Draft

Lake Chelan Subbasin Summary

May 17, 2002

Prepared for the
Northwest Power Planning Council

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Lake Chelan Subbasin Summary

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Subbasin Description

General Description

Subbasin Location

The Lake Chelan basin is in Chelan County in north-central Washington. Its northern boundary is the North Cascades and the Chelan County border. The basin covers approximately 589,000 acres or 923 square miles (R.W. Beck, 1991, p. III-6 - 7). The upper portion is within the North Cascades National Park and the Lake Chelan National Recreation Area. The middle part of the basin is in the Wenatchee National Forest. Most of the lower basin, which contains the majority of the development, is privately owned (R.W. Beck, 1991, p. III-8). (See Figure 1.)

Lake Chelan, which dominates the basin, is the largest and deepest natural lake in Washington. It is approximately 50 miles long, with an average width of 1.5 miles and a maximum depth of approximately 1,500 feet (R. W. Beck, 1991, p. III-7). It is bordered on the north by the Sawtooth Mountains and on the south by the Chelan Mountains and the Glacier Peak complex. Water from Lake Chelan flows from its southern end into the shortest river in Washington, the 4.1-mile-long Chelan River. This river falls 400 feet in its descent through a steep, rocky gorge to the Columbia River.

Although Lake Chelan is a natural lake, its levels and outfall (the Chelan River—called the “bypassed reach” because its flow is diverted much of the year), are controlled as part of the Lake Chelan Hydroelectric Project, owned and operated by Chelan County Public Utility District No. 1. The PUD's license to operate the facility expires in 2006. As a condition of its current license and as part of its application to the Federal Energy Regulatory Commission (FERC) for relicensing, Chelan PUD has conducted numerous studies of resources in the basin. Many of these studies, as well as documents prepared by other agencies as part of the relicensing process, are cited at length in this summary.

Climate

The climate of the area is characterized by hot, dry summers and mild to severe winters. Precipitation and temperature vary widely depending on the elevation and proximity to the Cascade Crest. Locally, Lake Chelan is a moderating influence on temperatures (R. W. Beck, 1991, p. III-8). Weather patterns also are influenced by the Columbia River basin. Winds typically are funneled down the lake valley in an easterly direction towards the Columbia River basin, where warm air masses are rising. This pattern causes increased wind speeds in the evenings, especially on the north shore of Lake Chelan (USFS, 1998 p. 3-3).

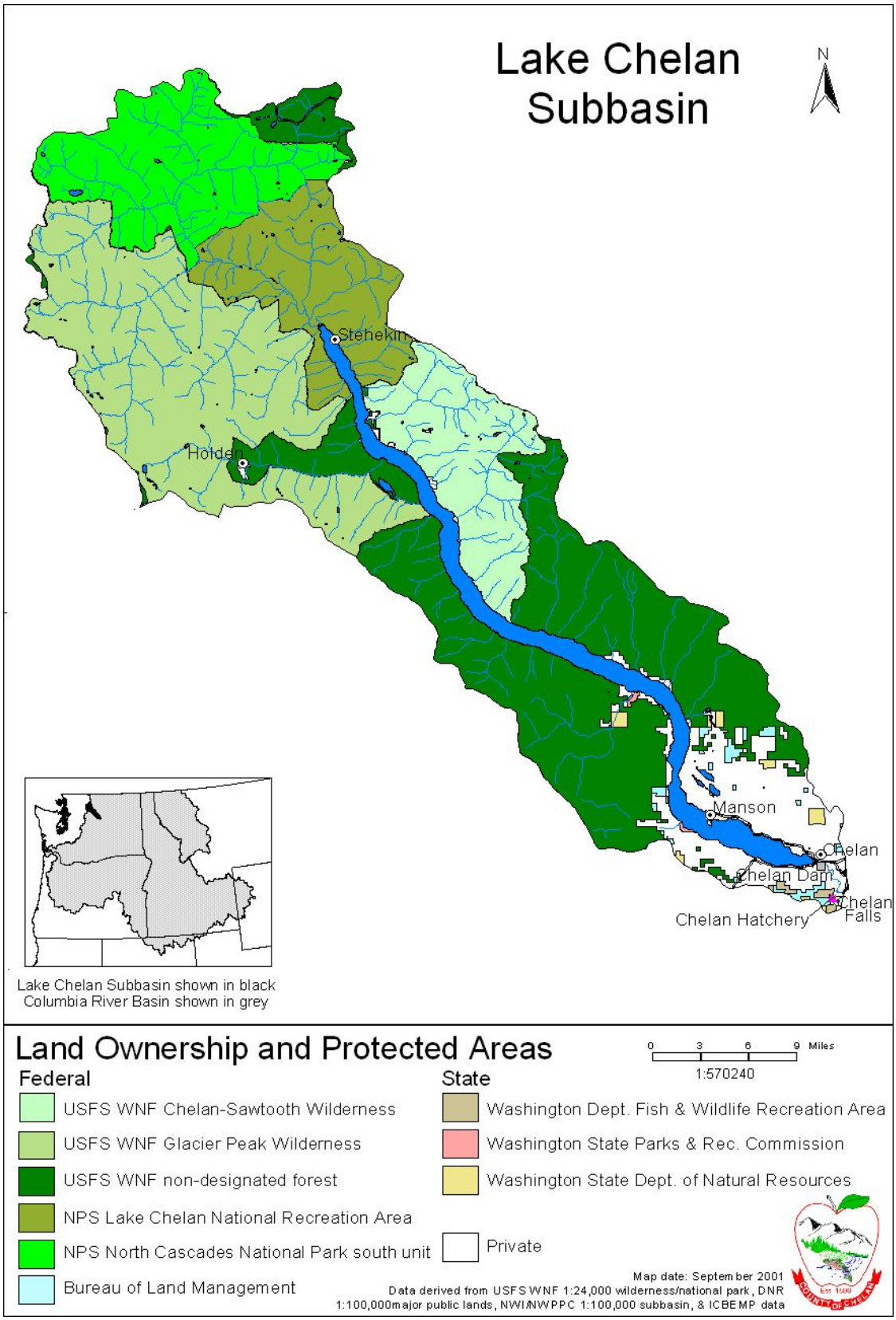

Figure 1. Land Ownership and Protected Areas

Average annual precipitation in the area ranges from a high of 150 inches near the crest of the Cascade Mountains to a low of 11 inches at the Columbia River. Total annual precipitation at Stehekin at the head of the lake averages 35 inches, the majority of which is snowfall from November through March (FERC, 2001, sect. 5.1). In the City of Chelan, the average precipitation is 11 inches per year (R. W. Beck, 1991, p. III-8). Data from Chelan Boat Co. indicate that precipitation in the lower Chelan basin can vary from year to year by 200% (i.e., with a low of 4 inches and a high of 16 inches) (USFS, 1998, p. 3-2).

The average summer maximum temperature for July is 86.4 degrees Fahrenheit, and the average winter maximum temperature is 19.8 degrees Fahrenheit (R. W. Beck, 1991, p. III-8).

Geology/Topography

The Lake Chelan basin is located between two significantly different physiographic provinces in north-central Washington, the Cascade Mountains to the north and west and the Columbia Plateau to the south and east. The lake itself is bordered to the south by the Entiat and Chelan Mountains and Glacier Peak complex and to the north by the Sawtooth Mountain Range. Topographic elevations in the project vicinity range from over 9,000 feet above sea level at the crest of the Cascade Mountains to 700 feet on the Columbia River (FERC, 2001, sect. 5.1).

Lake Chelan and its immediate surroundings are the result of the complex interaction between two glacial masses. The lake was formed approximately 18,000 years ago during the Wisconsin glacial period. During this time, the Chelan Glacier moved down the valley from the north and the Okanogan-Columbia Valley lobe of the Cordilleran ice sheet extended upward from the south. The two glaciers approached each other and nearly met at Wapato Point and at a constriction known as “The Narrows” respectively. The approach and recession of these two glaciers caused erosion in the mid and upper portion of the lake, and geologic moraine deposits at the lower end of the lake. Together these effects created Lake Chelan (Kendra and Singleton, 1987; and Hillman and Giorgi, 1999 [in] Viola and Foster, 2000)

The area is characterized by underlying rock formations covered by a layer of soils in the valleys and frequent rock outcroppings in the mountains. Glacial features such as cirques, truncated spurs, moraines, horns, and U-shaped valleys are common in the mountains, while alluvial deposits and glacial drift are often found along the valley floors. (R. W. Beck, 1991, p. III-8).

Lake Chelan lies within the elongated, steeply sloped fjord basin formed by the glaciers. The lake extends 50 miles from Chelan to Stehekin, with 110 miles of shoreline and 32,980 surface acres of water. It is the largest and deepest natural lake in Washington and the third deepest lake within the continental United States (after Crater Lake and Lake Tahoe). A maximum depth of 1,486 feet (453 meters) occurs off the mouth of Big Goat Creek. The mean depth of the lake is approximately 474 feet (144 meters) (Viola and Foster, 2000; Patmont et al., 1989, p. 2-1).

Due to the effects of the two glaciers, the lake now consists of two basins with differing topography. A shallow sill at The Narrows separates these two basins. The Lucerne basin extends from The Narrows northerly for 38 miles and is deep and fjord-like; the maximum depth occurs in this basin. The Wapato basin extends for 12 miles south of The Narrows and is relatively wide and shallow in comparison, with a maximum depth of 400 feet (Hillman and Giorgi, 1999 [in] Viola and Foster, 2000). Table 1 summarizes the morphometric characteristics (from Patmont et al., 1989, p. 2-1 - 2-4).

Table 1. Lake Chelan morphometric characteristics

Parameter	Wapato Basin	Lucerne Basin	Lake Chelan
Max. Length (km)	19.3	61.8	81.1
Max. Width (km)	2.9	2.3	2.9
Mean Width (km)	1.8	1.6	1.6
Max. Depth (m)	122	453	453
Mean Depth (m)	43	180	144
Shoreline Length (km)	44.4	132.4	175.7
Surface Area (sq km)	35.0	99.9	134.9
Percent of Lake Surface Area	26	74	100
Watershed Area (sq km)			2,393
Water Residence (yrs)			10.6
Lake Surface Elevation (m)			335

Hydrology

Lake Chelan

Lake Chelan is oriented generally in a northwest-to-southeast direction within a deeply glaciated valley and occupies approximately 50 miles of the 75-mile-long basin. The majority of inflow to Lake Chelan is from two major tributaries: the Stehekin River, which feeds into the lake from the west, provides 65 percent; Railroad Creek provides 10 percent. Approximately 50 small streams provide the remaining 25 percent of the inflow. Due to the shape of the valley, most tributaries have relatively steep gradients and are relatively short (FERC, 2001, sect. 5.1).

As explained in the Geology/Topography section, the lake consists of two distinct basins separated by a relatively shallow sill 135 feet below the surface of the lake at its narrowest part. The larger Lucerne Basin contains over 92 percent of the total lake volume. Water entering the Lucerne Basin has an average residence time of approximately 10 years. The residence time of water within the smaller, shallower Wapato Basin is much shorter, ranging from approximately 0.2 to 1 year, depending on climatic factors (FERC, 2001, sect. 5.3.2).

Lake Chelan waters drain into the Columbia River either through releases at the Lake Chelan Project dam into the 3.9-mile long bypassed reach of the Chelan River or through a diversion at the dam into a 2.2-mile-long power tunnel (penstock), which passes the water through the powerhouse for hydroelectric generation (FERC, 2001, sect. 5.3.2).

Chelan River/Bypassed Reach

Figure 2 shows the relationship between the Chelan River and the hydroelectric project and its diversion tunnel (from Anchor, 2000, Figure 2).

Nearly the entire Lake Chelan outflow, averaging approximately 2,000 cubic feet per second (cfs), is diverted through the penstock, which has a vertical drop of 401 feet. The bypassed reach (original Chelan River channel) is without flow during most of the year; normally, the only flow in the bypassed reach comes during the spring and early summer when snow melt raises the lake to levels requiring spill for flood control (Chelan PUD, 1998, p. E3-10). As shown in Figure 2, the bypassed reach is comprised of four distinct sections (Chelan PUD, 1999). The upper two sections, Sections 1 and 2, are relatively low gradient areas (approximately 55 ft/mi) extending a length of 3.0 miles. Section 3, referred to as the gorge, is 0.4-mile long with steep and narrow canyon walls. The gradient in this part of the channel is very steep, approximately 480 ft/mi. Waterfalls, from 5 to 20 feet high, numerous cascades, bedrock chutes, and large, deep pools characterize the stream channel in the gorge reach. Finally, Section 4 is 0.5-mile long and characterized by a wide floodplain. This section of the bypassed reach has a relatively low gradient (22 ft/mi) and a substrate comprised of gravel, cobble, and boulders. Section 4 extends from the bottom of the gorge section downstream to the confluence with the tailrace and Columbia River (Anchor, 2000).

Tributaries

Table 2 shows the hydrologic characteristics of major tributaries in the Lake Chelan Basin (DES, 2001a).

Table 2. Maximum discharge and estimated base flow, April 4 - September 28, 2000

Creek	Maximum Peak Flow (Cfs)	Date	Baseflow (Cfs)	Date
First	97.8	April 14	7.6	May 15 – Sept 28
Mitchell	6.5	April 31	1.8	May 15 – Sept 28
Gold	11.1	April 20	0.7	June 1 – Sept 28
Grade	35.8	April 22	2.6	July 1 – Sept 28
Twentyfive Mile	145	May 23	8.5	July 1 – Sept 28
Safety Harbor	141[1]	June 8	5.3	July 1 – Sept 28
Prince	531	June 18	26.1	July 1 – Sept 28
Railroad	1,284	June 15	153	Aug 1 – Sept 28
Fish	526	June 21	24.6	July 1 – Sept 28
Stehekin River[2]	6,010	May 22	1,130	Aug 1 – Sept 28

1. Low confidence; gauge location was subject to excessive turbulence during high flows.
2. USGS year 2000 provisional data

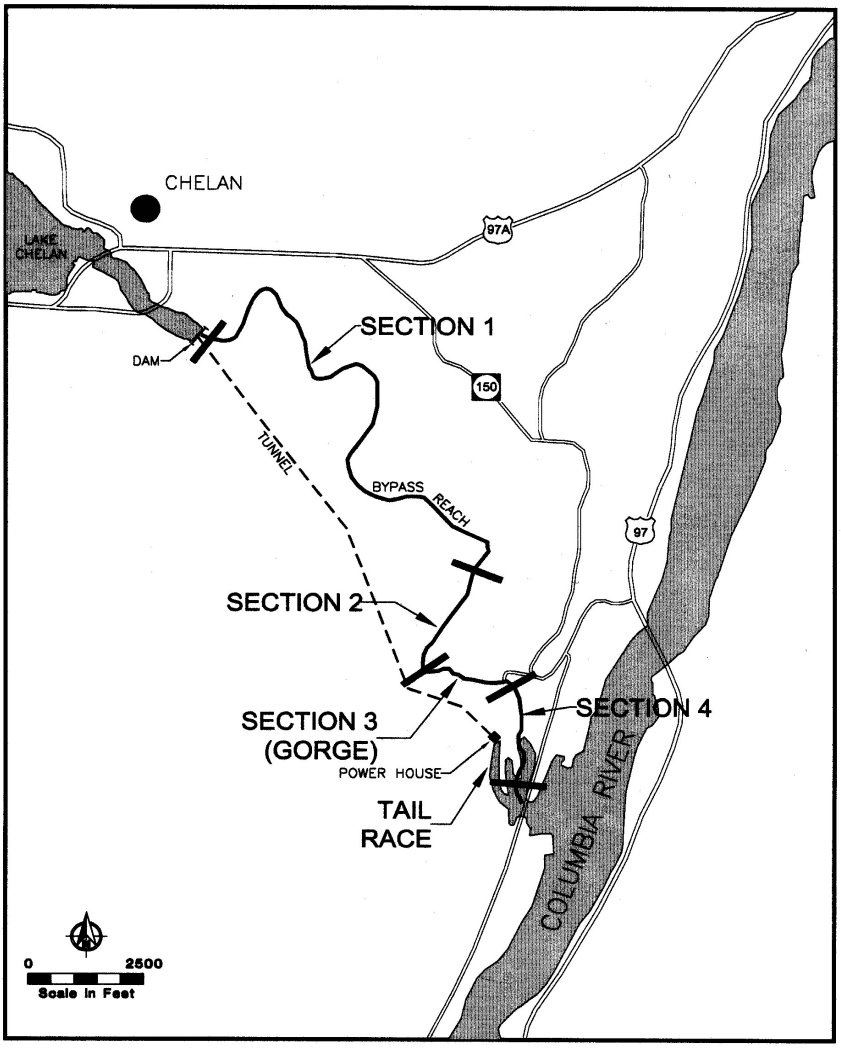

Figure 2. Chelan River (Bypassed Reach) by section and Lake Chelan Hydroelectric Project

Soils

Throughout much of the basin, the soils consist of alluvial deposits and glacial drift. Volcanic pumice and ash from the Glacier Peak region are also present in many areas. The mountainous terrain consists mainly of large rock outcroppings and shallow soils (R. W. Beck, 1991, p. III-9). Soils typically are coarse textured, with a low percentage of fines and minimal development. Pumice and ash deposits are relatively deep on north-facing slopes, whereas erosion has removed much of this material from south-facing slopes where bedrock outcrops are common (USFS, 1998, p. 1-14).

Land Uses

Table 3 summarizes land uses within the Lake Chelan basin (from Patmont et al., 1989, p. 2-7) (see also Figure 1). The table illustrates the importance in this basin of forested lands and the lake, which are used primarily for recreation and the preservation of natural resource and wilderness values. The lake is used for recreation, power production, irrigation, commercial navigation, and as habitat for a variety of game fish and other species. Recreation on land and water is an important part of the economy of the basin. While timber harvest occurred in the past, little timber is harvested now. Mineralized formations producing copper, gold, zinc and silver were mined at the Holden Mine on Railroad Creek from 1938 through 1957 (R. W. Beck, 1991, p. III-8). Mining currently is a minor activity in the basin; however, in addition to the large claim at Holden, patented mining claims exist in private inholdings throughout the basin. Under current mining laws they could be proposed for development.

Most development has occurred in the lower basin around the towns of Chelan (population 3,000 – 6,000) and Manson (population 2,000 – 4,000), although there are small communities near the upper end of the lake at Holden and Stehekin, and residences in private inholdings throughout the basin in the valley bottoms and along the lake shore. Population decreases significantly in winter months.

Table 3. Existing land use within the Lake Chelan Basin

Land Use	Area (km^2)	Percent of Total
Lake Chelan	135.0	5.6
Other Water Bodies	4.0	0.2
Forested Public Lands	2,000.0	83.6
Forested Private Lands	163.0	6.8
Agriculture - Orchard	47.0	2.3
Agriculture - Non-Orchard	31.0	1.3
Residential	6.0	0.2
Roadways	6.0	0.2
Commercial and Public Buildings	1.0	0.0
TOTAL	**2,393.0**	**100.0**

Impoundments and Irrigation Projects

Although Lake Chelan is a natural lake, its levels are now affected and controlled by the Lake Chelan Hydroelectric Project, a dam and powerhouse owned and operated by Chelan County Public Utility District, which is located at the mouth of the lake on the Chelan River. As stated in the Hydrology section, Lake Chelan waters drain into the Columbia River either through releases at the Lake Chelan Project dam into the 3.9-mile long bypassed reach of the Chelan River or through a diversion at the dam into a 2.2-mile-long power tunnel, which passes the water through the powerhouse for hydroelectric generation (FERC, 2001, sect. 5.3.2).

The Lake Chelan Project, constructed in 1927, is a 40-foot-high concrete gravity dam that raised the elevation of the lake by 21 feet above normal high water levels. The project reservoir, Lake Chelan, is operated between elevations of 1,079 feet and 1,100 feet to ensure optimum use of the reservoir for power generation, fish and wildlife conservation, recreation, water supply, and flood control. The annual drawdown of the lake begins in early October, with the lowest lake elevation normally occurring in April. The average annual drawdown is 15.8 feet, to elevation 1,084.2 feet. The lake refills during May and June and is maintained at or above elevation 1,098 feet from June 30 through September 30 each year, the peak recreation season. The upper 21 feet of the reservoir is allocated as storage (677,400 acre-feet), usable by the project for hydroelectric generation and other purposes. (FERC, 2001, sect. 5.3.2; Anchor, 2000).

Surface water is pumped from the lake to serve domestic water supplies for the towns of Chelan and Manson. In Chelan, the average winter use (February) is about 500,000 gallons per day; the average summer (August) use is 2,600,000 gallons per day but can be as much as 3,500,000 gallons per day (Bill Greenway, City of Chelan). In Manson, 325,000,000 gallons a year supply a winter population of 2,000 and a summer population of 4,000 (Paul Cross, Lake Chelan Reclamation District manager). Residents on private land at places like First Creek, Twentyfive Mile Creek, Fish Creek and Canoe Creek also withdraw minor amounts of water for domestic use.

Manson also has a large pumping station which supplies irrigation water through an underground system to 6,500 acres of farms (Paul Cross, Lake Chelan Reclamation District manager).

Protected Areas

Figure 1 at the beginning of this summary shows land ownership and protected areas in the Lake Chelan Basin, including the predominance of federal agency management. Special management areas include North Cascades National Park, Lake Chelan National Recreation Area, Chelan-Sawtooth Wilderness Area, Glacier Peak Wilderness Area, and various Washington State parks, wildlife, and recreation sites.

Fish and Wildlife Resources

Fish and Wildlife Status

Fish

Table 4 lists fish species historically and currently present in Lake Chelan Basin and whether they are native or introduced (from FERC, 2001, Table 5 in original).

The predominant salmonid species native to the Lake Chelan Basin are westslope cutthroat trout and bull trout, previously classified as Dolly Varden (Cavender, 1978; Pratt, 1992); however, bull trout are presumed to be extirpated from the basin. The other top-level predator in the lake is burbot (freshwater ling cod). Many cyprinid and catastomid fish are native to Lake Chelan; the more abundant species are northern pikeminnow, redside shiner and bridgelip sucker (Hillman and Giorgi, 2000 [in] FERC, 2001, section 5.3.3.1a). Lake Chelan does not, and historically probably did not, contain anadromous fish species because of the steep gorge in the Chelan River at the mouth of the lake (Hillman and Giorgi, 2000). However, fish populations from the Columbia River, including migrating salmonids, have been found in the Lake Chelan Project tailrace and in the lower part of the Chelan River (FERC, 2001).

Lake Chelan supports an important sport fishery consisting of kokanee (landlocked sockeye salmon), landlocked chinook salmon, rainbow trout, cutthroat trout, lake trout and burbot. Other game fish found in Lake Chelan include smallmouth bass, pygmy and mountain whitefish, and a variety of spiny rays. Many of these fish were introduced to establish and support recreational fisheries (see "Artificial Production" section). Brown (1984) provides an overview of the Lake Chelan fishery resource, based on intensive creel, limnological and tributary surveys done in 1981 and 1982. Relicensing studies conducted for Chelan PUD on Lake Chelan in 1999 and 2000 provide comparative data to those collected by Brown in 1984 (DES, 2000a [in] FERC, 2001, sect. 5.3.3.1a). The current and historical status of many of these species are discussed below.

Table 4. Species historically or currently present in Lake Chelan Basin

Species	Scientific name	Origin
Bull trout	*Salvelinus confluentus*	Native
Cutthroat trout	*Oncorhynchus clarkii*	Native
Rainbow trout	*Oncorhynchus mykiss*	Introduced in 1917
Lake trout	*Salvelinus namaycush*	Introduced in 1980
Kokanee	*Oncorhynchus nerka*	Introduced in 1917
Chinook salmon	*Oncorhynchus tshawytscha*	Introduced in 1974
Mountain whitefish	*Prosopium williamsoni*	Native
Pygmy whitefish	*Prosopium coulteri*	Native
Burbot	*Lota lota*	Native
Smallmouth bass	*Micropterus dolomieui*	Introduced approx. 1990
Northern pikeminnow	*Ptychocheilus oregonensis*	Native
Slimy sculpin	*Cottus cognatus*	Native
Bridgelip sucker	*Catostomus columbianus*	Native
Lake chub	*Couesius plumbeus*	Presumed native
Largescale sucker	*Catostomus macrocheilus*	Presumed native
Longnose sucker	*Catostomus catostomus*	Presumed native
Peamouth chub	*Mylocheilus caurinus*	Presumed native
Redside shiner	*Richardsonius balteatus*	Presumed native
Threespine stickleback	*Gasterosteus aculeatus*	Presumed native
Carp	*Cyprinus carpio*	Introduced
Tench	*Tinca tinca*	Introduced
Bluegill	*Lepomis macrochirus*	Introduced

Sources: Brown, 1984; Hillman and Giorgi, 2000; DES, 2001a)

Lake Chelan

Westslope cutthroat trout (Regional Forester's Sensitive Species)

In the late 1800s and early 1900s, cutthroat trout fishing was popular at Lake Chelan. Currently, few native cutthroat trout are caught by anglers (Brown, 1984; Hagen, 1995; DES, 2000a; Hillman and Giorgi, 2000), and cutthroat comprise a very small part of the Lake Chelan fish community. Brown (1984) suggested that a combination of several factors contributed to the decline of the cutthroat trout fishery: (1) the Washington Department of Game (WDG, now the Washington Department of Fish and Wildlife [WDFW]) trapped adult cutthroat trout in tributaries to use as broodstock for a statewide hatchery program; (2) in 1917, WDG introduced non-native rainbow trout and kokanee salmon into the lake, resulting in some hybridization of adfluvial rainbow and cutthroat trout and decreased productivity from competition between the species; and (3) high harvest rates of cutthroat trout, a species typically vulnerable to high fishery exploitation, rapidly reduced their abundance and productivity (FERC, 2001, section 5.3.3.1a). Figure 3 shows their distribution in the basin.

Bull trout (Threatened--ESA)

Native bull trout are thought to be extirpated in Lake Chelan. None have been observed in Lake Chelan, its tributaries or in sport catch counts since the early 1950s, although they were stocked at one time (P. Archibald, USFS, pers. comm., 9/11/01). The historical population probably exhibited both adfluvial (lake-resident) and stream-resident life history patterns (see Figure 4 for presumed historic distribution). Some remnant populations probably now reside in several tributaries of Lake Chelan, but verified captures of bull trout have not occurred from the lake in two decades (Brown, 1984; Hagen, 1995).

Little is known about the historical status of this species in Lake Chelan. The floods of 1948-49 may have wiped out the bull trout's spawning areas and caused its decline. However, it is more reasonable to believe that an exotic pathogen introduced into the lake caused the decline of bull trout. Randy Morse reported in Brown (1984) that, "Dolly Varden fishing held up well until the fall of 1951, when the fish almost completely disappeared from the waters of Lake Chelan. They were seen in great numbers along the shores at Stehekin, covered with a gray fungus, sick and dying. Relatively few have been caught since that time." (FERC, 2001).

It is not known why this species did not recover. Brown (1984) suggests that population was reduced to such a low level that angling pressure prevented recovery by the harvest of spawner recruits. (FERC, 2001). The U.S. Forest Service (USFS) suggests that introduced species have filled the predatory niche vacated by bull trout (USFS, 1999a, p. 28). Regardless, their numbers remain at levels undetectable in creel surveys or tributary production surveys (DES, 2000a [in] (FERC, 2001).

Burbot

Burbot are one of the three game fishes native to Lake Chelan, along with cutthroat trout and bull trout. Burbot are piscivorous, feeding on benthic fishes and crayfish (Carlander, 1969; Wydoski and Whitney, 1979 [in] FERC 2001, section 5.3.3.1a). Very little is known about burbot in Lake Chelan. However, Brown (1984) reported that because "their natural fecundity (about 180,000 eggs per pound of female) is so high, . . . angling mortality is unlikely to have any measurable effect on their population in a lake the size of Lake Chelan and with the intensity of the present fisheries." (Viola and Foster, 2001)

WDFW sampled burbot with set lines in 1999. Many of the fish in these samples had infected gonads. Samples were examined both by a WDFW pathologist and the University of Washington’s fish health lab. Ovaries and testes contained moderate to severe multi-focal granulomas which generally are caused by a mycobacterial fungus infection (Viola and Foster, 2001).

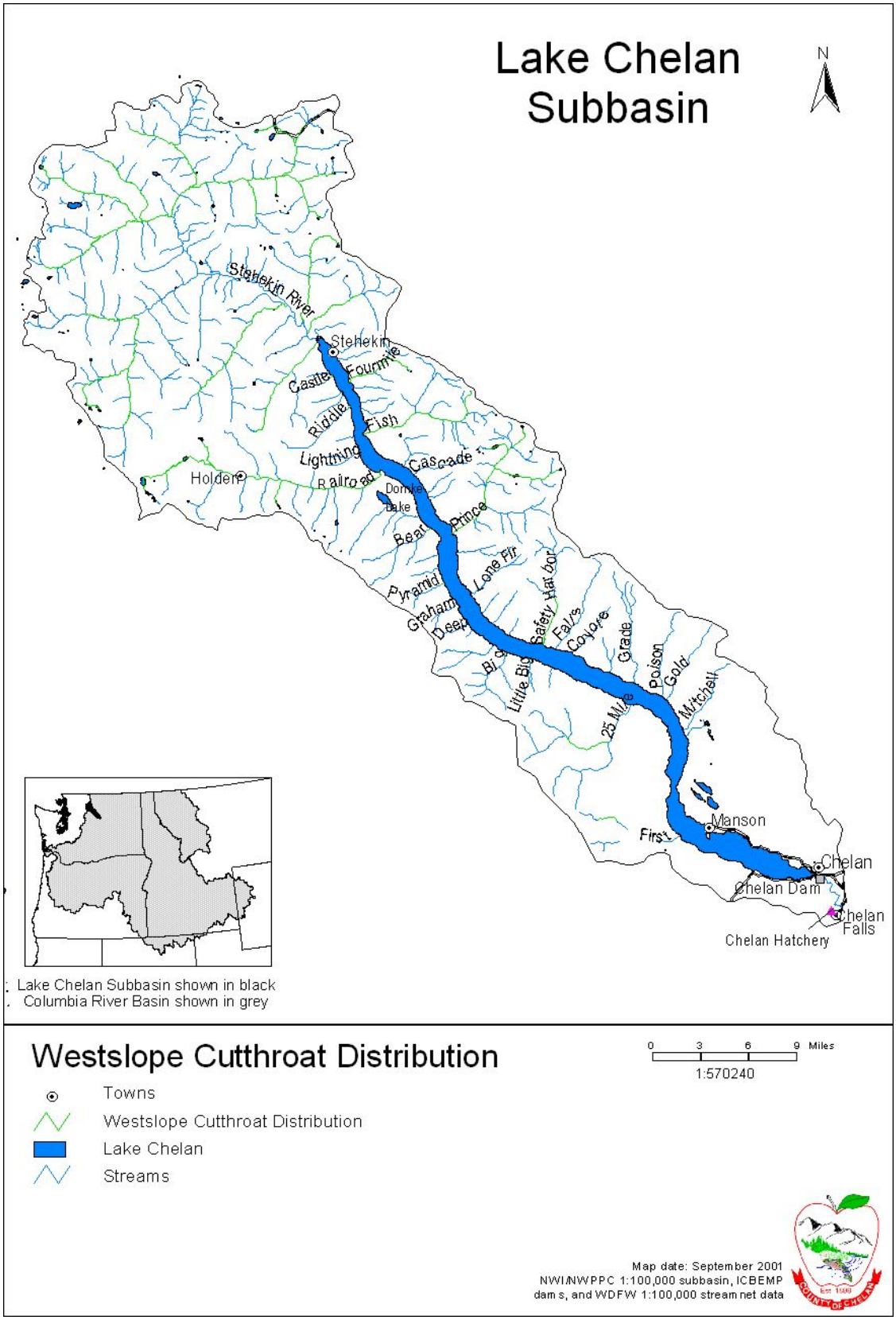

Figure 3. Westslope cutthroat trout distribution

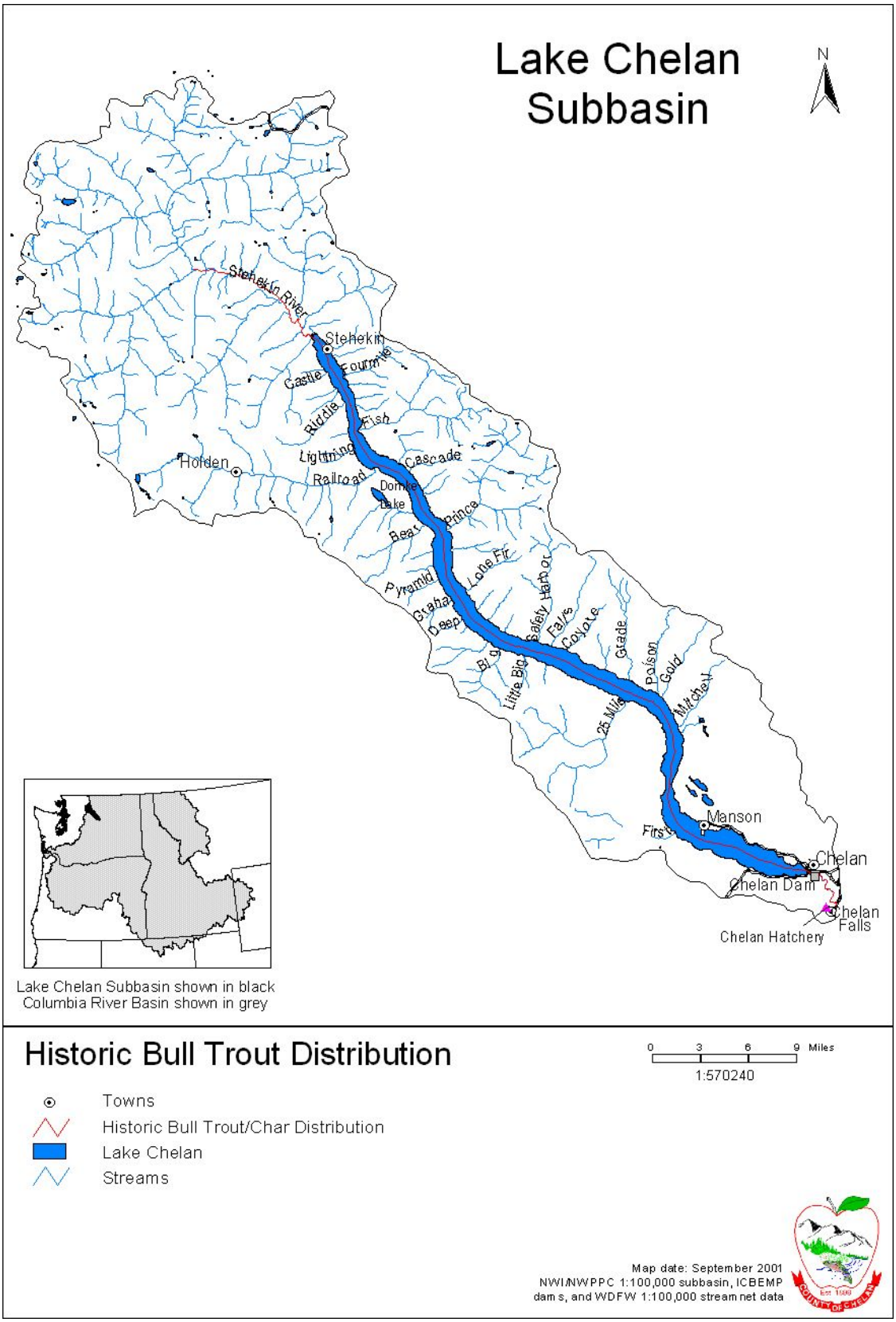

Figure 4. Historic bull trout distribution

Pygmy whitefish (WDFW Priority Species)

The presence of pygmy whitefish in Lake Chelan was documented during deep water netting in 1996. The status of the pygmy whitefish populations in Lake Chelan, and possibly the tributaries, has yet to be established. Pygmy whitefish in Washington have been extirpated from six of the fifteen lakes where they historically occurred by the introduction of exotic fishes and/or deteriorating water quality, and in one case, by the use of a piscicide. Pygmy whitefish are listed as a Priority Species under WDFW Priority Habitats and Species (PHS) Program. Their limited distribution in Washington makes this species vulnerable to extirpation (Viola and Foster, 2001).

The pygmy whitefish, a remnant of the last ice age, typically resides in deep, cold, oligotrophic lakes and streams of mountainous regions. Throughout most of the year it inhabits deep water. This small, delicate fish is therefore at risk of being consumed in Lake Chelan by lake trout and landlocked chinook. Lake dwelling pygmy whitefish enter shallow littoral zones to spawn during late summer to early winter and during this period are at risk of being consumed by smallmouth bass, adult rainbow trout, cutthroat trout and northern pikeminnow (Viola and Foster, 2001).

Kokanee

Kokanee (landlocked sockeye salmon) became the mainstay of the Lake Chelan fishery shortly after they were introduced in 1917. Catch rates of kokanee have varied considerably since 1940, when angler records were first available, and vary with both management actions and natural phenomena. Catch rates were highest (about 3.0 kokanee per hour) in the mid-1940s when the hatchery outplants were large. They were lowest in the 1950s and the 1980s. In the early 1950s, catch rates were less than 0.1 fish per hour. This was probably a combined result of the catastrophic floods of 1948 and 1949 and the reduction in hatchery production. The population rebounded through the 1960s and 1970s (catch rates reached about 2.0 kokanee per hour) but then dropped to less than 0.1 fish per hour in the 1980s. This was likely a result of the introductions of landlocked chinook salmon, a predator of kokanee, and Mysis shrimp, which are believed to compete with kokanee for food. In the 1990s, catch rates varied from 0.12 fish per hour to 0.338 fish per hour, depending on the season sampled (FERC, 2001, section 5.3.3.1a). Currently, kokanee predators include lake trout and chinook, in addition to sport anglers (Foster and Viola, 2001).

Rainbow trout

Introduced to Lake Chelan in 1917, rainbow trout have provided a consistent fishery for the past several decades. The rainbow trout fishery enhancement increased after 1990 when Chelan PUD began funding a program to release catchable-size rainbow trout into Lake Chelan. The larger fish were intended to provide immediate benefits to the sport fishery, with the potential to allow some overwinter survival for harvest of larger fish in the following years. Rainbow trout would also provide a longer fishery in the lower lake (May through September) in comparison to kokanee (May and June) (FERC, 2001, section 5.3.3.1a).

Studies by Hagen (1995) indicate that the sport fishery effectively harvested hatchery fish during their year of release and that only about 8 - 10 percent of the released hatchery rainbow

trout survived over winter to contribute to the following year's fishery (FERC, 2001, section 5.3.3.1a). A portion of the hatchery-reared rainbows stocked into Lake Chelan have been exiting the lake and entering the Columbia River (J. Osborn, Chelan PUD, 9/2/99, memo on Lake Chelan Hydro Fish Stranding Survey).

Landlocked chinook salmon

Beginning in 1974 and annually through 1978, the WDF (now WDFW) introduced landlocked chinook salmon into the lake. The objective was to provide a trophy fishery for Lake Chelan. Residing deeper in the water column and piscivorous in nature, they provide a different sport fishery from either kokanee or rainbow trout (Chelan PUD, 1998, p. E3-9). Some landlocked chinook have established adfluvial populations and spawn in the Stehekin River, Company Creek and Blackberry Creek. In the years following the introduction of landlocked chinook salmon, the kokanee and landlocked chinook populations (based on spawner counts) have suggested a typical predator-prey relationship (Fielder, 1999 [in] FERC, 2001, section 5.3.3.1a).

The first year of the landlocked chinook salmon fishery in 1975 consisted entirely of small immature fish. Fishery managers examined gut contents and found the hatchery landlocked chinook fed primarily on aquatic and terrestrial insects (WDFW, 1976). Over the next few years, creel surveys indicated anglers caught fish weighing 2 kilogram (kg), with larger fish reaching 6 kg (Brown, 1984). This indicated good early growth of the initial plants, but by 1978 growth rates decreased considerably. Concurrent with the rapid early growth of the landlocked chinook in the initial plants was the collapse of the kokanee population, which appeared to be rebuilding prior to the introduction of landlocked chinook (Brown, 1984). The original landlocked chinook stocking program was terminated in 1979. All hatchery-reared chinook juveniles released are marked by fin-clipping, and catches indicate hatchery chinook are not contributing to the sport catch (FERC, 2001, section 5.3.3.1a).

The landlocked chinook population has remained at low levels in recent years but has been a very popular sport fishery nonetheless. In response to requests by sport fishers, WDFW re-established the hatchery outplants in 1990. Based on a 1993 creel survey, catch per unit effort (CPUE) remains low (0.02 fish per hour; Hagen, 1995). In 1999, average catch per hour was 0.008, ranging from a high of 0.020 fish per hour in the Lucerne Basin to a low of 0.003 in the Wapato Basin (DES, 2000a). However, the CPUE for fishermen stating their target species was landlocked chinook was much higher, at a rate of 0.049 fish per angling hour (FERC, 2001). In 1995, flooding of the Stehekin River severely diminished juvenile chinook production, subsequently reducing the sport harvest (Viola and Foster, 2001).

Lake trout

Often called mackinaw, lake trout were introduced to Lake Chelan in 1980 by fishery managers, believing they would be a better top-level predator than landlocked chinook. Lake trout are longer lived than landlocked chinook and have successfully exploited Mysis shrimp and kokanee populations in lakes where one or both have been introduced. Like landlocked chinook, however, they require an abundant food base to achieve a large size for a trophy fishery. Lake trout have become very popular as a trophy sport fish in Lake Chelan due to the increase in individual fish size and decrease in the landlocked chinook population (DES, 2000a). The Washington state record lake trout (33.65 lb.) was caught from Lake Chelan on August 9, 2001 (Spokane Mirror,

August 15, 2001). The previous record-size lake trout was also from Lake Chelan. Stocking of lake trout has now been discontinued. Recently, natural production of lake trout has been confirmed in Lake Chelan (FERC, 2001, section 5.3.3.1a).

Smallmouth bass

Smallmouth bass were illegally stocked into Lake Chelan sometime in the 1990s. Since then, these fish have responded well to conditions in the lake, and a population of bass is now present in the limited shallow littoral area of southerly Wapato Basin. Smallmouth bass, a species favoring rocky shorelines, is likely limited in the lake by the mostly steep underwater topography (Viola and Foster, 2001).

Mysis shrimp

Mysis shrimp were transplanted into Lake Chelan from Kootenay Lake, B.C. in 1968, 1969 and 1971 (1.5 million total) and were firmly established by 1975. The Mysis were transplanted to provide a large food organism for kokanee. The intent was to produce larger kokanee for that sport fishery. Kokanee size increased, but the total population decreased, clouding any relationship between the Mysis shrimp food source and kokanee (FERC, 2001, sect. 5.3.3.1a).

Mysis shrimp in Lake Chelan have a life cycle of 15 to 18 months, the young being produced in midwinter and the parent year class disappearing about the end of June as the oncoming brood approaches 8-10 mm in length. Their growth (measured as length) is nearly linear throughout their life cycle, with faster growth occurring in summer. Analysis of growth rates of Mysis shrimp in Lake Chelan indicate that their growth is not food limited (Brown, 1984). Modal size of mature Mysis shrimp is 18 mm, with a range of 8-22 mm (Brown, 1984). As in other oligotrophic water bodies, Mysis shrimp exhibit daily vertical migrations that are influenced by both light and temperature. In general, Mysis shrimp remain deeper than 46 meters during the day and deeper than the 18º C thermocline at all times (Brown, 1984 [in] FERC, 2001, sect. 5.3.3.1a).

Brown (1984) found the density of Mysis shrimp in Lake Chelan during the 1981 and 1982 sampling period was 0.56 to 1.62 Mysis/m^3. This is considerably lower than found in other oligotrophic lakes, such as Lake Pend Oreille (Idaho) and Lake Tahoe (California/Nevada) (FERC, 2001, sect. 5.3.3.1a).

The population of Mysis shrimp has increased nearly fourfold since 1982, and their predation on larger zooplankton has likely shaped the zooplankton community to favor smaller organisms such as Cyclops bicuspidatus thomasi (DES, 2000a). Though cyclops is abundant, relative to other zooplankton, it is not a preferred prey item for kokanee or rainbow trout. Consequently, the sparse density and the shift to less preferred prey species has created a zooplankton community unable to provide adequate forage for kokanee, cutthroat trout or rainbow trout. In addition, because of negative phototaxis exhibited by Mysis (it moves away from light), it is not available as forage when kokanee feed. Lake trout, however, and possibly landlocked chinook salmon, may use Mysis as a food source that could lead to higher survival rates of juvenile lake trout and, consequently, higher predation on the kokanee, rainbow trout and cutthroat trout populations (FERC, 2001, sect. 5.3.3.1a).

Other species

Over the years, other species of fish have been introduced into Lake Chelan, either by management agencies or illegally by individuals. The WDFW planting records also indicate that sockeye salmon, Kamloops strain of rainbow trout, brook trout, and grayling have been planted into Lake Chelan at one time or another. Incidental catches of bluegill and other species have also been reported (FERC, 2001).

The lake also has abundant populations of "non-game fish": northern pike minnow, red side shiner, and peamouth. During summer, fish biomass in the lower basin is most likely greater than 90 percent coarse fish (Brown 1984 [in] Viola and Foster, 2001).

Tributaries

Note: This section is taken entirely from FERC, 2001, section 5.3.3.1.

One of the goals of fisheries investigations undertaken for the Lake Chelan Project relicensing application was to determine the efficacy of the kokanee, cutthroat, and rainbow trout stocking/hatchery programs in terms of contribution to Lake Chelan spawning populations of these species (DES, 2000a). In 1999, an assessment of the salmonid population was made by electrofishing in each of eight selected study streams and identifying and analyzing the species found (see "Existing and Past Efforts, Chelan PUD, Tributaries" section). Electrofishing was not conducted in Railroad Creek due to the continued high flows that made electrofishing conditions inefficient and unsafe.

Rainbow trout were captured during two samplings on the same day in each of the selected tributaries. Cutthroat were captured in Grade, Safety Harbor, Prince and Fish creeks. Six brook trout were captured in Twentyfive Mile Creek. The results of the electrofishing study are listed in Table 5.

Table 5. Electrofishing results and estimated population statistics for all trout in 8 tributaries

				Estimated Population				
Creek	Sample 1	Sample 2	Total Catch	100 Meter	1/4 Mile (402.3m)	1999 per km	Brown (1984) per km	percent 1999:1984
First	35	14	49	58	235	583	1552	37.6
Mitchell	68	43	111	185	744	1850	800	231.2
Gold	32	17	49	68	275	683	4927	13.9
Grade	59	32	91	129	268[1]	1289	2060	62.6
25 Mile	51	31	82	130	523	1301	2430	53.5
Safety	47	27	74	111	444	1105	3440	32.1
Prince	42	29	71	136	546	1357	3820	35.5
Fish	21	10	31	40	161	401	1932	20.8

Source: DES, 2000a

[1] Only 211 meters (1/8 mile) are available to adfluvial fish, so fish population is estimated for that distance.

A comparison to the results from Brown (1984) shows that the population of trout in the selected tributaries was lower in 1999, with the exception of Mitchell Creek. The population of trout in Mitchell Creek was 2.3 times higher in 1999 than reported by Brown (1984). From 1992 to 1994, the USFS constructed a number of fish habitat enhancement structures in Mitchell Creek and improved the riparian community along the creek, which likely has contributed to the increase in the fish population (see "Existing and Past Efforts, Other Entities" section). Other than Mitchell Creek, it is difficult to determine a direct cause for the difference in fish populations found in the other creeks due to a number of variables in both the environmental conditions and data collection methodologies.

Snorkeling surveys were done in 8 selected tributaries in 1999 and in 9 tributaries in 2000, in spring, summer, and fall, to determine fish presence and use at the creek mouths and in the lower reaches of the streams, in particular by adult adfluvial trout and rainbow trout for staging upstream migration.

Bridgelip or largescale suckers were the dominant species observed at the creek mouths in both years. These fish appeared to be feeding on material washed out by the creeks. In April, a night snorkeling survey was conducted at First and Twentyfive Mile creeks to compare daytime and nighttime use. Juvenile northern pikeminnow were observed on these surveys. In July, snorkeling was conducted at the creek mouths and for a distance upstream. Large numbers of suckers were observed in pools in the creeks. These fish were assumed to be migrating upstream to spawn. Large adult rainbow and cutthroat trout were observed in Prince Creek in July of 1999. In 2000, resident trout were observed in all nine study streams and adfluvial trout were observed in First, Grade, Twentyfive Mile, Safety Harbor, Prince and Railroad creeks. Based on their size, these fish were believed to be adfluvial fish migrating upstream to spawn (FERC, 2001). Twentyfive Mile Creek is known to support a robust self-sustaining population of introduced brook trout (*Salvelinus fontinalis*) (WNF 1989 and 1998 [in] USFS, 1999a).

Natural production of trout in the study tributaries to Lake Chelan is limited primarily by the scarcity of spawning habitat and possibly by species interactions. Cobbles and boulders

dominate substrate in the study streams, with very little appropriately sized gravel for trout spawning. Historically, the Lake Chelan population of native cutthroat trout began spawning in early May and continued through June. The timing of trout spawning appeared to be delayed in 1999 by the high stream discharge in the tributaries due to the high snowpack, based on back-calculating time of emergence (DES, 2001b). With the exception of Mitchell and Railroad creeks, spawning timing for the year 2000 was estimated to occur within the historical period (DES, 2001a).

Researchers estimated that trout spawned from June 10 through August 10 in 1999, with a majority spawning in July. In 2000, trout spawning was estimated to occur from April 30 through August 12, with most trout spawning during June and July. During the snorkeling surveys, large numbers of suckers (most likely bridgelip sucker) were observed in the stream channels spawning in June and July. The fish were in spawning condition, with bright orange lateral bands on their sides. The spawning timing of both adfluvial and resident trout appears to coincide with sucker spawning, and competition for spawning habitat may occur. Bridgelip suckers broadcast spawn over rocky substrate ranging in size from gravel to cobbles (Dauble, 1980). Since spawning substrate is limited in the stream channels, the bridgelip sucker, which is a larger and more numerous fish, may push the trout further upstream or into less favorable spawning habitat. In addition, the emergent sucker fry may compete with the emergent trout fry for food. The increased competition for spawning and rearing habitat will diminish natural production of trout.

Kokanee spawning surveys have been conducted annually in five tributaries to Lake Chelan, and in five additional tributaries intermittently, since 1984. These five primary tributaries contain the majority of the kokanee spawning in the Lake Chelan drainage and include: First Creek, Twentyfive Mile Creek, Safety Harbor Creek and two tributaries of the Stehekin River: Company and Blackberry creeks. Landlocked chinook salmon spawners are also recorded during the kokanee spawning surveys. Landlocked chinook spawning has been documented only in Company Creek, Blackberry Creek and the Stehekin River.

Spawning surveys from 1990 through 2000 show that kokanee runs are much higher than have been seen since intensive surveys of those spawning streams started in 1981 (Fielder, 2000). From 1984 through 1995, kokanee escapement in streams surveyed rarely exceeded 40,000 spawners. However, in 1996 and 1997, over 54,000 and 67,000 spawners, respectively, used the spawning streams. In 1999, the total estimated numbers of kokanee spawners (excluding spawning in the mainstem Stehekin River) exceeded 101,000 fish, which is the highest count on record (Fielder, 1999) and the escapement of 90,700 kokanee spawners in 2000 was nearly as high (Fielder, 2000). Company Creek and Blackberry Creek, both tributaries of the Stehekin River, support most of the kokanee spawning within the drainage, frequently upward of 95 percent since 1990.

Chelan River/bypassed reach and Lake Chelan Project tailrace

Note: this section is from Chelan PUD, 1998, p. E3-10 – 11.

Because the bypassed reach is dry most of the time, there are no fish populations that propagate and persist there.

The tailrace contains populations of fish that enter from the Columbia River. Sports anglers are commonly found fishing the tailrace area, with smallmouth bass most often the target species. Several native fish species have been observed by Chelan PUD biologists congregating on the alluvial fan where the tailrace, the bypassed reach of the Chelan River and the Columbia River converge. Suckers have been observed spawning in the spring. Summer or fall chinook salmon spawn on gravel in this area in the fall. The gravel and flow conditions also are appropriate for native cyprinid fishes, such as chiselmouth chub, peamouth chub and northern squawfish. Large schools of these fish have also been observed in the confluence of the Columbia and Chelan rivers.

Redd counts of chinook spawning on the alluvial fan at the end of the tailrace and in the confluence of the Chelan and Columbia rivers have increased from the 16 - 69 redds per year between 1981 and 1990 (Chelan PUD 1991) to over 200 in 2000 (Jeff Osborn, Chelan PUD, personal communication, 9/25/01). Spawning occurs in October when water temperatures have declined to below 60 degrees F. The spawning locations, velocity, depth and substrate preferences for chinook salmon spawning in the tailrace under conditions present in 1990 and 1991 were reported by Giorgi (1992). While the factors that characterize preferred spawning habitat have not changed, major spill events in the bypassed reach subsequent to 1995 have changed the spawing locations to a broader area than documented by Giorgi. Giorgi reported that a fall/winter flood in 1990 deposited several feet of bedload material on top of redds he had marked that fall, which were located on the steep edge where the alluvial fan of the bypassed reach spilled into a deep channel at the end of the tailrace. The spills subsequent to 1990 were higher flow events that deposited large amounts of bedload material in the tailrace and into the Columbia River, completely filling the deep channel surveyed by Giorgi. The filled channel now provides suitable velocity, substrate and depth across the full width of the river where the tailrace and bypassed reach converge. A few redds have also been observed in the Columbia River on the new bar formed during the flood events subsequent to 1990.

The tailrace area affords limited habitat and food organisms for juvenile fish. The fish present in the tailrace are likely transient residents that depend on the ecosystem of the Columbia River for food, cover and other habitat needs for most life stages. The high quality of gravel and consistent flow regime from the powerhouse discharge are probably the reasons this area is heavily used by spawning fish of species that need areas of gravel with flowing water for spawning habitat. Juveniles resulting from this spawning activity would use the Columbia River for rearing and feeding. The presence of adult smallmouth bass in the tailrace is related to their preference for the warmer summer and winter temperatures found in the water from Lake Chelan than is present in the Columbia River.

Wildlife

A number of documents contain comprehensive lists of terrestrial species that occupy various parts of the Lake Chelan basin (Chelan PUD, 1998; USFS, 1998; FERC, 2001). This summary

focuses on species that are important as: 1) typical of major functional groups found in major habitats in the basin; 2) game species; and/or 3) as species in decline and listed on key state or federal lists.

Species typical of major basin habitats

Figure 5 shows major wildlife habitat types. The following is not a comprehensive list of species that occupy each habitat, but rather a list of functional types (e.g., raptor, ungulate, terrestrial predator, small mammal, non-charismatic micro-fauna, primary cavity excavator) that are typical of that habitat (Mallory Lenz, USFS, pers. comm., 9/10-11, 2001).

Grassland: Ferruginous hawk, bighorn sheep, badger, coyote or wolf, Chelan Mountain snail.

Shrub steppe: Ferruginous hawk, mule deer, wolf.

Ponderosa pine forest: Flammulated owl or great horned owl, white-headed woodpecker, mule deer, wolf or grizzly bear, western gray squirrel.

Mixed conifer closed canopy forest: Goshawk or spotted owl (depending on area), northern 3-toed woodpecker, mule deer, marten or fisher, bushy tailed woodrat, Douglas squirrel.

Cliff: Peregrine falcon, mountain goat, cougar.

Lodgepole pine: Goshawk, snowshoe hare, lynx.

Subalpine/alpine: Goshawk or peregrine falcon, mountain goat, wolverine, pika.

Riparian: Beaver, ruffed grouse.

Important game species

In the Lake Chelan basin, WDFW manages the following species for game: mule deer, mountain goats, bighorn sheep, black bears, cougars, and Rio Grande wild turkeys (an introduced species).

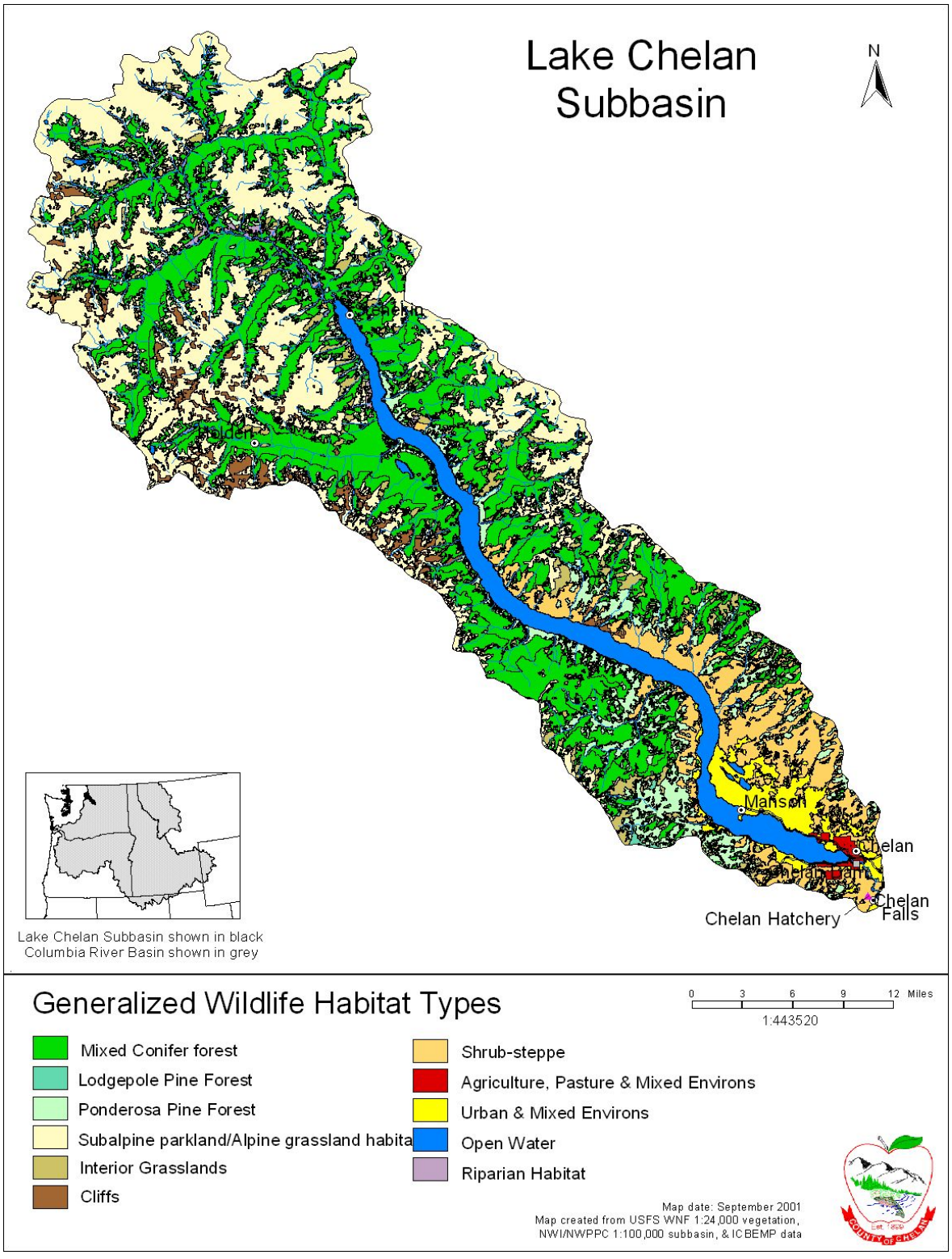

Figure 5. Wildlife habitat types in the Chelan Basin

Threatened, endangered, and sensitive species

Chelan PUD conducted a search of state and federal databases and consulted with resource agencies regarding the presence of threatened and endangered species within the project area. Their research identified 39 wildlife species, known to potentially occur in the study area, that have federal or state status (letter from Kurt R. Campbell, Supervisor, USFWS, Moses Lake Field Office, Moses Lake, Washington, to Steve Bondi, EDAW, Inc., Seattle Washington, dated May 1, 1998; letter from Lori Guggenmos, Cartographer, WDFW PHS [Priority Habitat Species], Olympia, Washington, to data requesters, dated May 15, 1998). Five federally listed threatened or endangered wildlife species were identified by the USFWS as potentially occurring in the vicinity of the Lake Chelan Project (letter from Kurt R. Campbell, Supervisor, USFWS, Moses Lake Field Office, Moses Lake, Washington, to Steve Bondi, EDAW, Inc., Seattle, Washington, May 1, 1998 [in] FERC, 2001, p. 101).

Table 6 lists species listed as Threatened, Endangered, Candidate, or Species of Concern (SC) under the Endangered Species Act (ESA); as Management Indicator Species (MIS) or Regional Forester's Sensitive Species (SS) for the Wenatchee National Forest (WNF); and on State of Washington lists (PHS and Heritage Database). (Note: the original table came from FERC, 2001, Table 14, p. 102-103, but was modified by combining results of a recent query of the state lists and information from USFS on MIS species. Any inaccuracies are the result of changing status and data and the editor's excessive zeal in wanting to show it all.) Following the table are brief descriptions of some key species from the various categories.

Table 6. Specially designated wildlife species in the Lake Chelan basin

Common Name	Scientific Name	Federal Status	State Status
Bald eagle	*Haliaeetus leucocephalus*	T	T
Beaver	*Castor canadensis*	MIS	
Bighorn sheep	*Ovis canadensis*	SS	Priority Species
Black-backed woodpecker	*Picoides arcticus*		Candidate
Canada lynx	*Lynx canadensis*	T; SS	T
Cascades frog	*Rana cascadae*	SC	
Columbia spotted frog	*Rana luteiventris (= Rana pretiosa, eastern population)*	Candidate	Candidate
Common loon	*Gavia mimer*		Sensitive
Ferruginous hawk	*Buteo regalis*	SS	
Flammulated owl	*Otus flammeolus*		
Golden eagle	*Aquila chrysaetos*		Candidate
Gray wolf	*Canis lupus*	E	E
Grizzly bear	*Ursus arctos*	T	E
Lewis' woodpecker	*Melanerpes lewis*		Candidate

Table 6. Specially designated wildlife species in the Lake Chelan basin

Common Name	Scientific Name	Federal Status	State Status
Little willow flycatcher	*Empidonax traillii brewesteri*	SC	
Loggerhead shrike	*Lanius ludovicianus*	SC	
Marten	*Martes americana*	MIS	Priority Species
Mountain goat	*Oreamnos americanus*	MIS	Priority Species
Mule deer	*Odocoileus hemionus hemionus*	MIS	Priority Species
Northern goshawk	*Accipiter gentilis*	Candidate	Candidate
Northern three-toed woodpecker	*Picoides tridactylus*	MIS	
Northern sagebrush lizard	*Sceloporus graciosus graciousus*	SC	
Northern spotted owl	*Strix occidentalis caurina*	T	E
Olive-sided flycatcher	*Contopus borealis*	SC	
Pacific Fisher	*Martes pennanti pacifica*	Candidate	E
Peregrine falcon	*Falco peregrinus*	SS	
Pileated woodpecker	*Dryocopus pileatus*	MIS	Candidate
Rocky Mt. Elk		MIS	
Ruffed grouse	*Bonansa umbellus*	MIS	
Swainson's hawk	*Buteo swainsoni*	SS	
Tailed frog	*Ascaphus truei*		Candidate
Townsend's big-eared bat	*Plecotus townsendi*	SS	
Western gray squirrel	*Sciurus griseus griseus*	Candidate	T
White-headed woodpecker	*Dendrocopus albolarvatus*		Priority Species
Wolverine	*Gulo gulo luscus*	SC; SS	
Yuma myotis	*Myotis yumanensis*	SC	

E - Endangered; T - Threatened; SC - Species of Concern; MIS - Management Indicator Species or SS - Regional Forester's Sensitive Species for the Wenatchee National Forest (WNF)

Bald eagle (Threatened—ESA and State)

Bald eagles use Lake Chelan during the winter months, primarily between mid-November and early March. Since 1982, the WDFW has conducted bald eagle surveys every two weeks during this period every year. Bald eagle populations were reduced due in part to loss of snags when lake levels were raised for the Lake Chelan Hydroelectric Project; and could continue to be affected by fish containing DDT in their tissues. During the past five years, peak counts have ranged from six in 1993-94 to 29 during the 1996-97 survey. On average, 2.6 bald eagles have been observed per survey (FERC, 2001, p. 101). The 1986 federal recovery plan administered by

U.S. Fish and Wildlife Service (USFWS) (USFWS 1986 identified a recovery goal of 20 bald eagle territories in the recovery zone (6) that includes the Lake Chelan Project. That goal has been met: there were 34 occupied territories in the zone in 1997 (pers. comm., John Grettenberger, USFWS, Olympia, Washington, May 22, 1998 [in] Chelan PUD, 1998, p. E3-67).

Bighorn sheep (Regional Forester's Sensitive Species, Washington Priority Species)

Bighorn sheep were reintroduced to the north shore of Lake Chelan in March of 1999. Ten ewes and a yearling ram were obtained from Lincoln Cliffs and two 3-year-old rams were obtained from Quilomene for the Chelan reintroduction. A helicopter survey in June found two lambs, in addition to ten ewes and one adult ram (WDFW, 1999). WDFW conducted a survey on June 9, 2001, and counted 44 sheep (32 ewes, 10 lambs, and 2 rams) between Mitchell Creek up-lake to Deer Point. The number of lambs was up from the 7 counted in the 2000 survey. The estimated 24% predation rate (6 of 25 collared sheep lost) is similar to the rate for collared deer in Chelan County (*Lake Chelan Sportsman's News*, July 2001). Loss of grassland to development, and its replacement by bitterbrush and shrubs, has reduced bighorn populations while favoring mule deer.

Canada lynx (Threatened—ESA and State; Regional Forester's Sensitive Species)

The lynx is the rarest of three cat species native to Washington, probably numbering fewer than 100 individuals in the state (Stinson, 2001). Lynx occupy subalpine fir and lodgepole pine forests. In Chelan County, they occur in favorable habitats above 4,500 feet (1,000 meters) elevation (WDFW, 1991). The Canada lynx is reproducing in the basin (50 CFR 17, March 24, 2000) (FERC, 2001, p. 102; M. Lenz, USFS, pers. comm., 9/11/01).

The lynx depends on a small number of prey species, particularly the snowshoe hare, for its survival. This dependency is thought to influence lynx population dynamics (WDFW, 1991), although the 10-year cycle has not been clearly demonstrated in Washington (Stinson, 2001). During times of hare abundance, lynx reproduction is high, mortality is low, and densities are high; during times of low hare abundance, lynx reproduction is low, mortality is high, and densities are low. This dependency also influences lynx home range size, as they must increase movement when hare densities are low (WDFW, 1991). Some may immigrate from populations in Alberta and British Columbia. Lynx populations are also affected by forest management, fire and fire suppression, insect epidemics, and lynx management in British Columbia (Stinson, 2001).

Gray wolf (Endangered—ESA and State)

The gray wolf, a wide-ranging species, has been slowly re-establishing populations in the North Cascades. After years of relatively few sightings, a den was documented in North Cascades National Park in the late 1980s. Since then, the number of known dens and gray wolf observations has increased throughout the North Cascades (FERC, 2001, p. 101-102).

Grizzly bear (Threatened—ESA; Endangered--State)

The WDFW PHS database has three records of grizzly bear sightings in the region, all distant from Lake Chelan (letter from Lori Guggenmos, Cartographer, WDFW PHS, Olympia, Washington, to Chelan PUD, dated May 15, 1998). Currently, this area (approximately 10,000

square miles) probably supports fewer than 20 grizzlies, and only one sighting of an adult grizzly and cub near Moore Point has been reported since 1991 (Almak et al., 1993 [in] in FERC, 2001, p. 102).

Mule deer (Management Indicator Species—WNF; Washington Priority Species)

Mule deer require the juxtaposition of food, cover, and water. Areas without water available within 1 mile (1.6 km) show decreased use. Deer use cover both to hide and to regulate temperature. They feed primarily on shrubs such as bitter brush, except in spring, when they prefer herbaceous materials. Summer and winter ranges are most often geographically separate (WDFW, 1991).

The 1994 Tyee fire removed much of the deer winter browse in the Chelan PMU (Population Management Unit). Recovery from the fire has been slow. In addition, the winter of 1996-97 was severe. As a result of lost habitat and winter weather, the deer population within the Chelan PMU is low. Mild winters will allow this population to rebuild, but until shrub communities re-establish on winter range, this population will not reach pre-fire levels (WDFW, 1999).

Mountain Goat (Management Indicator Species—WNF; Washington Priority Species)

Mountain goats use steep, high-elevation habitats on both the north and south shores of Lake Chelan. Goats winter at lower elevations along the lake to avoid deep snow; they seek higher elevations for summer range where forage conditions are better. From 1982 to 2001, Chelan PUD had conducted 12 surveys per year along Lake Chelan between November and March as part of its hydropower license (WDFW, 1999). Current population is approximately 100 animals, down from an estimated 550 in 1961 (T. McCall, WDFW, 9/20/01).

Table 7 shows population composition and levels 1989 – 1998. The population has been relatively stable on average at 115 animals per year since the early 1980s, but is below the population objective of 150 animals. Although goat hunting was suspended in 1980, the population has not increased.

Table 7. Mountain goat population, Lake Chelan area, 1989-1998

Year	Kids	Adults	Population	Estimate K:100[1]
1989	29	112	141	26:100
1990	18	98	116	18:100
1991	27	155	185	17:100
1992	16	88	104	18:100
1993	13	92	105	14:100
1994	25	98	123	26:100
1995	12	109	121	11:100
1996	7	47	70	15:100
1997	18	105	124	17:100
1998	17	88	105	19:100

[1] K:100 = kids per 100 adults

Northern spotted owl (Threatened—ESA; Endangered--State)

Based on the WDFW PHS database, six spotted owl territories occur in the vicinity of Lake Chelan. Two territories exist at the western end of Lake Chelan and include portions of the lake and shorelines and the Stehekin River. Three of the four remaining territories occur south of the lake between Domke Lake and Lake Chelan State Park; the fourth is in the western part of the basin (FERC, 2001, p. 101).

Pacific fisher (Candidate—ESA; Endangered—State)

Fishers inhabit dense coniferous and mixed coniferous/deciduous forests with extensive, continuous canopy. They use riparian areas, ridgelines, and lake shores in and adjacent to forests for foraging and as movement corridors. They feed on a variety of small to medium-sized mammals and birds, and on carrion (WDFW, 1991).

Pileated woodpecker (Management Indicator Species—WNF; Candidate—State)

Pileated woodpeckers inhabit mature and old growth forests and second growth forests with significant numbers of large snags and fallen trees. East of the Cascades, preferred tree species are western larch, ponderosa pine, and black cottonwood. These birds feed mainly on carpenter ants, beetle larvae, and other insects. Snags take on special importance in winter for roosting and foraging when logs and stumps may be covered with snow. Pileated woodpeckers may excavate large rectangular holes during foraging that may be used by smaller birds for nesting and roosting (WDFW, 1991).

White-headed woodpecker (Washington Priority Species)

Primarily birds of mature ponderosa pine forests, white-headed woodpeckers require large, decayed snags and forage mainly on large ponderosa pines in the puzzlebark stage (> 24”). They

prefer insects on the scaly bark of trees and, during winter, feed heavily on seeds from unopen pine cones. Ponderosa pine does not produce heavy seed crops until 60-100 years of age.

Little information is available on the nesting ecology of this bird. Breeding season is from mid-April to early August. It excavates cavities in dead or dying trees, with a preference for ponderosa pine. This species has low versatility because of its primary association in Washington with limited forest types and stand conditions (WDFW, 1991).

Habitat Areas and Quality

Water Quality

Lake Chelan is characterized as ultra-oligotrophic (low biological productivity and high water clarity) and is considered one of the most pristine water bodies in North America. There have been a number of water quality studies conducted in the Chelan Basin. Periodic monitoring of the water quality of Lake Chelan began in the 1960s, and the first detailed baseline water quality characterization of the lake was completed in 1987. The results of this baseline study, two subsequent comprehensive studies and 1999 field studies are summarized in Table 3 in FERC, 2001 but are not reproduced here. The FERC table lists summary statistics for various water quality parameters that were measured in 1987 (Patmont et al., 1989); in 1995 (Congdon, 1995); in 1996 (Sargeant, 1997); and in 1999 (Anchor, 2000).

Maintenance of the ultra-oligotrophic status of Lake Chelan, with its extremely high clarity, has been a major focus of programs to maintain water quality. Management of nutrient loading to the lake is a critical component. The biological productivity of the lake is phosphorous-limited (Patmont et al., 1989). Levels of chlorophyll *a*, zooplankton, and benthic organisms have been reported as quite low, particularly in the Lucerne basin (FERC, 2001). The Wapato Basin contains most of the developed land in the watershed and contributes a proportionally greater percentage of the total nutrient and bacterial loading to the lake (Anchor, 2000).

Documented water-quality deficiencies in the lake have included elevated bacterial levels near water supply intakes, elevated metals (iron, zinc and arsenic) in Railroad Creek due to runoff from abandoned contaminated tailings at the Holden Mine, and elevated pesticide residues in lake sediments and fish populations. There also have been releases of pesticides, especially DDT, and polychlorinated biphenyls (PCBs) into Lake Chelan. In 1998, Lake Chelan was listed as an Impaired and Threatened Water Body due to the detection of elevated concentrations of DDT metabolites and PCBs in fish tissues (WDOE, 1998). The historical reservoir of DDT present in sediment deposits of the lake appears to be at least partially responsible for elevated DDT metabolite concentrations detected in fish tissues (Davis and Johnson, 1994; Davis and Serdar, 1996). These levels are expected to decrease slowly over time as a result of natural sedimentation processes (FERC, 2001).

In 1993, the Environmental Protection Agency (EPA) approved a total maximum daily load (TMDL) for phosphorous in Lake Chelan. This TMDL was established at the threshold for maintaining the ultra-oligotrophic condition of the lake. The Lake Chelan Water Quality Committee (LCWQC) coordinates with local agencies and the public to implement protective measures. The LCWQC is composed of five local agencies and the USFS, who jointly prepared a

Lake Chelan Water Quality Plan (R. W. Beck, 1991) to provide a framework to maintain and monitor water quality (FERC, 2001).

Temperatures in Lake Chelan range seasonally from 2° C to 23° C at the surface. Both basins in Lake Chelan develop a seasonal thermocline at an average depth of 100 to 150 feet during the summer (R.W. Beck, 1991). Summer surface temperatures in the Wapato Basin reach 23° C, while summer temperatures in the upper portions of the Lucerne Basin average 15 - 16° C. Deep-water temperatures in both basins average 5 - 6° C throughout the year. Surface temperatures in the Wapato Basin are cooler in winter than in the Lucerne Basin due to the smaller volume (and therefore lower heat retention capacity) of the Wapato Basin (FERC, 2001).

Figure 6 shows streams listed on Environmental Protection Agency's (EPA's) 303d list for impaired water quality due to dissolved oxygen and pH levels.

When there is water in the bypassed reach, its temperature is determined by water temperatures in the lower end of Lake Chelan. Near-surface water from the lake enters the Chelan River as it flows over a shallow sill at the outlet of the lake. Temperatures in the bypassed reach cover the same range as the surface waters of the lake: 2º C during the coldest period of winter to 23º C during the hottest days of summer. Water flowing through the penstock and discharged from the powerhouse into the tailrace is neither cooled nor heated in transit. Water spilled into the bypassed reach is subject to both cooling and heating effects. The degree of heating and cooling is primarily a function of the total flow (mass volume) released through the bypassed reach, the width-to-depth ratio of the river sections, the difference between the initial water temperature and the air temperature, and solar radiation. A small amount of ground water, about 2 cfs, enters the bypassed reach in the steep areas within the gorge, but the cooling effect of this flow is negligible except at low flows of less than 100 cfs (Chelan PUD, 2000).

Figure 6. EPA 303d Water Quality Listings

Vegetation

Except where noted, the information in this section comes from Chelan PUD, 1998, section E3.2.1.1.

With annual precipitation ranging from 11 inches at the City of Chelan to over 150 inches on the Cascade crest, the Lake Chelan Basin includes a diversity of life zones and a variety of plant and animal species. The basin is characterized by six primary vegetation zones: *Pinus ponderosa, Pseudotsuga menziesii, Abies grandis, Pinus contorta, Abies lasiocarpa*, and *Artemisia tridentata/Agropyron spicatum* (Franklin and Dyrness (1973).

The *Pseudotsuga menziesii* (Douglas fir) zone dominates most of the project area, extending from lakeshore to about the 4,000 foot elevation, where it blends into the *Abies grandis* (grand fir) and subalpine forest zones. The Douglas fir zone occurs along the upper 3/4 of the lake and along the Stehekin Valley. The major tree species in the zone are Douglas fir, ponderosa pine, lodgepole pine, and larch. Any of these four tree species may dominate forest stands in the Douglas fir zone. Douglas fir is the climax species, but the other three tree species are better adapted to fires. Snowberry, spirea, and rose are dominant shrubs in the Douglas fir zone understory, and bluebunch wheatgrass and fescue are dominant grasses.

The southeastern portion of Lake Chelan is bordered by a mixture of ponderosa pine and steppe zones with agricultural crops intermingled. The ponderosa pine zone typically lies between the Douglas fir zone above it and the steppe zone below it. The ponderosa pine zone has a short growing season, minimal summer precipitation, summers with hot days and cool nights, and low winter temperatures, resulting in heavy snow accumulations. Within the Lake Chelan area, this zone is vegetated by ponderosa pine, Douglas fir, and in riparian bottoms, aspen and cottonwood. Common shrubs include bitterbrush, sagebrush, rose, ceanothus, and serviceberry. Dominant forbs and grasses are arrowleaf balsamroot, eriogonum, bluebunch wheatgrass, needle and thread, and recently, cheatgrass. Ponderosa pine forests often form a mosaic with steppe and shrub steppe communities in eastern Washington.

The steppe zone, at the foot of Lake Chelan to the Columbia River, is occupied by the *Artemisia tridentata/Agropyron spicatum* (big sagebrush/bluebunch wheatgrass) association. This association is generally composed of four vegetation layers: 1) shrub layer of principally big sagebrush, bitterbrush, and rabbitbrush, 2) a layer of perennial grasses dominated by bluebunch wheatgrass, 3) a layer of low growing grasses such as Sandberg bluegrass and cheatgrass, and 4) a surface crust of crustose lichens and mosses.

The forested and non-forested plant communities which are present today would have been present historically, though perhaps occupying more or less area historically. Frequent wildfires maintained and shaped the forested and shrub steppe portions throughout the Lake Chelan area, particularly before widespread fire suppression.

The climate of the upper portion of Lake Chelan has a strong maritime influence which is reflected in the diversity of species found within the dominant plant communities. A number of species more characteristic of the West Cascades are due to this maritime climatic influence (Taylor, 1985).

Several factors have altered the historic vegetation of much of the basin and thus, to varying degrees, the species that occupy it. These include: grazing, logging, mining, fires and fire suppression, farming, residential development, reservoir operation, and weed invasion. (The section on wildlife habitat briefly discusses the effects on wildlife of these activities.)

Fire is the dominant agent of change in this basin. Fire suppression has created unnatural vegetation patterns. Forested stand conditions on north/northeast facing slopes have a higher number of smaller (pole-sized) stems per acre of Douglas fir, lodgepole pine and ceanothus, causing the canopy to be more closed than would naturally have occurred. The bitterbrush component has increased on south/southeast facing slopes where grasses were more prominent than they are today (USFS, 1998).

Wetlands and Riparian Resources

(This section is taken from FERC, 2001.) Historically, riparian vegetation along the shoreline of Lake Chelan was concentrated in the few areas of relatively flat terrain on tributary alluvial fans, in the Stehekin area, and in a few scattered pockets near Manson. The basin is mostly steep-sided, due to its formation by glacial activity, and much of the shoreline is rocky, with little soil. The long and narrow basin results in heavy wave action during the frequently windy conditions, which limits the establishment of riparian vegetation along most of the shoreline.

The USFWS National Wetlands Inventory (NWI) maps detailing the Lake Chelan area indicate small, localized wetlands along lake tributaries. Pockets of wetlands are identified on the Stehekin River delta entering the lake and within the bypassed reach exiting the lake. Chelan PUD conducted a detailed riparian zone investigation in 1999 along eight focus tributaries and the bypassed reach. The final riparian zone investigation report provides the results of the investigation (DES, 2000d). Table 8 provides descriptions of the environmental setting and general conditions. According to the field investigations, conifer forest dominates the upper basin, and shrub steppe habitat prevails in the lower basin. The Stehekin River was the only site in the study area with emergent wetlands.

The riparian habitats along the eight Lake Chelan focus tributaries exhibited considerable variation. At one extreme, riparian habitat along Grade Creek occurs in a narrow and sparse band that is relatively isolated from similar habitats by site topography (steep canyon) and surrounding vegetation (shrub steppe). At the other extreme, the Stehekin River is situated in a relatively broad valley, is part of a long riparian corridor, and is surrounded by forests. Three primary factors influence the condition and extent of riparian habitats along the focus tributaries: (1) the drainage configuration; (2) the aspect of the drainage; and (3) the presence of human activities, including hydroelectric project operation.

Table 8. Environmental setting and general conditions at 8 focus tributaries and Chelan River

Study Area	Aspect	Regional Setting	Valley Configuration	Riparian Habitat
Chelan River	NW	Shrub steppe, open coniferous forest, cliffs, and urban areas.	Steep-walled gorge descends to a broad floodplain.	Sparse, deciduous trees and shrubs, mostly restricted to upper and lower reaches.
Mitchell Creek	SW	Shrub steppe with widely scattered conifers.	Narrow channel confined within a V-shaped valley with moderately steep slopes and some terraces.	Mostly narrow but typically dense deciduous tree and shrub habitats.
Grade Creek	SW	Shrub steppe with widely scattered conifers.	Narrow channel confined within a deeply incised canyon.	Sparse and narrow, limited to creek bank; mostly small deciduous trees.
Box Canyon	NE	Predominantly open coniferous forest with some shrub steppe.	Narrow channel with broad terraces confined within a steep-walled canyon.	Narrow riparian zone alongside incised creek bed; in places dense shrub habitats; deciduous forest occurs on terraces outside of riparian influence.
Big Creek	NE	Predominantly open coniferous forest with some shrub steppe.	Narrow channel confined within a narrow gorge; steep side slopes.	Narrow riparian zone along creek consisting mostly of mature western red cedar forest (small grove of deciduous trees at mouth).
Bear Creek	NE	Predominantly coniferous and mixed forest.	Narrow channel confined within a U-shaped valley with moderately steep slopes and some terraces.	Narrow riparian zone along creek consisting of dense shrub and deciduous tree habitats; adjacent areas of mixed forest occur on higher ground that is probably outside of riparian influence.
Prince Creek	SW	Open coniferous forest.	Moderately wide channel; V-shaped valley terminates in a broad alluvial fan.	Narrow riparian zone alongside creek consisting mostly of shrub-sized cottonwoods and willows, and occasional larger trees.
Fish Creek	W	Coniferous forest.	Moderately wide channel; V-shaped valley terminates in a broad alluvial fan.	Narrow bands of mixed forest and shrub habitats along main channel and overflow channels.

Table 8. Environmental setting and general conditions at 8 focus tributaries and Chelan River

Study Area	Aspect	Regional Setting	Valley Configuration	Riparian Habitat
Stehekin River	SE	Extensive coniferous and mixed forest, with scattered clearings; private residential developments and public recreation areas.	Wide alluvial channel within a broad U-shaped glacial trough with broad terraces.	Extensive riparian zone that includes stands of deciduous trees, scrub-shrub habitat, and emergent wetlands; riparian areas occur in bottomlands along the river channel, along a tributary stream (Devore Creek), and along a broad alluvial delta at the confluence with Lake Chelan.

The drainage configuration ultimately determines the amount of land suitable for the growth and persistence of riparian vegetation along the tributaries. Because riparian vegetation requires available water, narrow steep-walled drainages or deeply incised creek channels limit the area suitable for riparian habitats. This accounts for the condition of riparian habitats at Grade Creek, which is confined to a narrow steep-walled canyon. The riparian zone at Mitchell Creek was recently enhanced by planting shrubs. This has resulted in a dense but narrow band of riparian shrub habitat. The width of the riparian zone at Mitchell Creek is narrow because the creek channel is deeply incised in some areas, limiting the area suitable for riparian vegetation. Similarly, the riparian zones along Box Canyon, Big Creek, Bear Creek, Prince Creek and Fish Creek are relatively narrow due to incised creek beds and/or confining canyons. However, the Stehekin River has a wide alluvial channel within a broad U-shaped valley with abundant lowlands suitable for riparian vegetation.

The aspect of the tributaries has a significant influence on the local microclimate and thus the surrounding vegetation. Sites with a southwest aspect tend to have relatively drier microclimates resulting in arid habitats surrounding narrow riparian corridors. The dominant vegetation surrounding both Grade Creek and Mitchell Creek are arid shrub steppe habitats. Further west (i.e., uplake), the vegetation surrounding sites with a west to southwest aspect, including Prince Creek and Fish Creek, consists predominantly of relatively open conifer habitats. Sites with a northeast aspect, such as Box Canyon and Bear Creek, tend to have more dense vegetative cover within and adjacent to the riparian zone. The northeast aspect helps retain moisture, which promotes dense vegetative growth both within and adjacent to the riparian zone. This results in habitats characterized by heavy shade, cool temperatures and high humidity. Sites with a northeast aspect also tend to have soils with significant amounts of organic material, while the soils associated with sites having a southwest aspect tend to have a lower proportion of organic material. Due to the low organic content, these sites are relatively sandy, and they drain more quickly, resulting in less than ideal conditions for riparian vegetation. The importance of aspect is even illustrated at some sites by differences in side-slope vegetation patterns, where somewhat more arid conditions prevail on east-facing slopes.

Human activities may also influence the extent and condition of riparian zones. Developed camping areas are located adjacent to Mitchell Creek, Big Creek, Prince Creek, Fish

Creek and the Stehekin River. There is an undeveloped campsite located at Grade Creek. These camping areas, particularly Mitchell Creek, Prince Creek, Fish Creek and the Stehekin River, were heavily used during the 1999 field studies. Although most recreation activity was concentrated within the designated camping areas and trails, some activity was noted within riparian habitats. This may result in the trampling or cutting of riparian vegetation and disturbance of wildlife. Campers and day-users were also observed at Grade Creek; uncontrolled use of this area was partly responsible for somewhat degraded riparian conditions near the mouth of the creek. However, recreation activities are a relatively insignificant factor influencing riparian habitats compared to human development. There is considerable residential development near the mouth of the Stehekin River where native vegetation has been removed and low areas filled in. This development consists primarily of seasonal homes. Much of the development at the Stehekin River is adjacent to high-quality riparian habitats, and human disturbance to riparian habitats and wildlife probably occurs. Although no dwellings were located near the other tributaries studied, there is development occurring within the alluvial fans of other tributaries to Lake Chelan.

Fish Habitat

Lake Chelan is characterized by deep, cold, clear water, little organic material in the sediments, high dissolved oxygen levels, and relatively low nutrient levels. This type of water body supports cold-water fish species, especially trout (FERC, 2001, sect. 5.3.3.1a). (See "Fish" sections above under "Fish and Wildlife Resources.")

Tributaries to Lake Chelan from Manson to Stehekin are similar to each other morphometrically. They are deeply incised stream channels with cobble, boulder and large gravel substrate, with fair to poor channel stability. The fish-rearing habitat is fair, with an adequate number of pools and riffles, but spawning habitat is limited due to the lack of appropriate-sized gravel. The amount of woody debris in the stream channels is also very low. Instream cover for fish is limited to cobbles and boulders with a few pieces of woody debris (FERC, 2001, sect. 5.3.3.1a).

The Stehekin River, which provides most of the inflow to the lake, is very different from the other tributaries. It is not deeply incised, has a lower gradient, has a wide, broad floodplain, and has a mostly gravel substrate. Because it is not deeply incised, it has more meanders, so rearing capacity is excellent. It has good pool-to-riffle ratio, good spawning gravel, and plenty of large woody debris (P. Archibald, pers. comm., 9/11/01).

Tributaries in the Wapato Basin, except First Creek, are intermittent. They have a lower gradient than up-lake streams and less channel confinement, but have a similar gravel/cobble/boulder substrate. Except for First Creek, they generally do not sustain enough flow for fish (P. Archibald, pers. comm., 9/11/01).

Table 9 shows characteristics of selected tributaries to Lake Chelan as recorded in September 1982 by Brown (1984) (in Chelan PUD, 1998, p. E3-16). This is a one-day record of certain characteristics of streams that support trout and kokanee. Table 2 in the “Hydrology” section gives a picture over time of flow characteristics for some of these streams.

Most of the Chelan River (bypassed reach) is currently unsuitable habitat for fish, given that it is dewatered most of the year. However, numerous species of fish are found in salvage

operations conducted by Chelan PUD (see fish stranding survey reports). Discussions about maintaining perennial flow in the Chelan River are ongoing as part of Chelan PUD's relicensing process (Chelan PUD, 2001b and Appendix B). If perennial flow were restored, steelhead and chinook spawning could be restored in the lower reach where it enters the Columbia River (P. Archibald, pers. comm., 9/11/01).

Westslope cutthroat trout

Special attention is given in this summary to westslope cutthroat trout because it is a native species whose populations are at risk but which has, much more so than bull trout, some hope for recovery.

Historically, tributary inflows to Lake Chelan may have served as important spawning and rearing areas for native cutthroat. Habitat conditions in these tributary mouths have been altered by the Lake Chelan Hydroelectric Project. Effects include changes to the character of material deposited in deltas, changes to riparian vegetation, and changes in quantity and quality of water at these sites. Effects are limited to adfluvial cutthroat. Cutthroat refugia upstream from the glacial trough-wall zone (nearly vertical walls created by the glacier) are naturally isolated and not affected by lake level fluctuation (USFS, 1998 [in] USFS, 1999a, p. 30).

Tributary trout populations estimated during relicensing studies, particularly cutthroat trout, appear to be lower than those estimated by Brown (1984). Barriers to upstream spawning migration, in the form of depth, gradient, and/or velocity, were identified in most tributary mouths investigated (DES, 2000a). The Natural Sciences Working Group[1] concluded that these barriers were created as a result of hydro project operations since 1981, the term of the second license, and are, most likely, contributing to the decline of trout populations in Lake Chelan tributaries (Chelan PUD, 2001a).

[1] A group of mostly fish and wildlife biologists representing all stakeholder agencies and a number of non-governmental organizations, which is participating in the relicensing process for the Lake Chelan Hydroelectric Project.

Table 9. Characteristics of tributaries to Lake Chelan (excluding Stehekin River and tributaries) that support adfluvial trout and kokanee

Stream location Stream name	Temperature ° C	Flow (cfs)	Width (m)	Gradient (%)	Accessible length (m)
North shore, Chelan to Safety Harbor					
Mitchell	15.0	2.4	2.2	6.0	<600
Gold	15.0	1.2	2.3	10.0	300
Poison	15.0	1.7	2.4	9.0	60
Grade	13.9	5.9	3.2	10.0	400
Coyote	13.3	0.4	1.6	26.0	30
Safety Harbor	15.0	4.6	4.0	6.0	>300
South shore, Chelan to Big Creek					
First	10.6	7.4	3.4	5.0	>1,600
25-Mile	13.3	8.1	4.8	4.0	>3,200
Little Big	11.1	0.5	2.6	19.0	50
Big	11.1	5.2	3.7	8.0	75
North shore, Safety Harbor to Stehekin					
Lone Fir	13.3	0.9	2.1	23.0	26
Prince	12.2	9.5	5.6	10.0	>300
Cascade	11.1	0.6	1.8	12.0	150
Fish	11.1	7.1	5.4	8.0	>400
4-Mile	9.4	2.2	3.0	12.0	>300
South shore, Big Creek to Stehekin					
Deep Harbor	12.2	0.9	2.1	23.0	26
Graham Harbor	12.8	0.9	2.2	20.0	33
Pyramid	10.6	4.2	3.3	19.0	>300
Bear	8.9	8.6	3.2	11.0	100
Railroad	7.7	106.6	13.3	4.0	>1,600
Lightning	7.8	1.3	1.9	11.0	60
Riddle	11.1	3.3	3.4	13.0	>70
Castle	3.2	11.0			100

Wildlife

Figure 5 in the "Fish and Wildlife Status" section shows wildlife habitat types in the basin. Distribution of wildlife species and habitats is in large degree directed by the type and condition of the vegetation, which is in turn a result of topography and precipitation. In general, the lower elevations and downlake portions of the basin support species associated with shrub steppe vegetation, such as mule deer. As precipitation increases, ponderosa pine and its dependent wildlife species increase in abundance. On north aspects and at higher elevations, Douglas fir and lodgepole pine increase, creating habitat conditions more favorable to species that require higher canopy closure and more complex forest structure. Ecosystem processes such as fire, wind, and avalanche all serve to create and maintain habitat conditions favorable to a wide variety of relatively rare species such as lynx, fisher and wolverine, as well as other species of concern such as the white-headed woodpecker and black-backed woodpecker. The north shore supports large areas of unroaded wildlife habitat including winter range and spring emergence habitat for grizzly bears as well as comparatively large areas of fire-regenerated habitats favored by lynx and cavity-dependent species. On the other hand, these same processes have created limited habitats for species associated with interior habitats (USFS, 1998, p. 1-13 - 14).

Human activities have influenced the distribution and condition of wildlife habitats throughout the basin to a greater or lesser degree. Domestic sheep grazing at the turn of the century eliminated bighorn sheep from the area. Grazing has also affected riparian habitats and the condition of meadows and winter ranges. Critical mule deer winter ranges have been affected by residential and agricultural development, reservoir operation, timber harvest activities, and fire exclusion. Logging has resulted in the widescale removal of large ponderosa pine trees and subsequently reduced populations of dependant species, as well as snag dependent species in some areas. Road building, irrigation, and reservoir construction and operation, as well as numerous other management activities have reduced the extent and quality of riparian habitats and populations of dependent species such as amphibians. Management attempts to influence ecosystem processes such as fire have had widespread and significant effects on the condition of wildlife habitat throughout the area, resulting in decreased habitat for some species and increased habitat for others. The numbers of large carnivores and large raptors have declined significantly due to predator control and other management activities (USFS, 1998, p. 1-13 - 14).

Watershed Assessment

The following section briefly describes assessments done in the Lake Chelan Basin that have been used as sources for the Lake Chelan Subbasin Summary.

- Brown, L.G. 1984. Lake Chelan fishery investigations. Report to Chelan PUD and Washington Department of Game. Olympia, WA. 238p.

  Detailed report about native fish species, introductions, creel data, lake water quality and limnological data, tributary habitat and use, and fish management recommendations.

- Chelan PUD. 1998. Initial consultation document for the relicensing of the Lake Chelan Hydroelectric Project, FERC Project No. 637. Public Utility District No. 1 of Chelan County. Wenatchee, WA.

  Comprehensive review of aquatic, terrestrial, cultural and recreational resources within the Lake Chelan subbasin, and potential impacts to resources as a result of Lake Chelan Hydroelectric Project.

- Chelan PUD. 2001a. Lake Chelan Comprehensive Fishery Management Plan. Final Draft. Lake Chelan Hydroelectric Project, FERC Project No. 637. Public Utility District No. 1 of Chelan County. Wenatchee, WA. May 31, 2001. 15pp.

  Collaborative plan to address the management of fish species within Lake Chelan and its tributaries; incorporates policy and management recommendations from the USFS, National Park Service (NPS), USFWS, WDFW, Lake Chelan Sportsman's Association (LCSA), and the city of Chelan, as well as the PUD. Attached in full as Appendix A.

- Chelan PUD. 2001b. Chelan River Comprehensive Management Plan. Third Draft. Lake Chelan Hydroelectric Project, FERC Project No. 637. Public Utility District No. 1 of Chelan County. Wenatchee, WA. September 14, 2001.

  Collaborative plan to develop proposed measures and mitigation and monitoring for the Chelan River; incorporates policy and management recommendations from the NMFS, USFS, NPS, USFWS, WDFW, LCSA, People for Lake Chelan, and the city of Chelan, as well as the PUD. Attached in full as Appendix B.

- FERC (Federal Energy Regulatory Commission). 2001. Preliminary draft environmental assessment for hydropower license, second draft. Lake Chelan hydroelectric project, FERC Project No. 637. Prepared for Federal Energy Regulatory Commission, Office of Energy Projects, Division of Environmental Engineering and Review. Washington, D.C. Prepared by Public Utility District No. 1 of Chelan County. Wenatchee, WA. 165pp.

  Second draft of Environmental Assessment for the relicensing of the Lake Chelan Hydroelectric Facility. Comprehensive review of affected environment, especially aquatic and terrestrial species, and assessment of impact from hydro project operations to these resources.

- Fielder, P.C. 1998. Lake Chelan big game status report, Winter 1997-1998. Public Utility District No. 1 of Chelan County. Wenatchee, WA. 16pp.

  Annual report of big game population surveys, produced as part of a stipulation in the PUD's FERC license that requires that big game, especially mule deer and mountain goat, are protected and enhanced.

- Patmont, C.R., G. J. Pelletier, E. B. Welch, D. Banton, and C.C. Ebbesmeyer. 1989. Lake Chelan water quality assessment. Final Report. Prepared for Washington Department of Ecology. Prepared by Harper-Owes. Seattle, WA.

Investigation of basin geology, hydro-geology, septic systems, groundwater quality, hydrodynamics, nutrient cycling and distribution, water dissolved oxygen levels, microorganisms, metals and pesticides. Also provides discussion of management goals for the lake.

- R.W. Beck and Associates. 1991. Lake Chelan water quality plan. Final. Prepared for the Lake Chelan Water Quality Committee and Washington Department of Ecology. 100 pp.

  Includes basin characterization, problem identification, pollution source control alternatives, management alternatives, and implementation actions for a water quality plan.

- USFS. 1998. North Shore of Lake Chelan Watershed Analysis, Version 1.0. USDA Forest Service, Pacific Northwest Region, Wenatchee National Forest, Chelan Ranger District, August 1998.

  Documents the existing condition of resources within the watershed and recommends activities to meet management direction. Divides the region into fire regimes and identifies conditions and strategies common to the region as well as by fire regime.

- USFS. 1999. Existing Information Analysis for Lake Chelan Hydroelectric Project No. 637. U.S. Department of Agriculture (USDA) Forest Service, Pacific Northwest Region, Wenatchee National Forest. January 1999. 33 pp.

  Reviews PUD relicensing plans and issues, and discusses alternative management recommendations from the USFS viewpoint.

- WDFW (Washington Department of Fish and Wildlife). 1991. Management Recommendations for Washington's Priority Habitats and Species. E. Rodrick and R. Milner, Technical Editors. Washington Department of Wildlife, Wildlife Management, Fish Management, and Habitat Management Divisions.

  General management recommendations for priority species and habitats found within Washington State.

- WDFW. 2001. Priority Habitats and Species (PHS) and Heritage GIS databases.

  PHS and Heritage GIS databases were queried to generate a list of known species and habitats which occur in the Lake Chelan subbasin.

- WDFW/NWPPC. 2001. IBIS subbasin query database. Taken from www.nwhi.org (root html address).

  Subbasin search identified known habitat types, and predicted/known wildlife associations for each of the identified habitats.

Limiting Factors

The following summarizes general limiting factors in the basin as they apply to many fish and wildlife species. The North Shore of Lake Chelan Watershed Analysis (USFS, 1998, Table 2.3) provides a detailed outline of limiting factors for individual species and species groups, and by fire regime.

Scarcity of spawning habitat

Natural production of trout in the tributaries to Lake Chelan is limited primarily by the scarcity of spawning habitat. Cobbles and boulders dominate substrate in the study streams, with very little appropriately sized gravel for trout spawning (see "Fish and Wildlife Status, Fish, Tributaries" section).

Species interactions

Competition between native fish species and introduced game fish has reduced and possibly eliminated certain native fish populations. The importance of the recreational fishery, which is based largely on introduced species, could limit the ability to reintroduce bull trout (Chelan PUD, 2001a). This issue is being addressed in the Lake Chelan Comprehensive Fishery Management Plan (CFMP) (Appendix A).

Barriers at tributary mouths

Lake Chelan Hydroelectric Project operations have created barriers to tributaries for spawning adfluvial trout. This issue is being addressed in the Lake Chelan CFMP (Appendix A).

Lack of perennial flow in Chelan River

This lack of flow limits the use of the lower reach of the river by Columbia River salmonids. The issue is being addressed in the Chelan River Comprehensive Management Plan (Appendix B).

Lack of substantial riparian habitat

Because of the mountainous terrain, human developments are focused in riparian areas, which contain most of the level land. Riparian areas are already severely limited in the Lake Chelan Basin, so such development further reduces an already limited resource. Development at the mouth of the Stehekin River in particular has removed high-quality riparian and wetland habitat. Grazing and lake level changes due to hydroelectric operations have also reduced riparian habitat which is important for water, food production, and cover for many species. Specifically, large trees, snags, and woody debris are limited; and some riparian areas, particularly from Mitchell Creek downlake, lack not only the large tree component but also mid- to low-level shrubs and forbs/grasses (USFS, 1998).

Lack of large woody debris (LWD)

Large woody debris is considered a navigational hazard on the lake, so much of it is removed, thus requiring human intervention to replace this important fish habitat component.

Lack of fire

Fire is the dominant agent of change in the basin. Fire not operating in its natural regime can be a limiting factor for some species but can increase habitat for others (M. Lenz, USFS, pers. comm., 9/11/01). For example, suppression of fires in mountain goat habitat over the last 50 years may have reduced the quantity and quality of their forage. Goat use of some areas of winter range along Lake Chelan has decreased since the early- to mid-1980s. In summer 2001, the Rex Creek fire on the north side of Lake Chelan burned over 50,000 acres, including approximately 50% of the goat winter range (T. McCall, WDFW, pers. comm., 9/20/01).

Reduction in shrub steppe and grassland habitats

These habitats are required in winter for a number of species. However, much of the available shrub steppe and grassland habitat is in the lower reaches of the basin where residential and agricultural development is concentrated and increasing.

Presence of noxious weeds

Noxious weeds change the natural habitat. Cheat grass, for example, changes the fire ecology by lengthening the fire season into spring and increasing the potential for stand replacement fires (M. Lenz, USFS, pers. comm., 9/11/01).

Past use of DDT

Although no longer in use, DDT has persisted in the environment. It is still found in fish tissues, which in turn may be consumed by peregrine falcons, osprey, and bald eagles (M. Lenz, USFS, pers. comm., 9/11/01). DDT residues are known to cause fragile eggs in bird species, thus limiting their reproduction.

Artificial Production

Kokanee

Kokanee (landlocked sockeye salmon) became the mainstay of the Lake Chelan fishery shortly after they were introduced in 1917. They were artificially propagated from 1940 to 1946 at the Lake Chelan Fish Hatchery (FH), yet some smaller outplants of hatchery kokanee have occurred from 1934 through 1966 (Brown, 1984). Broodstock were collected from Twentyfive Mile Creek, Railroad Creek, Prince Creek, Safety Harbor Creek and Stehekin River; egg take ranged from 1.8 million in 1941 to 21.9 million in 1943. Kokanee fry were planted extensively, with over 40,000,000 released in the main body of Lake Chelan from 1934 through 1966 by WDG (planting records for years prior to 1934 are not available). Little is known about the success of these outplants. Many of the larger early plants were probably not successful as they were of swim-up fry placed in the lake in winter when plankton densities were low (FERC, 2001, section 5.3.3.1a).

As part of the 1975 application to relicense the Lake Chelan Project, Chelan PUD agreed to fund a WDFW hatchery program to plant 1.5 million kokanee fry annually into Lake Chelan. The primary goal of the enhancement program was to increase sport fishing opportunities by increasing the kokanee population. Under the terms of the cooperative agreement, Chelan PUD agreed to increase annual hatchery capacity at Chelan Falls FH to two million kokanee eggs (or 1.5 million fry). Kokanee releases since 1980 have totaled nearly 10,000,000 juveniles. However, only once have more than one million kokanee fry been planted in Lake Chelan since 1984, because the hatchery could not acquire sufficient eggs from outside sources to meet program objectives. Since the hatchery could not meet the 1.5 million fry production goal, fishery managers, with voluntary funding from Chelan PUD, elected to enhance the sport fishery, particularly in the Wapato Basin, in another manner by releasing catchable-size rainbow trout beginning in 1990. This rainbow trout program has continued with annual plants from 1990 to the present (FERC, 2001, section 5.3.3.1a). (See “Rainbow trout” section below).

Rainbow trout

Introduced to Lake Chelan in 1917, rainbow trout have provided a consistent fishery for the past several decades. Plants of juvenile rainbow trout totaled over 2.5 million fish prior 1970. Since

1970, stocking of juveniles continued. Total stocking of rainbow trout has been nearly 2 million fish, juveniles and larger, since 1980.

When it was found that Chelan Falls FH could not meet its production goal for kokanee (1.5 million fry annually released into Lake Chelan), fishery managers examined other alternatives for enhancing the sport fishery, particularly in the lower, more populated end of the lake. In 1990, Chelan PUD began funding a program to release catchable rainbow trout (average size of 2.5 to 4.5 fish per pound [fpp]). Between 1990 and 1999, 818,900 catchable rainbow trout were released by Chelan Falls FH in various locations of Lake Chelan (Chelan PUD, 1998, p. E3-7; FERC, 2001, section 5.3.3.1a).

Westslope cutthroat trout

Although highly desired by anglers, the cutthroat trout fishery is mostly incidental to kokanee and rainbow trout. To improve the sport catch, WDG planted hatchery-reared cutthroat trout (Lake Chelan and Twin Lakes strains) in Lake Chelan and its tributaries sporadically from 1927 to 1976. The success of these plants is not known, but Brown (1984) speculated that the fish planted in the upper lake and Stehekin River during the later years had relatively high survival. Cutthroat trout have been planted into the following tributaries to Lake Chelan: Twentyfive Mile Creek, Rainbow Creek, Railroad Creek, Pyramid Creek, Safety Harbor Creek, Mitchell Creek, Fish Creek, First Creek, Stehekin River, and Domke Lake. The population size of cutthroat trout in these streams, or their genetic relation to the historic native population, is not known. However, Brown found no historical or biological evidence of interbreeding with introduced Twin Lakes cutthroat trout (Chelan PUD, 1998, p. E3-2 - E3). Since 1980, juvenile cutthroat have been stocked into Lake Chelan on nearly an annual basis, totaling nearly 2,000,000 cutthroat through 1999 (FERC 2001, section 5.3.3.1a).

The cutthroat trout egg collection program in the Stehekin River, which occurred prior to construction of the Lake Chelan Project, included plants of cutthroat fry back to Lake Chelan. These fry releases totaled nearly 8.5 million, but diminishing cutthroat returns to the Stehekin resulted in termination of the hatchery program (FERC, 2001, section 5.3.3.1a).

Landlocked chinook salmon

From 1974 to 1978, the Washington Department of Fisheries (WDF; now WDFW) introduced chinook salmon into the lake. The initial plant in 1974 was 16,500 fish at 3 fpp (5,500 pounds). Subsequent plants made from 1975 to 1978 were of smaller fish: 70,500, 72,500, 123,800, and 40,000 fish, ranging from 48 fpp to 8 fpp. Releases were from net pens located near Twentyfive Mile Creek, with some isolated smaller releases in the lower end of the lake. The objective was to provide a trophy fishery for Lake Chelan; but despite an initial success, the fishery declined after a few years. The original chinook salmon stocking program was terminated in 1979 (Chelan PUD, 1998, p. E3-9).

The chinook salmon population has remained at low levels but has been a popular sport fishery nonetheless. In response to request by sport fishers, WDF re-established the hatchery outplants in 1990, using late-spawning ocean-type chinook salmon from Wells FH. In this operation, 100,000 fall chinook salmon fry (1,000 lbs. at 100 fpp) are planted into the lake annually from a net pen near Fields Point (Chelan PUD, 1998, p. E3-9). A total of 1.4 million

chinook have been stocked into Lake Chelan since the program began in 1974 (FERC, 2001, section 5.3.3.1a).

Lake trout

Often called mackinaw, lake trout were introduced to Lake Chelan in 1980 by fishery managers, believing they would be a better top-level predator than landlocked chinook. The program has been discontinued but releases of hatchery lake trout totaled over 770,000 through 1999 (FERC, 2001, section 5.3.3.1a).

Existing and Past Efforts

Fisheries Studies and Enhancement Efforts

Chelan PUD

This section is taken from Chelan PUD, section E3.1.5, p. E3-14.

Reservoir

Chelan PUD funded the Lake Chelan Fishery Investigations report prepared by the Washington Department of Game (Brown, 1984). It evaluated limnology, creel censuses, and tributary streams; it presented discussion on water quality and productivity, zooplankton, Mysis, kokanee, rainbow trout, cutthroat trout, bull trout, chinook salmon, burbot, other species, angler preferences, food-web interactions, and trophy fisheries; and it made recommendations for management and enhancement.

During April, May, and June of 1985 and 1986, Chelan PUD conducted creel censuses and plankton surveys in the portion of the lake between Twentyfive Mile Creek and the town of Chelan. The plankton surveys were conducted to identify increases in plankton numbers (plankton blooms) so that kokanee fry releases could be coordinated with the increase in forage for the fry. However, hatchery operations did not allow for fish releases to be timed with plankton blooms. Plankton surveys found relatively low population densities of plankton in Lake Chelan. Brown (1984) found the highest zooplankton levels at the southeast portion of the lake and lowest levels in the northwest portion of the lake. These differences were attributed to water temperatures and localized eutrophication (near the towns of Manson and Chelan).

The 1985 and 1986 creel censuses were intended to evaluate the early season kokanee fishery. Those surveys found relatively low catch per unit of effort (0.09 fish/hour of effort and 0.28 fish/hour of effort, respectively).

Creel censuses were conducted again in 1993 and 1994 to evaluate the contribution of hatchery-produced rainbow trout to the sport fishery in the southeast portion of the lake near Chelan. The survey found that the fisherman success rates in 1993 and 1994 (0.3 and 0.5 fish/hour, respectively) was an improvement over previous years (Hagen, 1995). The majority of the rainbow trout caught were recently planted (i.e., the same year) hatchery fish. The catchable-size rainbow trout program created a shoreline-based fishery where one did not generally exist before. It also provided a longer duration fishery compared to the kokanee fishery, thus extending the recreational opportunities for anglers in the lower lake.

Tributaries

Population studies. The Lake Chelan Fishery Investigations report (Brown, 1984) included information about fish spawning in the tributaries to Lake Chelan. Brown (1984) identified 23 tributaries (excluding the Stehekin River and its tributaries) that support adfluvial trout and kokanee populations (see Table 9), and estimated a minimum of 10,002 linear meters of stream accessible to rainbow trout, and 6,044 linear meters of stream accessible to kokanee. Based on electrofishing surveys of these streams, Brown (1984) estimated a late summer 1982 standing crop of 18,104 rainbow trout and 658 cutthroat trout.

One of the goals of fisheries investigations undertaken for the Lake Chelan Project relicensing application was to determine the efficacy of the kokanee, cutthroat and rainbow trout stocking/hatchery programs in terms of contribution to Lake Chelan spawning populations of these species (DES, 2000a). An assessment of the salmonid population was made by electrofishing 100 meters (328 feet) in each of eight selected study streams. Each captured fish was identified to species and measured for weight and fork length. Scale samples were taken from a sample of kokanee, rainbow trout and cutthroat trout to determine whether the origin of the fish was from natural or hatchery reproduction. Fin clips were taken from a total of 14 cutthroat trout for genetic analysis to determine their stock origins. Electrofishing was not conducted in Railroad Creek due to the continued high flows that made electrofishing conditions inefficient and unsafe.

Snorkeling surveys were done in 8 selected tributaries in 1999 and in 9 tributaries in 2000, in spring, summer, and fall, to determine fish presence and use at the creek mouths and in the lower reaches of the streams, in particular by adult adfluvial trout and rainbow trout for staging upstream migration.

Kokanee and chinook spawning surveys. Beginning in 1984, Chelan PUD conducted annual kokanee and chinook spawning surveys in the major tributaries of Lake Chelan. Annual reports at the end of each spawning season summarize the results. These tributaries include the majority of the kokanee spawning in the Lake Chelan drainage and include: First Creek, Twentyfive Mile Creek, Safety Harbor Creek, and two tributaries of the Stehekin River: Company and Blackberry creeks. Chinook have been found spawning only in Company Creek, Blackberry Creek, and the Stehekin River.

Other entities

Twentyfive Mile Creek spawning channel. To restore kokanee spawning habitat after the floods of 1948/49, WDG replaced spawning gravel in the Stehekin River and constructed a spawning channel on Twentyfive Mile Creek in 1965. Natural gravel deposition slowly replaced the gravel bars in Stehekin River and gravel pockets in the smaller tributaries. The spawning channel was rebuilt in 1991.

Mitchell Creek watershed restoration. This work was done 1992 – 1994 and is documented in the Mitchell Creek Watershed Restoration Environmental Assessment (WNF, 1991). This work, which involved construction of several fish habitat enhancement structures in Mitchell Creek, is thought to account for an increase in the trout population in this creek (see "Fish and Wildlife Status, Fish, Tributaries" section).

Large woody debris (LWD) replacement. In late 1995 and early 1996, the Stehekin River deposited a mass of logs and woody flood debris in Lake Chelan. The mass was so extensive (>700 tons) that it was considered a serious hazard to safe navigation on the lake. In mid-1996 a multi-agency review of the situation resulted in an emergency flood debris removal project. The Chelan Ranger District was a partner in this project.

During the project, most of the woody flood debris was collected by barge and chipped for disposal. To mitigate the loss of large woody debris due to the removal project, WDFW required the larger and better quality pieces to be stockpiled for fish habitat enhancement in Lake Chelan and its tributary streams.

Prince Creek and Safety Harbor Creek were selected as tributary streams where in-stream large woody debris was deficient and where the use of flood debris for fish habitat enhancement would be beneficial to cutthroat trout, rainbow trout, and kokanee. These species contribute to a highly-valued recreational fishery in the lake. All three species are known spawn in the lowest quarter mile of Prince and Safety Harbor creeks.

Project implementation occurred above the maximum lake elevation and was designed and permitted by WDFW. Project work was performed by a low-impact walking excavator to avoid any detrimental impacts to stream banks, channels, and vegetation. The project was funded entirely by the Lake Chelan Sportsmen's Association.

During the ensuing years (1997-2000) several of the LWD pieces gradually captured bedload. This created vertical drops in excess of 12 inches that became partial passage barriers to upstream migrating kokanee at low flow.

A project currently proposed would reposition several pieces of the in-channel large woody debris in Prince and Safety Harbor Creeks to remove the passage barriers. Effectiveness monitoring will occur as part of Chelan County PUD annual spawning surveys with assistance from USFS and state fish biologists. Project success will be measured in terms of kokanee use of spawning habitat upstream from the repositioned logs. Follow-up treatment, if needed, will occur in future years (Archibald, 2001).

First Creek culvert removal and bridge construction. This project, undertaken in 1999, removed two state highway culverts that were limiting kokanee and rainbow trout access to and production from several miles of First Creek, and replaced them with bridges. A short segment of First Creek Road was relocated to accommodate installation of the upper bridge. Physical channel connectivity has been restored between Lake Chelan and USFS waters in First Creek. Chelan County PUD spawning surveys reported 1,215 kokanee spawners in First Creek during the autumn of 1999, a 123% increase over the 17-year average of 544 spawners per year. Eighty-five of the spawning fish were observed above the lower bridge, spawning in a segment of the creek that had been blocked by the culverts for more than 30 years.

The project was a collaborative effort that included three state agencies (WDFW, Washington Department of Transportation, Washington State Parks); USFS (Chelan Ranger District); Chelan County Conservation District; Washington Conservation Corps; two nonprofit citizen groups (Lake Chelan Sportsmen’s Association, Save Chelan Alliance); and three private landowners. (“Accomplishment Report: Project: First Creek, Chelan Ranger District, Wenatchee National Forest” supplied by P. Archibald, 9/11/01).

Chelan PUD

Note: This section is from Chelan PUD 1998, section E3.2.3, p. E3-65.

As part of its current license for the Lake Chelan Project, Chelan PUD developed the Lake Chelan Fish and Wildlife Management Plan (Exhibit S of the Lake Chelan Project license). The plan was guided by a baseline study (Fielder and McKay, 1984) and coordinated with and agreed to by Chelan PUD, Washington Department of Wildlife (now Washington Department of Fish and Wildlife), USFS, USFWS, and NPS. That plan, and findings and suggestions derived from the annual Lake Chelan Big Game Status Reports, has guided wildlife survey and management work along Lake Chelan since 1984.

Exhibit S required detailed analysis of:

1) selenium levels in the diet and body tissues of big game and the implications on herd productivity and
2) the results and success of the mountain goat transplant from the Olympic Mountains to the Lake Chelan shorelines.

Results of both studies were published in scientific literature and are summarized here.

Selenium is a trace element found naturally in soils. It is generally scarce in new soils and soils of volcanic origin (as in eastern Washington). Selenium deficiency in wildlife is a cause of white muscle disease and has also been linked to reduced production and neonate survival. During the selenium study (Fielder, 1986), samples of mountain goat forage, fecal pellets, hair, blood, and liver were found to have deficient selenium levels compared to desirable levels of livestock. Selenium levels in mule deer and Rocky Mountain elk were higher than in mountain goats, but still less than the desirable levels found in livestock. Findings of this study proposed that, in selenium deficient areas, wild ungulates be supplemented with selenium to increase herd health and productivity (Fielder, 1986).

In 1983 and 1984, 44 mountain goats were trapped and transplanted from the Olympic Mountains to the Lake Chelan shores to increase the population. The transplanted goats were marked and sightings were compiled. Released goats occupied vacant goat range, joined native goat bands within the drainage, or left the drainage. A minimum of ten kids were born to transplanted nannies during the three summers after initial release. The study considered the transplant successful because:

1) the transplanted goats intermixed and bred with members of the local population to add genetic variability and
2) the total goat population was increased by the goats that remained in the drainage and the nannies that produced kids (Fielder and Keesee, 1988).

Wildlife habitat improvement projects completed and/or ongoing along Lake Chelan, under the authorization of the Exhibit S, have included:

1) prescribed burns on mountain goat and mule deer winter ranges to improve forage availability and quality,

2) aerial fertilization of wintering ranges to improve forage quality,

3) planting conifer trees to provide thermal and escape cover,

4) seeding and planting bitterbrush and wild buckwheat (Eriogonum) plants to provide deer winter browse forage,

5) thinning and pruning browse plants to improve deer forage availability, quality, and deer access to browse areas,

6) a variety of water development projects including spring rehabilitation, water guzzler construction and repair, and stream-side trail stabilization,

7) assisting with a supplemental deer feeding program following a large wildfire on deer winter range, by constructing 50 deer feeders and keeping them filled throughout the winter,

8) placement of up to 3.5 tons per year of trace mineral blocks with selenium on deer and goat winter range to improve herd health and productivity, and

9) closures of roads and rehabilitation of the road beds to restrict human access and improve deer security and escape conditions within important areas along Lake Chelan used by mule deer during late fall, winter, and early spring.

Present Subbasin Management

Existing Management

Fisheries Management Framework

Note: This section is taken primarily from Chelan PUD 1998, section E3.1.4, p. E3-12.

The Revised Exhibit S, Fish and Wildlife Plan, Agreement Relating to Lake Chelan Project Conservation and Enhancement Program for Fish and Wildlife, provides the framework for much of the fisheries management on Lake Chelan. Signatories are Chelan PUD, the WDFW (part of which was formerly called the Department of Game [WDG]), the USFWS, the USFS, and the NPS.

Federal Management

U.S. Fish and Wildlife Service

The responsibility of the USFWS is to manage species listed under the Endangered Species Act as threatened or endangered. The ESA requires consultation with the USFWS regarding actions that may affect threatened or endangered species. A fish species of primary concern to USFWS in the basin is bull trout, listed as Threatened under the ESA. The USFWS has not developed, to date, specific goals and objectives regarding bull trout stock status in Lake Chelan. The USFWS also is concerned with conservation of the Lake Chelan sports fishery per the Revised Exhibit S.

National Marine Fisheries Service

A primary responsibility for the NMFS is to manage anadromous salmonids, including those listed under the ESA. In this basin, anadromous fish use only the lowest portion of the Chelan River—a tiny proportion of the basin.

U.S. Forest Service

The USFS provides leadership in the protection, management, and use of the nation's forests, rangeland, and aquatic ecosystems. Management of USFS lands in the Lake Chelan basin is guided by the Land and Resource Management Plan for the Wenatchee National Forest. (See greater detail in the next section entitled "Terrestrial Resources Management Framework.")

National Park Service

The NPS is dedicated to conserving, unimpaired, the natural and cultural resources and values of NPS lands. Additionally, the NPS shares responsibility for implementation of programs that will provide benefits of natural and cultural resource conservation and outdoor recreation. In this area, lands and resources in the North Cascades National Park and Lake Chelan National Recreation Area are under their management. (See greater detail in the next section, entitled "Terrestrial Resources Management Framework.")

Colville and Yakama Tribes

The Tribes support the state and federal anadromous fish concepts. They might want to consider the potential for anadromous fish in the basin.

State Management

Washington Department of Fish and Wildlife

The WDFW is the primary entity responsible for managing fisheries resources in the Lake Chelan Hydroelectric Project area. The WDFW regulates fisheries resources in Lake Chelan through imposing species catch restrictions, catch limits, minimum size limits, and seasons. Chelan PUD, through the Revised Exhibit S, is responsible for funding WDFW activities in the following areas:

- Hatchery kokanee enhancement—increasing the capacity of the Chelan Falls FH to accommodate rearing and hatching 1.5 million kokanee eggs. Hatchery supplementation is designed to achieve the plan goal of 600,000 standing stock catchable size kokanee in Lake Chelan.
- Lake Chelan fisheries studies—WDFW evaluation of kokanee enhancement and overall program success.
- Rainbow trout stocking program—WDFW hatchery programs that rear and release 100,000 catchable size rainbow trout into the Wapato Basin of Lake Chelan to enhance sport fishing opportunities, and 50,000 sublegal size Twin Lakes strain cutthroat trout for release at Stehekin.

Washington Department of Ecology

Goals and objectives of the DOE are to protect, preserve, and enhance Washington's environment, and promote wise management of air, land, and water resources. WDOE and partner governments and agencies monitor many water quality attributes in the Lake Chelan Basin. Efforts are guided by the Lake Chelan Water Quality Plan, completed in 1991 (R.W. Beck, 1991).

Terrestrial Resource Management Framework

This section is taken primarily from Chelan PUD 1998, section E3.2.4, p. E3-66 71.

Privately owned land borders most of the lower 19 miles of Lake Chelan. The middle 27 miles of the lake are within the Chelan Ranger District of the Wenatchee National Forest (WNF), approximately 18 miles of which are designated Wilderness Area. Several small privately-owned inholdings also occur within the WNF along the lake. The upper 9 miles of the lake and the Stehekin River are located within the Lake Chelan National Recreation Area (NRA) administered by the NPS. Most of the lake and river shorelines within the Lake Chelan NRA are, however, bordered by privately owned parcels. The uppermost portion of the basin is within North Cascades National Park. In addition to the major landowners, the Bureau of Land Management (BLM), Washington State Department of Parks and Recreation (WDPR), Washington Department of Natural Resources (WDNR), and WDFW all administer lands in the lower portion of the basin (see Figure 1). Chelan PUD has flowage easements on private properties surrounding Lake Chelan and the bypassed reach area. Lands within the bypassed reach are owned outright by Chelan PUD.

Federal Management

U.S. Fish and Wildlife Service

Management of non-marine species that are federally listed or proposed as threatened or endangered is the responsibility of the USFWS. Management of bald eagle habitat in the basin is partially controlled by the federal recovery plan for this species (USFWS, 1986), which is administered by the USFWS. Similarly, habitat for the northern spotted owl, gray wolf, and grizzly bear in the upper portion of the basin is covered by recovery plans (USFWS, 1992; USFWS, 1987; USFWS, 1993).

U.S. Forest Service

Management of the wildlife and botanical resources on USFS lands near Lake Chelan, including those in the Chelan-Sawtooth and Glacier Peak Wilderness Areas, is guided by the Land and Resource Management Plan for the Wenatchee National Forest (WNF) (USFS, 1990). The Plan guides all natural resource management activities and establishes management standards and guidelines for the Wenatchee National Forest. It describes resource management practices, levels of resource production and management, and the availability and suitability of lands for resource management. The goal of the Plan is to provide a mixture of management activities that allow use and protection of the Forest resources; fulfill legislative requirements; and address local, regional and national issues and concerns. The Plan resulted from extensive analysis which was addressed in an EIS and Record of Decision (FERC, 2001, section 8.0).

Management activities affecting spotted owl habitat are guided by the President's Northwest Forest Plan (BLM and FS, 1994) as well as the draft recovery plan for this species. Bald eagle management on USFS land is also guided by the bald eagle species management plan (Rees, 1989 [in] Chelan PUD, 1998, p. E3-67).

The Northwest Forest Plan's standards and guidelines are meant to improve conditions for late-successional forest-related species beyond the protection granted in individual forest plans (BLM and FS, 1994). Unless otherwise noted, any standards and guidelines in existing forest plans apply where they are more restrictive or provide greater benefits to late-successional forest-related species than the Northwest Forest Plan.

The USFS and BLM are also proposing to develop and implement a coordinated, ecosystem-based management strategy for lands they administer east of the Cascade Range in Washington and Oregon. The preferred alternative in the Draft Environmental Impact Statement (EIS) indicates that forested lands adjacent to Lake Chelan are to be conserved (USFS and BLM, 1997). One of the findings from this EIS is the regional importance of the Lake Chelan Basin to conservation of rare carnivores due to the amount of unroaded remote habitat available.

The management direction for the WNF is to maintain viable populations and distribution of suitable habitat to prevent species from becoming federally listed as endangered or threatened. Wildlife and botanical objectives are aimed at the Management Indicator Species (MIS); endangered, threatened, and sensitive species; and unique or special habitats and species (USFS, 1990).

The USFS has completed watershed analyses for the Chelan basin, including, the First/Twenty-five Mile Creek Watershed (USFS, 1995), the North Shore Watershed Assessment (USFS, 1998), the Antoine Watershed Assessment (USFS, 1999b), the Middle Chelan Watershed Assessment (USFS, 1999c), and the Upper Chelan Watershed Assessment (USFS, 2000). These documents develop goals and priorities for ecosystem restoration projects and meet the requirements of the Northwest Forest Plan (BLM and FS, 1994). The watershed analyses address wildlife habitat; late successional habitat; proposed, endangered, threatened, and sensitive (PETS) plants and animals; noxious weeds; fire effects; and ecosystem health and biological diversity.

National Park Service

The Lake Chelan NRA was established to (1) provide public outdoor recreation benefits; and (2) conserve scenic, scientific, historic, and other values contributing to public enjoyment. The Lake Chelan NRA Final General Management Plan/Implementation Plan Alternatives/Environmental Impact Statement (NPS, 1995) provides management direction for the NPS lands within the Lake Chelan NRA.

Under the GMP, the rustic setting of the Lake Chelan NRA is a part of a transition from the downlake residential, agricultural and industrial setting to a very wild and natural North Cascades National Park, Lake Chelan NRA wilderness and adjacent USFS administered wilderness areas. The NRA is managed as an integral part of a larger regional ecosystem and socioeconomic region. The use of recreation area resources by visitors and residents is managed in order to preserve the natural, scenic and cultural values of the area (FERC, 2001, section 8.0).

All recreational activities in the Lake Chelan NRA are managed to prevent impacts on resources and to minimize conflicts among users. Activities that infringe upon the solitude and natural beauty of the NRA or cause unacceptable impacts on resources are discouraged or prohibited (FERC, 2001, section 8.0).

The upper portion of the Stehekin River basin is within the North Cascades National Park and is managed according to the management plan for the North Cascades National Park Complex (NPS 1988) (pers. comm., P. Campbell, Management Assistant, North Cascades National Park Complex, NPS, Chelan, Washington, May 26, 1998). Hunting is prohibited in the North Cascades National Park but is allowed in the NRA and is regulated by the WDFW (Chelan PUD, 1998, p. E3-69).

Revised resource management plans were completed for the Lake Chelan NRA and the North Cascades National Park in 1999/2000 (Bruce Freet, NPS, pers. comm., August 2001).

Bureau of Land Management

The BLM administers several scattered tracts of land in the vicinity of eastern Lake Chelan and the Chelan River. The BLM manages them according to the Spokane Resource Management Plan (BLM 1987). BLM lands near Chelan Butte are managed cooperatively with the WDFW for wildlife habitat; fire protection is dictated under a cooperative agreement with the USFS. The BLM scattered tracts are not included within the range of the northern spotted owl. Some BLM lands, however, support owls; in these areas the BLM must adhere to the standards and guidelines of the Northwest Forest Plan (pers. comm., J. Fisher, Area Manager, BLM, Wenatchee, Washington, May 26, 1998).

U.S. Army Corps of Engineers

The COE is responsible for protecting and maintaining the nation's waters by administering provisions of the Clean Water Act (CWA) and the Rivers and Harbors Act. Areas under COE jurisdiction include wetlands, rivers, intermittent streams, ponds, reservoirs, lakes, and other waters of the United States. Any activity that would potentially alter or affect a wetland or water body may require a permit from the COE. For example, Section 404 of the CWA prohibits the discharge of dredge or fill material into a wetland or water of the United States without a permit. Other activities subject to permitting under Section 404 include mechanized land clearing, ditching, draining, excavating, grading, and placement of pilings.

Under Section 10 of the Rivers and Harbors Act, the COE issues permits for activities "in, over, or affecting" navigable waters. During the Section 10 permit process the COE evaluates potential impacts to navigation, flood control, and fish and wildlife habitat.

State Management

Washington Department of Fish and Wildlife

The WDFW is responsible for management of wildlife resources in the basin. The WDFW shares wildlife management tasks with the USFS, NPS, and BLM on federal lands. WDFW's overall policy is to provide for diverse and healthy wildlife populations, emphasizing native species and natural production (Washington Wildlife Commission, 1991). WDFW regulates hunting, fishing, and trapping and works with the USFWS in managing habitat for threatened and endangered

species. WDFW and BLM cooperatively manage the Chelan Butte Wildlife Area south and west of Chelan, where the primary management objective is enhancement of mule deer and upland game bird habitat. This land was acquired from Chelan PUD in 1969, which periodically provides management funds and personnel (pers. comm., Mark Hallet, On-site Administrator, WDFW, Wenatchee, Washington, May 22, 1998). Similarly, the WDFW and USFS cooperatively manage the Entiat State Wildlife Area, west of Highway Alternate 97.

Washington State Department of Parks and Recreation

The WDPR manages two state parks along the southern shore of Lake Chelan: Lake Chelan and Twentyfive Mile Creek. Both of these sites have boat launches and overnight camping facilities and are accessible by vehicle from USFS Road No. 23. Lake Chelan State Park has 201 campsites and is bordered entirely by private land; Twentyfive Mile Creek has 85 campsites and adjoins both private and USFS land. Both receive heavy recreational use and have limited wildlife habitat.

Washington Department of Natural Resources

There are several scattered parcels of WDNR land north and south of Lake Chelan, particularly along the downstream half of the lake. These lands are managed for timber resources, although several of the parcels are within the range of the northern spotted owl and managed in accordance with the multispecies Habitat Conservation Plan (HCP) adopted by the WDNR (WDNR, 1997). The HCP calls for specific spotted owl and riparian habitat conservation strategies intended to protect and enhance habitat for all federally listed threatened and endangered species in the range of the spotted owl.

County and City Management

This section from Chelan PUD, 1998, p. E6-2, except where noted.

Chelan County regulates private land use and has the responsibility for protecting wetlands in the county. Chelan County land management requirements cover all non-federal areas in the Lake Chelan area outside the Chelan city limits.

Local government planning processes must be consistent with Washington's Growth Management Act. It is the template law for land-use planning in the state. The Act requires specific planning elements be addressed by each jurisdiction and that implementing regulations be consistent and concurrent with the plan. The primary purpose of the GMA is to help curb urban sprawl by directing where growth will occur within a given county or city and to recognize and protect critical resource lands including wetlands and riparian zones along lakes and rivers (FERC, 2001, Section 8.0).

Chelan County uses the Chelan-Entiat Comprehensive Plan as its primary planning tool. The county is in the process of completing requirements of the Growth Management Act. They have adopted interim urban growth boundaries for Chelan (county must affirm city-designated boundary) and Manson, and they have some critical area ordinances. Currently the county has ordinances for fish and wildlife, aquifer recharge lands, riparian zones and wetlands, geological hazard areas, commercial agriculture resource lands, forest resource lands, and mineral resource lands. The county also has a Shoreline Master Program addressing shoreline development.

The City of Chelan has adopted its comprehensive plan and implementing regulations. They have established an urban growth boundary, as well as critical areas including aquifer recharge areas, frequently flooded areas, wetlands and floodplains, geological hazard areas, and fish and wildlife areas. They also have a Shoreline Master Program addressing shoreline development waterward of the 1,100-foot elevation and within a 200-foot buffer zone upland of this elevation.

Existing Goals, Objectives, and Strategies

Federal Energy Regulatory Commission

The following are FERC's recommendations for protection, mitigation, and enhancement (PME) measures as a condition of relicensing approval for Lake Chelan Project, taken from the Environmental Assessment on the project (FERC, 2001, section 7.1). The section includes measures addressing recreational and historical/archeological resources, but only those addressing fisheries and terrestrial resources are listed here. Measure numbers correspond to numbers in the original document.

(1) provide funds for monitoring and repairing selected erosion sites;

(2) provide funds for developing and implementing plans to address issues related to riparian revegetation, wildlife and dust control in the Stehekin Flats area and to monitor for changes to the Stehekin River channel at its mouth;

(4) implement a new lake level operating plan to improve tributary access for fish;

(5) release a minimum flow of 80 cubic feet per second (cfs) year-round into the bypassed reach to enhance fishery habitat and ecosystem function and release an additional 120 cfs in May and June during average water years (approximately 60 percent of the time) or an additional 240 cfs in May and June during wet water years (approximately 20 percent of the time);

(6) design and construct spawning and rearing habitat in the lower end of the bypassed reach and tailrace to enhance habitat for anadromous fish;

(7) implement the Comprehensive Management Plans for Lake Chelan and the Chelan River; see "Chelan Public Utility District" below and Appendices A and B.

(13) establish a Lake Chelan Endowment Fund for social and natural resources as a source of matching funds for future improvements.

Chelan Public Utility District

For fish in the basin, the most comprehensive outline of objectives and strategies is the Fourth Draft (Final) of the Lake Chelan Comprehensive Fishery Management Plan, which is proposed as part of the relicensing process for the Lake Chelan Hydroelectric Project. It is appended to this summary as Appendix A. The Chelan river Comprehensive Management Plan also addresses needs for fish. Still in draft form, it appears in full as Appendix B. Key provisions of both plans are summarized below.

Numerous stakeholders participated in the development of the plans. Many articulated their goals at the beginning of the relicensing process. Those goals are reproduced below and were taken into account in development of the plans.

The following stakeholder goals were recorded at the April 23, 1998, Fish Group Meeting (Chelan PUD, 1998, p. E3-12 and p. E3-69).

U.S. Fish and Wildlife Service: Management goals and objectives of the USFWS include, in addition to responsibilities under ESA, preservation and enhancement of the nation's fish and wildlife resources, and assurance that fish and wildlife will be given equal consideration with the Lake Chelan Project's purpose.

National Marine Fisheries Service: Goals and objectives specific to the Lake Chelan Project are protection of habitat for spawning, incubation and rearing of fall chinook salmon in the lower Chelan River and Project tailrace.

U.S. Forest Service: Goals and objectives include implementation of management plans to ensure sustainable ecosystems and provide recreation, water, timber, minerals, fish and wildlife, wilderness and aesthetics for current and future generations.

Bureau of Indian Affairs: Goals and objectives relative to the Lake Chelan Project are to maintain a trust responsibility to trust lands involved. This trust is a blanket trust for fish, human and cultural resources.

Yakama and Colville Tribes: Goals and objectives relative to the Lake Chelan Project are to provide recreation that is compatible with healthy fish and wildlife populations, protect and enhance fish and wildlife habitat, and implement a management plan to maintain the compatible mix of native and non-native species to satisfy present and future sport fishing demands.

Washington Department of Fish and Wildlife: Management goals and objectives are to preserve, protect, and perpetuate diverse fish and wildlife resources and habitat.

Washington Department of Ecology: Goals specific to the Lake Chelan Project are to maintain water quality and to preserve water clarity.

National Park Service: The Lake Chelan NRA Final General Management Plan/Implementation Plan Alternatives/Environmental Impact Statement (NPS, 1995) provides management direction for the NPS lands within the Lake Chelan NRA. The plan addresses the following issues and corresponding goals:

- Lower Stehekin River channel and floodplain management—preserve and restore the free-flowing character and natural processes of the river and its tributaries;
- Wetlands—preserve and restore ecological processes and conditions in wetlands, floodplain, shoreline, and riparian areas;
- Forest fire management—actively manage forest fuels to protect human life and property and to manage late-succession forest;
- Threatened, endangered, or rare species—preserve and restore species and ecological relationships that would exist were it not for human impacts;

- Non-native fish and plant species—control and prevent invasion by non-native plant species and control non-native fish species to allow recovery of viable populations of native species in at least portions of their historic ranges; and
- Recreation—provide a variety of activities while minimizing unacceptable impacts on resources.

The Lake Chelan Comprehensive Fishery Management Plan (Appendix A) identifies the following primary management objectives for Lake Chelan:

1. Emphasize restoration/enhancement of native species, where feasible;
2. Support the recreational sport fishery;
3. Manage the lake elevation to enhance tributary production;
4. Determine compatibility of management actions with potential future bull trout re-introduction;
5. Develop an M&E framework that includes an Adaptive Management component.

The following three objectives, with appropriate strategies, are summarized from the CFMP. Refer to Appendix A for more detail on these and other objectives.

Objective 1 **Restore native fish species to Lake Chelan while supporting the existing recreational trout fishery.**

Strategy 1. Over a four-year period, with careful monitoring and evaluation, replace the current allotment of 100,000 rainbow trout (RBT) with increasing proportions of Twin Lakes cutthroat until only cutthroat are stocked.

Strategy 2. Eliminate, immediately, stocking of RBT in high lakes and tributaries in the Chelan Basin, and in the Lucerne Basin of Lake Chelan.

Strategy 3. Move toward stocking Westslope cutthroat trout (WSCT) of Twin Lakes origin. Accomplish through:
- stocking catchable size Twin Lake WSCT
- planting Twin Lake WSCT eyed eggs in tributaries
- maintaining recreational trout fishery with Twin Lake WSCT
- giving priority to fish management needs of Lake Chelan in the allocation of Twin Lake WSCT eyed eggs
- locating an alternative source of Twin Lakes cutthroat or other stocks of cutthroat to be used in other waters throughout the state.

Strategy 4. Manage lake water levels to provide tributary access for spawning, incubation and rearing.

Strategy 5. Develop monitoring and evaluation (M&E) program to assess efficacy of management actions.

Strategy 6. Delay opening fishing at mouths of lake tributaries to August 1 to protect spring spawning adult salmonids.

Strategy 7. Delay stocking of catchable cutthroat trout until at least mid-September (enable carry-over to next year, after spill terminated).

Strategy 8. Investigate feasibility of stocking triploid RBT to support recreational fishery if fish in addition to WSCT are needed.

Objective 2 Balance the populations of species inhabiting Lake Chelan (e.g., kokanee, landlocked chinook salmon, and lake trout).

Strategy 1. Develop kokanee population size objectives compatible with recovery and protection of native fish species, and compatible with park management goals for the Stehekin River.

Strategy 2. Monitor kokanee population (see specifics in Appendix A).

Strategy 3. Release stocked kokanee after spill has stopped (September/October).

Strategy 4. Focus on landlocked chinook as apex predator species (see specifics in Appendix A).

Strategy 5. Evaluate impacts of chinook on native fish species in Lake Chelan and investigate management actions that would limit potential impacts. Support recreational fisheries for chinook if impacts to native fish populations are minimal.

Strategy 6. Discontinue lake trout stocking of juveniles and reduce adult population.

Strategy 7. Develop M&E program to assess efficacy of management actions, particularly for assessing contribution of kokanee stocking program.

Objective 3 If feasible, reintroduce self-sustaining populations of bull trout in waters they historically inhabited in the tributaries that drain into the Stehekin River or directly into Lake Chelan.

Strategy 1. Conduct a survey designed to locate any bull trout population that might still exist.

Strategy 2. If a fluvial bull trout population is found, then determine if habitat conditions exist which have limited their re-colonization of the system.

Strategy 3. Eliminate the factor(s) limiting bull trout or determine if adequate population exists to provide broodstock.

Strategy 4. Investigate the feasibility of re-introducing fluvial and adfluvial bull trout.

Strategy 5. Maintain recreational fishing opportunities for other species as a high priority.

Strategy 6. Develop an M&E program to assess efficacy of management actions.

The following goals and objectives relate specifically to the Chelan River (Bypassed Reach). They are summarized from the Chelan River Comprehensive Management Plan (Chelan PUD, 2001b). Details of flow proposals and other strategies can be found in Appendix B.

The primary management goals of the plan for the Chelan River are to:

- Establish a viable riverine ecosystem, with habitat attributes necessary to support fish populations consistent with natural limiting factors.
- Meet water quality standard for designated beneficial uses.
- Provide spawning and rearing habitat for summer chinook and steelhead in Reach 4.

- Provide spawning and rearing habitat for summer chinook and steelhead in the Project tailrace.
- Have WDFW provide a test of the passage of summer chinook salmon and steelhead through Reach 3.
- Reduce the potential for entrainment of fish from Lake Chelan into the power intake via periodic monitoring of modified trash racks.

The following objectives have been proposed in the Chelan River plan. A number of specific proposals to achieve those objectives are included in the plan, including flow proposals for various seasons and runoff conditions. See Appendix B for more detail.

Objective 1 **Establish a naturally functioning aquatic ecosystem in the bypassed reach of the Chelan River**

Objective 2 **Establish minimum flows adequate to support riparian vegetation, benthic food organisms, cutthroat trout and native cool-water species in Reaches 1, 2 and 3**

Objective 3 **Establish flows and habitat adequate to support spawning, incubation and early rearing of chinook salmon and steelhead trout in Reach 4 and the tailrace.**

Wildlife

Washington Department of Fish and Wildlife

WDFW's overall policy is to provide for diverse and healthy wildlife populations, emphasizing native species and natural production (Washington Wildlife Commission, 1991). The goals of this policy are to:

- Maintain diversity, distribution, and a reasonable abundance of all native wildlife and their habitats.
- Maintain abundant populations of naturally reproducing game species for consumptive use.
- Restore depleted native game populations to healthy levels.
- Achieve recovery and delisting of threatened and endangered species.
- Ensure security of sensitive species populations to prevent the need for them to be listed as threatened or endangered.
- Prevent the illegal harvest, abusive use, and inappropriate commercialization of wildlife. (Chelan PUD, 1998, p. E3-70)

In the Lake Chelan Basin, a major focus species for WDFW is the mountain goat. The following lists the objective and strategies related to that species.

Objective 1 **Assess the impact of the Rex Creek fire on the goat population on the north side of Lake Chelan. The north side of Lake Chelan would serve as the treatment (burned) and the south side as the treatment (unburned).**

Strategy 1. Continue annual boat surveys of goats along Lake Chelan to assess changes in the number and composition of the goat population on the burned and unburned areas.

Strategy 2. Monitor habitat use by goats to assess use of burned versus unburned areas.

Strategy 3. Compare the nutritional quality of vegetation and body condition of mountain goats on the burned and unburned areas. (T. McCall, WDFW, pers. comm., 9/20/01)

U. S. Forest Service

The Wenatchee National Forest has completed watershed analyses for the North Shore, the Middle and Upper Chelan, and the Antoine subbasins. Each document contains, in addition to an assessment of current conditions, lists of desired conditions and management strategies for a wide range of fish and wildlife species and habitats. The USFS could implement strategies related to fish, particularly westslope cutthroat trout and bull trout, in addition to those identified in the Chelan PUD plans attached as Appendices A and B. For example, the North Shore Watershed Analysis identifies a strategy to reintroduce westslope cutthroat to Mitchell Creek above barrier falls (USFS, 1998). Because WNF appears to have the most comprehensive management strategies for wildlife documented in the basin, that is the focus here. The strategies are described at length in the analysis documents so are only briefly summarized here, using some North Shore strategies as examples. This list is far from complete. See USFS, 1998, Tables 2.2 – 2.5 for details and many other objectives and strategies. The other USFS watershed analyses have similar outlines.

The following are examples of some management strategies common to all fire regimes.

Objective 1 **Manage cover for large ungulates to be compatible with natural fire rotation and to provide at least 20% thermal cover of 40-60% canopy closure.**

Strategy 1. Thin small diameter stands to encourage development of overstory thermal cover, and promote use of stand interiors.

Objective 2 **Provide mule deer cover and forage and bighorn sheep foraging and security areas that have minimal overlap in critical deer winter and spring ranges.**

Objective 3 **In riparian habitat, support a well-developed overstory of large trees and achieve a full range of species and sizes in both the shrub and forb/grass component, and provide diverse foraging, nesting, security, thermal, fawning, and travel habitats.**

Strategy 1. Promote development of large trees (including planting), to provide snags and large woody debris.

Strategy 2. Help aggrade downcut streams ("living dams").
Strategy 3. Place large woody debris.
Strategy 4. Reroute riparian roads or stabilize them.
Strategy 5. Control grazing in riparian areas.
Strategy 6. De-compact soils in grazed areas.

Objective 4 Promote wetland recovery from previous impacts to provide key reproductive habitats.

Strategy 1. Conduct condition surveys on known wetlands and survey for other potential habitats. Specific riparian and wetland habitats of concern include Antilon Lake, Mitchell Creek, Coyote Basin, Grade Creek headwaters, Falls Creek headwaters, Stinky Pond, and all riparian areas, particularly where affected by grazing, fire, harvest, and roads (Union Valley).

Additional strategies relate to the following wildlife species; strategies may be specific to a particular fire regime (low, moderate, or high):

- Large ungulates – mule deer, bighorn sheep
- Large carnivores – grizzly bear, fisher, wolf, wolverine, lynx
- Large raptors – peregrine falcon, golden eagle, bald eagle, goshawk, ferruginous hawk, Swainson's hawk
- Ponderosa pine-dependent species – pygmy nuthatch, flammulated owl, white-headed woodpecker, western gray squirrel, pileated woodpecker
- Interior forest habitat species – spotted owl
- Other species of concern – Chelan mountain snail

Research, Monitoring, and Evaluation Activities

Periodic monitoring of the water quality of Lake Chelan began in the 1960s, and the first detailed baseline water quality characterization of the lake was completed in 1987. Additional studies were done in 1995, 1996, and 1999. Results are documented in FERC, 2001. Original studies are documented in Patmont et al., 1989, Congdon, 1995, Sargeant, 1997, and Anchor, 2000.

Chelan PUD and WDFW have been monitoring fish and wildlife on and near the lake and its tributaries for many years as part of the licensing agreement for operation of the Lake Chelan Hydroelectric Project; it is expected to continue. Currently, focus species are:

- Kokanee
- Westslope cutthroat trout
- Rainbow trout
- Landlocked chinook salmon
- Bighorn sheep
- Mule deer
- Mountain goats

Future monitoring might include bull trout. The scope of M&E studies and funding responsibilities are still being negotiated between Chelan PUD and other parties.

Monitoring activities conducted for the Chelan River would include spawning surveys and spawning habitat use, surveys of aquatic invertebrates, incubation survival evaluations, snorkel surveys in Reaches 1 and 2, and juvenile salmon surveys in Reach 4 and the tailrace. An experiment to introduce steelhead trout into Reach 4 and the tailrace to attempt establishing a naturally reproducing population would also be conducted.

The monitoring and evaluation (M&E) program will continue to resolve uncertainties and provide information needs for future management decisions to meet biological objectives while reserving lake storage and generation resources. M&E activities could be intensive for the first

10 years of the new license as proposed protection, mitigation, and enhancement measures are implemented. M&E activities are expected to be implemented at a lower, more routine level of effort during the remainder of the license period.

The following lists proposed M&E measures for the Chelan River (Chelan PUD, 2001b). They are described in more detail in the Chelan River Comprehensive Management Plan (Appendix B).

- Monitor aquatic macroinvertebrates
- Conduct steelhead spawning surveys
- Measure steelhead redd characteristics
- Evaluate steelhead egg-fry success
- Conduct steelhead snorkel surveys (Reach 4, tailrace)
- Conduct chinook spawning surveys
- Measure chinook redd characteristics (primarily tailrace)
- Evaluate chinook egg-fry success
- Conduct coho spawning surveys
- Conduct snorkel surveys: Reaches 1 and 2
- Monitor temperatures
- Monitor bull trout

The U.S. Forest Service monitors numerous species and habitats on an ongoing basis; they are too numerous to list here. Primary efforts focus on:

- prescribed fire management and monitoring;
- dry forest vegetation management and monitoring;
- monitoring of efforts to sustain and improve habitat for species associated with shrub steppe, ponderosa pine, Douglas fir, and grassland habitats; and
- research associated with crupina infestations.

In addition, there will be rehabilitation and monitoring of areas associated with the recent Rex Creek fire.

The National Park Service has many monitoring programs. Monitoring of specific species includes bald eagles and osprey; and they are working with a panel of scientists to develop monitoring of forest birds including migratory neo-tropical birds and their productivity.

NPS also does ecological monitoring such as modeling sources of dust at Stehekin, where fugitive dust in spring during lake drawdown is a significant problem. They have also mapped large woody debris and hydro modification locations in GIS; and have been monitoring glacial output/mass balance since 1993/94 (in cooperation with U.S. Geological Survey), because snowfields throughout the North Cascades are disappearing.

Future monitoring could include ecological monitoring of the Stehekin River, particularly harlequin duck habitat on the lower Stehekin and the effect of reservoir high water on upstream habitat (Bruce Freet, NPS, pers. comm., August 2001).

Statement of Fish and Wildlife Needs

The following list of needs has been compiled from various sources, including the management plans for fish in Lake Chelan (Appendix A); the Chelan River management plan (Appendix B); U.S. Forest Service documents and personal communication with Forest Service contributors to this summary; and personal communication with National Park Service contributors. Most needs listed are not species-specific but reflect needs for many species in the basin.

- Remove barriers to migrating fish in tributaries to Lake Chelan.
- Restore perennial flows to the Chelan River.
- Preserve and restore riparian habitat.
- Preserve and restore grassland habitat.
- Increase the amount of large woody debris in stream habitat.
- Maintain water quality.
- Return fire regimes to a more natural pattern.
- In some cases, remove non-native fish species that are threatening native fish populations.
- More actively control noxious weeds, especially cheat grass, yellow star thistle, dalmation toad flax, knapweed, milfoil, and crupina.
- Study and monitor a variety of fish and wildlife populations, including rare carnivores, raptors, woodpeckers, pygmy whitefish, bull trout, and species such as the Chelan Mountain snail, to determine their population status, distribution, and limiting factors in order to develop ecologically sound management recommendations to benefit them.

Lake Chelan Subbasin Recommendations

Projects and Budgets

No project proposals were submitted in the Lake Chelan Subbasin.

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