Marten	-,SV	Present
Bald Eagle	LT, LT	Present
Northern Spotted Owl	LT,LT	Present
Northern Goshawk	Soc, SC	Habitat Available, Presence uncertain?
Long-billed Curlew	-, SV	Not Documented, Habitat Available
American White Pelican	-, SV	Present
Black-backed woodpecker	-, SC	Present
Flammulated Owl	-, SC	Not Documented, Habitat Available
Great Gray Owl	-, SV	Present
Greater Sandhill Crane	-, SV	Present
Pileated Woodpecker	-, SV	Present
White-headed woodpecker	SoC, SC	Present
Yellow Rail	SoC, SC	Present
Sage Grouse	SoC, SC	?
Mountain Quail	SoC, SV	?
Oregon Spotted Frog	C, SC	Present
Columbia Spotted Frog	C, SU	Present

***Federal Listing Categories:**
LE = Listed Endangered. Taxa listed by the U.S. Fish and Wildlife Service (USFWS) as Endangered under the Endangered Species Act (ESA).
LT = Listed Threatened. Taxa listed by the USFWS, NMFS, ODA, or ODFW as Threatened.
C = Candidate taxa for which NMFS or USFWS have sufficient information to support a proposal to list under the ESA.
SoC = Species of Concern. Forrner C2 candidates which need additional information in order to propose as Threatened or Endangered under the ESA.
Oregon Sensitive Species Categories:
CRITICAL (SC) - Species for which listing as threatened or endangered is pending; or those for which listing as threatened or endangered may be appropriate if immediate conservation actions are not taken.
VULNERABLE (SV) - Species for which listing as threatened or endangered is not believed to be imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring.
UNDETERMINED STATUS (SU) - Animals in this category are species for which status is unclear.

Northern Bald Eagle

Northern bald eagle (*Haliaeetus leucocephalus*) is listed as a Threatened species under the ESA. In the watershed, threats to bald eagles include recreation and other human disturbance, logging, shooting, pesticides, and land development. Bald eagle mid winter survey data is available for 1988 to present and nesting season data has been collected since the mid-1970s from the Oregon Eagle Foundation, Inc. Annual reports summarizing these data were summarized by Recovery Zones as established by the Bald Eagle Recovery Plan. To support the Recovery Plan the DNF identified Bald Eagle Management Areas (BEMAs) that have specific requirements for maintenance and protection of eagle habitats. The Crescent Ranger District has 12 BEMAs and 5 identified eagle nest sites outside of the allocation. No BEMAs have been identified to protect roost sites on the DNF. All of the BEMAs include existing or historic nest sites and are closely associated with lakes and streams in the southern or upper part of the watershed.

According to the Big Marsh Watershed analysis, bald eagles historically nested and foraged on Crescent Lake where they fed on bull trout, rainbow trout, whitefish, and waterfowl (Deschutes National Forest, 1997). Bald eagles probably winter in the dense, non-fragmented stands adjacent to Crescent Lake. The habitat use around Crescent Lake is similar to other nest locations within the watershed where fish form a primary prey base.

Bald eagle nests are protected under the ESA on both public and private lands. There are no known nest sites on private lands within the subbasin. Development on private lands can impact bald eagles dispersed foraging activities. The disturbance is through direct human disturbance from recreational activities and through a loss of fish prey species resulting from dewatering. In addition, fluctuating lake levels and recreational use have impacted lakeside riparian habitat reducing eagle habitat quality in the Crescent Lake area (Deschutes National Forest, 1997). Bald eagle prey on fish and carrion, including roadkill. Road kill numbers are higher in the southern part of the watershed along Highway 97 (see section below). Traffic use and likely road kill increases with increased vehicle trips. Because bald eagles can forage 10-15 miles from a nest location these road kill may be utilized (Shane Jefferies, wildlife biologist, DNF, personal communications, 2002).

Northern Spotted Owl

Northern spotted owls (*Strix occidentalis caurina*) require mature or old-growth coniferous forests with complex structure such as multiple layers. This bird is listed as Threatened under the ESA. The population size is a function of amount and distribution of suitable habitat. Nesting, roosting and foraging habitat is available on the DNF. This area is reported as the eastern extent of the owl's range. Spotted owl pairs are generally located within the mature/old growth conifer Plant Association Groups (PAGs) associated with the buttes or high elevation mountains (Deschutes National Forest, 1997).

The Crescent Ranger District has a total of nine pairs of owls with one resident male that has not bred (Deschutes National Forest, 1997). There are five pairs of owls within the Crescent fifth field watershed. Critical habitat was only designated on federally managed lands and these areas are legally protected under the Late Successional Reserves (LSRs) or Congressionally Reserved Areas. There are two LSRs in the Crescent fifth field-watershed; Crescent Lake and Upper Big Marsh LSRs. Upper Big Marsh has had minimal impacts from humans with the exception of wildfire suppression. The Crescent LSR has 73 summer homes along the north shore of Crescent Lake (Deschutes National Forest, 1997). Although protected there are still some impacts to owl habitat from insect, disease, wildfire, and timber harvest.

Owl habitat is in the southern and southwestern portion of the watershed. Dispersal habitat across the DNF is heavily fragmented by roads, timber harvest units, or by areas that have been burned or defoliated by insect and disease. Connectivity is lacking or widely dispersed on this and other dry eastside forests. However, the historic range of the northern spotted owl was probably similar to the current range (Deschutes National Forest, 1997). In the ponderosa pine and mixed conifer dry PAGs, historic harvest of ponderosa pine stands and fire suppression activities have resulted in the growth of a dense understory of white fir. These activities have created better quality spotted owl habitat in the ponderosa pine and mixed conifer dry plant association groups. This habitat is susceptible to wildfires and is not stable over time (Deschutes National Forest, 1997).

Canada Lynx

Canada Lynx (*Lynx canadensis*) is listed as Threatened under the ESA. To date, historical records from a lynx specimen collected in1916 indicated an occurrence roughly 35 miles west of Bend near Lava Lake. Surveys have been conducted for Canada lynx on the DNF but no recent confirmed sightings or hair samples have been collected in Oregon. There are no current standards or guidelines, designated Management Areas, or other specific requirements related to historic or potential lynx habitat. Lynx Analysis Units (LAUs) were developed by the Forest Service for analysis of proposed projects on the Forest lands and one LMU was identified on the Deschutes National Forest encompassing the Three Sisters area.

Wolverine, Fisher, Marten

The distribution of wolverine, marten and fisher in Oregon have been dramatically reduced over the past 40-50 years and is most likely attributable to loss of late successional forest habitat (Deschutes National Forest, 1997). In the Crescent fifth-field watershed a fisher was sighted in 1996 and two records of wolverines one in 1995 and one in 1994 were recorded (Deschutes National Forest, 1997). Numerous marten have been observed throughout the watershed.

Within the Little Deschutes River Subbasin historic wolverine habitat was likely similar to current conditions since they occur in higher elevation areas where land management activities and development have been minimal (Deschutes National Forest, 1997).

Marten and Fisher habitat is located throughout mixed conifer, lodgepole and hemlock plant associations. Timber harvest activities have fragmented the mixed conifer and lodgepole pine stands reducing the canopy cover and downed woody debris subsequently reducing the quality of marten and fisher habitat. Fisher travel corridors along the mixed conifer belt with riparian areas providing key travel corridors. It is likely private development has caused fragmentation of connective habitat for fisher (Deschutes National Forest, 1997). Martens use a variety of plant association groups as travel corridors; this habitat is not likely a limiting factor for this species (Deschutes National Forest, 1997).

Black-backed Woodpecker

Numerous sightings of black-backed woodpeckers (*Picoides arcticus*) have been recorded throughout the Crescent fifth-field watershed (Deschutes National Forest, 1997). Habitat is located in the lodgepole and mixed conifer plant association groups. Some of the habitat in the Crescent fifth-field watershed has been fragmented due to natural mortality and timber harvesting (Deschutes National Forest, 1997).

Flammulated and Great Gray Owls

There are no documented sightings of flammulated owls (*Otus flammeolus*) in the watershed, but they are suspected to be present around Crescent Lake (Deschutes National Forest, 1997). The lack of low intensity fires due to aggressive fire suppression has reduced most of the suitable habitat for the flammulated owl within the ponderosa pine and mixed conifer PAGs which have historically provided habitat (Deschutes National Forest, 1997).

Two sightings of great gray owls (*Strix nebulosa*) have occurred in the Crescent fifth-field watershed (1995 and 1997) (Deschutes National Forest, 1997). There is suitable nesting and foraging habitat around Big Marsh, Whitefish and Crescent Creeks. The amount and distribution of habitat around riparian areas, meadows, and lodgepole wet stands is similar to historic habitat (Deschutes National Forest, 1997).

Greater Sandhill Crane

During the spring and summer, sandhill cranes (*Grus canadensis*) can be heard and observed at Big Marsh. Two confirmed nests were located at the marsh in 1996 and 1997; one nesting pair was located on Big Marsh Creek near the confluence with Crescent Creek (Deschutes National Forest, 1997). Based on the observed activity it is suspected six or more nesting pairs use the area.

Sandhill crane nests and young are susceptible to coyote, raven, raccoon, and skunk predation as well as predation by uncontrolled domestic dogs. Disturbance from humans and development in wet meadows, shallow marshes, and wetlands reduces habitat quality (Deschutes National Forest, 1997).

Pileated Woodpecker

Pileated woodpeckers (*Dryocopus pileatus*) occur in the subbasin primarily in mid-elevation mature and old growth mixed conifer forests. Foraging habitat includes large diameter dead and downed woody debris. Timber harvest, personal firewood collection,0 and increased distribution of white fir have fragmented habitat and reduced the number of large diameter dead trees (Deschutes National Forest, 1997).

White-headed Woodpecker

White-headed woodpeckers (*Picoides albolarvatus*) use open canopy ponderosa pine and mixed conifer stands. Loss of many of the large ponderosa pines due to timber harvest and development of the white pine understory creates a risk of losing additional habitat.

Yellow Rail

Breeding bird surveys at Big Marsh identified one male yellow rail (*Coturnicops noveboracensis*) in 1996 and four in 1997 (Deschutes National Forest, 1997). This is one of few nesting four yellow rail populations in Oregon (Deschutes National Forest, 1997). Yellow rails use shallow freshwater marshes and wet meadows for nesting (Terres, 1991). Big Marsh provided optimal habitat prior to draining in the 1940's and sheep and cattle grazing.

Amphibian Species

Oregon spotted frog (*Rana pretiosa)* and the Columbia spotted frog (*R. luteiventris*) are under review and as yet do not have an ESA status. The spotted frogs have communal egg laying sites which are apparently used repeatedly. They also prefer warmer waters which overlap with preferred habitats of introduced predatory warm water fish, and they over winter in springs. These factors make the frogs susceptible to impacts because there are a limited number of warm water reaches in the Pacific Northwest, and alterations to egg laying sites or springs used for over wintering will impact the local populations.

Some amphibian surveys have been conducted in the watershed. Rick Demmer, wildlife biologist, BLM, Prineville, provided a map and some population data on four species. He does not submit his data into the ONHP because it is not tracked in a format useful or is incomplete to support his needs. Species surveyed for include: Long-toed salamander (*Ambystoma macrodactylum*), western toad (Bufo *boreas),* pacific tree frog (*Hyla regilla)* and bullfrogs *(Rana catesbelana).* In addition, surveys have been completed by the DNF. Big Marsh contains a large population of spotted frogs and is the largest area of suitable habitat in which an extant population has been found (Hayes 1995).

The introduction and continued stocking of fish in lakes that did not historically contain a fishery is probably directly responsible for reductions in aquatic amphibian populations. A local survey documented that a stocked trout had consumed ten long-toed salamanders in one feeding (Deschutes National Forest, 1997). Declines in amphibian population levels have been documented in the DNF where non-native fish stocking occurs and where recreational use and cattle grazing impact riparian areas (Deschutes National Forest, 1997).

7.3 Mule Deer Migration

The Deschutes County Regional Problem Solving Project (Deschutes County, 1998) identified the area, between La Pine and Sunriver, as containing the largest mule deer migration corridor in the state. There were concerns that pattern of continued development and the associated roads and traffic would impact mule deer migrating through the area.

Mule deer and elk populations within the watershed have increased over time as a result of past timber harvest which creates forage in close proximity to cover (Deschutes National Forest, 1997). There has also been an increase in the effective deer and elk cover where fire suppression has resulted in dense under stories of white fir (Deschutes National Forest, 1997). Elk in the region are considered as "non-migratory" by the ODFW (Steve George, 2000, personal communication). They move from east to west across the Cascades during the summer. They don't travel east across Highway 97. Elk were not indicated as an issue under scoping for this project.

There are six populations of mule deer in the region (i.e., Metolius, Tumalo, North Polina, South Polina, Silver Lake and Fork Rock). They migrate through the watershed from east to west to summer range on the east side of the Cascades in the spring, from the end of April through June. In the fall, from the end of November through December, the deer migrate to winter ranges in the Fort Rock, Christmas, and Silver Lake Basins on the east side of Highway 97. The migration corridor extends roughly from Bend to Klamath Falls the movement patterns are best described as a "sheet" rather than a "corridor" because of the width (approximately 130 miles) of the area they travel across (Steve George ODFW, 2002 pers. comm.). Migration is defined as a "sheet" in this area because there are no defined corridors or east-west oriented watersheds to 'funnel' deer, creating dispersed movement patterns. However, deer will stay in dense vegetation that provide screens/cover and avoid human developments (Steve George ODFW, 2002 personal comm.).

The quality of habitat during migration is also important for herd health. Migration habitat, including cover and forage requirements, has not been mapped in this watershed. No specific data on the migration patterns or timing are available. There is track count data available from ODFW that provides some insight into gross areas of higher use versus presence of dogs, but does not identify any specific corridors of use (Steve George ODFW, 2000 personal communication). Although the ODFW recognizes primary mule deer summer and winter ranges as being located outside the watershed, mule deer do use the upper reaches of the watershed during the summer (Shane Jefferies, 2002, personal communications).

Road kill data collected in 2000 by the Oregon Department of Transportation provides some insight into the number of animals crossing highway 97 (Figure 7-1). These data are not collected in a systematic manner and do not include all animals killed, only those reported. However, despite the limitations, the data appear to show more animals are killed in the southern portion of the watershed, south of Crescent, than in the area between La Pine and Sunriver. This is consistent with the expectation that the deer are expected to avoid the densest areas of human development. The gender and ages of animals was only noted for 67 of the 83 animals reported with the distribution as follows: 12% or 18% of the road-kill deer were fawns, 37% or 55% were does, and 18% or 27% were bucks.

In addition to deer reported as road kill along highway 97 there were 4 elk, 1 dog, and 1 buzzard. Data from other highways in the watershed were less specific. Along Highway 31 between mileposts 0 to 25, there were 38 deer, and 1 porcupine reported. Highway 58 between mileposts 51 to 73, there were 26 deer and 2 elk.

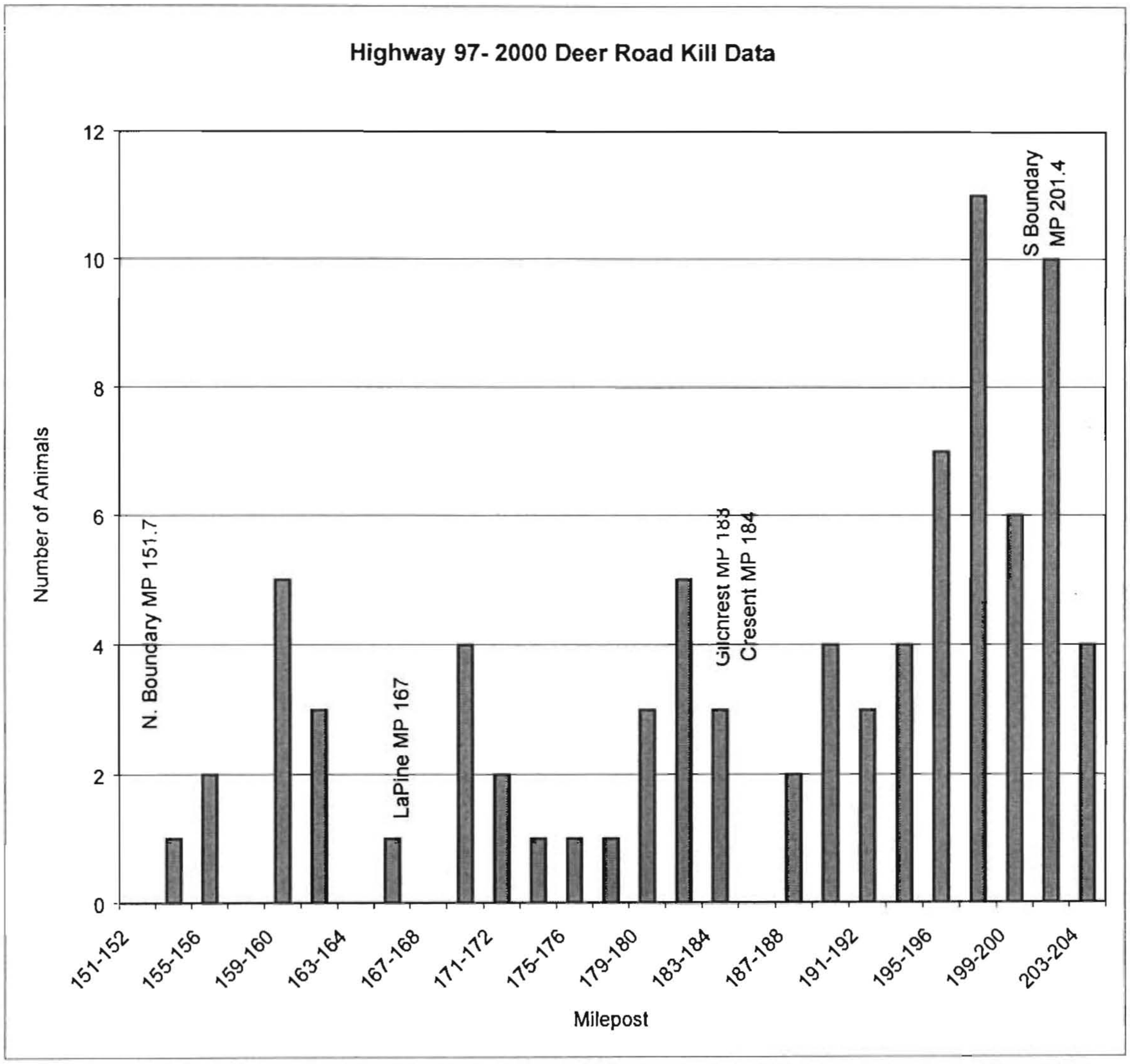

Figure 7-1 : Roadkill Deer along Highway 97 in the Little Deschutes River Subbasin (2000 Oregon Department of Transportation data).

8.0 Fisheries and Aquatic Habitat

The purpose of the Fisheries and Aquatic Habitat assessment is to summarize what is known about fish and other aquatic species populations, the condition of their habitats, and actions that can be taken to enhance or restore those habitats. The information comes primarily from Oregon Department Fish and Wildlife (ODFW) and USFS fisheries surveys and management plans. Where feasible, this report identifies opportunities for voluntary actions that can be taken in specific reaches of the Little Deschutes River and its tributaries.

8.1 Critical Questions

1. What fish species occur in the watershed? What is their abundance and distribution?

2. What other aquatic species, especially those of special interest, are found in the watershed? What is their distribution?

3. What are the aquatic habitat conditions in the watershed?

4. What are the locations and relative magnitude of channel modifications as identified in existing reports?

5. What portions of the channel network are likely sites for restoration?

8.2 Methods

Available reports on fisheries and aquatic habitats were obtained from the Oregon Department of Fish and Wildlife (ODFW) and the Deschutes National Forest (DNF). Primary contacts were Nate Dachtler with the Crescent Ranger Station, DNF, and Steve Marx, with ODFW in Bend.

The Upper Deschutes Subbasin Fish Management Plan (Wise et al., 1996) provides a good overview of the fish species present in the watershed and aquatic habitat conditions at a broad scale. More detailed information on fish presence, habitat limitations, and restoration opportunities is summarized in habitat survey reports completed by the DNF and ODFW. The DNF surveys were conducted from 1989 to 2000 and cover the upper Little Deschutes River and tributaries. The reports vary in content since the methods used and report styles vary over time, but the reports still provide useful information on fish distribution and habitat condition. The ODFW fish habitat survey addresses the lower 75 miles of the Little Deschutes River from the mouth to the Forest Service boundary. Between the two agencies, the habitat surveys provide good spatial coverage of the river and main tributaries.

8.3 Findings

8.3.1 *Fish Species and Management*

As described in the historic conditions section, the Little Deschutes River was not accessible to anadromous salmonids due to a series of falls on the Deschutes River. Thus, fish species in the Little Deschutes River were historically native species of trout and sculpin, including redband trout, bull trout, mountain whitefish, and reticulate sculpin (Wise et al., 1996). There are historical accounts of bull trout occurring in Crescent Creek and Crescent Lake (Wise et al., 1996), with the last record of a bull trout in Crescent Lake in 1979.

Like most of the river systems of the west, non-native fish were introduced to the streams and lakes of the Little Deschutes River Subbasin. It is not known precisely when brown and brook trout were introduced into the Little Deschutes River system, but the timing was probably similar to the Deschutes River – in the early part of the century, certainly before the 1920's (Wise et al., 1996). The first fish stocking in Crescent Lake occurred in 1915 with the release of brook trout; lake trout were first released into the lake in 1917. Brook trout continued to be stocked in the lake until 1939. Tui chub were introduced at an unknown time to Big Marsh Creek (Wise et al., 1996). Stocking of non-native fish species (brook trout, kokanee, and brown trout) continued through the 1970's. Current status and pertinent life history information for species of management interest are listed in Table 8-1.

Table 8-1: Game fish in the Little Deschutes River Subbasin.

Species	Status	Description and Management Implications
Brook Trout (*Salvelinus fontinalis*)	Introduced	Brook trout is a charr, a trout family that includes lake trout and bull trout. Brook trout, native to the eastern United States, were introduced widely across the country. Brook trout readily hybridize with and out-compete bull trout. Consequently, ODFW manages brook trout to reduce their impact on native trout populations. Brook trout are no longer stocked, and are not protected by harvest regulations.
Brown Trout (*Salmo trutta*)	Introduced	Brown trout, native of Europe, are predators on fish, and effective competitors with other trout species in altered habitats with warm temperatures such as occur in the Little Deschutes River. Brown trout spawn mid-September to mid-November in the Little Deschutes.
Redband Trout Rainbow Trout (*Oncorhynchus mykiss*)	Native (State sensitive species) Introduced	This species includes the rainbow, redband, and steelhead subgroups. Redband trout are inland resident fish, native to the Little Deschutes River. Steelhead are the anadromous form that do not occur in the Little Deschutes River due to downstream falls. Hatchery Rainbow trout, of unknown hatchery origin, were stocked in the river to improve fisheries. Fish management objectives are now directed toward enhancing the native redband populations.
Bull Trout (*Salvelinus confluentus*)	Native Federal - Threatened species (USFWS) State – Sensitive Species	Bull trout are inland native charr that require cold water to successfully reproduce. Bull trout were historically distributed throughout the upper Deschutes River, but were extirpated in the L. Deschutes through hatchery introductions and changes in habitat. A limited population of natural adfluvial bull trout occurs in Odell Lake, in the nearby upper Deschutes River basin.
Mountain Whitefish (*Prosopium williamsoni*)	Native	Mountain whitefish is a member of the salmonid family native to streams and lakes in Oregon. Whitefish feed primarily on bottom dwelling insects in streams. Unlike salmon and trout, whitefish do not dig a redd (nest) to bury their eggs, but broadcast spawn instead. Whitefish are not listed as threatened and endangered species.

Fisheries management

Game fish management in the Little Deschutes River Subbasin is primarily directed toward brown trout, redband trout, brook trout, and mountain whitefish. Rainbow trout were stocked for many years in the Little Deschutes River, but this practice was discontinued in 1978. Existing river habitat is considered better habitat for brown trout than rainbow trout, due to warm water temperatures and aquatic plant growth favored by brown trout. Brown trout generally out compete rainbow trout because they occupy the best habitat and are a longer-lived fish. Current policies are to manage mountain whitefish and redband trout for natural production under the Wild Fish Alternative for trout; manage brown and brook trout for natural production under the Basic Yield Management Alternative; and state that hatchery trout will not be stocked in the Little Deschutes River and tributaries.

The Upper Deschutes River Subbasin Fish Management Plan identified five fisheries management issues (Wise et al., 1996):

1. Introduced brown and brook trout have extirpated native rainbow and bull trout from much of the upper Little Deschutes; bull trout have been completely eliminated, and rainbow trout are found only in a small portion of their former range.

2. Reintroduction of bull trout and expansion of rainbow trout to their former range is considered technically infeasible at this time.

3. None of the irrigation diversions in the Little Deschutes River Subbasin are screened. The most significant unscreened diversion is the Walker Basin canal. The extent of trout loss to these diversions is unknown. The diversion locations were not specified in the report.

4. Fluctuations in streamflow in Crescent Creek and the Little Deschutes downstream from Crescent Creek due to irrigation withdrawals from Crescent Lake impact survival of trout in those streams.

5. Much of the Little Deschutes River system is in private ownership, and not accessible to the public.

The Fish Management Plan recommended a number of actions for addressing these issues. Actions that potentially can be taken by the Watershed Council and local landowners are identified in the Recommendations Section below.

8.3.2 *Fish Stocking*

Current fish stocking records for the Little Deschutes River date back to 1945 when fingerling rainbow trout of unknown stock were planted in the river. Legal-size rainbow were first stocked in 1948, and each year from 1954-1975 and from 1977-1978. There has been no stocking of hatchery rainbow trout since 1978. Numbers stocked ranged from 800 to 14,000 rainbow trout annually. Brook trout, brown trout, and kokanee were also stocked in the river. Table 8-2 summarizes these fish stocking records.

Table 8-2: Fish stocking records for Little Deschutes River (Wise et al., 1996).

Year	Species	Number	Size
1945	Rainbow trout	52,000	Fingerlings
1954-1975	Rainbow	800 - 14,000	Legal-size
1977-1978	Rainbow	800 - 14,000	Legal-size
1950	Brook trout	26,240	Fingerlings
1954	Brook trout	1,000	Legal-size
1969	Kokanee	25,600	Fry
1970	Brown trout	462	Legal-size
1974	Brown trout	13,327	Legal-size

Current stocking records show Crescent Creek was stocked only once in 1950 with 4-6 inch rainbow trout. However, Crescent Lake was stocked with brook and lake trout at the turn of century. Brown trout in Crescent Creek most likely moved downstream from Crescent Lake or upstream from the Little Deschutes River.

Current records show Big Marsh Creek was stocked in 1968-1969 with four to five thousand legal-size rainbow trout, reared at Klamath hatchery. Brown trout in Big Marsh Creek likely migrated from Crescent Creek. The origin of brook trout in Big Marsh Creek is unknown.

8.3.3 *Fish Distribution and Relative Abundance*

Information on fish distribution comes from Deschutes National Forest habitat surveys on the upper segment, primarily above Highway 58, and from ODFW surveys on the lower reach. The National Forest surveys were completed over several years using different protocols. The surveys completed in the 1990's and later generally included electrofishing or snorkeling, and therefore provide more reliable information.

Observation of fish species occurrence from the Forest Service surveys is summarized in Table 8-3. In general, these surveys show that brook trout are the dominant species in the tributaries and a section of the Little Deschutes River above Highway 58, and brown trout are the dominant species below Highway 58. These surveys also generally indicate that the population has shifted from native redband trout (and possibly bull trout) in these headwater streams to the non-native species. Brook trout now make up 95% of the population in the upper Mount Thiesen Wilderness.

Table 8-3: Distribution of fish species in the Little Deschutes River Subbasin.

Stream/Segment	Location	Species Occurence	Source
Cold Creek	*Trib. to Crescent Creek*	*Brook, Redband* (*Noted ideal habitat for bull trout)	*Dachtler, 1999*
Whitefish Creek	*Trib. to Crescent Lake*	*Brook; 2-9 inches* Rainbow (stocked) Brown	*Meyer & Foster, 1991a*
Refrigerator Creek	*Trib. to Big Marsh Creek*	*Brook, Brown*	*Branum, 1996a*
Upper Refrigerator Creek	Trib. to Big Marsh Creek	No fish observed Long-toed Salamander	Dachtler, 1997a
Big Marsh Creek	Trib. to Crescent Creek	Brook – 95%, redband –3%, brown – 2%	Dachtler, 1997b
Clover Creek	Trib to L. Deschutes	Brook, Brown	Hollister & Houslet, 1990a
Rabbit Creek	Trib. to Spruce Cr.	Small trout observed	Meyer & Foster, 1991b
Spruce Creek	Trib. to Hemlock Creek (to LDR)	Brook – dominant Brown - scarce	Dachtler, 1998
L. Deschutes River *River mile 95 - 93*	Clover Cr. to Burn Cr.	Brook - dominant Brown - scarce	Houslet, 2001
L. Deschutes River *River mile 86 - 93*	From Clover Creek downstream	Brown – dominant Brook - scarce	Houslet, 2001
Paulina Creek	Trib. to L. Deschutes	Brook – 6-7 inch size Rainbow	DNF, 1989

Relative abundance of fish species in the Little Deschutes River was evaluated by ODFW in 1974 and again in 1990/1992. ODFW surveys focused on the lower section of river below the national forest boundary. The most abundant species in the 1974 study (Lorz, 1974 cited in Wise et al., 1996) were brown trout, mountain whitefish, brown bullhead, and Tui chub (Table 8-4). In the 1990's survey only 10 rainbow trout (3 to 9 inches) were captured in the reach extending from the mouth of Little Deschutes River to Cow Camp. Brook trout up to 7 inches long were abundant in the upper reach, but were scarce below Highway 58. Brown trout were the most abundant trout species, increasing in numbers from the headwaters to Highway 58, and then declining in abundance toward the mouth of the Little Deschutes River. Declining habitat conditions are believed to have allowed the brown and brook trout to out-compete the historically dominant rainbow trout.

Table 8-4: Relative abundance of fish species in the Little Deschutes River, 1974 (Wise et al., 1996).

Species	Relative Abundance	Status
Brown trout	Abundant	Non-native
Mountain whitefish	Abundant	Native
Brown bullhead	Abundant	Non-native
Tui chub	Abundant	Non-native
Brook trout	Common	Non-native
Reticulate sculpin	Common	Non-native
Rainbow trout (redband)	Scarce	Native

Fisheries in Paulina Creek are minimal due to habitat limitations. Only a few brook trout, 6-7 inches in length, were noted in a habitat survey (Deschutes National Forest, 1989). Although rainbow trout were stocked into the creek, no live fish were observed during the survey.

ODFW surveys from 1992 (below Highway 58) found rainbow trout to be the most abundant trout species in Crescent Creek with fewer species being captured downstream. The high proportion of rainbow trout in the sample in comparison to brown trout was attributed to the greater stream gradient in the canyon section below Highway 58. As gradient decreased the fish community shifted toward brown trout. The report noted low fish densities in Crescent Creek, and speculated that the stream should support a greater population.

Summary of Fish Distribution

The distribution of salmonid species is summarized in the attached maps (Maps 8-1, 8-2, and 8-3). In the upper Little Deschutes River fifth field watershed (in comparison to the Crescent Creek fifth field) brook trout are the dominant species in the tributary streams (Map 8-1). Below approximately Hemlock Creek, the fish community shifts to brown trout (Map 8-2), and further downstream below Highway 58, brown trout become the dominant species. Thus, it appears that the non-native brook trout have displaced the native bull trout in the upper cooler tributaries, and non-native brown trout have displaced the native redband trout (Map 8-3). It should be noted that the ODFW Fish Management Plan (Wise et al., 1996) identified the occurrence of a nematode parasite in the brown trout, and speculated if the decline in the brown trout population from 1960-1970 might be attributed in part to the effect of this parasite.

8.3.4 *Aquatic Habitat Conditions*

Habitat conditions and potential actions for restoration (where needed) are summarized in Table 8-5. The source of information is listed in the last column of the table.

Table 8-5: Aquatic habitat conditions and restoration opportunities.

Stream	Habitat Conditions	Opportunities	Source of Information
Cold Creek	Riparian zone, streambanks, LWD, and spawning gravel in good condition. Water source – cold-water springs. Pools provided by old beaver dams are declining.	Survey indicates a high quality habitat with springs that maintain cold water temperatures. The report suggests high quality habitat for bull trout.	Dachtler, 1999
Whitefish Creek	Wilderness designation in upper reach limits enhancement. Lower reach has unstabilized banks and lacks cover.	Riparian plantings to stabilize banks and provide cover.	Meyer & Foster, 1991a
Refrigerator Creek	Spring-fed, providing cold temperatures. Falls in upper section limits fish distribution. Habitat impacted by RR and road crossings.	The report indicated presence of oil barrels at RR crossing at time of survey. Road crossing may need to be evaluated further as source of sediments.	Branum, 1996a
Upper Refrigerator Creek	Spring fed, dense undisturbed riparian canopy.	Protected by Oregon Cascade Recreation Area. No management indicated.	Dachtler, 1997a
Big Marsh Creek	Past grazing and dewatering in Big Marsh restoration project in 1997.	Continued protection of marsh needed during recovery.	Dachtler, 1997b
Clover Creek	Clover Cr. is in the designated wilderness area. Grazing at time of survey caused limited bank damage.	Survey indicated some minor changes to season of use, but the survey is 10 years old	Hollister & Houslet, 1990a
Rabbit Creek	Small high quality stream provides cold water to Spruce Cr.	No enhancement indicated other than continued protection.	Meyer & Foster, 1991b
Spruce Creek	Low gradient stream, sand substrate. Past grazing practices caused downcutting and entrenchment.	Current streamside management practices will assist stream recovery. No stream enhancement needs indicated.	Dachtler, 1998
L. Deschutes River **River mile 95 - 86**	Low gradient, meandering, with sand substrate. Temperatures exceed water quality criteria.	Temperatures increase until criteria of 14C exceeded starting at Highway 58. Potential for riparian enhancements to increase shade and cover.	Houslet, 2001
L. Deschutes River, ***River mile 80 - 63*** ***Highway 58 to Gilchrist Mill Pond.***	Insufficient information.		Wise et al., 1996
L. Deschutes River, ***River mile 63 - 00*** ***Gilchrist Mill Pond to mouth.***	Altered flow regime, high temperatures, degraded riparian conditions.	Riparian enhancement to restore sedge/willow streambank community, examination of minimum streamflows.	Wise et al., 1996
Paulina Creek	Lacks pool habitat, cover & spawning gravel, Falls as migratory barriers.	Opportunities may be limited by natural conditions – falls and bedrock channels.	DNF, 1989

9.0 Surface Water Quality

The purpose of the surface water quality section is to summarize existing information sources, and identify the key data gaps that may require further study. The primary source of information on water quality is from the Oregon Department of Environmental Quality (ODEQ), Deschutes National Forest (DNF), and local governments. Where feasible, the report will identify specific actions that can be taken by the Council to address data gaps and improve water quality.

A common source of confusion regarding water quality assessment is the unique jargon used to describe water quality goals and measures. The terms – *beneficial uses, water quality standards, water quality criteria, water quality limited*, etc. have a distinctive meaning derived from the federal Clean Water Act and incorporated into Oregon water quality regulations. We will bring these terms into context, and then describe the application to the Little Deschutes River Subbasin.

9.1 Critical Questions

1. What are the designated beneficial uses for streams in the watershed?
2. What are the water quality criteria that apply to streams in the watershed?
3. Are there stream reaches identified as water quality limited on the State's 303(d) list?
4. What do water quality studies or other summary documents indicate about water quality conditions?
5. What are the key data/information gaps in water quality information?

9.2 Methods

Information on beneficial uses, applicable water quality criteria, and 303(d) listed streams were identified from the Oregon Water Quality Standards, and approved 303(d) list provided by ODEQ. Existing water quality data were available and were obtained by checking the ODEQ, Environmental Protection Agency, and U.S. Geological Survey online databases and agency websites. Information on planned water quality studies, clarification of the 303(d) listing, and non-published reports were obtained directly from Bonnie Lamb, ODEQ Bend office. This information was reviewed for description of existing water quality conditions and potential data gaps.

9.3 Water Quality Regulations

In a broad sense, the term, water quality, includes the water column, the stream channel, and the associated riparian areas that influence the stream. The goal of the federal Clean Water Act, "*to protect and maintain the chemical, physical, and biological integrity of the nation's waters*", identifies the importance of assessing both water chemistry and the habitat required for maintaining fish and other aquatic organisms. In Oregon, this goal is incorporated into the state Water Quality Standards and the associated regulations.

Water Quality Standards include the list of beneficial uses of the stream, the criteria designed to protect those uses, and policies to implement the standards. *Beneficial uses* refer to a list of specific uses for which water is to be protected, such as drinking water supplies, fisheries, and recreation. *Water quality criteria* are defined to protect these beneficial uses of water. Water quality criteria are comprised of narrative statements and numeric criteria. Numeric criteria are established when it is feasible to identify specific limits that protect these uses across the basin. Narrative criteria are used when it is infeasible to set specific targets at a regional or statewide level. Information from the scientific literature is then used on case-by-case basis to interpret the narrative criteria and apply it to the specific watershed. For example, water quality criteria are specified that limit the suspended solids and bacteria that can be present in drinking water. To protect trout in streams, the criteria provide specific numeric limits for temperature, dissolved oxygen, and toxic agents. However, nutrients and sedimentation are covered only by narrative statements.

The beneficial uses and criteria identified in the Water Quality Standards provide the basis for a TMDL, the Total Maximum Daily Load, for a stream segment. The federal Clean Water Act requires states to maintain a list of streams, called "*water quality limited streams,* " that do not meet water quality standards. The 303(d) list of water quality limited segments refers to the section of the Clean Water Act that identifies the requirement. Streams on the list may be studied further to determine if the listing was appropriate in the first place; if not, the stream segment can be removed from the list. If the 303(d) listing is warranted, data are collected to calculate the TMDL. The TMDL is based on identifying the maximum pollutant load that can be supported and still meet water quality criteria. Pollutant loads, above the level that meet water quality criteria, are required to be reduced over time using pollution control technology for point sources, such as wastewater treatment plants, and using BMPs, best management practices, for non-point sources.

The beneficial uses of water, water quality criteria, and 303(d) listed streams in the Little Deschutes River are identified in the next section.

9.4 Findings

9.4.1 *Beneficial Uses and Water Quality Standards*

Beneficial uses in the Little Deschutes River Subbasin and water quality criteria applicable to the Deschutes Basin are listed in Table 9-1 and Table 9-2.

Table 9-1: Beneficial uses of water protected in the Deschutes Basin.

Beneficial Uses: Deschutes River Basin (OAR 340-41-562)	
Public Domestic Water Supply*	Salmonid Fish Spawning
Private Domestic Water Supply*	Resident Fish & Aquatic Life
Industrial Water Supply	Wildlife & Hunting
Irrigation	Fishing
Livestock Watering	Boating
Anadromous Fish Passage	Water Contact Recreation

Salmonid Fish Rearing	Aesthetic Quality

* With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards. (ODEQ, 2001a).

Table 9-2: Summary of applicable water quality criteria.

Parameter (Beneficial Use)	Criteria Type/ Measurement	Criteria *
Aquatic Weeds or Algae (Water contact recreation, aesthetics, fishing)	Narrative Criteria (biological monitoring)	Growth of fungi or other growths having a deleterious effect on aquatic life or which are injurious to public health, recreation, or industry are not allowed. See also Nutrients.
Bacteria (Water contact recreation)	NumericCriteria *Escherichia coli*	126/100 ml. (30 day log mean) 406/100 ml. (Single sample)
Biological Criteria (Resident fish and aquatic life)	Narrative Criteria (measured using macroinvertebrates)	Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Dissolved Oxygen (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria Dissolved oxygen (mg/L)	Salmonid Spawning: Greater than 11 mg/L Cold Water Aquatic Life: Greater than 8.0 mg/L. (Several conditions apply, see standards for details.)
Habitat & Flow Modification (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria (Habitat measurements, flow assessment)	Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Nutrients (Aesthetics)	Narrative Criteria (phosphorus, nitrates, ammonia)	No criteria for the Deschutes Basin. Suggested screening criteria from OWEB Manual (WPN 1999). Total Phosphorus 0.05 mg/L Total Nitrate 0.30 mg/L
pH (Resident fish and aquatic life, water contact recreation)	Numeric Criteria (pH)	pH: 6.5 – 8.5
Sedimentation (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria	Formation of bottom deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry are not allowed
Temperature (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria (temperature)	Salmonid fish rearing: 64 ° F. Salmonid spawning: 55 ° F.
Toxics (Resident fish and aquatic life)	Numeric Criteria	Numeric criteria are identified for 120 organic and inorganic toxic substances in Table 20 in the Oregon Water Quality Standards (ODEQ 2001).
Turbidity (Resident fish and aquatic life, water supply, aesthetics)	Narrative Criteria (turbidity (NTU))	Not greater than 10% increase over natural stream turbidity. Suggested screening criteria – 50 NTU (WPN 1999)

* The criteria are abbreviated in this table. Most criteria have associated conditions and exceptions that apply. Obtain the full text of the regulations (ODEQ, 2001a) for specific applications.

The water quality standards become meaningful when applied to specific issues in the Little Deschutes River Subbasin. The 303(d) listing (described below) and the Regional Problem Solving document (Deschutes County, 1998) address several water quality problems. Currently, stream segments are listed on the 303(d) list for temperature. The application of the temperature standards to these segments are important since ODEQ is required to develop a TMDL and water quality management plan for the listed segments. The Regional Problem Solving document highlights a concern with the impact of continued residential development and the effect of septic systems on water quality. Although the issue has been primarily directed to groundwater contamination, this development may have an effect on surface waters as well. Specific criteria that may be of concern from sewage disposal are nutrients, bacteria, and associated pathogens. The concern with nutrients is the stimulation of excess aquatic plant growth, which then can cause other deleterious effects on the aquatic ecosystem such as shifts in pH and dissolved oxygen. Narrative criteria that apply to aquatic weeds or algae and numeric criteria for dissolved oxygen and pH also may become important.

9.4.2 *Water Quality Limited Streams – 303(d) listing*

The Little Deschutes River has four segments listed on the 1998 303(d) list (ODEQ, 1998) for temperature as listed in Table 9-3 and shown on Map 9-1. The listing is based on ODFW and USFS continuous temperature data collected over several years. In addition, the Little Deschutes River, from the mouth to Crescent Creek, is on the 303(d) list as needing data for bacteria, flow modification, habitat modification, nutrients, and sediments. The basis for this listing is the statewide non-point source assessment (ODEQ, 1988). The non-point source assessment was based on a questionnaire procedure, and therefore needs validation through data collection.

Table 9-3: 303(d) listed waters in Little Deschutes River Subbasin.

Stream Segment (Description)	Parameter/ Criteria	Supporting Data or Information
Crescent Creek (mouth to Crescent Lake)	Temperature Rearing (64° F) 303 (d) List	USFS Data , 2 Sites: Above and Below Big Marsh Cr: 7 day average of daily maximums of 68.3/68.5 with 56/60 days respectively exceeding standard in 1989; ODFW Data (RM 18.5): 7 day average of daily maximum of 73.6 with 102 days exceeding 64 in 1994.
Little Deschutes River (mouth to Crescent Creek)	Temperature Rearing (64° F) 303 (d) List	ODFW Data (4 Sites between RM 62 - 80): 7 day average of daily maximums exceeded standard (64) with values ranging from approximately 68 to over 73 in 1994.
Little Deschutes River (Crescent Creek to Hemlock Creek)	Temperature Rearing (64° F) 303 (d) List	(Same as row above)
Paulina Creek (mouth to Paulina Lake)	Temperature Rearing (64° F) 303 (d) List	USGS Data (Site 14063300; below Paulina Lake outlet): 7 day average of daily maximums of 70.9/64.9/71.9 with 69/8/65 days exceeding standard (64) in 1992/1993/1994 respectively.
Little Deschutes River (mouth to Crescent Creek)	303 (d) Listing Status: Needs Data	Needs Data for bacteria, flow modification, habitat modification, nutrients, sedimentation. Based on Oregon Nonpoint Source Assessment (ODEQ 1988).

9.4.3 *Water Quality Information*

The primary emphasis on water quality in the Little Deschutes River has been on the effect of septic systems on nitrates in groundwater, and, therefore, surface water quality data are fairly limited. ODEQ initiated a comprehensive water quality study in 2001 to collect data for development of TMDLs in the Little Deschutes watershed. This study will provide much needed objective information to understand water quality conditions in this watershed for which little data is available to date. Available water quality information for the watershed is provided in the following sources, which will be summarized briefly below.

1. A 1997-1998 ODEQ study, the Upper Deschutes River Basin, Regional Environmental Assessment Program (REMAP). Study results are summarized in three reports: temperature (Mochan, 1998), water chemistry (Hubler, 1999), and fisheries (Hubler, 2000).

2. Data in the ODEQ water quality database, Laboratory Analytical Storage and Retrieval Database (ODEQ, 2001b).

3. Oregon Water Quality Index station located at Little Deschutes River at Highway 42(#10696).

Upper Deschutes River Basin, REMAP study.

The study's objective was to evaluate the Deschutes River at a basin scale. The study design approach used randomly selected monitoring sites within the basin, so few monitoring stations were located within the Little Deschutes River Subbasin. As a result, the study provides little useable information relative to water quality issues in the Little Deschutes River. The information does provide some context for understanding how the Little Deschutes River compares to other rivers in the basin.

In general, water quality in the Upper Deschutes Basin was good to excellent using the ODEQ water quality index scores as an indicator. It was noted that the Little Deschutes River site exhibited some potential dissolved oxygen problems; fluctuations in dissolved oxygen characteristic of a river with high algal/aquatic plant productivity (Hubler, 1999). An inspection of the ortho-phosphorus and nitrate data in the report shows an increase in these nutrients from the tributaries (Hemlock and Crescent Creek) to the lower Little Deschutes River. The temperature summary (Mochan, 1998) provides no data interpretation useful for the Little Deschutes River Subbasin.

Water Quality Stations

There are 14 water quality stations in the ODEQ water quality database. Many of these stations were associated with the 1997-1998 REMAP study. Other stations are located to monitor the effects of the Gilchrist millpond and the Gilchrist sludge lagoons. The data available at these stations is summarized in Table 9-4.

Table 9-4: ODEQ water quality monitoring stations in Little Deschutes River Subbasin.

Station Number	Station Description	Begin Date	End Date	Representative Number of samples*
Little Deschutes River Basin				
12883	Hemlock Cr. 75ft. downstream of Road 5830	8/5/97	8/5/97	1
12884	L. Deschutes R., 0.5 mi downstream USFS Rd. 100	8/7/97	9/2/98	5
10703	L. Deschutes R., upstream Gilchrist Mill Pond.	4/29/69	1/24/96	22

10702	L. Deschutes R., downstream Gilchrist Mill Pond.	4/29/69	5/7/75	15
10701	L. Deschutes R., downstream 1st sludge lagoon	4/29/69	3/31/70	3
10700	L. Deschutes R., downstream 2nd sludge lagoon	3/31/70	8/4/70	2
10699	L. Deschutes R. at Road 2320	3/31/70	1/23/96	15
10698	L. Deschutes R. at Masten Rd	3/31/70	1/23/96	5
10922	Long Prairie Slough	11/17/70	11/14/72	5
10697	L. Deschutes R. at Burgess	8/1/95	1/24/96	4
12560	L. Deschutes R., State Park Road.	8/1/95	1/24/96	5
10696**	L. Deschutes R. at Hiway 42	8/1/95	3/13/01	40
10595	L. Deschutes R. downstream Vandervert Ranch	3/31/70	11/14/72	8
10921	Paulina Cr. at Highway 97	11/14/72	11/14/72	1
Crescent Creek Basin				
10713	Crescent Cr. @ RR Crossing	9/1/98	9/1/98	1
12564	Crescent Cr. @ Crescent Cr. cutoff	8/1/95	1/24/96	4
12565	Crescent Cr. @ Little River	8/1/95	8/2/95	2
10704	Crescent Cr. @ Roads 2027/2320 (Gilchrist)			

* Sample frequency and parameters varies by station. To provide an indication of the amount of data available, the table shows the number of samples for nitrates as a representative parameter.
** Little Deschutes River trend station. Source is ODEQ, 2001b.

Sample periods, frequency, and parameters vary at these stations. As a result, data interpretation using these existing data sets is not particularly useful. The trend station and the TMDL study results described below will provide more useable information.

Trend Station

The monitoring station, Little Deschutes River at Highway 42 (#10696), was added to the statewide ambient water quality monitoring network in 1995. The ODEQ maintains a network of ambient water quality monitoring sites to monitor trends over time using consistent methods across the state. Overall conditions and trends are evaluated using a water quality index. The Oregon Water Quality Index (OWQI) analyzes a defined set of water quality variables and produces a score describing general water quality. The water quality variables included in the OWQI are temperature, dissolved oxygen (percent saturation and concentration), biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogens, total phosphorus, and fecal coliforms. OWQI scores range from 10 (worst case) to 100 (ideal water quality).

The Little Deschutes River trend station was included in the latest summary report (Cude, 2000) in which sites were grouped into categories by score: 90-100 excellent, 85-89 good, 80-84 fair, and 60-79 poor. In this analysis the Little Deschutes site scored a summer average score of 91 falling into the excellent category. The analysis provides some general comparison to water quality on a statewide basis, but does not address local issues and water quality conditions that can be addressed in a concentrated study. The TMDL study described below will be helpful in evaluating the local water quality issues.

TMDL Study

The Upper/Little Deschutes TMDL Water Quality Monitoring Plan (Lamb, et al., 2001) was initiated in the 2001 field season. This is an ongoing project, but the information is useful to summarize here to understand what data gaps are currently being addressed. For the Little Deschutes River Subbasin the study is addressing two objectives, temperature and the effects of excessive plant productivity.

The temperature study includes several components designed to assess the existing temperature condition, evaluate sources, and provide sufficient information to run the ODEQ temperature model. Temperature data will be collected at sixteen locations in the Little Deschutes River Subbasin using continuous temperature recorders from May through October. A Forward-Looking Infrared Radiometry (FLIR) flight will be completed during the summer. The FLIR flight provides an infrared map of surface water temperature to help delineate heating and cooling sources throughout the length of the river. In conjunction with collection of FLIR data, streamflow, physical stream measurements, and riparian vegetation data will be collected. These data are used to provide inputs into a temperature model, *Heat Source*, used by ODEQ to simulate processes that influence temperature, evaluate predictions of restoration strategies, and allocate heat loading for TMDLs.

To evaluate the effect of plant productivity (both algae and aquatic plants) on pH and dissolved oxygen, ODEQ plans to collect data over two one-week intensive periods during July and October 2001. Timing of the intensive surveys is designed to target the critical period during the summer for pH and during the fall for dissolved oxygen. The fall survey will assess dissolved oxygen during the critical period for salmonid spawning, such as brook and brown trout, when the water quality standards require the highest dissolved oxygen concentrations. Dissolved oxygen, temperature, pH, and conductivity will be collected continuously using Hydrolab meters, and water chemistry samples for nutrients and associated parameters will be collected on a daily basis.

Together these data sets should be useful for evaluating water quality issues that have been raised as concerns in agency and local planning documents. One potential issue that is not being addressed with these studies is bacterial contamination of surface waters from septic systems. Bacteria data are not being collected since it has not been indicated as a surface water problem in previous data sets. This may be a data gap that can be addressed at the local level, as it specifically relates to private and community waste disposal systems.

10.0 Surface Water Quantity, Groundwater Quantity & Quality

Surface water refers to the water flowing in streams and in lakes. Groundwater is water moving below ground. It is important for land managers to have an understanding of how much water is available in their watershed, where it comes from, and how it moves through the watershed. This information is key to determining how land management activities, water use, and development may be impacting the quality and quantity of water.

This portion of the assessment summarizes the available groundwater and surface water data to identify and quantify the components of the hydrologic budget in the basin and identify data gaps and potential watershed enhancement options. The information comes primarily from United States Geological Survey (USGS) reports and data from the Oregon Water Resources Department (OWRD).

10.1 Critical Questions

Surface Water

1. What are the streamflow characteristics?

2. How has the natural hydrologic pattern/cycle been altered?

3. What are the sources and amount of surface water use in the subbasin?

Groundwater

1. What is the hydrogeologic setting of the basin and how does it influence groundwater flow in the region?

2. What are the components and quantities of water identified by the USGS in their water budget calculations?

3. What are the sources and estimated amounts of groundwater recharge to the basin?

4. What are the sources and estimated amounts of groundwater withdrawals in the basin?

5. What fluctuations in groundwater levels have been identified and what are some of the possible causes?

6. What are the groundwater/surface water interactions in the basin?

7. What are some of the potential impacts of growth on groundwater and surface water supplies?

10.2 Methods

Available reports on groundwater hydrology were obtained from the USGS. Reports included *"Ground-Water Hydrology of the Upper Deschutes Basin, Oregon"*, Water Resources Investigation Report 00-4162 (Gannett et al. 2001) and *"Chemical Study of Regional Ground-Water Flow and Ground-Water/Surface-Water Interaction in the Upper Deschutes Basin, Oregon"* Water Resources Investigation Report 97-4233 (Caldwell, 1997). Surface flow data was obtained from USGS web sites containing data from gauging stations on the Little Deschutes and Deschutes Rivers. Water rights data was obtained from the OWRD web site and Kyle Gorman, OWRD Water Master.

The *Ground-Water Hydrology of the Upper Deschutes Basin* report (Gannett et al. 2001) gave a good overview of the hydrologic regime in the Upper Deschutes River and quantified components of the water budget. The Little Deschutes River Subbasin is tributary to the Upper Deschutes Basin and has geology, topography, soils, vegetation and precipitation typical for the entire Upper Deschutes. While the quantities given in the report are specific to the Upper Deschutes River, a comparable range of values can be expected in the Little Deschutes River Subbasin. Specific data, where available, are presented for the Little Deschutes River Subbasin.

10.3 Surface Water

Surface water sources in the Little Deschutes River Subbasin include the Little Deschutes River, Paulina, Crescent, Big Marsh, Whitefish, Cold, Refrigerator, Clover, Rabbit, and Spruce Creeks and a number of unnamed tributaries. Surface water withdrawals are closed to any additional appropriation of surface water. Hence, future water development needs in the area will have to rely on groundwater as a water source.

10.3.1 *Streamflow Characteristics*

Streamflow data for the Little Deschutes River near La Pine, Oregon gauging station was obtained from the USGS. Data were compiled for the period of record (1923-1995) and minimum, maximum, and mean data were computed for each day of the irrigation year (Figure 10-1). For example, on October 1 for the period of record, the lowest flow recorded was 9 cubic feet per second (cfs), the highest flow was 332 cfs and the mean flow was 84.7 cfs. The very high value for December 25 represents the 24-hour average flow at La Pine during the 1964 flood event when a flow 3240 cfs was recorded.

The figure illustrates a typical spring runoff pattern with increasing flows in the months of March, April, and May from melting snow pack and decreasing flows by the end of June. The hydrograph illustrates the river is dominated by surface flow. A groundwater component to the flow is present, however, as shown by the percent of the minimum flow relative to the mean.

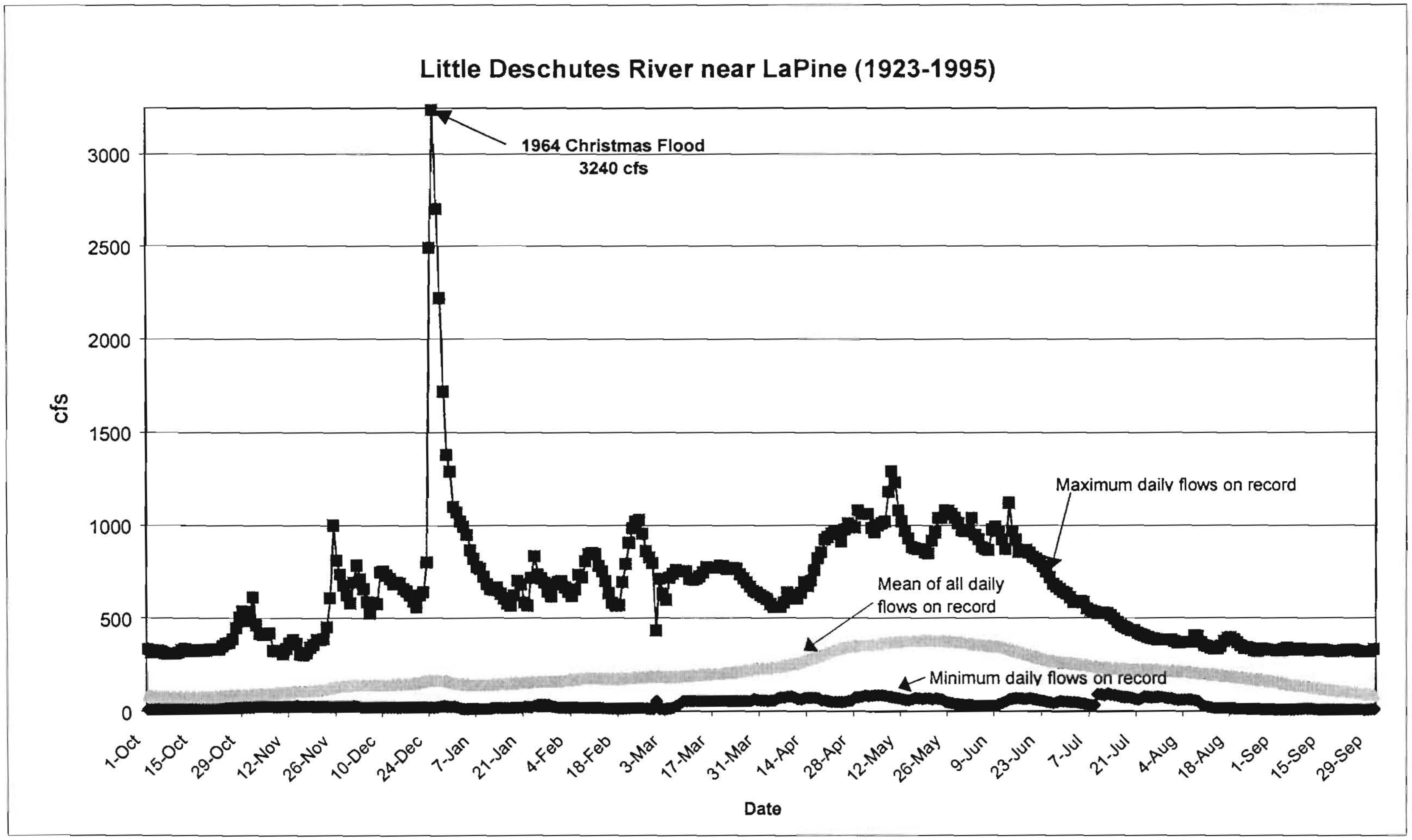

Figure 10-1: Mean, Minimum and Maximum daily flows on the Little Deschutes River, Oregon for period of record 1923-1995. Data compiled from the United States Department of the Interior, Bureau of Reclamation historical data from HYDROMET.

10.3.2 *Alteration of Natural Hydrologic Pattern*

The natural hydrologic cycle of a watershed can generally be described as inflow to the system in the form of rainfall or snowmelt and outflow in the forms of streamflow (or runoff) and evapotranspiration (Figure 10-2). Any change to this pattern results in an alteration of the natural hydrologic pattern. Examples of alterations include dams, stream diversions, pumping, and storm drains.

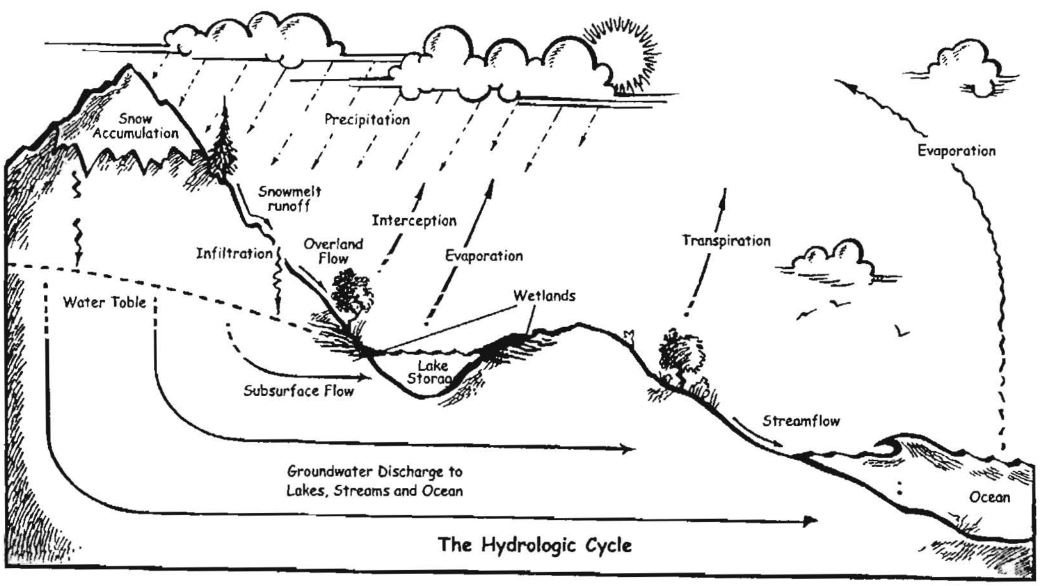

Figure 10-2: Illustration of a generalized hydrologic cycle (WPN, 1999).

Crescent Lake and Paulina Lake are natural lakes with man-made outlet structures to store water and control outflow for irrigation. Some irrigation diversions are present in the basin, but the number and amount of water rights on the Little Deschutes River does not significantly alter flow in the river. Similarly, groundwater pumping in the Little Deschutes River Subbasin does not comprise a significant component of groundwater discharge in the basin. This will be discussed in greater detail in the Hydrologic Budget section.

10.3.3 *Surface Water Use*

A portion of the Surface water use in the Little Deschutes River Subbasin is for irrigation. Total use was calculated using water right information from the OWRD. Valid water rights were totaled for each stream and creek tributary to the Little Deschutes River. Rights no longer considered valid were not included in the summary. Table 10-1 summarizes the total flow rights on each stream or creek. Mr. Kyle Gorman of OWRD and water master for the Deschutes River indicated that diversions on the smaller creeks and the Little Deschutes River do not have measuring devices so actual diversion measurements are unavailable. Consequently, the total amount diverted annually was computed by assuming each diversion took their full right every day for the irrigation period May 1 through September 30 – which is likely to overestimate the actual water used.

Table 10-1: Summary of Surface Water Rights on Little Deschutes River and Tributary Creeks (ODWR water rights data).

Stream	Water Rights (cfs)	Total Acre-Feet
Crescent Lake		86,050
Paulina Lake		249,850
Cold Creek	0.1	30
Whitefish Creek	No rights	0
Refrigerator Creek	No rights	0
Big Marsh Creek	0.44	133
Clover Creek	No rights	0
Crescent Creek	5.92	1,796
Rabbit Creek	No rights	0
Spruce Creek	No rights	0
Little Deschutes River	16.75	5,083
Paulina Creek	8.3	2,519

Mr. Gorman indicated the only creek that goes dry at any time during the year is Paulina Creek but stated it is not due only to irrigation demand. The total water rights on Paulina Creek are not so large as to cause the creek to run dry during the year. The flow in the creek is controlled at Paulina Lake and the amount of water released into Paulina Creek is based on the elevation of the water in the lake and/or the amount of water needed for irrigation. Consequently, as happens in the winter months, if the inflow into the lake is relatively low, there will be very little water released from the lake and the creek will run dry. Also, the reach immediately downstream of Paulina Lake is a losing stream reach, which will also result in the creek going dry at low flows. This will be discussed in the section on stream leakage.

10.4 Groundwater

10.4.1 *Hydrogeologic Setting*

The storage and flow of groundwater is controlled to a large extent by geology. The principle geologic factors that influence groundwater flow are the porosity and permeability of the rock or sediment through which it flows. Porosity is the proportion of a rock or deposit that consists of open space. Permeability is a measure of the ability of water to move through the soil or rock. Deposits with large interconnected open spaces, such as gravel, have little resistance to groundwater flow and are considered highly permeable. Rocks with few, very small or poorly connected open spaces offer considerable resistance to groundwater flow and have low permeability.

The Little Deschutes River Subbasin is dominated by deposits of volcanic ash and pumice as the result of lava flows from the Cascade Mountains from the west and Newberry Crater from the east. This highly permeable volcanic material has created coarse, rapidly draining soils and high groundwater tables. As a result, precipitation to the subbasin in the form of rainfall and snowmelt infiltrates quickly and migrates downward to the underlying aquifer.

The principal aquifer underlying the Little Deschutes River Subbasin is the Deschutes Formation that consists of a variety of materials which are highly permeable: lava flows, vent deposits, and sand and gravel layers. The aquifer ranges in thickness from zero to over 2,000 feet at its westernmost exposure in the Cascade Range.

Regional groundwater flow in the Little Deschutes River Subbasin is primarily controlled by the distribution of recharge areas, the geology, and the location and elevation of streams. Groundwater flow in the Little Deschutes River Subbasin is from recharge areas in the Cascade Range and Newberry Crater to the north, parallel to flow in the Little Deschutes River. Map 10-1 illustrates regional groundwater flow in the entire Upper Deschutes River basin. The Little Deschutes River Subbasin is located in the southern portion of this figure.

Groundwater underlying the La Pine subbasin forms a relatively flat surface, with an elevation of about 4,200 feet and a slight gradient generally toward the north-northeast. In this area the water table is shallow, often within several feet of land surface.

10.5 Hydrologic Budget Components and Estimates

The USGS report *Ground-Water Hydrology of the Upper Deschutes Basin, Oregon* (Gannett, et al., 2001), provides a quantitative assessment (hydrologic budget) of the regional groundwater system. A hydrologic budget identifies the components and amounts of recharge and discharge in a basin. Recharge is defined as infiltration of water that moves downward into the underlying aquifer. Discharge is defined as groundwater flowing toward the surface where it may escape as a spring, seep, well, or base flow in a stream. Groundwater may also discharge as evapotranspiration, which is groundwater used by plants, trees, shrubs, etc.

The report identified the following sources of recharge to the Little Deschutes River Subbasin: infiltration of precipitation, canal leakage, on-farm losses, stream leakage, drainage wells, and interbasin flow. Sources of discharge include: groundwater discharge to streams, groundwater discharge to wells, and groundwater discharge to evapotranspiration. Figure 10-3 illustrates the elements and relative contributions of each element to the overall Little Deschutes River Subbasin groundwater budget. Each component of the budget is discussed below.

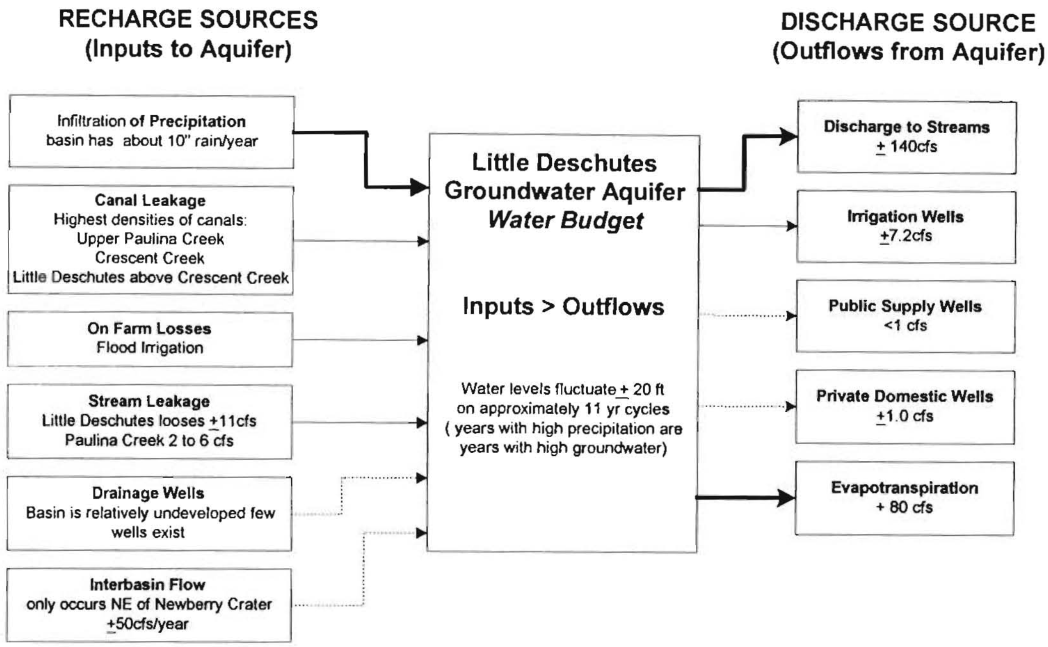

Figure 10-3: Flowchart of Little Deschutes River Subbasin groundwater budget components (Summary of data in Gannett, et al. 2001).

10.5.1 *Groundwater Recharge*

Infiltration of Precipitation

Recharge from precipitation occurs where rainfall or snowmelt infiltrates and percolates through the soil and reaches the saturated part of the groundwater flow system. Recharge is the quantity of water remaining after runoff and evapotranspiration take place.

The USGS study used a deep percolation model to estimate mean monthly and annual recharge from precipitation to the aquifer. The model uses precipitation, temperature and solar radiation data to estimate the amount of recharge to the aquifer. The model estimated recharge between 1962-1997. Estimated recharge ranged from less than 3 inches in the drought years of 1977 and 1994 to nearly 23 inches in 1982. The mean for this period was 11.4 inches/year; this converts to an annual rate of about 3,800 cfs or 7,540 acre-feet.

Approximately 84 percent of recharge from precipitation occurs between November and April. Recharge peaks in December and again in March and April. The December peak results from percolation of precipitation after fall rains and early winter snowfall and melt have saturated the soils. After January, precipitation is reduced, but snowmelt sustains recharge at the higher elevations through April. By May, increasing evapotranspiration begins to deplete soil moisture storage and reduce recharge rates to nearly zero.

At the regional scale the geographic distribution of recharge mimics that of precipitation. The Cascade Range, which constitutes the western boundary, locally receives in excess of 200 inches per year, mostly as snow. The thin soils allow rapid infiltration of much of the rain and snowmelt making the Cascade Range the source for most of the groundwater recharge in the basin. The central part of the basin typically receives less than 10 inches per year and is not an area of significant recharge relative to recharge in the Cascade Range to the east.

Canal Leakage

The largest canal diverting from the Little Deschutes River is the Walker Basin Irrigation Canal with approximately 30 miles of canals and 30 miles of laterals that carry water. Canal leakage rates vary greatly depending on the geology of the canal bottom and the extent to which the cracks and voids have been filled or sealed by sediment. Canal leakage rates for the Little Deschutes River Subbasin are not available. In areas where streams lose water in canals, water is also being lost in the streams through seepage to groundwater. Mr. Gorman indicated that the seepage studies he completed determined that canals in areas where there are losing stream reaches also leak into the subsurface and recharge the aquifer. Consequently, canals in the vicinity of upper Paulina Creek, Crescent Creek above the confluence with the Little Deschutes River, and the Little Deschutes River above the confluence with Crescent Creek will have some leakage into the subsurface. This will be discussed in greater detail in the section ***Stream Leakage***.

On-Farm Losses

On-Farm losses are considered to be water lost to evaporation, wind drift, runoff, and deep percolation. Deep percolation is water that migrates through the unsaturated zone of the soil profile and enters the saturated zone (or aquifer). The amount of on-farm losses depends on the type of irrigation system in use. In the Little Deschutes River Subbasin, flood irrigation is the predominant method of irrigation. These areas receive up to 10 inches/year of recharge from surface water.

Stream Leakage

Losing streams are defined as those where the elevation of a stream is above that of the underlying water table and water can leak from the stream to recharge the groundwater system, decreasing streamflow. Conversely, in areas where the stream elevation is below that of adjacent aquifers, groundwater can discharge to streams, increasing streamflow. Such streams are termed gaining streams.

In the Little Deschutes River Subbasin, losing streams are much less common than gaining streams (Map 10-2). Seepage runs indicate some losses along the Little Deschutes River as it flows through the La Pine subbasin. Most of the measured losses are small, 1 to 3cfs, and are within measurement error of the streamflow rates. Measured losses along the Little Deschutes between Gilchrist and Crescent Creek range from 11 to 14.4 cfs (21.8 to 28.6 acre-feet). The river crosses lava flows along this reach and it is likely that water is being lost into permeable lava. Mr. Gorman indicated this water immediately recharges groundwater in the area.

Paulina Creek had measured net losses of approximately 2 to 6 cfs (3.96 to 11.9 acre-feet). This loss accounts for roughly 20 to 40 percent of the flow at the times the measurements were made.

Drainage Wells

Drainage wells include drilled disposal wells and hand-dug shallower drywells used to dispose of storm runoff in urban areas. Runoff disposed of in drainage wells is routed directly to permeable rock beneath the land surface, bypassing the soil zone from which a certain amount of water would normally be returned to the atmosphere through evaporation or transpiration by plants. Once routed to permeable rock beneath the soil, the runoff percolates downward to recharge the groundwater system. This source of groundwater recharge is very small relative to other sources of recharge and is estimated to be approximately 2.3 cfs (4.6 acre-feet) in Bend and 0.28 (0.55 acre-feet) cfs in Redmond. Runoff calculations are not available for the Little Deschutes Basin but it is unlikely this is a significant component of groundwater recharge.

Interbasin Flow

The final source of recharge is subsurface flow from adjoining basins. In general, the lateral boundaries of the Little Deschutes Basin study area are considered to be no-flow boundaries. That is, the rocks are relatively impermeable and no flow passes into the basin. There are two areas where flow from an adjacent area is probable: northeast of Newberry Crater and to the south from the Fort Rock and Christmas Lake Basins. The estimated inflow from these areas are about 50 cfs and 14 cfs, respectively (99.1 and 27.7 acre-feet).

10.5.2 *Groundwater Discharge*

Groundwater discharges from the aquifer to streams, wells (both public and private), and by evapotranspiration. Discharge to streams is the principal mechanism by which water leaves the groundwater system. Each component is discussed below.

Groundwater Discharge to Streams

Groundwater discharges to streams in areas where the stream elevation is lower than the elevation of the water table in adjacent aquifers. The amount of groundwater discharging to streams or leaking from streams varies geographically and with time. Estimates of groundwater discharge to major streams in the Little Deschutes River Subbasin are provided in Table 10-2. These values represent approximate long-term average conditions.

Table 10-2: Estimated Stream Gains and Losses Due to Groundwater Exchange, Upper Little Deschutes River Subbasin.

Stream Name	Reach (river mile)	Estimated gain (+) or loss (-) (in cfs)	Data Source
Little Deschutes	Entire drainage above Hwy 58	31.5	OWRD 10/95
Little Deschutes	Hwy 58 to above Crescent Ck	-15.6	OWRD 10/95
Little Deschutes	Above Crescent Ck to Crosswater	9.3	OWRD 10/95
Big Marsh Creek	Drainage above gage near Mouth	21	USGS statistical summary
Crescent Creek	Crescent Lake outlet to Hwy 58	18.7	OWRD 10/95
Crescent Creek	Hwy 58 to above mouth	-1.5	OWRD 10/95
Paulina Creek	Paulina Lake outlet to Road 21	-1.7 to –6.1	USGS Water Resources Inv.
Odell Lake	Above gage at lake outlet	41	USGS statistical summary
Odell Creek	Odell Lake outlet to OWRD gage	41	USGS & OWRD gage data

As shown by the blue lines in Map 10-2, groundwater constitutes a portion of the flow in many streams in and along the margin of the Cascade Range in the southern part of the Little Deschutes River Basin. Stream reaches not recharged by groundwater are in pink and include the upper parts of Paulina Creek, Crescent Creek before the confluence with the Little Deschutes, and the Little Deschutes River below Highway 58 before the confluence with Crescent Creek. Under average flow conditions, groundwater discharge to streams in the Little Deschutes River subbasin is approximately 140 cfs (278 acre-feet).

Groundwater Discharge to Wells

Groundwater is pumped from wells for a variety of uses in the Little Deschutes Basin, including irrigation, public supply, and private domestic use. Irrigation is primarily agricultural, but can include watering of golf courses and parks. Public supply systems include publicly and privately owned water utilities, which are typically located in urban and suburban areas. Public supply use includes not only drinking water but also commercial, industrial, and municipal uses. Private domestic use generally refers to pumping by individual wells that typically supply a single residence. Each of these is discussed below.

Irrigation Wells

Pumping of groundwater for irrigation was estimated using water rights information from the State of Oregon and crop-water requirement estimates. Pumping of groundwater for irrigation in the Little Deschutes Basin was estimated to be 520 acre-feet/year (an average annual rate of 7.2 cfs) during 1994. The geographic distribution of annual groundwater pumping for irrigation from 1993 to 1995 is shown in Map 10-3. As illustrated in this figure, irrigation pumping in the Little Deschutes River Subbasin is low relative to other parts of the Deschutes River Subbasin.

Public Supply Wells

Public water supply pumping has increased in recent years in response to population growth but is still very limited. Currently public supply wells exist for Sunriver, the La Pine School District, the La Pine incorporated well, and a well at the Oregon Water Wonderland south of Sunriver. It is estimated that these wells account for less than 1 cfs. One cfs is equal to one foot of water covering approximately two acres of land.

Private Domestic Wells

It is estimated that 24 percent of the population in Deschutes County obtains water from private domestic wells or small water systems. If an average per capita pumping of 100 gal/day is used, groundwater pumping by private domestic wells (assuming 7,000 individuals in the Little Deschutes Basin) is an average annual rate of 1.0 cfs. Virtually all of the homes on private domestic wells also use on-site septic systems so most water is returned to the groundwater system. Actual consumptive use of groundwater by private domestic wells in the Little Deschutes Basin is likely less than 1.0 cfs. One cfs is equal to one foot of water covering approximately two acres of land.

Groundwater Discharge to Evapotranspiration

The majority of evapotranspiration within the basin occurs from consumption of water from the soil profile or unsaturated zone. Plant roots intercept and utilize some of the available soil water prior to reaching the groundwater table or saturated zone. This type of evapotranspiration is not considered groundwater discharge. Under certain circumstances, plant roots of sufficient depth can interface with shallow groundwater resulting in the utilization and evapotranspiration loss of groundwater. This rooting groundwater interface can occur within or near the capillary fringe. Evapotranspiration of water in this manner is considered groundwater discharge. The La Pine subbasin is the only significantly large region in the study area where conditions exist for groundwater discharge to occur from evapotranspiration. In general, these zones of groundwater loss occur where deeper rooted plants interface with groundwater within 10 ft of the land surface. Based on land area size estimates and rates of evapotranspiration, the average annual rate of loss is 80 cfs (158 acre-feet) (Gannett et al, 2001). This value is considered a rough estimate.

10.6 Groundwater Fluctuations

The elevation of the water table is not static and fluctuates with time in response to a number of factors including recharge from precipitation in the form of rainfall and snowmelt, canal operations, and pumping.

10.6.1 *Large Scale Water-Table Fluctuations*

The most substantial groundwater level fluctuations in the Little Deschutes River Subbasin occur in parts of the La Pine subbasin. These fluctuations are illustrated in the hydrograph of well

21S/11E-19 CCC near La Pine (Figure 10-4). The La Pine well is shown in the middle of the hydrograph as a dotted line; the cumulative departure from mean annual precipitation at Crater Lake is shown at the top of the graph as a solid line. The graph plots the depth to water (in feet) in the La Pine well when the well is not pumping (i.e. static water level) and compares the depth to water in the well to the precipitation at Crater Lake. For example, in 1965 the depth to water in the well was slightly greater than 40 feet and precipitation at Crater Lake was approximately 8 inches less than average for the period 1962 through 1998. In 1965 the depth to water in the well was 20 feet while precipitation at Crater Lake was approximately 9 inches more than the average for the period 1962 through 1998.

The water level in the well near La Pine fluctuates up to 20 feet with a cycle averaging roughly 11 years. A comparison of this fluctuation with precipitation in the Cascade Range indicates that a period of high groundwater levels generally correspond to periods of high precipitation and low water level elevations correspond to periods of low precipitation. This relationship is to be expected.

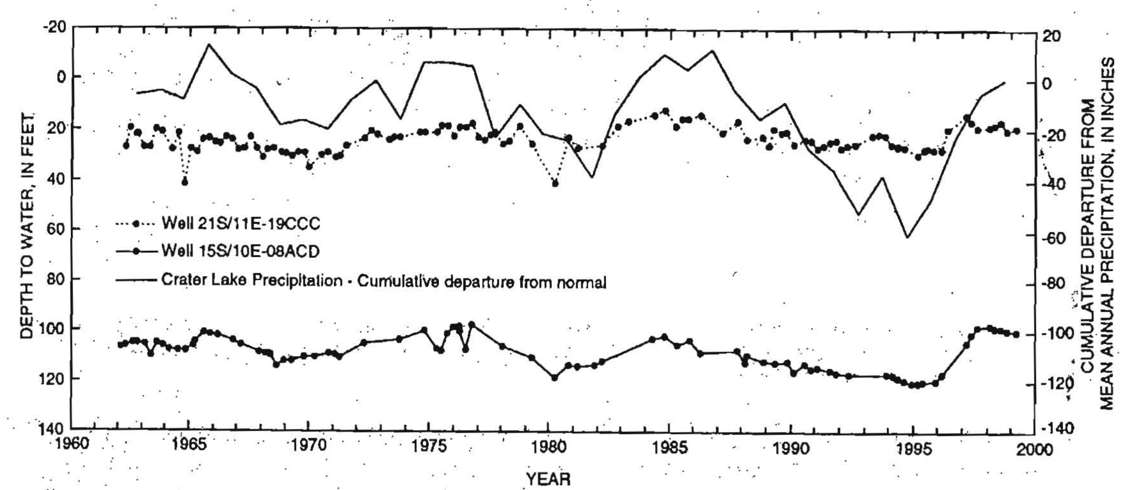

Figure 10-4: Static water levels in well 21S/11E-19CCC in the Little Deschutes Basin, Oregon and cumulative departure from normal annual precipitation at Crater Lake, Oregon (Gannett, et. al 2001).

During periods of high precipitation the rate of groundwater recharge exceeds, at least temporarily, the rate of discharge. When groundwater recharge exceeds discharge, the amount of groundwater in storage must increase, causing the water table to rise. During dry periods the rate of discharge may exceed the rate of recharge and groundwater levels drop as a result.

Fluctuations in the water table elevation in response to variations in recharge are most prominent in the Cascade Range, the recharge area. Hydrographs of wells in the area show that as the distance from the recharge area increases, the magnitude of fluctuations decreases, and the timing of the response is delayed.

During the period 1993 through early 1999, water levels in wells near the Cascade Range rose over 20 feet due to the change from drought to wetter-than-normal conditions. Wells several miles to the east exhibited only a slight rise in water level, less than 2 feet, in response to the end of the drought. The wells also exhibited an apparent delay in response.

Water level fluctuations are attenuated with increasing depth as well as with increasing horizontal distance from the recharge area. Hydrographs of two wells in the La Pine area are illustrated in Figure 10-5. Well 21S/11E-19 CCC is 100 feet deep and well 22S/10E-14 CCA is 550 feet deep. The water level in the shallow well was declining due to drought conditions until early 1995 when it started to rise in response to increased precipitation. The water level rose over 15 feet by early 1997. The water level in the deep well, however, declined until early 1996 and by 1999 had risen only 7 feet in response to the end of drought conditions.

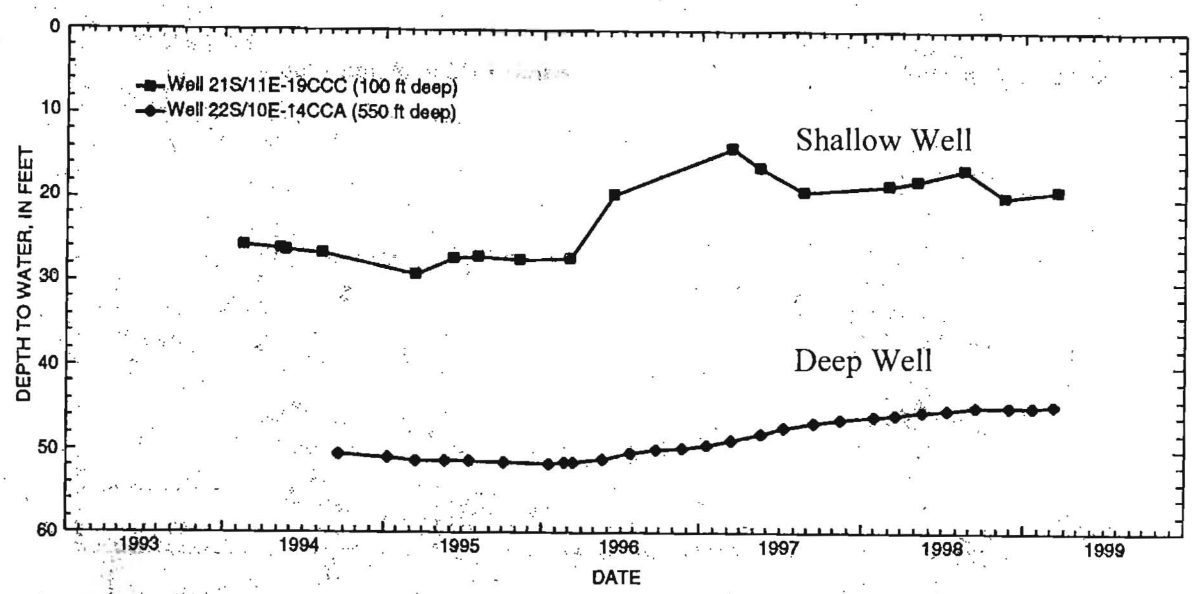

Figure 10-5 Static water-level variations in a shallow well and a deep well in the La Pine subbasin, Oregon (Gannett, et al 2001).

10.6.2 *Local Scale Water Table Fluctuations*

In addition to basin-wide groundwater elevation fluctuations, smaller-scale, localized water-table fluctuations occur. These more isolated fluctuations are due to varying rates of recharge from local sources such as leaking streams and canals, and by groundwater pumping. Fluctuations due to irrigation canal leakage occur in many wells throughout the irrigated areas with water levels rising during the irrigation season and dropping when canals are dry. The magnitude of the fluctuations varies depending on the proximity of the well to the canal, the depth of the well, and the local geology.

10.7 Groundwater-Surface Water Interactions

Groundwater levels in the Little Deschutes River Subbasin ranges from at ground surface to 70 feet below ground surface. The interaction between groundwater and surface water is controlled largely by the relative elevations of the water table and adjacent streams. In the La Pine subbasin, south of Benham Falls, the water table elevation is near land surface. Stream gains and losses along most of the Little Deschutes River in this area are small, indicating relatively little net exchange between groundwater and surface water. Other groundwater and surface water interactions are shown in Map 10-2 illustrating the location of losing and gaining stream reaches in the subbasin.

10.8 Groundwater Quality

The groundwater quality in the subbasin has been impacted by development of thousands of small lots served by on-site sewage disposal systems (septic systems), including standard drain fields, cap and fill systems, and sand-filter systems. The construction of these systems upon highly permeable, rapidly draining soils and a high groundwater table with relatively cold-water temperatures results in elevated levels of nitrates. The nitrates are a by-product of septic systems and an indicator of human pathogens, these are poorly retained in the septic systems because of the fast draining soils and do not easily break down due to the cool groundwater temperatures. There has been measurable loading of nitrates in the shallow groundwater aquifer that is also the source of drinking water for the residents in the area (Deschutes County, 1998).

The USGS study of groundwater in Central Oregon concludes that groundwater in the Little Deschutes River is connected to nearby surface waters. Due to the existing pattern and density of development ODEQ is predicting that nitrate levels will continue to increase over time, even if measures were taken now to alter the development pattern. Mr. Rodney Weike of the ODEQ has been working on a groundwater quality study in the La Pine area in the Little Deschutes River Subbasin for the past three years. Final data and a report will be published in cooperation with the USGS in the spring of 2002. Data were to be made available on the internet this fall but were delayed due to a computer virus.

Discussions with Mr. Weike indicate that nitrogen in the form of nitrate-nitrogen is the constituent of concern relative to groundwater. The primary sources of nitrogen are from human and animal wastes, primarily septic systems. Due to the nature of the soils in the La Pine area, sewage can flow quickly through the porous soil and into the underlying aquifer without decomposing. Preliminary loading data provided by Mr. Weike are given in Table 10-3 below.

Table 10-3: Nitrogen Loading to Groundwater in the Little Deschutes River Subbasin.

Year	1960	1970	1980	1990	1999
kg/year nitrogen loaded to groundwater	2,900	10,020	30,900	38,000	53,200