CHAPTER THREE

AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS

INTRODUCTION

This chapter describes the components and scope of the human environment that may be affected by implementation of the alternatives outlined in Chapter 2 and discloses the potential consequences of implementing each alternative including the mitigation measures, watershed best management practices and management requirements associated with each alternative. The description of the affected environment centers primarily on the issues outlined in Chapter 1, but it also briefly discusses other resources that may potentially be affected. A complete description of each alternative is found in Chapter 2. This chapter presents the scientific and analytic basis for the comparison of alternatives. The effects[1] are discussed in terms of social and environmental changes from the current situation and include quantitative assessments where possible as well as qualitative assessments. All discussions are tiered to the Umpqua National Forest Plan Final Environmental Impact Statement, as amended.

ACTIVITIES THAT CONTRIBUTE TO CUMULATIVE EFFECTS:

Potential cumulative effects are analyzed by considering the proposed activities in the context of past, present, and reasonably foreseeable actions. For this project activities are considered in the entire Diamond Lake Fifth Field Watershed and in Lake Creek, Poole Creek, and Calamut Lake Sixth Field Subwatersheds of the Lemolo Lake Fifth Field Watershed. These are the areas where cumulative effects have occurred or may occur. In addition, some activities have an influence that may extend downstream of the project area boundary through the North Umpqua River system as far as Rock Creek. This broad area is referred to as the "cumulative effects analysis area" and in general all alternatives are considered in the context of relevant past, present, and reasonably foreseeable activities in this area[2].

The following past management activities have occurred in the cumulative effects analysis area (Table 9).

Table 9. Past Management Activities in the Cumulative Effects Analysis Area.

[1] Direct effects are the immediate environmental changes that occur as a result of implementing project activities. Indirect effects are environmental effects that are caused by the action at a later time or occur in a different place (i.e. downstream from the project area), but are reasonably certain to occur. Cumulative effects are effects that are caused by other projects and activities in the same area as the project being considered. Cumulative effects are analyzed by considering the proposed activities in the context of past, present, and reasonable foreseeable actions.
[2] However, cumulative effects are analyzed at scales most appropriate for individual resources.

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
Sheep Grazing	1880s – 1943	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety.	Unregulated grazing occurred prior to 1908. After 1908, the McGowan, Kelsay Valley, and Dog Prairie Allotments allowed for regulated grazing within the analysis area. Associated activities and structures included camps, cattle guards, water systems, drift fences, corrals, loading chutes, and stock driveways.
Federal Land Designation	1893 and 1908	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety.	Cascade Range Forest Reserve designated in 1893, which included the analysis area. The Umpqua National Forest was established in 1908. Road building and access increased as a result of National Forest designation.
Telephone Line Installation	1909 – 1965	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety.	A system of telephone lines was installed connecting Big Camas Ranger Station with the outlying guard stations and lookouts, including Diamond Lake, Mount Bailey, Kelsay Valley, Cinnamon Butte, and Windigo Pass.
Fish Stocking, Diamond Lake	1910 – 1939	Diamond Lake, Diamond Lake	Kamloops rainbow trout fry stocked. 1 or 2 million per year, 32 million total.
	1940 – 1949	Diamond Lake, Diamond Lake	Kamloops rainbow trout fry stocked. 2 - 4 million per year, 21.3 million total. No fish stocked in 1949.
	1950 – 1959	Diamond Lake, Diamond Lake	Kamloops rainbow trout legals and fry stocked. 32 – 49,000 legals stocked per year, 177,000 total. 250,000 – 1.014 million fry stocked per year, 3.094 million total. No fish stocked in 1954.
	1960 – 1969	Diamond Lake, Diamond Lake	Kamloops rainbow trout fry and mixed fingerlings stocked. 1.063 – 1.175 million fry on select years, 2.238 million total. 400 – 500,000 fingerlings on select years, 3.62 million total.
	1970 – 1979	Diamond Lake, Diamond Lake	Oak Springs rainbow trout fingerlings stocked. 300 – 450,000 stocked per year, 4.82 million total.
	1980 – 1989	Diamond Lake, Diamond Lake	Oak Springs rainbow trout fingerlings stocked. 350 – 400,000 stocked per year, 3.9 million total.
	1990 – 1999	Diamond Lake, Diamond Lake	Oak Springs rainbow trout fingerlings, Cape Cod rainbow trout legals, Williamson rainbow trout fingerlings, and Kamloops rainbow trout trophies stocked. 350 – 475,000 Oak Springs fingerlings stocked per year, 3.85 million total. 5 – 14,000 Cape Cod legals stocked on select years, 64,700 total. 12 – 50,000 Williamson fingerlings stocked on select years, 162,000 total. 5,000 Kamloops trophies stocked, 1999.
Fish Stocking, Diamond Lake	2000 – 2002	Diamond Lake, Diamond Lake	Oak Springs rainbow trout fingerlings, Cape Cod rainbow trout legals, Kamloops rainbow trout trophies, and North Umpqua Spring Chinook fingerlings and legals stocked. 50 – 60 thousand Oak Springs fingerlings stocked per year, 160,000 total. 26 – 38,000 Cape Cod legals stocked on select years, 95,000 total. 15,000 Kamloops trophies stocked per year, 45,000 total. 40,000 chinook fingerlings and 24,000 chinook legals stocked in 2002.

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
Diamond Lake Fish Hatchery Construction	1919 - 1949	Diamond Lake, Diamond Lake	Hatchery building constructed on Lake Creek with egg-taking stations constructed on Short and Silent Creeks. The Lake Creek facility burned and was reconstructed in 1949.
USFS Camps	1920 – 1965	Diamond Lake, Diamond Lake	Campgrounds were established and in use by 1920. Facilities eventually included developed campsites, pit/vault toilets, and potable water from springs.
Diamond Lake Shoreline Road	1922	Diamond Lake, Diamond Lake	A road was constructed around the north, west, and south shores of Diamond Lake. The road was completed in 1922 and graveled in 1928.
Diamond Lake Improvement Company	1922 – 1965	Diamond Lake, Diamond Lake	Special use permit issued to Diamond Lake Improvement Company to build a resort at the North end of Diamond Lake. The improvements consisted of a lodge, a store, and several tents.
Permitted Camps	1923 – 1959	Diamond Lake, Diamond Lake	Diamond Lake Boy Scout Camp, 1923 – '38. Civilian Conservation Corp Camp, 1933 – '42. Latter Day Saints Camp, permit terminated in 1959.
Diamond Lake Recreation Cabins	1924 – present	Diamond Lake, Diamond Lake	Permits were issued between 1924 – mid-1950s for a total of 102 cabin sites and associated improvements.
North Umpqua Road Construction	1939	Diamond Lake, Diamond Lake Lemolo Lake, Lake Creek	The original road connecting Roseburg and Diamond Lake was completed in 1939, based on an old Indian trail. The surface was originally dirt and rock. East of Copeland Creek, the North Umpqua Road was located south of the current Highway 138 route.
Mechanical and Chemical Control of Tui Chub	1946 – 1953	Diamond Lake, Diamond Lake	Seining and spot rotenone treatments of shallow water areas were implemented to reduce the chub population. Control activities were carried out annually and resulted in the removal of millions of tui chub.
Lemolo 1 Hydroelectric Project	1952 – 1955	Lemolo Lake, Poole Creek	The Lemolo 1 project was a portion of the North Umpqua Hydroelectric Project. Physical project structures included Lemolo Dam, Lemolo Reservoir (454 acres), 16,705 feet of waterways (canals), 7328 feet of penstock, a power plant, and a substation. Associated improvements included maintenance/access roads, transmission/distribution lines, crew camps, and a school. The plant began operation in June 1955.
Rotenone Treatment of Diamond Lake	1953 – 1954	Diamond Lake, Diamond Lake	Physical improvements constructed in 1953 included a canal (spanning 1000 feet on land and 900 feet into the lake at a depth of eight feet) and a flow control structure. The rotenone treatment occurred in September 1954 and involved 100 tons of powder rotenone and 275 gallons of liquid rotenone. An estimated 32 million chub that totaled 400 tons were killed.
Fish Stocking, Lemolo Lake	1955 – 1972	Lemolo Lake, Calamut Lake Poole Creek Lake Creek	Brown trout, rainbow trout, kokanee salmon, and brook trout were stocked in Lemolo Lake and its tributaries. All of the above species, with the exception of rainbow trout, established wild populations, although brown trout are the most common species.

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
Timber Harvest	1950 – 1959	Lemolo Lake, Lake Creek Poole Creek	A total of 141 acres of regeneration harvest were completed. Associated activities included road building and slash treatment.
	1960 – 1969	Diamond Lake, Diamond Lake West Lemolo Lake, Lake Creek Poole Creek	A total of 351 acres of regeneration harvest were completed. Associated activities included road building and slash treatment.
	1970 – 1979	Diamond Lake, Diamond Lake South Diamond Lake West Silent Creek Lemolo Lake, Lake Creek Poole Creek	A total of 862 acres of regeneration harvest were completed. Associated activities included road building and slash treatment. A portion of these sales was for salvage of timber killed by a mountain pine beetle outbreak in the mid-1970s. This outbreak occurred mostly south of Diamond Lake and posed a significant fire hazard to the Diamond Lake area facilities.
	1980 – 1989	Lemolo Lake, Lake Creek Poole Creek	A total of 518 acres of regeneration harvest were completed. Associated activities included road building and slash treatment.
	1990 – 1999	Lemolo Lake, Lake Creek Poole Creek	A total of 292 acres of regeneration harvest were completed. Associated activities included road building and slash treatment.
Lemolo Lake Area Improvements	1963 – 1984	Lemolo Lake, Poole Creek	A Special Use Permit was issued in 1963 for the Lemolo Lake Resort. Initial facilities included a restaurant, store, four cabins, and a marina, but more cabins, a gas station, and an RV park were added over the years. Poole Creek Campground was issued a water right in 1963 and 40 sites with associated facilities existed. Major reconstruction began in 1982, which included paving, vault toilets, a new well, hydrants, waterlines, a boat launch, and a group campsite. Reconstruction efforts ended in 1984.
Highway 138 Improvements	1964	Diamond Lake, Diamond Lake East Diamond Lake South Lemolo Lake, Lake Creek	Highway 138 was completely paved from Roseburg to Highway 97.
Diamond Lake RV Park	1965 – present	Diamond Lake, Diamond Lake	A special use permit was issued by the USFS to create a privately operated RV park near the southwest corner of Diamond Lake.
Pesticide Use for Mosquito Abatement	Mid-1960s – 1982	Diamond Lake 5th Field in its entirety	Douglas County officials, permittees, and later the USFS used malathion and MLO-FLIT for mosquito abatement in the Diamond Lake area. Chemicals were applied to South Shore Marsh and to areas around the lakeshore.
Diamond Lake Area Improvements	1968 – 1972	Diamond Lake, Diamond Lake East Diamond Lake South Diamond Lake West Silent Creek Lemolo Lake, Lake Creek	Major water and sewer facilities were constructed to reduce water quality impacts to Diamond Lake. Improvements included: deep wells and storage for potable water supply, 13 miles of water lines, flush restrooms and fire hydrants, 11 miles of underground electrical lines, sewage pump stations and treatment lagoons, and fish cleaning and trailer dump stations. Diamond Lake Resort and RV Park connected to the sewage treatment

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
			system at this time also. Diamond Lake Resort also began full year operation in 1968, increasing winter recreation opportunities in the area.
Water Rights Issued	1970s	Diamond Lake, Diamond Lake	Water rights were issued to Diamond Lake Resort, Diamond Lake RV Park, and the US Forest Service of not more than 0.30 cfs for domestic use, emergency use, and use in the campgrounds. Oregon Dept. of Fish and Wildlife was issued a right to hold up to 5800 acre-feet of water in Diamond Lake to mitigate the effects of the Rock Creek Hatchery diversions.
Sediment Coring	1972 and 1996	Diamond Lake, Diamond Lake	Sediment coring was done in Diamond Lake to assess water quality changes over time.
Highway 138 Reconstruction	1977 – 1978	Diamond Lake, Diamond Lake East Diamond Lake South Lemolo Lake, Lake Creek	A bypass was constructed so that traffic on Hwy 138 would not be congested due to recreational activities at Diamond Lake. The result of the construction effort is present day Highway 138. Pit Lake #1, near Lake Creek, was excavated to provide rock for this project. The "pit" eventually filled with water and was stocked by ODF&W with 200 rainbow trout fingerlings in 1979. Stocking levels increased and continued over time. The related Pit Lake #2 was excavated in 1982.
Herbicide Use for Road Maintenance Purposes	1980 – 1983	Diamond Lake, Diamond Lake East Diamond Lake South	Herbicides were used by Douglas County officials along Highway 138 to clear vegetation from road shoulders. Chemicals used included Cimizine, 2, 4 Dichlorophenol, and Trichlopyr.
Snowcat Skiing	1981 – present	Diamond Lake, Diamond Lake West Silent Creek	A snowcat skiing operation was created to offer expert skiers the finest backcountry skiing experience in the Northwest.
Herbicide Use for Silvicultural Purposes	1982	Lemolo Lake, Lake Creek	Herbicides were used by the USFS to reduce competition between conifers and early successional plants. Hand application of glyphosate on seven acres in Cinnamon Butte Timber Sale Unit #1.
Diamond Lake Area Improvements	Mid-1980s – early-1990s	Diamond Lake 5th Field in it's entirety	Over three million dollars of improvements were made to meet demands, afford resource protection, and upgrade campgrounds and facilities. Improvements included: paving all campground roads, paving and improving boat ramps and South Shore Picnic Area, construction of the paved Dellenback Bike Trail, adding two shower facilities and an amphitheater, improving handicapped accessibility, removing some lakeshore campsites, reducing the total amount of

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
			roads, and adding barriers to keep vehicles in designated areas. Diamond Lake Resort also increased the size of its facility at this time by adding more cabins and expanding the main lodge.
Diamond Lake Paving Project (Phase I)	1995	Diamond Lake, Diamond Lake South Diamond Lake West Silent Creek	The Diamond Lake Loop Road was widened and paved all the way around the Lake.
Lemolo Fuels Reduction Project	1998 – 2002	Lemolo Lake, Calamut Lake Lake Creek Poole Creek	A fuels reduction project was completed by the Diamond Lake RD Fire Staff. A total of 1,432 acres were treated on Bunker Hill and along roads #2610, 2614, 2612, and 60.
Diamond Lake Fuels Reduction Project (Phase I)	1998 – 2002	Diamond Lake, Diamond Lake	A fuels reduction project was completed by the Diamond Lake RD Fire Staff. A total of 876 acres were treated in the vicinity of Diamond Lake, mostly focusing around the campgrounds, the Lodge, the RV Park, and Summer Homes.
Mechanical Removal of Tui Chub	2000	Diamond Lake, Diamond Lake	A commercial herring seiner was contracted to remove tui chub from Diamond Lake for four days. A total of 40,000 chub (1,200 pounds) were removed from the lake and destroyed. Carcasses were buried off-site. The cost of the project was approximately $25,000.
Lake Use Restrictions	2001 – 2002	Diamond Lake, Diamond Lake	Various restriction levels were imposed due to particularly large blooms of Anabaena phytoplankton. Restrictions ranged from posting information to no boating or water contact.

There are multiple ongoing activities that may contribute to cumulative effects for the Diamond Lake Restoration project. Table 10 displays relevant present activities within the cumulative effects analysis area.

Table 10. Present Management Activities in the Cumulative Effects Analysis Area.

Activity	Location (5th, 6th Field)	Description and Extent of Activity
Diamond Lake Fuels Reduction Project	Diamond Lake, Diamond Lake	An ongoing fuels reduction project is being completed by the Diamond Lake RD Fire Staff. The project will total 876 acres of treatment in the vicinity of Diamond Lake, mostly focusing around the campgrounds, the Lodge, the RV Park, and Summer Homes.
Diamond Lake Paving Project (Phase II)	Diamond Lake, Diamond Lake South Silent Creek Lemolo Lake, Lake Creek	A paving overlay is planned for the south end of the Diamond Lake Loop Road and at the Lake Creek crossing.
Fire Camp Improvements	Diamond Lake, Diamond Lake South	Improvements were made to the Broken Arrow Campground Overflow Area to provide a site for expanded fire camps. Improvements included rocking existing roads, spreading

Activity	Location (5th, 6th Field)	Description and Extent of Activity
		woodchips on high use areas, and clearing areas for parking. The fire camp area was used for the Kelsay Fire in 2003.
Fishery Monitoring	Diamond Lake, Diamond Lake Lemolo Lake, Lake Creek	ODF&W is monitoring the Diamond Lake fishery in several ways: trap netting on Diamond Lake, creel surveys at Diamond Lake, a screw trap at the outlet of Diamond Lake, and a Passive Integrated Transponder (PIT) tagging system to monitor the migration of spring chinook salmon through Lake Creek.
Fish Stocking, Diamond Lake	Diamond Lake, Diamond Lake	The "Experimental Fish Stocking Plan" was developed by ODF&W and is being implemented. It involves stocking 60,000 spring Chinook, 24,000 Eagle Lake rainbow trout, 27,000 Fishwich rainbow trout, 15,000 Kamloops rainbow trout, and 50,000 Oak Springs rainbow trout per year.
Hazard Tree Removal	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	A Title II (PAYCO) funded project is being implemented in Fall, 2003. This project will remove approximately 2,000 trees in the Diamond Lake area. Hazard trees will continue to be removed from areas of high recreational use and when localized events (blowdown, bugkill, fire, etc.) require tree removal for safety and/or structure protection purposes.
Herbicide Use for Noxious Weeds	Diamond Lake, Diamond Lake East Diamond Lake South Lemolo Lake, Lake Creek Poole Creek	The herbicide Pickloram is being used by the Oregon Department of Agriculture along roadsides to control spotted and diffuse knapweed populations. Pickloram is spot-sprayed on individual plants or groups of plants.
Hydrologic Monitoring of Diamond Lake	Diamond Lake, Diamond Lake	Various monitoring activities include: primary productivity (1x/month), nutrients, chemical profile, algae, and zooplankton (3x/month), secchi disk (daily), secchi disk and chemical profile (weekly), fish netting (intermittently), algae and toxins (as needed), temperature and light intensity profile (continuous), aeration test (as needed), and gas sampling (as needed).
Hydrologic Monitoring of Groundwater	Diamond Lake, Diamond Lake East Diamond Lake South Diamond Lake West	Groundwater monitoring is being assessed at 18 sites on a weekly basis. Monitoring includes drilling to the water table then documenting stage, temperature, and major ions and nutrients.
Hydrologic Monitoring of Lake Creek	Lemolo Lake, Lake Creek	Lake stage, temperature, and discharge are monitored continuously.
Hydrologic Monitoring of Silent and Short Creeks	Diamond Lake, Diamond Lake	Nutrient load, field chemistry, major ions, and discharge are monitored three times per month.
Lake Use Restrictions	Diamond Lake, Diamond Lake	Various restriction levels were imposed due to particularly large blooms of Anabaena phytoplankton. Restrictions ranged from posting information to no water contact.
Lemolo Lake Fuels Reduction Project	Lemolo Lake, Calamut Lake Lake Creek Poole Creek	An ongoing fuels reduction project is being completed by the Diamond Lake RD Fire Staff. The project will total 1,432 acres of treatment on Bunker Hill and along roads #2610, 2614, 2612, and 60.

Activity	Location (5th, 6th Field)	Description and Extent of Activity
Maintenance Activities	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Maintenance activities are ongoing. Maintenance is required for trails, roads, culverts, buildings, water and sewer systems, campground facilities, and signs.
PacifiCorp Operations	Lemolo Lake, Poole Creek	Lemolo 1 project is a portion of the North Umpqua Hydroelectric Project. Physical project structures include Lemolo Dam, Lemolo Reservoir (454 acres), 16,705 feet of waterways (canals), 7328 feet of penstock, a power plant, and a substation. Associated improvements include maintenance/access roads and transmission/distribution lines.
Recreational Use	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Recreational use in the area is down from historic levels, but is the highest on the Umpqua National Forest. USFS campgrounds, Diamond Lake Resort, Diamond Lake RV Park, and the Summer Homes have a total capacity of 780 available units. The most common recreational activities include sightseeing, hiking, camping, fishing, bicycling, boating, swimming, hunting, backcountry skiing, and snowmobiling.
Water Rights	Diamond Lake, Diamond Lake Lemolo Lake, Lake Creek	Water rights issued in the past are being utilized. Water rights were issued to Diamond Lake Resort, Diamond Lake RV Park, and the US Forest Service of not more than 0.30 cfs for domestic use, emergency use, and use in the campgrounds. Oregon Dept. of Fish and Wildlife was issued a right to hold up to 5800 acre-feet of water in Diamond Lake to mitigate the effects of the Rock Creek Hatchery diversions. The Oregon Department of Transportation continues to utilize water from Lake Creek, not to exceed 0.01 cfs, for shop uses and sanitary facilities.

Reasonably foreseeable actions in the analysis area can also contribute to cumulative effects (Table 11). No private land is located in the Diamond Lake or Lemolo Lake Watersheds. For the Umpqua National Forest, the following activities are likely to occur over the next five years.

Table 11. Reasonably Foreseeable Management Activities in the Cumulative Effects Analysis Area.

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
Boat Ramp Improvements	2004	Diamond Lake, Diamond Lake	Boat ramp improvements for the South Shore Boat Ramp are scheduled to occur in 2004. Improvements will involve adding fill to the shoreline to access deeper water for the ramp. The project is funded but does not yet have a signed decision.
Campground Improvements	2004 – 2009	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Campground improvements will be made as funding from PAYCO, Fee Demo, PacifiCorp, and other sources becomes available. The area occupied by the

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
			current facilities will not increase as a result of improvements.
Diamond Drive	2005 – 2009	Lemolo Lake, Calamut Lake Lake Creek Poole Creek	The project will involve a paving overlay on the 2610 and 2614 roads. There is currently no signed decision for this project.
Diamond Lake Fuels Reduction Project (Phase II)	2004 – 2007	Diamond Lake, Diamond Lake	Approximately 500 acres are planned to be treated for hazardous fuels. Treatment will likely involve mechanical thinning, chipping, and handpiling. Project areas are to include stands north of the Hilltop Shop and south and west of Broken Arrow Campground.
Diamond Lake Viewpoint	2005	Diamond Lake, Diamond Lake East	A Scenic Byway Enhancement Project is planned to allow visitors a place to enjoy the scenery and rest, picnic, etc. The Environmental Assessment has been signed and the project is funded.
Fire Camp	2004 – 2009	Diamond Lake, Diamond Lake South	The recently improved South Diamond Firecamp will be used if large fires occur in the area and extensive suppression efforts are applied.
Fishery Monitoring	2004 – 2006	Diamond Lake, Diamond Lake Lemolo Lake, Lake Creek	ODF&W will monitor the Diamond Lake fishery in several ways: trap netting on Diamond Lake, creel surveys at Diamond Lake, a screw trap at the outlet of Diamond Lake, and a Passive Integrated Transponder (PIT) tagging system to monitor the migration of spring chinook salmon through Lake Creek.
Fish Stocking, Diamond Lake	2004 – 2006	Diamond Lake, Diamond Lake	Fish stocking activities are largely dependant on the outcome of the Diamond Lake Restoration Project. The current plan involves stocking 60,000 spring Chinook, 24,000 Eagle Lake rainbow trout, 27,000 Fishwich rainbow trout, 15,000 Kamloops rainbow trout, and 50,000 Oak Springs rainbow trout per year.
Fish Stocking, Lemolo Lake	2004 – 2006	Lemolo Lake, Calamut Lake Lake Creek Poole Creek	Fish stocking will continue with rainbow trout hatchery catchables, as needed, to provide a recreational fishery during the mid-summer months when brown trout are hard to catch.
Hazard Tree Removal	2004 – 2009	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Hazard trees will continue to be removed in the future from areas of high recreational use and when localized events (blowdown, bugkill, fire, etc.) require tree removal for safety and/or structure protection purposes.
Herbicide Use for Noxious Weeds	2004 – 2009	Diamond Lake, Diamond Lake East Diamond Lake South Lemolo Lake, Lake Creek	Herbicides will continue to be used by the Oregon Department of Agriculture along roadsides to control spotted and diffuse knapweed populations. The chemical used in the past has been

Activity	Time Period	Location (5th, 6th Field)	Description and Extent of Activity
		Poole Creek	Pickloram and has been spot-sprayed on individual plants or groups of plants.
Hydrologic Monitoring of Diamond Lake	2004 - 2005	Diamond Lake, Diamond Lake	Various monitoring activities include: primary productivity (1x/month), nutrients, chemical profile, algae, and zooplankton (3x/month), secchi disk (daily), secchi disk and chemical profile (weekly), fish netting (intermittently), algae and toxins (as needed), temperature and light intensity profile (continuous), aeration test (as needed), and gas sampling (as needed).
Hydrologic Monitoring of Groundwater	2004	Diamond Lake, Diamond Lake West Silent Creek Lemolo Lake, Lake Creek	Groundwater characteristics will be monitored at 18 sites, on a weekly basis. Monitoring includes stage, temperature, and major ions and nutrients.
Hydrologic Monitoring of Lake Creek	2004 – 2009	Lemolo Lake, Lake Creek	Lake stage, temperature, and discharge will be monitored continuously.
Hydrologic Monitoring of Silent and Short Creeks	2004 – 2005	Diamond Lake, Diamond Lake	Nutrient load, field chemistry, major ions, and discharge will be monitored three times per month.
Lake Closures	2004 – 2009	Diamond Lake, Diamond Lake	Lake use restrictions will continue to be implemented if conditions warrant potential safety concerns.
Lemolo Watershed Project Activities	2004 – 2009	Lemolo Lake, Calamut Lake Lake Creek Poole Creek	The Lemolo Watershed Projects involve several timber sales and associated road building and restoration. The proposed action would harvest timber on 1617 acres, construct or reconstruct 49.1 miles of road, decommission 10.7 miles of road, build 3.5 miles of temporary road, subsoil 232 acres, and treat fuels on 282 acres. In addition to the proposed action, a wide range of alternatives exists. An environmental impact statement is currently being prepared for these projects. Work is scheduled to begin in 2004 or 2005.
Maintenance Activities	2004 – 2009	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Maintenance activities will continue at current levels. Maintenance activities include trails, roads, culverts, buildings, water and sewer systems, campground facilities, and signs.
PacifiCorp Operations	2004 – 2009	Lemolo Lake, Poole Creek	Lemolo 1 project is a portion of the North Umpqua Hydroelectric Project. Physical project structures include Lemolo Dam, Lemolo Reservoir (454 acres), 16,705 feet of waterways (canals), 7328 feet of penstock, a power plant, and a substation. Associated improvements include maintenance/access roads and transmission/distribution lines.

Activity	**Time Period**	**Location (5th, 6th Field)**	**Description and Extent of Activity**
Recreational Use	2004 – 2009	Diamond Lake and Lemolo Lake 5th Field Watersheds in their entirety	Recreational use in the area is likely to continue at or above current levels, which is the highest on the Umpqua National Forest. USFS campgrounds, Diamond Lake Resort, Diamond Lake RV Park, and the Summer Homes have a total capacity of 780 available units. The most common recreational activities include sightseeing, hiking, camping, fishing, bicycling, boating, swimming, hunting, backcountry skiing, and snowmobiling.
Water Rights	2004 – 2009	Diamond Lake, Diamond Lake Lemolo Lake, Lake Creek	Water rights issued in the past will continue to be utilized. Water rights were issued to Diamond Lake Resort, Diamond Lake RV Park, and the US Forest Service of not more than 0.30 cfs for domestic use, emergency use, and use in the campgrounds. Oregon Dept. of Fish and Wildlife was issued a right to hold up to 5800 acre-feet of water in Diamond Lake to mitigate the effects of the Rock Creek Hatchery diversions. The Oregon Department of Transportation will continue to utilize water from Lake Creek, not to exceed 0.01 cfs, for shop uses and sanitary facilities.

GEOLOGICAL ENVIRONMENT

Information on the geologic environment enhances understanding of many of the watershed processes described in other sections of this document.

The Diamond Lake project planning area straddles the crest of the High Cascades physiographic sub-province[3] (Peck et al. 1964) and is underlain by layers of young and relatively unaltered lava flows that lie atop older, deeply weathered Western Cascades volcanic deposits. The initial pulse of High Cascade volcanic activity in the Diamond Lake area began about 2 million years ago and is noted by voluminous outpourings of highly fluid lava that emanated from a series of north-south-trending broad, gently sloping volcanoes. Overlapping lava flows of basaltic andesite (a type of volcanic rock) constructed a broad plateau above the older Western Cascades. About 300,000 years ago, a more explosive phase of volcanic activity in the region formed the modern day steep-sided volcanoes atop this plateau. The snow-capped and glacially sculpted peaks of Mt. Theilsen, Crater Lake caldera (ancestral Mt. Mazama) and Mt. Bailey encircle Diamond Lake to the east, south and west, respectively (Sherrod 1991; Priest et al. 1983). The most recent volcanic event of significance to occur in the Diamond Lake area is the climatic eruption of Mt. Mazama some 7,500 years ago, altering the physical appearance of the landscape in the region (Bacon 1983).

Sherrod (1991) surmised that Diamond Lake came into existence when Mt. Mazama erupted, causing a massive ash-flow that swept down its flanks burying and extensively altering existing stream networks within surrounding lowland valleys. According to this hypothesis, a lobe of the ash-flow choked and blocked a section of stream channel that had once previously flowed through a broad valley now occupied by Diamond Lake. As the newly formed lake began to fill, a natural bedrock-controlled spillway became established several hundred yards east of the ancestral stream channel. The outlet to Diamond Lake is now controlled by this bedrock ledge, which today, is Lake Creek.

Sherrod (1986, 1991) describes the bedrock and surface geology of the High Cascades volcanic terrain in west-central Oregon, including the area encompassing Diamond Lake. Figure 32 in the Groundwater section of this chapter displays the various geologic map units found in the area. In geologic time, the High Cascades is a youthful landscape that is characterized by a very low-density drainage network and minimal amount of landscape dissection. The young, relatively gentle landscape makes for a low density of stream channels compared to other landscapes. In other words, the youthful landscape has not had time to erode deep canyons.

The Soil Resource Inventory (USDA 1976) characterized the landform and soil characteristics of the Diamond Lake vicinity. The depth of the ash cap from Mt. Mazama varies from two to six meters, a depth that in most places exceeds the rooting depth of plants. Recent glacial action scoured the land surface down to bedrock on the upper slopes of mountain sides and

[3] Physiographic province is a contiguous region, in which all parts are similar in geologic structure with a unified geologic and geomorphic history, and whose topography and landforms differ appreciably from that of adjacent regions.

valley walls, leaving a bedrock surface that was covered with Mazama ash since the retreat of the last glaciers. At the same time, the recent glaciation (10,000 to 1 million years ago) that scoured the landscape left few buried soils at this elevation, soil materials that might otherwise store water. In valley bottoms and on the concave foot slopes of valley walls, the glaciers deposited till and sediments. Many of these deposits were compacted by the weight of the ice leaving a surface that today is impermeable to the water that percolates through soils. In fact, this impermeable, compact till perches the water table and is often the foundation for springs and seeps on the lower slopes of mountain sides as well as in valley bottom wetlands. The wetlands at south end of Diamond Lake may be an example of a water table perched on glacial materials.

The hydrology of the Diamond Lake area is strongly influenced by the underlying bedrock substrate as well as the local cover of Mazama air-fall and ash-flow deposits. Sherrod (1995) characterized the highly porous and permeable volcanic rocks that underlie the headwaters of the North Umpqua River as a principal factor controlling a stable and abundant groundwater flow. Numerous fractures in the lava flows allow for the storage of vast volumes of ground water. Furthermore, these fractures provide for the slow and steady passage of ground water through the rock mass. Snowmelt is the primary source of groundwater recharge (Ingebritsen et al. 1994; James and Manga 2000). The upper horizon (top three feet) of the Mazama ash-flow is highly porous with substantial infiltration capacity (this is the foundation of a shallow unconfined aquifer). Below this zone the Mazama ash-flow appears to be much denser and less permeable with a considerably lower infiltration capacity. The upper horizon of the Mazama ash-flow functions as a highly porous sponge that dampens the effects of runoff during sizable storm events (Sherrod 1995; Ingebritsen et al. 1994).

The immense bedrock aquifer underlying the Diamond Lake area contributes greatly to the outstanding water quality characteristics of the North Umpqua River, such as sustained summer base flows, coldness, and clarity due to low levels of dissolved solids (Ingebritsen et al. 1994; Grant 2002).

AQUATIC ENVIRONMENT

WATER QUALITY REGULATIONS AND BENEFICIAL USES

The state of Oregon has established water quality standards set out in Chapter 340, Division 41 of the Oregon Administrative Rules. Water bodies that do not meet state water quality standards are termed "water quality limited" and are placed on a list in accordance with Section 303(d) of the federal Clean Water Act (303(d) list). Table 12 documents relevant water quality limited streams within and downstream of the project area boundary.

In 1998, Diamond Lake was added to the Oregon Department of Environmental Quality's 303(d) list of water quality limited water bodies for the parameters of pH and algae. Diamond Lake remains on the most recent 303(d) list (2002). The list serves as a guide for developing water pollution control plans and ensures that "beneficial uses" of water are protected. The beneficial uses for Diamond Lake that are currently negatively impacted by water quality below current standards include: resident fish and aquatic life, water contact recreation, aesthetics, and fishing (OAR 340-41-0282).

The applicable pH standard for Diamond Lake is 6.0 to 8.5 (OAR 340-41-0285(2)(d)(C)). Annual monitoring data by the Oregon Department of Environmental Quality (ODEQ) and others demonstrates that pH values have not met water quality standards during the summer season every year from 1992-2002. Historic water quality data indicate pH values did not meet this standard for most of the 1970s as well.

Similarly, annual monitoring data from 1992-2002 indicate that state standard for algae are not being met at Diamond Lake. Specifically the standard states that development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or which are injurious to health, recreation, or industry shall not be allowed (OAR 340-41-0285(2)(h)). The water quality standard requires that a three-month (summer) average chlorophyll *a* value exceeding 0.01 mg/l (for natural lakes) be used to identify water bodies where phytoplankton (free-floating algae) may impair recognized beneficial uses (OAR 340-41-150(a)).

To address water quality problems, ODEQ calculates pollution load limits, known as Total Maximum Daily Loads (TMDLs) for each pollutant entering a body of water. TMDLs specify the amount of pollution that can be put into a water body while maintaining water quality standards and supporting beneficial uses. Efforts are currently underway to produce TMDLs for Diamond Lake. A final TMDL report for Diamond Lake is expected to be released by ODEQ in the spring of 2004.

Table 12. Water Quality Limited Streams and Water Bodies Within and Downstream of the Project Boundary (ODEQ, 2003).

Record ID	Waterbody Name	Sub-Basin	River Mile	Parameter	Season
		(Within	*Project*	*Boundary)*	
5452	Diamond Lake/Diamond Lake	NORTH UMPQUA	0 to 3.7	Aquatic Weeds Or Algae	
5562	Diamond Lake/Diamond Lake	NORTH UMPQUA	0 to 3.7	pH	Summer
5337	Lake Creek	NORTH UMPQUA	0.9 to 11.5	Temperature	Summer
5704	Lake Creek	NORTH UMPQUA	0.9 to 11.5	Temperature	Year Around
5563	Lemolo Lake/North Umpqua River	NORTH UMPQUA	91.8 to 93.5	pH	Summer
		(Downstream	*Project*	*Boundary)*	
5709	North Umpqua River	NORTH UMPQUA	77 to 78	Total Dissolved	Year Around

Record ID	Waterbody Name	Sub-Basin	River Mile	Parameter	Season
				Gas	
5710	North Umpqua River	NORTH UMPQUA	86.9 to 87.4	Total Dissolved Gas	Year Around
5711	North Umpqua River	NORTH UMPQUA	75 to 75	Total Dissolved Gas	Year Around
5713	North Umpqua River	NORTH UMPQUA	77 to 78	pH	Summer
5724	North Umpqua River	NORTH UMPQUA	75.5 to 83.3	Temperature	Summer
5725	North Umpqua River	NORTH UMPQUA	34.8 to 65.9	Temperature	Spring/Summer
5842	North Umpqua River	NORTH UMPQUA	68.3 to 72.3	Temperature	Summer
5862	North Umpqua River	NORTH UMPQUA	75 to 75	Total Dissolved Gas	Year Around
8094	North Umpqua River	NORTH UMPQUA	35 to 52	Arsenic	Year Around
8160	North Umpqua River	NORTH UMPQUA	0 to 47.7	Temperature	Summer

AQUATIC CONSERVATION STRATEGY

The Aquatic Conservation Strategy (ACS) was developed to restore and maintain the ecological health of watersheds and aquatic ecosystems contained within them on public lands (NWFP 1994). The ACS strives to maintain and restore ecosystem health at watershed and landscape scales to protect habitat for fish and other riparian-dependent species and resources and restore currently degraded habitats. Complying with ACS objectives means that an agency must manage the riparian-dependent resources to maintain the existing condition or implement actions to restore conditions. Improvement relates to restoring biological and physical processes within their ranges of natural variability. All of the alternatives are evaluated for consistency with ACS objectives in the Aquatic and Terrestrial Environment sections of this chapter.

SURFACE WATER – LAKE ECOLOGY

Lake ecology is relevant to all issues (significant and other) identified in scoping. However, this section primarily focuses on information pertaining to the issue of water quality. The remaining issues are addressed throughout this document. Scoping identified a concern about the effects of a lake draw down on down stream water quality. This issue is tracked under the titles water chemistry, primary production and phytoplankton and is also tracked under the title water quality in the stream ecology section. There is a concern about the effects of the rotenone treatment and subsequent fish stocking on the short-term and long-term condition of water quality in Diamond Lake proper. This issue is tracked throughout the section.

BACKGROUND AND LIMNOLOGICAL INVESTIGATIONS

Diamond Lake has been classified by scientists who study lakes (limnologists) as a highly productive water body due to the availability of nutrients that support the growth of aquatic plants. Periods of high algae abundance in the water (algae blooms) at Diamond Lake have been observed since the 1930s (Hughes 1970). Prior to the 1920s, developments at Diamond Lake consisted primarily of unimproved campgrounds. More extensive development began in the 1920s and included construction of a resort and lakeside residences. The construction of residences continued until the mid 1950s and expansion of the campground facilities continued up to 1972. Visitor use of the area has increased dramatically since the area was first developed. By the mid-1960s, Forest Service officials were concerned that nutrient-rich sewage and other wastes generated by Diamond Lake visitors could contribute to an increase in the growth of aquatic plants (eutrophication). Visitor use projections and possible health and aesthetic concerns led officials of the Forest Service to evaluate the waste collection and treatment needs of the Diamond Lake area and a plan was developed for an improved sanitation system (Burgess 1966). The system was designed to accommodate approximately 15,000 lake-visitors per day, including people using the resort, the south-shore area, the trailer court and various picnic sites and campgrounds (USDA Forest Service 1970). The private residences on the western shore of the lake were not included in the waste collection system. These residences rely primarily on septic systems and simple pit toilets for sewage disposal. As part of the waste water diversion system, sewage waters were diverted to waste-stabilization ponds (lagoons) located outside the lake's watershed. In some cases, septic-tank drainfield systems and simple pit-toilets were replaced by vaults which temporarily store wastes until they can be hauled away. The first use of the new facilities occurred in 1970 and by December 1975 all planned connections to the waste water diversion system were completed (Lauer et al. 1979). The Forest Service continues to operate and maintain these sewage diversion and treatment facilities up to the present time.

In 1971, the Forest Service and US Environmental Protection Agency (EPA) signed a Memorandum of Agreement to systematically study Diamond Lake and assess the effectiveness of nutrient diversion on the condition of the lake (Lauer et al. 1979). From 1971 to 1977 the EPA conducted a research program on Diamond Lake to collect limnological information and identify changes that could be attributed to the nutrient diversion. Following this period of study, EPA concluded that the lake's eutrophication rate had not been affected to any significant degree by sewage diversion, and nutrients from human sources represented a minor portion of the lake's total nutrient load. These researchers reported that nutrient enrichment in Diamond Lake was primarily a natural phenomenon, with the majority of nutrients derived from natural sources (Lauer et al. 1979).

Other investigators (Davis and Larson 1976; Meyerhoff et al. 1978; Salinas and Larson 1995; Eilers et al. 1997; Eilers et al. 2001b) reached a different conclusion implicating human activities as major sources of nutrient enrichment which has accelerated eutrophication.

Eilers et al. (2001a) concluded that Diamond Lake has experienced significant deterioration in the 20th century and these changes are associated to some extent with shoreline development but correspond more closely with changes in the introduced tui chub (*Gila bicolor*) population.

The Forest Service has implemented a monitoring program at Diamond Lake to collect limnological and water-quality information. During the summers of 2001, 2002 and 2003, blooms of the toxin producing blue-green algae (cyanobacteria) *Anabaena flos-aquae* occurred at Diamond Lake. The high abundance and associated public health risks of this planktonic (microscopic free-floating) blue-green algae prompted the Umpqua National Forest in cooperation with Oregon Health Division and Douglas County Health Department to close the lake to water contact activities for periods of time during each of these summer seasons.

LAKE MORPHOMETRY AND SEDIMENTS

AFFECTED ENVIRONMENT

Morphometry[4]

Diamond Lake is a large, relatively shallow natural lake with an elliptical shape. The lake bottom slopes gradually to the deepest portion located slightly north of the center (Figure 5). The maximum depth is 48.5 feet (14.78 m) and the mean depth is 22.5 feet (6.85 m). The majority of the lake area is relatively shallow with greater than 80 percent of the lake area being less than 36.1 feet (11 m) deep (Figure 6). The estimated time to refill the lake if it were emptied (hydraulic residence time) is 1.6 years (Johnson et al. 1985). The surface level of Diamond Lake is artificially elevated during the summer by controlling the flow at the outlet. The elevated level in the summer is approximately 2 feet (0.61 m) higher than levels during other seasons. Table 13 presents a summary of lake morphometry data.

The shallow nature of Diamond Lake significantly influences its ecological characteristics. Among the factors affected by the relatively shallow water is the ability of light to penetrate to the bottom of a large portion of the lake contributing to the growth of an extensive macrophyte[5] population. Also in shallow lakes, surface turbulence can mix particles including nutrient rich sediments into the water.

[4] Morphometry is the measurement of shape. For lakes, morphometric data include length, depth, volume, etc.
[5] Macrophytes are aquatic plants.

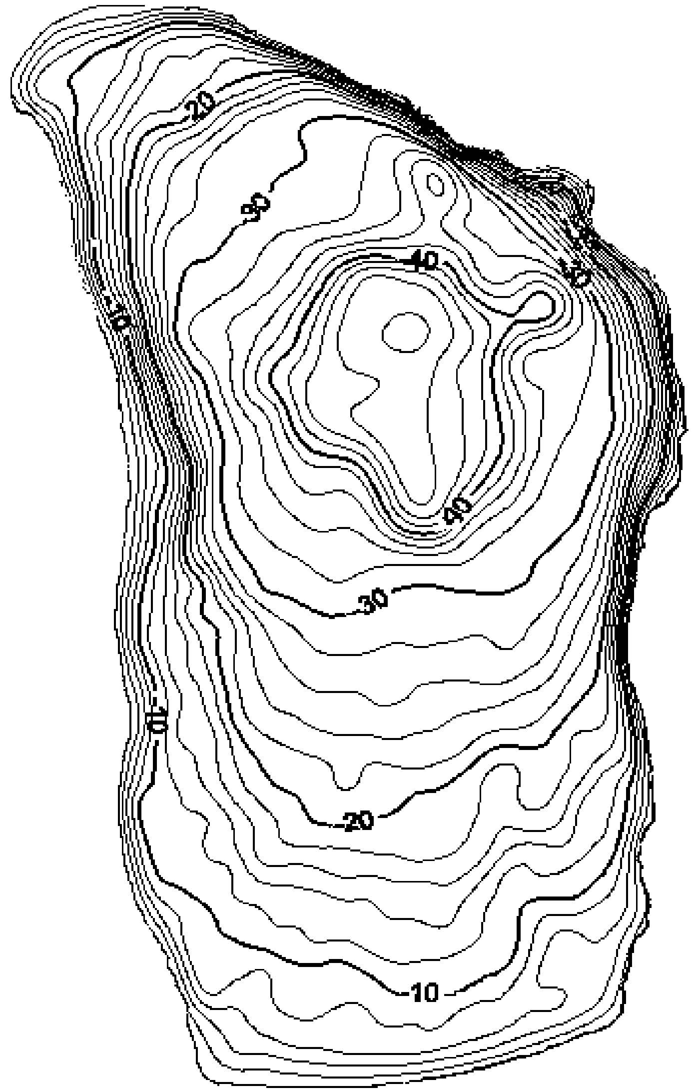

Figure 5. Diamond Lake Bathymetric Map (Source: JC Headwaters, Inc.). (contour lines are shown in feet)

Table 13. Morphometry of Diamond Lake

Attribute	**Metric**	**English**
Elevation*	1580 m	5183 ft
Lake Area**	1226 ha	3031 ac
Watershed Area*	136 km^2	55 mi^2
Maximum Depth**	14.78 m	48.5 ft
Mean Depth**	6.85 m	22.5 ft
Volume**	84.00 hm^3	68,099 ac-ft
Precipitation*	140-165 cm	55-65 in

* Source: Johnson et al. 1985
** Source: Eilers and Gubala 2003

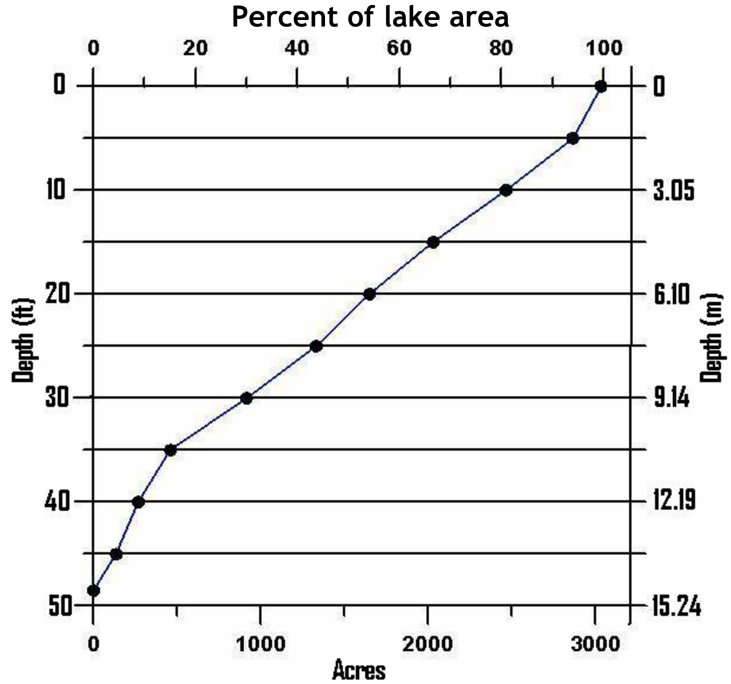

Figure 6. Diamond Lake area by depth (modified from JC Headwaters, Inc. 2003 data).

Sediments

The sediment in the littoral zones[6] of Diamond Lake has been described as flocculent[7], light brown, and often containing rooted aquatic plants (Lauer et al. 1979). The sediments near the center of the lake were described as typically flocculent, gray to brownish organic silt. The organic-rich sediments were observed to provide a habitat highly suitable for macroinvertebrates (Lauer et al. 1979). Eilers et al. (1997) described the sediment profile as relatively uniform, with a high water content, and high organic component. Concentrations of nitrogen, phosphorus, and silicon are high in the sediments.

Davis and Larson (1976) and Meyerhoff et al. (1978) reported an increase in total organic matter in the sediments of Diamond Lake corresponding with an increase in human activities in the watershed. In addition, these investigators observed changes in the planktonic diatom remains in the sediments suggesting an increase in the productivity of the lake associated with an increase in human use. Eilers et al. (2001b) reported an increase in the sediment accumulation rate from approximately 0.01 g/cm/yr around the beginning of the century (~1900) to a rate of approximately 0.03 g/cm/yr from the 1950s through the 1960s and a

[6] The littoral zone is the relatively shallow near-shore area.
[7] A fine, fluffy mass formed by the aggregation of small insoluble particles that will settle to the lake bottom over time.

similar increase again in the late 1980s to mid-1990s (Figure 7). These investigators concluded the sediment accumulation rate has increased approximately four-fold over the long-term baseline values and at least two-fold over values from near the beginning of the century. Although a small portion of the increase in the sediment accumulation rate was associated with watershed development, Eilers et al. (2002b) reported the majority of sediment originated within the lake and corresponds with two time periods of high tui chub abundance[8].

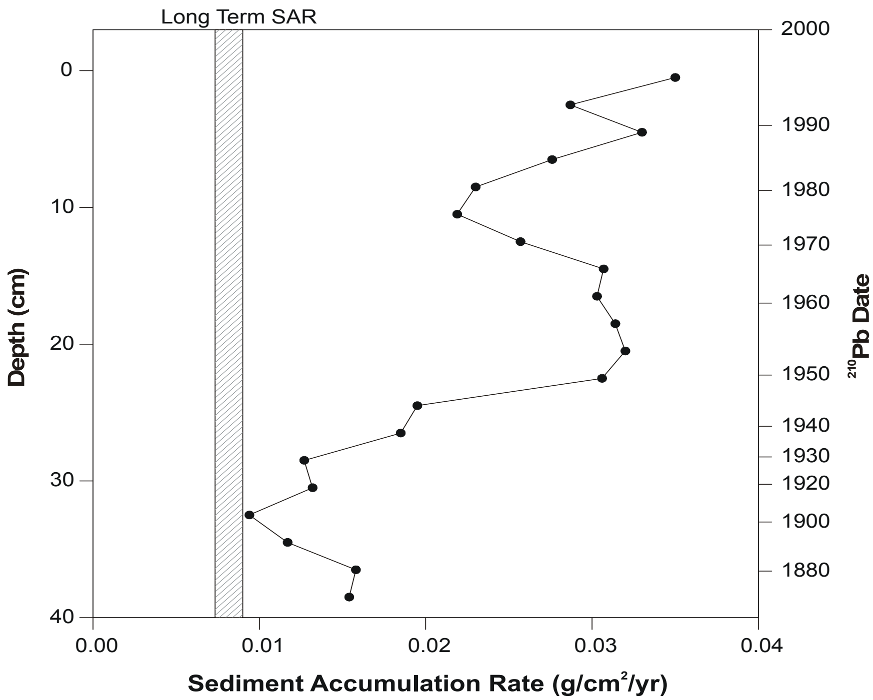

Figure 7. Sediment accumulation rate (Eilers et al. 2001a).

ENVIRONMENTAL EFFECTS ON MORPHOMETRY AND SEDIMENTS

Direct Effects:

Alternative 1 and Alternative 4 would have no direct effect on lake morphometry or sediments since these alternatives do not propose altering the lake level, canal dredging, or wetland expansion. Alternatives 2 and 3 would result in the redistribution of some lake sediments, the greatest effect occurring in the area dredged for canal re-construction and in the wetland expansion area.

Historically and under current operating procedures, the surface of Diamond Lake is artificially elevated during the summer and lowered by 2 feet (0.61 m) during the fall and winter. Under implementation of either Alternative 2 or 3, the surface level of Diamond Lake would be 8 feet (2.45 m) lower than the usual summer level following the fall/winter draw

[8] Although the increase in the sediment accumulation rate occurred during a period of warmer than normal air temperatures, these climatic variations likely accounted for only a small part of the observed increase because the rate did not return to background values during cool weather periods.

down period estimated to take 4 to 6 months. At the point of maximum draw down during the winter under these alternatives, the lake level would be 6 feet (1.83 m) lower than the usual seasonal water level. The surface area of the lake at the time of maximum draw down would be reduced by 13 percent compared to the normal summer water level and expose approximately 400 acres of sediments along the shoreline. Due to the gently sloping gradient of the southern most portion of the lake bottom, the edge of the water would recede the greatest distance from the normal water edge along this portion of the shoreline. Figure 8 displays the approximate area that would be exposed during the period of maximum draw down. The draw down of the lake surface would be a short-term effect. After the rotenone treatment, the lake would be refilled to the usual seasonal levels.

Alternatives 2 and 3 include excavation of a drainage canal near the current lake outlet. The dredge spoils from the canal construction would be used to expand a wetland along the northwest shore of the lake. Excavation of the drainage canal and the area of wetland expansion on the northwest shore would be a long-term alteration of a small portion of the lake bottom. High-resolution mapping of the lake bottom by Eilers and Gubala (2003) revealed that the canal excavated in 1953 to lower the lake level still exists to a significant degree. By following the route of the original canal excavation, the volume of dredge spoils from within the lake would be reduced to a large extent.

Dredging of the outlet channel under Alternatives 2 and 3 would result in reduced water quality in the lake from an increase in turbidity due to disturbance of bottom sediments during the dredging operation. Although these alternatives include the installation of a sediment screen fence around the wetland expansion area, a portion of the fine sediment particles in suspension would be expected to pass through the enclosure and could potentially increase turbidity levels over the entire lake. Due to the limited clay[9] content in the sediments and the relatively low degree of exposure to wind generated turbulence, elevated turbidity levels from dredging and wetland expansion activities would be highest in the northwest portion of the lake and would likely subside quickly after completion of the these activities.

Under either Alternative 2 or 3, the operators of the Diamond Lake Resort would request a permit to remove accumulated sediment and trash and repair docks at the resort marina during the low water period following the lake draw down. In addition, the resort operators would conduct similar work to remove old dock structures and moorage material from areas near the South Shore Store. This work would be accomplished using heavy equipment and would affect an area approximately 2/3 of an acre in size. Approximately 750 to 1,000 cubic yards of material would be hauled to an approved waste disposal site. Due to the small area impacted by these activities and no in-water work, no significant direct effects are anticipated from these connected actions.

[9] Fine textured clay particles tend to stay suspended in water for extended periods of time.

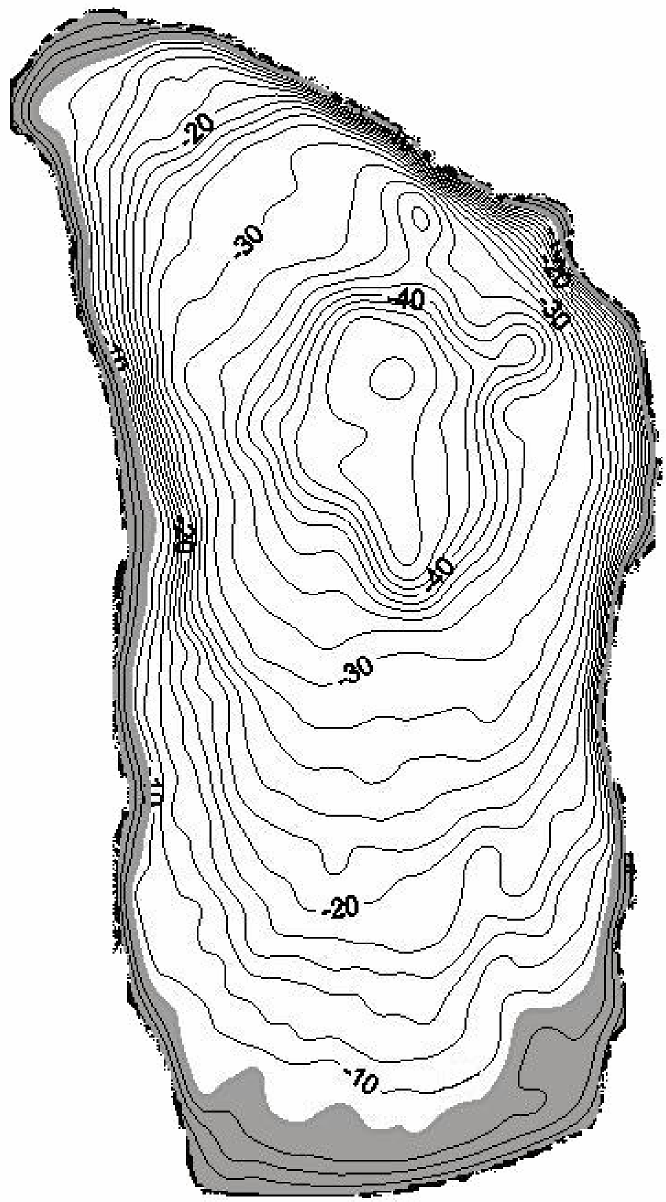

Figure 8. Area of exposed sediment (shown in gray) at time of maximum draw down.

The area of wetland expansion would be relatively small compared to the size of the lake and would affect an area estimated to be approximately 0.6 acres. Turbidity levels in the lake could remain above normal during the draw down operation due to wave action along the shoreline mobilizing and suspending sediments normally under water. However, hydroacoustic data of the lake indicates that the majority of the area exposed to an increase in wave action is composed of relatively hard sediments (Eilers and Gubala 2003). These relatively hard surfaces would be less susceptible to sediment mobilization by wave action reducing the severity of the potential turbidity increase.

The sediment accumulation rate would be affected outside of the wetland expansion area as sediments are disturbed by wave action within the draw down zone and due to settling of suspended sediment originating from activities associated with the dredging and wetland expansion. Following the rotenone treatment under Alternatives 2 and 3, there would be a temporary increase in the rate and quantity of organic material deposited in the sediments as organisms susceptible to the toxic effects of rotenone (primarily fish and zooplankton) die and settle to the lake bottom. Short-term increases in sediment accumulation rates represent a minor negative impact on the ecology of the lake.

Indirect Effects:
The sediment accumulation rate is also considered to be an indirect effect due to its long-term nature. Since an increase in the sediment accumulation rate has been found to be associated with high tui chub abundance and all alternatives except Alternative 1 would eliminate or severely reduce the tui chub population, the sediment accumulation rate would likely be reduced to some extent by implementation of any of the action alternatives; the reduced sediment accumulation rate would more closely resemble the natural (pre-management) rate and would be viewed as a positive impact. This reduction would likely occur after a period of approximately 3 years under Alternatives 2 or 3. A reduction in the sediment accumulation rate under Alternative 4 would be expected to occur within approximately 6 years from the time mechanical fish removal begins. Alternative 4 may be less effective in reducing the sediment accumulation rate compared to the other action alternatives in the long-term due to difficulties associated with mechanically maintaining reduced tui chub populations.

Differences between Alternatives 2 and 3 could occur due to the different fish stocking strategies implemented. Under Alternative 2, the feeding behavior typical of the type of trout proposed for stocking has a higher potential to impact the zooplankton population (particularly large bodied species) and bottom dwelling invertebrates of the lake. High predation of large bodied zooplankton combined with bottom feeding behavior of fish has the potential to affect nutrient distribution and cycling rates and increase overall phytoplankton abundance, possibly leading to an elevated sediment deposition rate. Alternative 3 proposes annual stocking of the lake during the angling season with a type of domesticated rainbow trout. This type of fish would be expected to have a low impact on potential food sources and would not be expected to survive harsh winter conditions. The low feeding rates of these fish would more likely result in conditions favoring high numbers of large zooplankton contributing to an overall reduction in phytoplankton density and a lower sediment deposition rate (see sections Aquatic Biology – Phytoplankton, Zooplankton, and Fisheries for a more complete explanation). Fish stocking strategies under any action alternative would be closely monitored to ensure fish populations levels are not contributing to adverse effects on the water quality of the lake[10].

Under any of the action alternatives a reduction in the sediment accumulation rate would be closer, but not likely equal to the rate before the lake was altered by human activities (positive effect). Under Alternative 1 the sediment accumulation rate would likely remain elevated above rates that existed before the lake was populated with large numbers of tui chub (negative effect).

Cumulative Effects:

[10] An ecologically-based index for guiding fish stocking decisions in Diamond Lake has been developed (Eilers 2003a); components include water chemistry, phytoplankton, zooplankton, and benthos.

Past management activities that were the primary contributors to a cumulative effect on morphometry and sediment accumulation in Diamond Lake were described in the affected environment (i.e. 1950s canal construction, lake-side developments, etc.). Ongoing and reasonable foreseeable actions are not expected to result in adverse effects on these resources.

Under Alternatives 1 and 4, the remains of the previously constructed canal would be filled by sediment deposition over time and no wetland expansion would occur.

Although implementation of Alternatives 2 and 3 include dredging of bottom sediments and wetland expansion, none of the action alternatives propose to expand the dimensions of the canal beyond the size of the original canal constructed in 1953. The sediment deposited in the wetland expansion area would cumulatively add to the natural sediment accumulation in that area and would be an addition to the small quantities of sediment originating from human activities in the watershed. In the majority of the lake, a small increase in the sediment deposition rate could occur during implementation of Alternatives 2 and 3 due to settling of sediment that was suspended as a result of management activities adding to the existing sediment accumulation rate. As mentioned previously however, very limited quantities of sediments are generated from areas that are impacted by human activities that drain into the lake and most suspended sediment would be likely to be deposited or settle in or near the wetland expansion enclosure. Since all action alternatives would reduce or eliminate the tui chub population and the associated increase in the sediment accumulation rate, any of the action alternatives in combination with other management activities that lower external nutrient loading (e.g. operation of the wastewater diversion system) would cumulatively lower the sediment accumulation rate in the long-term and thus represents a beneficial effect (see cumulative effects tables 9-11for a complete list of projects).

Conclusions:
In the long-term, all action alternatives would likely result in a reduction in the sediment accumulation rate that would more closely approximate the natural rate and the natural sediment regime. Since Alternatives 2 and 3 would alter only a small area of the lake bottom through canal excavation and wetland expansion, no long-term detrimental effects from this alteration are anticipated. If fish stocking levels were high under Alternative 2, the indirect effects could lead to elevated sediment accumulation rates as compared to Alternative 3. Among the action alternatives, Alternative 4 would have lower short-term impacts on turbidity and morphometry. However, Alternative 4 may have a reduced probability of achieving and sustaining lowered sediment accumulation rates in the long-term.

Implementation of any of the action alternatives would be consistent with attainment of Aquatic Conservation Strategy (ACS) objective number 5, "to maintain and restore the sediment regime under which the aquatic ecosystem evolved." Under Alternative 1 (No Action), the sediment accumulation rate would be higher than projections for the action alternatives and would remain elevated above the natural and average historic accumulation rate.

WATER TEMPERATURE AND THERMAL PROPERTIES

AFFECTED ENVIRONMENT

Water temperature is an important factor in the limnological analysis of lakes for several reasons including its influence on the rate of biochemical reactions. Water temperature in combination with the intensity of wind and lake geometry determines the degree surface waters are mixed with deeper water and as a result influences important processes within the lake.

Diamond Lake has sufficient depth so that layers of differing water temperature develop on a seasonal basis. As the intensity of solar radiation[11] increases during the spring and early summer months, thermal stratification occurs as a layer of warm surface water called the "epilimnion" develops over deeper, cooler water below. The depth of the epilimnion is directly related to the degree of wind-generated turbulence at the surface. During most summers, the surface waters of Diamond Lake reach a maximum temperature in the early part of August. The water in the deepest portion of the lake remains relatively cool throughout the summer and is referred to as the "hypolimnion". Between these two layers the area of most rapid change in temperature with depth is referred to as the "thermocline" or "metalimnion" (Figure 9).

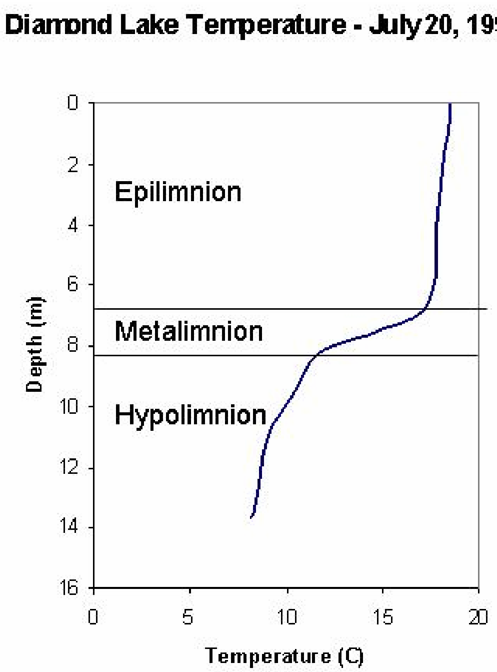

Figure 9. Temperature vertical profile showing epilimnion, metalimnion, and hypolimnion during typical summer thermal stratification.

Freshwater has a maximum density at 39.2˚F (4˚C) and is less dense at temperatures above and below this point (Wetzel 2001). Due to changes in the density of water with temperature, layers of differing temperature become highly resistant to mixing. However, immediately after the melting of winter ice in the spring, temperatures throughout the water

[11] Solar radiation refers to sunlight.

column of Diamond Lake become nearly uniform (isothermal). Also in the fall as air temperatures cool and input of solar radiation decreases, thermal stratification in the lake begins to break down as surface waters cool and temperatures again become isothermal and near the point of maximum density. Under these nearly uniform temperature conditions, resistance to mixing of water at various depths is low and a small amount of wind over the lake can supply sufficient energy to result in mixing of the entire water column of the lake.

During summer thermal stratification, the warmer water in the epilimnion is less dense than the deeper and cooler water of the hypolimnion. Because the layers of differing temperature and density are resistant to mixing, water in the hypolimnion becomes isolated from water near the surface resulting in differences in the chemical and biological properties of these different layers.

During most winters, an ice cover forms on Diamond Lake beginning in late December to early January and remains until approximately late March or April. During these periods of ice cover, inverse stratification occurs as surface waters become less dense as they cool below 39.2˚F (4˚C) while deeper water remains near the temperature of maximum density (Figure 10).

Due to its high elevation, development of summer thermal stratification in Diamond Lake generally occurs relatively late in the season (Johnson et al. 1985). Usually, the most prominent stratification occurs during the months of July and August. However, during periods of cool or windy weather, de-stabilization of the stratified layers can occur even during these months (Eilers and Kann 2002). Diamond Lake has been characterized as a dimictic (Lauer et al 1979, Salinas and Larson 1995), meaning that there is complete mixing throughout the water column twice each year, once in the spring, a short time after the melting of winter ice and a second time as the lake cools in the fall. The low stability of the stratification suggests however, that the lake behaves more as a system that mixes several times each year (polymictic). One of the consequences of limited duration of stratification is dissolved oxygen depletion in the isolated water of the hypolimnion generally does not persist for extended periods of time.

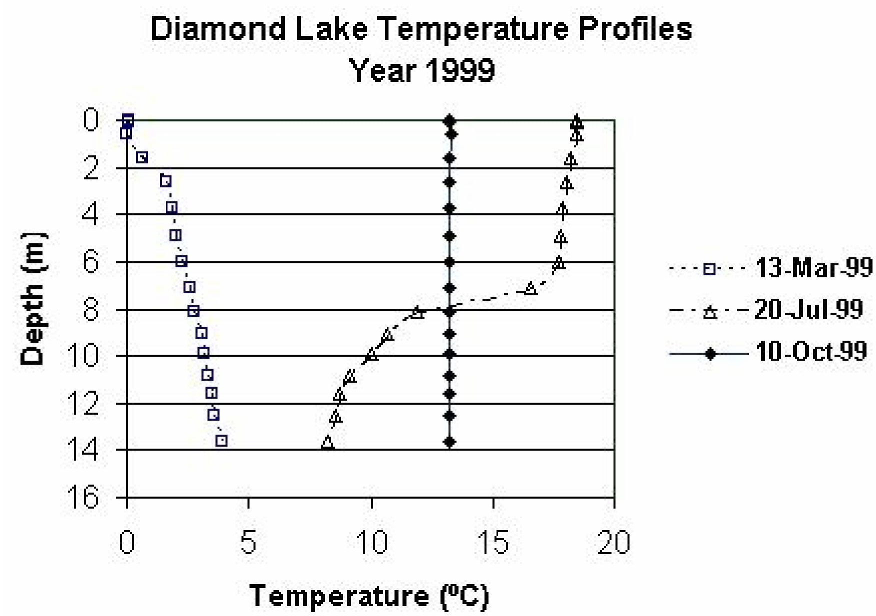

Figure 10. Typical seasonal temperature profiles from Diamond Lake: Winter/spring inverse stratification (March 13, 1999); summer thermal stratification (July 20, 1999), and; fall isothermal profile (October 10, 1999).

ENVIRONMENTAL EFFECTS ON WATER TEMPERATURE AND THERMAL PROPERTIES

Direct Effects:

Under Alternatives 2 and 3 the lake level would be lower by 8 ft (2.45 m) and thus shallower than usual during the summer following the draw down. Assuming the thickness of the epilimnion would remain the same as in years of normal lake level, wind generated turbulence would likely mix a higher percentage of the lakes total volume. As a result, the volume of the hypolimnion would be reduced. In addition, the shallower lake would be more susceptible to mixing of the entire water column resulting in an increase in the frequency of nearly uniform temperatures with depth. Under these conditions the duration of time the lake remains stratified would likely be reduced and this would have a positive impact on the length of time that the deepest part of the lake is oxygen-depleted (see Dissolved Oxygen section). No direct effects on water temperature or thermal properties would be anticipated under Alternatives 1 and 4.

Indirect and Cumulative Effects:

Since all alternatives would result in maintenance of the historic summer and fall/winter lake levels in the long-term, and no other activities are anticipated that would affect lake water temperature, no indirect or cumulative effects are anticipated under any alternative.

Conclusions:

Although Alternatives 2 and 3 could have short-term effects on the thermal stratification of Diamond Lake during the draw down period, in the long-term all alternatives are not likely to significantly affect the water temperature and thermal properties of the lake and would therefore have a neutral effect on attainment of Aquatic Conservation Strategy Objectives.

WATER QUALITY (DISSOLVED OXYGEN, NUTRIENTS, ALKALINITY and pH)

AFFECTED ENVIRONMENT

The water quality of Diamond Lake varies by season and depth. The majority of variation in water quality is associated with typical changes in seasonal productivity and thermal stratification. Nearly all of the available water quality data for the lake has been collected from May through October. Generally the water quality across the open water surface of the lake is relatively uniform (Salinas and Larson 1995). However, during the summer, variation in some water quality parameters near the surface can occur due to the patchy characteristic of blue-green algae (cyanobacteria) blooms common during this season. Diamond Lake is a highly productive water body with sufficient nutrients to support a high phytoplankton biomass during the summer season. High phytoplankton production in surface water results in elevated pH values occasionally greater than 9.3 and can reach values of 9.7 during daylight periods, exceeding water quality standards. During the summers since 2001, high values of chlorophyll *a* (a measure of algae abundance) and reduced light penetration through the water have been associated with severe blooms of toxin producing blue-green algae (cyanobacteria). Despite indications of a decline in water quality in recent years, few water quality parameters indicate clear trends over time. Eilers (2003) noted that inconsistencies in sampling design and frequency have made it difficult to detect trends in the water quality of Diamond Lake over time. Table14 displays a summary of water quality data from Diamond Lake collected between 1992 and 2003.

Table 14. Summary of water quality data for Diamond Lake (Source: Salinas 1992-2002, DEQ 2001-2002, Eilers 2003)

Parameter	Median	1992-1997	1998-2003
pH*	8.1	7.7 – 9.1	7.4 – 9.7
Chlorophyll a (mg/L)	0.006	0.001 – 0.027	0.005 – 0.064
Total dissolved phosphorus (mg/L)	0.016	0.011 – 0.025	0.008 – 0.030
Total Phosphorus**(mg/L)	0.020		0.010 – 0.060
Conductivity (µS/cm)	3.8	1.9 – 3.7	1.9 - 6.5
Nitrate-Nitrogen (mg/L)	0.001	0 – 0.011	0 – 0.516
Ammonia-Nitrogen (mg/L)	0.009	0.001 – 0.527	0 – 0.516

*Derived from maximum values.
**Data from years 2001-2003.

Dissolved Oxygen

Dissolved oxygen (DO) in lake water originates from exchange with the atmosphere and release from plants in the water. DO is required by fish and many other kinds of aquatic life. Although fish species vary in their tolerance to low oxygen, most fish cannot survive at less than 2 mg/L of oxygen (Wetzel 2001). Diamond Lake is typical of many highly productive lakes in that during periods of summer thermal stratification, high rates of photosynthesis in the epilimnion during the day result in elevated concentrations of oxygen near the surface. However in the deeper water of the lake, dissolved oxygen depletion occurs in both summer and winter.

Dissolved oxygen concentrations in the epilimnion of Diamond Lake are generally near saturation levels[12]. However, exceptions to this saturated condition can occur during the summer season. Eilers and Kann (2002) and data from ODEQ reported dissolved oxygen levels in epilimnetic waters below the expected saturation concentration[13] during the month of August 2001. Eilers and Kann attributed the lower dissolved oxygen concentrations to the dieback of a dense planktonic blue-green algae bloom. In the deeper water of the hypolimnion little light is available for photosynthesis. Also in the deeper zones, decaying organic material accumulates and oxygen is consumed by animal respiration, resulting in a depleted oxygen condition during the summer season.

Lauer et al. (1979) reported dissolved oxygen depletion below 32.8 feet in the lake (10 m) in both the summer and winter. Values less than 5 mg/L were found below 42.6 feet (13 m) during the months of July and August of every year between 1971 and 1977 with a low of 0.1 mg/L recorded on August 18, 1977. Lauer et al. observed winter minimum values of 0.5 mg/L and 1.5 mg/L of dissolved oxygen near the lake bottom in February 1972 and March 1975 respectively. Salinas and Larson (1995) reported during July and August in the years 1992 through 1994, concentrations of dissolved oxygen approached 0 mg/L below approximately 39.4 feet (12 m). Other studies have reported similar results in recent years indicating declining oxygen concentrations or anoxic[14] conditions in the hypolimnion during July and August (Eilers and Kann 2002, Salinas unpublished data 1995-2002, Eilers 2003, ODEQ 2001 unpublished data). Figure 11 below displays seasonal changes in dissolved oxygen concentration with depth during the year 2001 that would be typical of most years.

Oxygen depletion in the hypolimnion results in conditions that favor a series of chemical reactions with the largest effect occurring at the sediment water interface. Important consequences of these reactions are the increased solubility[15] and release of the nutrients phosphorous and silicon from bottom sediments. Increased concentrations of phosphorus in the lake water can contribute significantly to an increase in the growth of algae in the lake. Because the stability of summer thermal stratification in Diamond Lake is relatively low, the duration of stratification is usually insufficient to cause severe oxygen depletion for extended periods of time. However even brief periods of depleted oxygen may be important in contributing to the internal loading of phosphorus from the sediments to the lake water.

Low oxygen concentrations in the deep portion of the lake during periods of strong thermal stratification result in adverse conditions for fish and many other kinds of aquatic life. In addition to the lack of oxygen for oxygen consuming organisms, anoxic conditions in the hypolimnion favors chemical reactions that result in the formation of chemicals toxic to many aquatic organisms; these reactions include the formation of ammonia (NH_3), methane (CH_4), and hydrogen sulfide (H_2S).

[12] The maximum quantity of dissolved oxygen the water can contain at a given temperature and pressure.
[13] Approximately 7.5 mg/L
[14] The absence of oxygen.
[15] The relative capacity of a substance to dissolve into another.

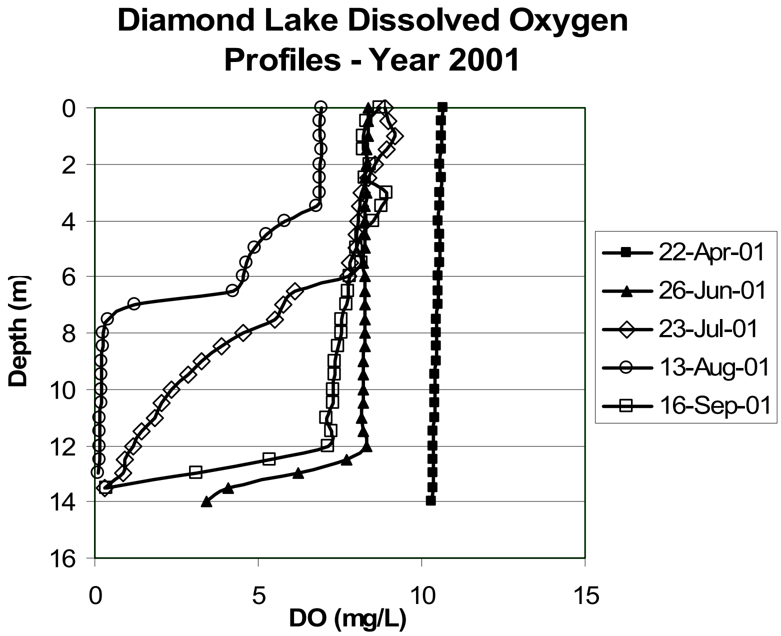

Figure 11. Dissolve oxygen profiles showing seasonal changes in the hypolimnion (data source: Salinas 2001).

Nutrients

Plants require a variety of nutrients to support active growth and photosynthesis. The availability of nutrients in water can limit the growth of aquatic plants (including phytoplankton) in freshwater systems. In addition, the relative abundance of some nutrients can significantly affect the phytoplankton community composition. Nutrient sources for lakes include external loading (groundwater or surface runoff flowing into the lake, rain/snow, and other sources outside the lake) and from internal loading from sources within the lake.

Although only small concentrations of some nutrients are sufficient to support plant growth, phosphorus and nitrogen are required in relatively high quantities. Frequently a correlation is found between the availability of one of these nutrients and the productivity of a lake. The form and concentration of these nutrients in the water is affected by both physical and biological processes. The amount of nitrogen and phosphorus in water can change rapidly because they can be taken up by aquatic organisms, stored, transformed, and excreted rapidly and repeatedly (Wetzel and Likens 1991). The availability of these nutrients in Diamond Lake determines to a large degree, the productivity of the lake.

Phosphorus

Phosphorus is one of the essential elements required by all living organisms for metabolic processes. Phosphorus is considered to be one of the nutrients that commonly limits algal growth in lakes. Among the variety of phosphorus compounds in lakes, phosphorus can be divided into two general forms, dissolved and particulate. Measurements of total phosphorus include both the phosphorus dissolved in the water (in solution) and in particulate form. The majority of phosphorus exists in a particulate form that is unavailable for uptake by plants. The three main classes of phosphate compounds in aquatic ecosystems include: orthophosphates, condensed phosphates, and organically bound phosphates (MacDonald et al. 1991). Generally, only soluble orthophosphate can be utilized for biological uptake and utilization by phytoplankton and as a result its concentration in lake water provides a good estimation of the availability of phosphorus for algae growth.

The phosphorus budget of lakes includes: (1) external phosphorus loading; (2) internal loading and cycling from within lake processes; and; (3) export downstream or loss to the sediments (Wetzel 2001). Lauer et al. (1979) reported that inflowing streams are the primary external source of phosphorus loading to Diamond Lake. Silent Creek was reported to be the main external source of phosphorus contributing approximately 61 percent of the total measurable load. Short Creek was reported to contribute 22 percent of the external loading during the 1971 to 1977 study period. Intermittent streams were reported to contribute 3 percent, and groundwater sources 10 percent of the external load. Lauer et al. (1979) reported phosphorus in precipitation contributed 4 percent of the total annual phosphorus load. Although Lauer et al. reported low values for groundwater input of phosphorus, current research evaluating the groundwater contribution to the lake may increase this factor in the future as this new data becomes available.

Over the winter months, phosphate generally accumulates in lake water. During the spring, the growth of algae increases the rate of uptake of phosphorus and reduces the concentration of phosphate in the water. As phytoplankton abundance increases in the spring, zooplankton feed on the phytoplankton and also become more abundant and subsequently may be preyed upon by fish. Phosphorus compounds are recycled through the digestive systems and excreted by fish, zooplankton, and bacterial activity into the water where they can again be utilized by phytoplankton.

Loss of phosphorus in the water of Diamond Lake can occur as organisms die and settle to the bottom and ultimately become part of the lake’s sediments. Dissolved phosphorus can also be adsorbed onto suspended matter such as fine silt particles and settle out (precipitate) to the lake sediments. Under oxygenated conditions, phosphorus can also combine with organic matter, metallic ions, and carbonates and precipitate out of the water. Although phosphorus precipitated to the sediments can reduce its concentration in the water, phosphorus can subsequently be recycled back into the water column by in-lake processes. Some phosphorus is exported from Diamond Lake through outflow into Lake Creek, however the overall outflow of phosphorus into Lake Creek is small compared to that retained within the lake. Based on an analysis of phosphorus concentrations in inflowing and out-flowing streams, Eilers and Kann (2001) estimated the lake is retaining approximately 0.8 metric tons (1,764 pounds) of phosphorus from April through September. Figure 12 displays the average total dissolved phosphorus and orthophosphate concentrations in Diamond Lake along with concentrations in the primary inflowing and out-flowing streams. Total dissolved phosphorus exceeds the concentration of orthophosphate in all cases. The nearly complete uptake of available phosphorus by aquatic plants and algae suggests that phosphorus may be a limiting nutrient for periods of time and therefore limit phytoplankton abundance.

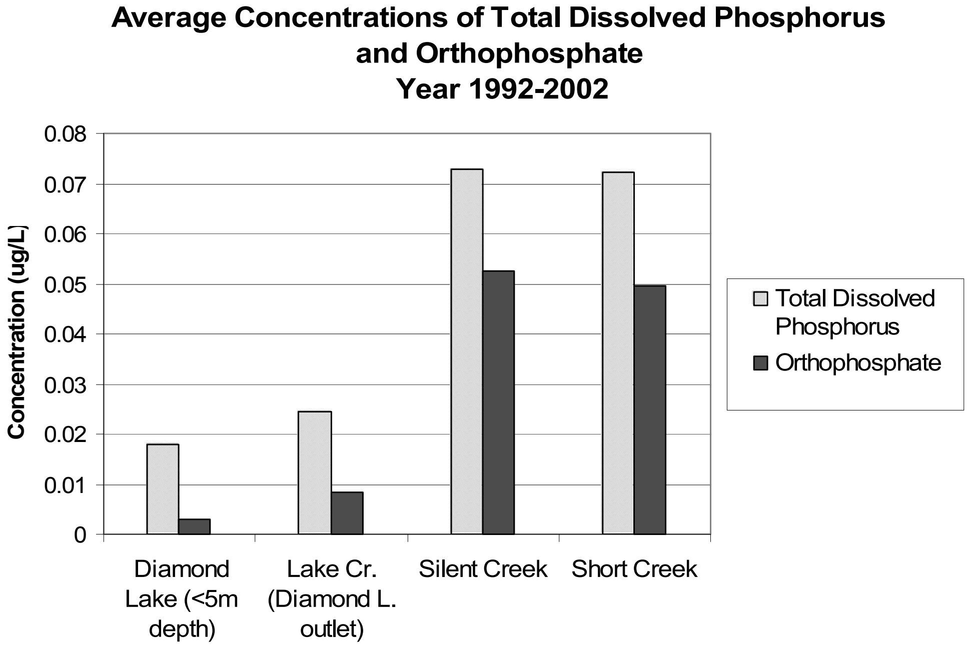

Figure 12. Average concentration of total dissolved phosphorus and orthophosphate 1992 - 2002 (data from Salinas and Larson 1992-1994 and Salinas 1995-2002).

The sediments of Diamond Lake are an important internal source of phosphate. As previously mentioned, in oxygenated water, phosphorus can combine with oxidized metals, particularly iron, and will precipitate into the sediments, resulting in the removal of phosphorus from the lake water. However, during summer stratification, the hypolimnion becomes depleted of oxygen and as a result of chemical changes[16] phosphorus is released from the sediments into the hypolimnion. The process of releasing phosphorus from the sediments is referred to as *internal loading*. When the hypolimnetic phosphorus is mixed throughout the entire water column it is available to support the growth of aquatic plants and algae.

Several blue-green algae species form spore like resting stages (akinetes) that can over-winter or withstand otherwise harsh environmental conditions in the sediments. During the summer when conditions favor their growth, colonies or cells of these species can migrate from the lake sediments up in to the water. Petterson (1998) found that the migration of colonies of the blue-green alga *Gloeotrichia echinulata* from the sediments to the epilimnion can be a significant source of internal loading of phosphorus. Based on an analysis of akinetes from the sediment of Diamond Lake, Eilers et al. (2001a) concluded that the blue-green algae population of the lake has increased up to 15-fold during the 20th century. Two major increases in the abundance of *Gloeotrichia* were found in the sediment record. Evidence of

[16] However, as oxygen levels decline in the hypolimnion, insoluble ferric phosphate molecules in the sediment undergo chemical changes that result in the formation of soluble ferrous phosphate (Wetzel and Likens 1991). The soluble ferrous phosphate is released from the sediments into the hypolimnetic water.

this species first appeared in the sediment record around 1920 following the introduction of trout 10 years earlier, and the second increase occurred around the time of the rotenone treatment in 1954. Eilers et al. (2001a) also reported *Anabaena flos-aquae* and *Anabaena circinalis* were found at low densities prior to the introduction of fish but showed major increases during the mid-20th century and again over the last decade. Since both *Gloeotrichia* and *Anabaena* are akinete forming cyanobacteria, the observed increase in abundance of these types of blue-green algae suggests that migration of akinetes from the sediments to the epilimnion during the summer could be a significant pathway contributing to the internal loading of phosphorus in Diamond Lake.

Fish can also contribute to a redistribution and increase in phosphorus in lake water through bottom feeding behavior followed by excretion of nutrients. The high population of tui chub in Diamond Lake is likely to contribute to the redistribution of nutrients through this process. The introduction of additional phosphorus to surface waters can promote the development of algal blooms.

Rooted aquatic macrophytes can play an important role in the availability of phosphorus in lakes. Macrophytes are common in Diamond Lake to a depth of 19.7 feet (6 m) (Eilers and Gubala 2003). Macrophytes in shallow areas can reduce the amount of phosphorus in the water by stabilizing sediments, making them less susceptible to mixing into the water column. Additionally, some species of macrophytes can remove phosphate from lake water by uptake through their foliage and thus compete with algae for nutrients. However, the degree to which macrophytes extract nutrients from the water through their foliage or roots varies considerably among species (Wetzel 2001). Concentrations of phosphorus in the pore spaces of lake sediments can be much greater than concentrations of phosphorus in the overlying lake water[17]. Numerous lake studies have shown the majority of macrophytes uptake phosphorus through their roots. (Horne and Goldman 1994). Lauer et al. (1979) suggested uptake of phosphorus by aquatic vascular plants from sediments may be a significant internal source of phosphorus for Diamond Lake. The phosphorus from the sediments incorporated into the plant organic material is eventually released into the water through the death and decay of the plants. Lauer et al. (1979) reported large mats of the macrophytes *Elodea* and *Potomogeton* washed up on the shore of Diamond Lake during storms and concluded that decay of these plants could contribute to nutrients in the water column.

Klotz and Linn (2001) reported that although there are some conflicting reports in the literature regarding the effects of lake draw down on phosphorus release from sediments, studies have shown that drying and freezing of sediments as a result of water level draw down increases the release of phosphorus upon subsequent re-wetting. These investigators attributed this effect to the release of phosphorus from microorganisms that are killed by drying and freezing. Klotz and Linn concluded that site specific characteristics will result in differences between lakes in the relative contribution of sediment drying and freezing to total internal phosphorus loading.

Nitrogen

[17] Lauer et al. (1979) reported orthophosphate concentrations of 250 µg/L in the pore water of Diamond Lake sediments.

All living cells require nitrogen in relatively high amounts compared to other nutrients. Nitrogen is an important component of all proteins and is required for most biochemical reactions. It is a major nutrient and its availability frequently is a factor determining the productivity of aquatic systems. Nitrogen is present in aquatic systems in inorganic and organic forms.

The most abundant inorganic form of nitrogen found in streams and lakes is the dissolved gaseous form (N_2). Other inorganic forms generally found in lower concentrations include the combined forms; ammonium (NH_4^+), nitrate (NO_3), and nitrite (NO_2^-). Under some conditions, un-ionized ammonia (NH_3) may also be present. Under aerobic conditions, nitrate is the most common form of combined inorganic nitrogen in streams and lakes. Nitrogen in its gaseous form can be utilized for growth only by some blue-green algae (cyanobacteria) that are capable of nitrogen fixation. This process can be an important source of combined nitrogen in lakes. The preferred form of nitrogen plants utilize for growth is ammonia and as a result under oxygenated conditions is typically rapidly removed from water. Nitrate can also be utilized by plants; however, its use requires the expenditure of greater amounts of energy. The waste products of animals that feed on plants or other animals contain ammonia and after these wastes are released into the environment, the ammonia generally is rapidly removed from the water by plants. This recycling of nitrogen in aquatic systems allows for the continued growth of algae in lakes even when other sources of nitrogen are depleted.

Ammonia is highly toxic to fish at relatively low concentrations. However, under oxygenated conditions, ammonia is rapidly removed by aquatic organisms or converted to nitrate. Under acidic to neutral conditions, the formation of ammonium (non-toxic) is favored over formation of ammonia. At high pH values however, the formation of toxic ammonia is favored over ammonium. Because high rates of photosynthesis in productive lakes can result in high pH values, fish die-offs can occur in poorly buffered[18] waters when a critical pH threshold is exceeded leading to the formation of high concentrations of ammonia (Lampert and Sommer 1997). Although Diamond Lake typically has high epilimnetic pH values during the summer, there are no reports of fish kills associated with high concentrations of ammonia.

Organic nitrogen may be present either as dissolved or suspended particulate matter in water. Organic nitrogen is generally considered to be unavailable for plants until it is converted (mineralized) into nitrate or ammonia. Organic nitrogen is found in a variety of forms including proteins and humic substances[19]. The organic nitrogen concentration is the difference of total Kjeldahl nitrogen (TKN) and the inorganic ammonia concentration. High concentrations of organic nitrogen in water may indicate high rates of production or organic pollution. Human or animal waste, decaying organic matter and live organic material including small algae cells (phytoplankton) can result in high organic nitrogen concentrations in lakes.

[18] Poorly buffered waters have a chemical makeup with a low ability to neutralize acids or bases without a great change in pH.

[19] Humic substances are natural organic compounds formed by the decomposition of plants and animals. They comprise an important component of the dissolved organic matter in many lakes and streams and can give the water a brown color.

The majority of nitrogen present in Diamond Lake originates from three sources: (1) surface and groundwater inflow; (2) precipitation; and (3) cyanobacterial fixation of dissolved nitrogen gas (N_2). Lauer et al. (1979) reported that ground water was the primary source of total inorganic nitrogen entering the lake during their study (1972-1977), averaging 80 percent of the external load. In addition, Lauer et al. reported other external sources including Silent Creek and direct precipitation with each of these sources averaging 8 percent. Salinas and Larson (1995) reporting on their study from 1992 to 1994, found that the inflow to Diamond Lake from Short Creek contained a higher concentration of nitrate than did Silent Creek (mean values of 19.4 and 2.3 µg/L respectively). No studies of Diamond Lake have quantified changes in nitrogen availability due to nitrogen fixation or denitrification[20].

Several studies have evaluated the concentration of inorganic nitrogen in Diamond Lake (Sanville and Powers 1973, Miller et al. 1974, Lauer et al. 1979, Salinas and Larson 1995). Concentrations of inorganic nitrogen in the lake vary seasonally and with depth. Both nitrate and ammonia are generally found in low concentrations in the epilimnion of Diamond Lake. Reduced concentrations of nitrogen in this near surface water during the summer months has a significant affect on the phytoplankton community composition and result in a shift favoring nitrogen fixing blue-green algae. In the deepest portion of the lake during the summer as the dissolved oxygen becomes depleted, ammonia concentrations increase (Figure 13); as stratification breaks down, ammonia from the hypolimnion mixes with surface water where it can stimulate plant growth (photosynthetic activity).

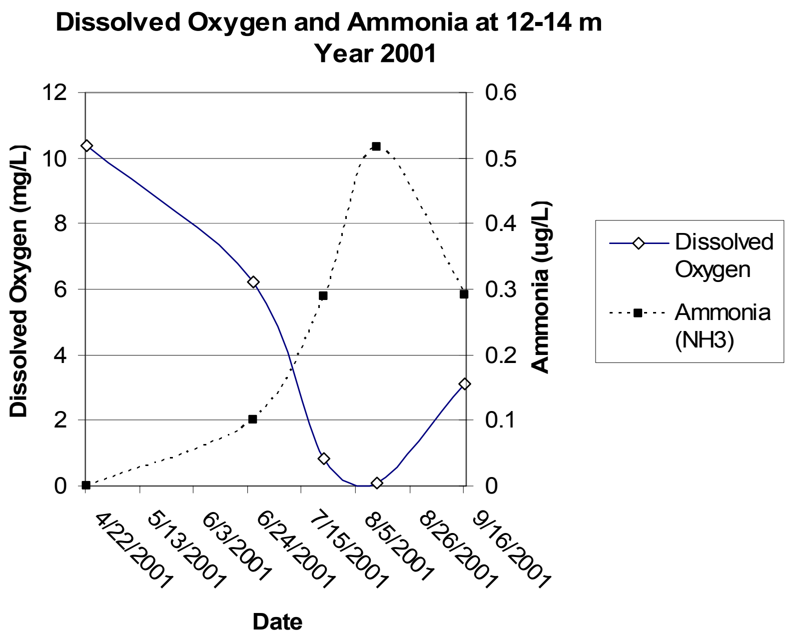

Figure 13. Typical seasonal changes in the concentration of ammonia (NH_3) and dissolved oxygen in the hypolimnion of Diamond Lake in 2001 (data from Salinas 2002).

The influx of nitrogen into Diamond Lake from streams is primarily inorganic nitrate, whereas in Diamond Lake the majority of nitrogen is found in the organic form (Eilers and Kann 2002)

[20] Conversion of nitrate into nitrogen gases under conditions of depleted oxygen.

(Figure 14). These differences reflect the high organic nitrogen component associated with the high phytoplankton biomass of the lake.

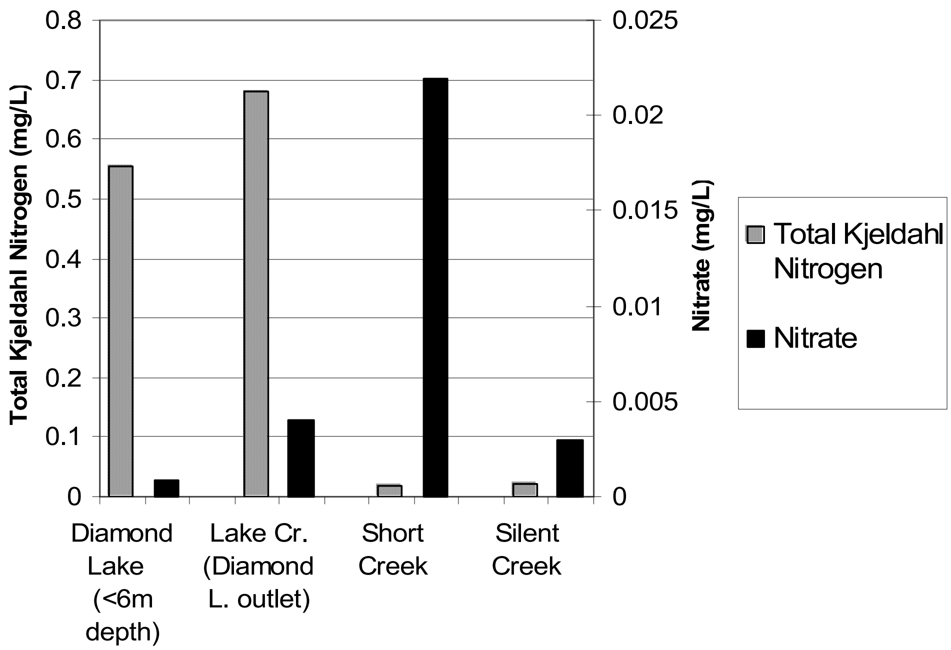

Figure 14. Average values summer season values of total Kjeldahl nitrogen and nitrate in epilimnion of Diamond Lake, and the streams; Lake Creek, Silent Creek and Short Creek (data source Salinas and Larson 1992-1994; Salinas 1995-2002).

Nutrient Loading and Human Activities

Lauer et al. (1979) found that the waste water diversion system at Diamond Lake reduced phosphorus loading by 14 percent and nitrogen loading by 18 percent. These investigators found that nutrients from human sources represented a minor portion of the lake's total nutrient load. Lauer et al. (1979) concluded that nutrient enrichment in Diamond Lake is primarily a natural phenomenon, with the majority of nutrients originating from ground water, inflowing stream water and the internal loading of nutrients from sediments.

Eilers (2001a) estimated the nutrient loads from the summer homes near the lake and compared these estimates with other nutrient sources for the lake. He concluded that there is little evidence to suggest that a reduction in nutrients from septic wastes originating from the summer homes near the lake would yield a measurable improvement in water quality. However, Eilers et al. (2001b) concluded that the introduction of fish into Diamond Lake has resulted in significant changes to the lake including a shift in nutrient availability and a decline in water quality.

Alkalinity and pH

The pH[21] of water is a measure of the activity of hydrogen ions. It is measured on a scale ranging from 0 to 14. Water with high concentrations of hydrogen ions is acidic with a pH below 7. Water that has low concentrations of hydrogen ions and contains higher concentrations of acid neutralizing chemicals such as bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), or calcium carbonate ($CaCO_3$) is alkaline[22] and will have a pH greater than 7[23].

Near the surface of Diamond Lake during the summer months, high rates of photosynthesis by phytoplankton and macrophytes remove dissolved carbon dioxide and bicarbonate from the water, resulting in an increase in pH. Several studies have determined that during the summer in the epilimnion of Diamond Lake, the pH typically exceeds 8 and during large algae blooms can be greater than 9 (Lauer et al. 1979; Sanville and Powers 1973; Salinas and Larson 1995; Salinas 1996-2002 and ODEQ unpublished data). Epilimnetic pH values typically reach their highest values during July or August. During the summer of 2001, the ODEQ measured a maximum pH value of 9.18 in the surface water of the lake during August and lower values (between 7.5 and 8.5) during May and June (Figure 15). Because the surface water of Diamond Lake frequently has not met state water quality standards during the summer due to high eplimnetic pH values, Diamond Lake is included on ODEQ's 303(d) list of water quality limited water bodies.

During summer thermal stratification, the deeper hypolimnetic water of Diamond Lake typically has lower pH values compared to surface water due to supersaturation[24] with carbon dioxide generated by decomposition of organic matter. Salinas and Larson (1995) reported slightly acidic conditions (pH 6.5-7.0) near the bottom of the lake during the summers of 1992-1994.

Based on an analysis of the diatom remains in the sediments of Diamond Lake, Eilers et al. (2001a) concluded that the pH of Diamond Lake has increased over pre-development values. Eilers et al. reported that the diatom-inferred pH during the pre-development time period (prior to 1910) averaged 7.9 (±0.31). Although this finding was statistically insignificant[25], an increase in pH during the twentieth century was determined to be consistent with increases in the sediment accumulation rate and shifts in the diatom community composition.

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[21] pH is defined as the negative log of the hydrogen ion concentration.

[22] Alkalinity is commonly expressed as milligrams per liter of bicarbonate or calcium carbonate.

[23] pH is measured in logarithmic scale. For each additional pH unit change, the hydrogen activity changes an order of magnitude. For example, a pH of 8 has ten times more hydrogen activity than a pH of 7. While a pH of 7 to 8 represents one order of magnitude change, the change in hydrogen activity from pH 7 to 9 is two orders of magnitude or 100 times difference in hydrogen ion concentration. Because of the logarithmic relationship, fractions of pH are significant changes in hydrogen ion concentration.

[24] To become more highly concentrated than is normally possible under given conditions of temperature and pressure.

[25] Insignificant at $P = 0.05$.

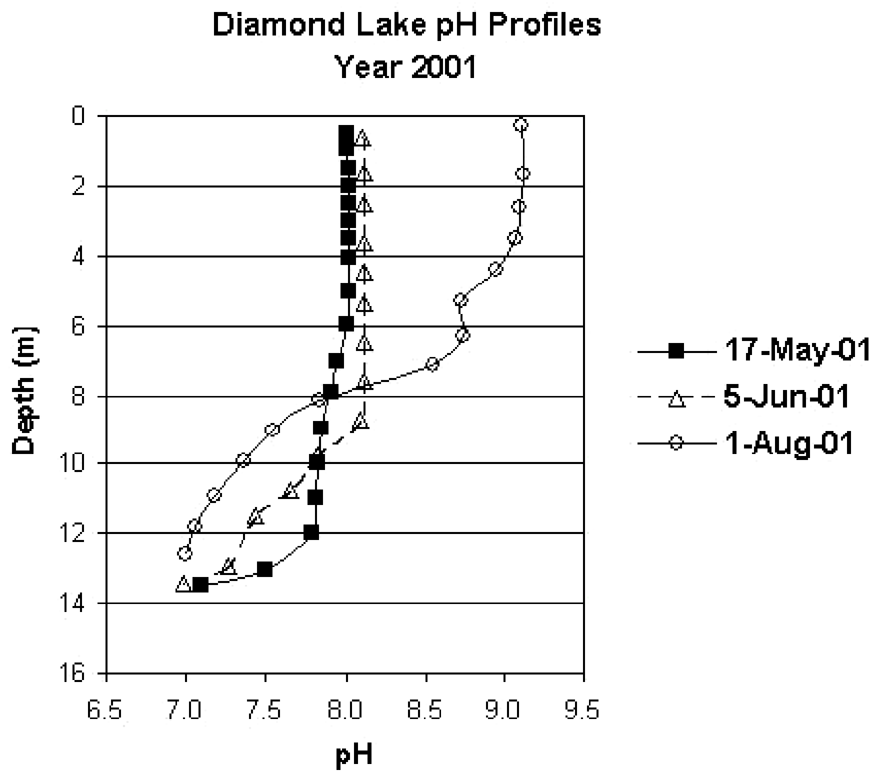

Figure 15. Diamond Lake pH vertical profiles measured by DEQ in 2001.

An important consequence of pH in lakes is its effect on the form and concentration of ammonia. Below pH 8, nearly all of the ammonia in freshwater exists in the ionic form as ammonium. This is an important source of nitrogen for aquatic bacteria, algae, and large plants. As the pH increases, the ammonium ion is transformed into ammonia, a form which can be toxic to aquatic animals including fish. Above pH 10.5, the ammonium ion becomes transformed almost exclusively into the toxic form-ammonia. Although high concentrations of ammonia can result in fish kills, none have been reported for Diamond Lake.

Rotenone and Water Chemistry

From a review of several studies that measured the effects of the application of rotenone to lakes, Bradbury (1986) concluded that no direct effects on water temperature, dissolved oxygen concentrations, nutrients, carbon dioxide, or pH would be expected post treatment, from the application of rotenone at concentrations used in fisheries management.

Bradbury (1986) also reported that lakes treated with rotenone generally have shown that algae levels typically increase 4 to 6 fold following a rotenone treatment compared to years without treatment. However, the increase in phytoplankton abundance following rotenone treatment is not due solely to changes in nutrient availability. A significant portion of this increase is due to a large decrease in the grazing pressure of zooplankton (see sections Aquatic Biology – Phytoplankton and Zooplankton).

A variety of factors influence the length of time rotenone remains toxic in the water. The two most important factors determining the rate rotenone degrades are water temperature and sunlight (Bradbury 1986). Rotenone degrades much faster in warm water than cold water (Gilderhus et al. 1986, Dawson et al. 1991). Other factors contributing to the rate of breakdown include the presence of organic debris, turbidity, lake morphology, dilution by inlets and the dosage used. In a wide survey of lakes treated with rotenone, Bradbury (1986) found that the majority of lakes detoxify within 5 weeks from the time of application and lakes in Washington were generally non-toxic to fish after 4 to 5 weeks. In studies conducted by the California Department of Fish and Game (CDFG 1994), the time required for rotenone to degrade to non-toxic levels generally varied from two days to three weeks. Similarly, Finlayson et al. (2000) reported rotenone generally persists from 1 to 8 weeks within a temperature range of 50-68ºF (10-20ºC). These authors also reported that following treatment, concentrations of rotenone in the sediments are similar to those in the water; however, the breakdown of rotenone in the sediments lags 1 to 2 weeks behind that in the water. Rotenolone, a metabolite of rotenone, persists longer than rotenone especially in cold alpine lakes. Finlayson et al. (2000) reported that rotenolone has been detected for as long as six weeks in water <50ºF (10ºC) at elevations >8,000 feet (2,438 m).

The liquid rotenone formulation Noxfish®, contains inert emulsifiers, solvents, and carriers that are important in ensuring the solubility and dispersion of rotenone in water. Waters treated with Noxfish® may contain rotenone, and volatile (xylene, trichloroethylene, toluene, and trimethylbenzene) and semi-volatile (naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene) organic compounds[26]. None of these volatile and semi-volatile compounds would be expected to persist in the water for greater than 3 weeks (Table 15). Many of the inert ingredients of the liquid rotenone formulations (trichloroethylene, naphthalene, and xylene) are present in the fuel of motor boats and as a result are commonly found in lakes where motorized activities occur. Although trichloroethylene is a known carcinogen, Finlayson et al. (2000, p. 189) reported that concentrations in water immediately following treatment with the liquid rotenone formulation would be below the U.S. Environmental Protection Agency (USEPA) maximum contaminant level[27] in drinking water (0.005 mg trichloroethylene per liter of water) (USEPA, 2002b). Finlayson et al. also reported that none of the other materials in the liquid rotenone formulation including xylenes, naphthalene, and methylnapthalenes exceed any water quality criteria or guidelines (based on lifetime exposure) set by the USEPA.

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[26] Primarily petroleum-based substances.

[27] Maximum contaminate level is the highest level of a chemical allowed in drinking water. It is an enforceable level under the Safe Drinking Water Act.

Table 15. Persistence of rotenone and other organic compounds in water and sediment impoundments treated with 2 mg/L rotenone formulation (Source: Finlayson et al. 2000, p. 192-193).

Compound	Initial water concentration (µg/L)	Water persistence	Initial sediment concentration (µg/L)	Sediment persistence
Rotenone	50	<8 weeks	522	<8 weeks
Trichloroethylene	1.4	<2 weeks	ND*	
Xylene	3.4	<2 weeks	ND	
Trimethylbenzene	0.68	<2 weeks	ND	
Napthalene	140	<2 weeks	146	<8 weeks
1-m-napthalene	150	<3 weeks	150	<4 weeks
2-m-napthalene	340	<3 weeks	310	<4 weeks
Toluene	1.2	<2 weeks	ND	

*ND = Below detection limits

ENVIRONMENTAL EFFECTS ON WATER CHEMISTRY

Direct Effects:

Under Alternative 1 fish biomass would not be removed from the lake and as a result nutrients would remain in the lake. Rapid nutrient cycling and nutrient redistribution from the bottom into the water column, associated with a high population of tui chub, would continue to contribute to nutrient availability and contribute to high phytoplankton production. In addition, relatively large summer blooms of blue-green algae would likely continue. Because Alternative 1 does not include a lake draw down, hypolimnetic dissolved oxygen and the associated nutrient release from the sediments would remain similar to current conditions.

Alternatives 2 and 3 would result in a lowered lake level during the summer season following the fall/winter draw down with a corresponding reduction in thickness and volume of the hypolimnion. The shallower lake would have a smaller area of bottom sediments exposed to low concentrations of dissolved oxygen during summer thermal stratification. In addition, the shallower lake would increase the probability that wind-generated turbulence could destabilize the thermal stratification and mix the entire water column, potentially reducing the duration of stratification (see discussion under Water Temperature and Thermal Properties). These factors could favor a temporary improvement in water conditions (lower pH and improved transparency) during the draw down period.

During the draw down proposed under Alternatives 2 and 3, wave action on exposed sediments along the shoreline would likely disturb fine particles and result in their suspension. In addition, wind or boat-generated turbulence in shallower water would have a higher probability of suspending sediments that would have been deeper underwater if no draw down occurred. These disturbed sediments can release phosphorus, increasing its availability for algal growth. Under oxygenated conditions, however, the extent that these nutrients from sediments would contribute to increased phytoplankton production is likely limited because phosphorus is strongly bound to sediment particles under oxygenated conditions.

Although the scouring of lake sediments from wave action or turbulence during the draw down period under Alternatives 2 and 3 would likely be reduced by the stabilizing effect of macrophytes, wave stress on macrophytes could reduce their effectiveness in keeping bottom sediments in place. Additionally, the macrophytes within the draw down zone would be exposed to desiccation[28] as a result of the low water level; however, the rooted submersed species inhabiting this area would normally be starting to senesce and die back at approximately the time the lake level would be lowered. Therefore, there would be little contribution of additional nutrients to the lake above the typical seasonal amounts from decaying plant material contributing to the nutrient load of the lake under these alternatives.

Under Alternatives 2 and 3, although application of rotenone is not expected to directly modify water temperature, dissolved oxygen concentrations, nutrients, carbon dioxide, or pH; there are numerous potential effects on water chemistry that would result from implementation of these alternatives. Alternatives 2 and 3 include mechanical fish removal followed by application of rotenone and carcass removal. The removal of fish carcasses from the lake would prevent some nutrients, particularly nitrogen and phosphorus, from recycling back into the water from the decaying fish. Complete removal of all fish carcasses would not be feasible under either of these alternatives. Results from other lakes treated with rotenone indicate that the majority of fish carcasses sink to the lake bottom so that even when a concerted effort is made to remove fish carcasses, only approximately 20 to 30 percent of the carcasses could be removed (Bradbury 1986). Even if these fish were not exposed to a rotenone treatment, the nutrients contained in their carcasses would eventually be released upon their natural death. In addition, while the fish are alive they continue to contribute phosphorus to the water through excretion. The contribution of the fish carcasses to nutrient loading can be viewed as a matter of timing. Treatment with rotenone would result in an addition of nutrients from the decaying fish as opposed to their contribution to nutrient cycling through feeding and excretion of nutrients.

Under Alternatives 2 and 3, the availability of both nitrogen and phosphorus from decaying fish carcasses could increase contributing nutrients for phytoplankton growth. However, the degree phosphorus released from fish carcasses would contribute to phytoplankton growth depends on the extent that the lake remains oxygenated. Bradbury (1986) concluded that because deep areas of productive lakes typically become oxygen depleted, rotenone-killed fish carcasses generally will not greatly increase the release of phosphorus from the sediments because oxygen levels generally are below 1 mg/L and even without the rotenone treatment, release of nutrients from lake sediments is favored under these conditions. The deepest portion of Diamond Lake typically becomes depleted of oxygen during the summer and winter releasing phosphorus from the sediments. Release of phosphorus from fish carcasses may have only a small effect of increasing nutrient availability in the water due to the existing high rate of nutrient release from the phosphorus-rich sediments of Diamond Lake. The decomposition of the fish carcasses on the lake bottom would create an additional oxygen demand, which could extend the time the sediment-water interface remains depleted

[28] Desiccation means "drying out".

of oxygen. A longer duration of depleted oxygen could contribute to elevated phosphorus concentrations in the water. A compensating factor however, is that the rotenone treatment would occur during the draw down period when the lake would be approximately 8 ft (2.45 m) shallower than the summer lake level. In addition, the rotenone treatment period (mid-September) coincides with a period of weak stratification. Both of these factors would favor mixing of surface water with the deeper water contributing to the maintenance of oxygenated conditions throughout the water column. Therefore, the release of phosphorus from fish carcasses represents a potential impact of limited scale and duration.

The rotenone treatment of Diamond Lake would likely be followed by a 4 to 6 fold increase in algae abundance compared to non-treatment years. The increase in phytoplankton abundance under Alternatives 2 and 3 would result in an increase in the organic nitrogen component of the surface waters of the lake. The increase in phytoplankton abundance would likely result in a temporary increase in the concentration of organic nitrogen in the outflow of the Diamond Lake (Lake Creek) compared to normal years.

Under Alternatives 2 and 3, dock cleanup activities by Diamond Lake Resort described as connected actions in Chapter 2 would occur; due to the small area impacted by these activities and no in-water work, no significant direct effects to the water chemistry of the lake are anticipated from these actions.

Alternative 4 would mechanically remove fish from the lake over a 6 year period. Since this would remove fish biomass and the associated nutrients over time, there would be a degree of nutrient loss immediately as fish removal begins and additional losses extending over the entire 6 year fish removal period.

None of the actions in the proposed alternatives would be expected to directly alter pH values.

Indirect Effects:
Under Alternative 1 rapid nutrient cycling would continue to occur due to the high population of tui chub and the associated predation on zooplankton. Thus, the existing negative effects on water quality described under direct effects would continue in the future. Under any proposed alternative, the changes in phytoplankton production depend to some extent on the abundance, species, and size composition of the zooplankton population and how these species respond to the fish stocking strategies adopted under different alternatives (see discussion under Aquatic Biology – Zooplankton and Fish).

Under the action alternatives, the rate of nutrient cycling in the lake would depend to some extent on the timing and effectiveness of fish removal from the lake. As the fish population declines, there would be a corresponding reduction in the degree nutrients are redistributed from the lake bottom area to the overlying water. In addition, predation pressure on zooplankton (particularly large bodied species) would be reduced and would contribute to a decline in the rate of nutrient cycling and a lower peak phytoplankton production. These outcomes represent beneficial effects to the lake.

As the lake water level is raised to the normal seasonal level following the draw down under Alternatives 2 and 3, there would likely be an increase in the internal loading of phosphorus due to the re-wetting of previously frozen and dried sediments within the draw down zone. This would increase the availability of phosphorus in the lake water and potentially increase algae production during the spring and summer following return of the lake level to normal seasonal conditions following the draw down period.

The effects of Alternative 4 would occur over a 6 year period as the tui chub population is reduced. The extent to which nutrient cycling changes would be determined by the extent the fish population is reduced and the response of the zooplankton population to reduced predation. As the tui chub population declines over successive years, the peak phytoplankton standing crop and primary production during the summer season would also likely be reduced, resulting in a beneficial effect.

Because rotenone and associated inert ingredients would not persist in the lake, indirect effects on water chemistry of the rotenone treatment under Alternatives 2 and 3 would primarily be associated with changes in the biology of the lake (see sections: Aquatic Biology – Phytoplankton and Primary Production, Zooplankton, and Fish). The degree any alternative would affect epilimnetic pH values during the summer season would depend on the degree the alternative affects the growth rate of phytoplankton. Under Alternative 1, the nutrient cycling rate would likely remain high during the summer season associated with a high tui chub population. Epilimnetic pH values above 8.5 would be expected to continue during the summer associated with high abundance and growth rates of phytoplankton resulting in continued degraded water quality into the future.

The degree epilimnetic pH values would be reduced during and immediately following mechanical fish removal under all action alternatives would depend on the timing and extent of the fish population reduction. Peak summer season phytoplankton production would likely be lower under Alternatives 2, 3, and 4 if mechanical removal reduces the fish population and associated predation pressure on zooplankton over the spring and summer months resulting in lower pH values during this time. Under Alternatives 2 and 3 following treatment with rotenone, the zooplankton population would be eliminated and since the rotenone treatment is proposed for mid-September, a time when phytoplankton abundance is typically high (particularly diatoms), phytoplankton production and elevated pH values could be greater in the fall than would occur under Alternatives 1 or 4. Studies of other lakes have shown that algae levels typically increase 4 to 6 fold shortly after rotenone treatment compared to levels in years without treatment (Bradbury 1986). However, since the high phytoplankton abundance typically found during the fall would naturally promote high pH levels, any increase in pH compared to non-treatment years would likely be small in scale. As the day length shortens and water temperature decreases as winter approaches, phytoplankton abundance would decline and likely be similar to historic winter levels. In the spring as the phytoplankton population increases rapidly, epilimnetic pH values would rise. The maximum pH values experienced would be a function of the air temperatures, the degree of solar radiation, wind, and grazing pressure from the zooplankton. Since the predation pressure on the zooplankton from fish would be temporarily eliminated and the zooplankton would have abundant food resources, the zooplankton would be expected to increase rapidly, particularly large bodied species. This would lead to a reduction in the standing crop and growth of phytoplankton, resulting in lower pH values. The period when lower pH values would be expected to occur under Alternatives 2 and 3 would depend how rapidly the zooplankton population recovers from the effects of the rotenone treatment and the degree of predation on the zooplankton population following fish stocking. Under Alternatives 2 and 3, peak summer pH values would be expected to decline within 3 years after treatment. The fish stocking strategy adopted under Alternative 3 would result in low predation pressure on zooplankton due to the feeding behavior of the type of salmonid stocked. Therefore Alternative 3 has a somewhat higher potential to result in lower summer pH values than Alternative 2 (see sections Aquatic biology – Phytoplankton, Zooplankton, and Fish for additional information). However, under any action alternative, monitoring lake conditions would be required to ensure the fish stocking strategy is maintaining zooplankton-phytoplankton interactions that would promote and maintain acceptable water quality[29].

Alternative 4 could result in similar results as Alternatives 2 and 3 over an extended period of time. Because the fish population would be reduced over a 6-year period under Alternative 4, changes in the phytoplankton standing crop, primary production, and pH values would likely occur incrementally over this extended time period. Since the tui chub population would be reduced but not eliminated from the lake, there is a higher risk in the long-term that this fish population would increase resulting in lower water quality conditions in the future.

Under Alternatives 2 and 3, no indirect effects are anticipated as a result of connected actions proposed by the operators of the Diamond Lake Resort.

Cumulative Effects:
Implementation of any of the action alternatives would be expected to result in a reduced rate of nutrient cycling and a lower standing crop and primary production of phytoplankton associated with the elimination or severe reduction in the tui chub population. The change in nutrient cycling would cumulatively have a positive affect on nutrient availability when combined with past projects. Past management activities that were the primary contributors (both positive and negative) to a cumulative effect on water chemistry in Diamond Lake include fish stocking, human developments adjacent to the lake, the 1954 rotenone treatment, and the installation of the waste water diversion system. Ongoing and reasonable foreseeable actions that would contribute to cumulative effects to a small degree include; boat ramp improvements, fish stocking, and water rights. However, as described earlier, the primary negative factor influencing Diamond Lake water quality is believed to be a high population of tui chub, rather than management actions. See cumulative effects tables 9-11 for a complete list of projects.

Conclusions:
Although there are some short-term impacts, in the long-term, implementation of any of the action alternatives would be beneficial toward attainment of Aquatic Conservation Strategy (ACS) Objectives. These alternatives particularly respond to portions of Objectives 4[30] and 5[31]

[29] An ecologically-based index for guiding fish stocking decisions in Diamond Lake has been developed (Eilers 2003a); components include water chemistry, phytoplankton, zooplankton, benthos.
[30] ACS Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity

concerning water quality, nutrients, and the natural sediment regime. Action Alternatives 2 and 3 would have the highest probability of providing improved water quality and reduced nutrient loading in the shortest time. The success of Alternative 2 at maintaining improved water quality over the long-term would depend on fish stocking levels and to some degree whether monitoring data is effectively utilized to determine appropriate stocking levels. Because the fish stocked under Alternative 3 would be less likely to result in high predation pressure on zooplankton, this alternative may be slightly more favorable at maintaining water quality in the long-term compared to Alternative 2. Alternative 4 would also contribute toward attainment of these ACS objectives; however, since this alternative would be implemented over a six-year period, progress toward meeting these objectives would be extended over the 6-year time period and due to the continued presence of tui chub, the long-term effectiveness would be less certain.

Table 16 provides a comparison of the alternatives effects on water quality (indicator pH).

Table 16. Comparison of Alternatives Effects on Summer pH in Diamond Lake.

Indicator	Alternative 1 – No Action		Alternative 2 – Rotenone with Put, Grow and Take		Alternative 3 – Rotenone with Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time period	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**
Expected summer pH	pH expected to remain high due to high phytoplankton primary production	pH expected to remain high due to high phytoplankton primary production	During the first 3 years after treatment, pH potentially would remain high and result in poor water quality	After 3 years following treatment, pH expected to decrease and result in improved water quality	During the first 3 years after treatment, pH potentially would remain high and result in poor water quality	After 3 years following treatment, pH expected to decrease and result in improved water quality	For 6 years pH would remain high. Near the end of the 6 years of treatment, pH potentially would decrease and result in improved water quality	After 6 years of treatment, pH would potentially be lower for a period of time resulting in improved in water quality. However, subsequent increase in pH and declines in water quality are likely as the tui chub population rebounds

of the system and benefit survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

[31] ACS Objective 5 – Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

LIGHT AND TRANSPARENCY

AFFECTED ENVIRONMENT

Sunlight provides the most important source of energy to lakes and has profound influences on their ecology. Light is utilized by plants for photosynthesis and its absorption and dissipation as heat affects the thermal properties of lakes. The depth that light is able to penetrate through water is determined by the transparency of the water. Transparency is affected by the amount of suspended organic particles (i.e. plankton), inorganic particles (silt and clay), and dissolved organic matter in the water.

A small portion of the sunlight that reaches the surface of a lake is reflected off of the surface and the remainder passes through the water where it is refracted[32] or absorbed. The intensity of light decreases exponentially with depth and different wavelengths of light are absorbed or refracted at different rates (Wetzel and Likens 1991). In very clear lakes, the high degree of scattering of blue light and absorption of other wavelengths accounts for the blue appearance. In lakes with an abundance of phytoplankton, green light is largely scattered and as a result the lake will have a green appearance. The transparency of water can be reduced by high concentrations of phytoplankton in highly productive lakes such as Diamond Lake, however, the light scattering effect of phytoplankton depends on algal cell size[33].

An approximation of the transparency of water can be made by using a Secchi disk. This method utilizes a weighted black and white disk, 20 centimeters in diameter. The disk is lowered into the water and transparency is determined by the average of the depths at which the Secchi disk can no longer be seen when observed from the shaded side of a boat and the depth it reappears while being raised (Wetzel and Likens 1991). Reduced summer Secchi disk measurements in Diamond Lake are primarily due to phytoplankton density. During periods of high phytoplankton abundance, Secchi disk transparency is significantly reduced. Figure 16 displays an example of the reduced transparency in Diamond Lake during a period of high phytoplankton abundance during July of 2002.

[32] Deflection from a straight path when a light ray passes at an angle from one median (e.g. air) into another (e.g. water).
[33] The transparency of water will be greater with the presence of large colonied species like many types of blue-green algae compared to small single cell or small colonied species at the same concentration of chlorophyll a (a measure of phytoplankton abundance).

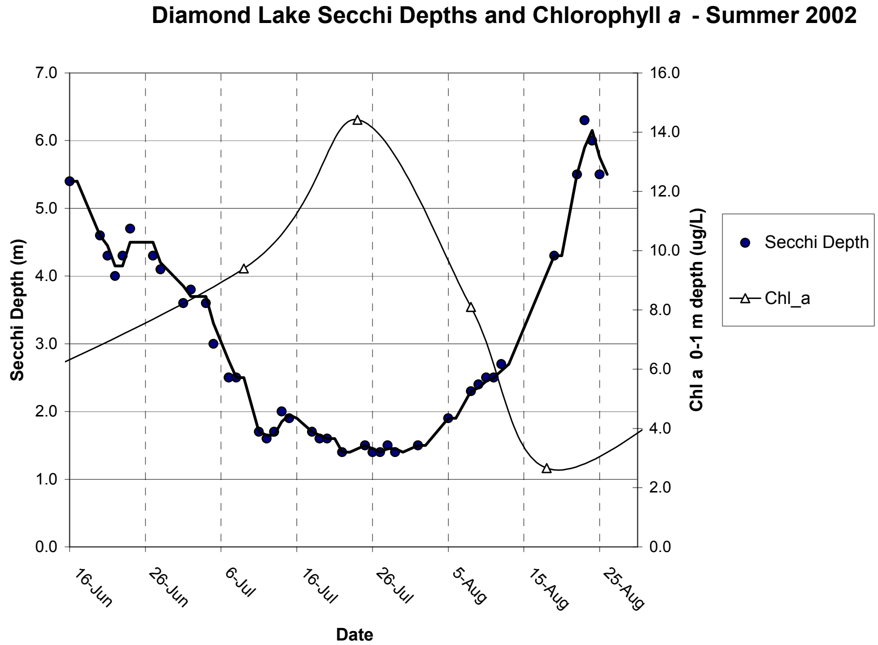

Figure 16. Concentration of chlorophyll *a* (0-1 m depth) and Secchi disk transparency (Summer 2002) (Oregon Department of Fish and Wildlife and Salinas unpublished data).

The changes in both intensity and spectral qualities of light with depth are an important aspect of lake ecology. The depth that light is able to penetrate the water of Diamond Lake is reduced during the summer season due to the dense surface blooms of phytoplankton. Reduced light penetration limits the light availability for macrophytes and deep water dwelling phytoplankton.

Plants contain light collecting pigments that are able to use light primarily between the wavelengths of 400 to 700 nanometers (nm). A light intensity of 1 percent or greater of surface radiation is considered sufficient to support the growth of plants. Monitoring data from Diamond Lake indicates that during periods of high phytoplankton abundance below approximately 19.7 feet (6 m) in depth, reduced light penetration would severely limit photosynthesis (See Limnology Report Figure 14). This finding is consistent with hydroacoustic data indicating that macrophytes currently only grow on the bottom of Diamond Lake where the water is less than 6 meters in depth (Eilers and Gubala 2003).

Based on analysis of sediment cores from Diamond Lake, Eilers et al. (2001b) reported that prior to the 20th century, the diatom assemblage (mix of species) of the lake consisted of attached, truly planktonic, and normally attached types in suspension, in approximately equal abundance. By the 1930s however, bottom dwelling attached types were declining in number while the proportion of truly planktonic types increased dramatically. These investigators concluded that this population shift was likely due to a decrease in transparency caused by an increase in planktonic diatoms resulting in insufficient light to support the growth of the deeper dwelling attached diatoms. This finding also suggests that the area of the lake bottom occupied by macrophytes may have been reduced over the 20th century due to reduced transparency. As a result, a portion of the lake's primary production has likely shifted from bottom dwelling plants to phytoplankton, altering aquatic habitat conditions.

ENVIRONMENTAL EFFECTS ON LIGHT AND TRANSPARENCY

Direct Effects:
Since Alternatives 2 and 3 would include wetland expansion activities and would lower the lake level beginning in the fall/winter, turbidity levels in portions of the lake are likely to be higher due to suspended sediments from canal dredging, suspended sediments dispersing from the wetland expansion area, and wave disturbance of exposed shoreline sediments. The increase in turbidity would reduce the depth of light penetration and could significantly reduce photosynthesis and as a result lower primary production of macrophytes (to a depth of approximately 6 m) particularly during the summer while the lake is at its low level. Disturbance of lake bottom sediments could result in the release of nutrients that would become available to algae and potentially increase primary production in those portions of the water column where there is sufficient light penetration. Under oxygenated conditions however, the extent that these nutrients from sediments would contribute to increased phytoplankton production is likely to be limited.

Under Alternatives 2 and 3, connected actions proposed by the operators of the Diamond Lake Resort (described in Chapter 2) would not involved any in-water work and would not be expected to have any direct effects on light and transparency in the lake.

Under Alternative 4, no draw down would occur so disturbance of sediments and the associated increase in turbidity associated with that action would not occur. Although extensive netting of tui chub could create minor increases in turbidity, this increase would likely be minimal in intensity and short in duration, quickly subsiding upon completion of the activity.

Under Alternative 1, turbidity levels would not be increased because no actions would take place to disturb of sediments. High rates of phytoplankton production during the summer months would continue and high phytoplankton abundance would continue to limit light penetration particularly during mid-summer. Reduced light penetration would limit the ability of macrophytes to occupy the lake bottom below approximately 20 feet (6 m) in depth.

Indirect Effects:
In the longer-term, during the weeks and months following rotenone application, indirect effects would occur under Alternatives 2 and 3. Phytoplankton production would likely rise significantly in Diamond Lake due to a dramatic reduction in grazing pressure from zooplankton (because zooplankton would be killed by the rotenone) and a potential increase in nutrient availability (from decomposing organisms). As the phytoplankton production increases, light penetration would decrease. The duration of the phytoplankton increase would be affected by seasonal changes including reduced temperatures and sunlight. As the fall progresses to winter, the phytoplankton production would decline and transparency would likely be similar to pre-treatment fall conditions. As spring approaches with longer periods of sunlight and warmer temperatures, a large bloom of phytoplankton would occur reducing

transparency and light penetration to an extent greater than would likely occur under the Alternative 1 or Alternative 4. The standing crop of phytoplankton during the summer season would remain high until the zooplankton population recovered to the extent that grazing pressure would lower the phytoplankton abundance. Under a fishless condition, the zooplankton population would likely increase rapidly, creating higher grazing pressure on the phytoplankton. Lowered production and a reduced standing crop of phytoplankton would potentially increase water clarity and promote deeper penetration of light through the water column of the lake. The increase in light penetration during the summer season has the potential to shift a portion of the primary production from the phytoplankton community to attached algae and macrophytes and extend the lake bottom area they are able to occupy. Under Alternatives 2 and 3, recovery of the zooplankton population and the associated effects on phytoplankton would likely occur over a 3-year period. Therefore, a long-term beneficial effect to lake transparency is likely as the peak phytoplankton density is lowered.

Under Alternative 4, the zooplankton population would not be eliminated by the use of rotenone so a shift in the species and size distribution of the zooplankton population would be expected to occur incrementally over a period of about 6 years. Phytoplankton primary production would likely decline over the 6 year implementation period of this alternative in response to changes in grazing pressure and nutrient cycling during the summer period of peak phytoplankton abundance. Since tui chub would not be eliminated from the lake under Alternative 4, in the long-term there is a high probability that an increase in the population of this species could lead to a decline in transparency and other water quality parameters.

Under Alternatives 2 and 3, connected actions proposed by the operators of the Diamond Lake resort including removal of accumulated sediment and trash and dock repair are not expected to have any indirect effects because no in-water work would occur.

Under all action alternatives, as phytoplankton production declines, the depth of light penetration would increase, allowing greater opportunities for macrophyte growth and moving the lake closer to pre-management conditions.

Cumulative Effects:

Any of the action alternatives have the potential to contribute cumulatively toward the maintenance or improvement in water clarity and reduced phytoplankton primary production. Increases in nutrient loading from human activities have the potential to increase the phytoplankton abundance resulting in reduced water clarity. Because suspended particles (including phytoplankton) in the water reduce water clarity, activities in the watershed that either reduce external nutrient loading (e.g. the waste water diversion system) or reduce sediment input into the lake (e.g. road paving and maintenance of roads and trails) would cumulatively contribute to this goal. See cumulative effects tables 9-11 for a complete list of past, ongoing, and reasonably foreseeable activities. All current and future projects incorporate Best Management Practices to ensure protection of water quality and beneficial uses through implementation of erosion control techniques and measures to minimize anthropogenic nutrient additions to Diamond Lake.

Conclusions:

Implementation of any of the action alternatives would be beneficial toward attainment of Aquatic Conservation Strategy (ACS) Objectives. These action alternatives particularly address portions of Objectives 4[34] and 9[35] that address water quality and restoration of habitat to support populations of native plants. Alternatives 2 and 3 would have the highest probability of providing water quality closer to the conditions under which the system evolved in the shortest time (within approximately 3 years). Because the type of fish proposed for stocking under Alternative 2 would more aggressively prey on zooplankton (particularly large bodied species), success of this alternative in providing long-term improvement in water quality would depend on utilizing the results of monitoring data to ensure stocking levels do not result in adverse conditions[36]. The type of domesticated trout proposed to be stocked under Alternative 3 have a lower probability of severe predation pressure on zooplankton and bottom dwelling organisms; therefore, this alternative has a slightly reduced risk of increased water quality degradation in the long-term. Alternative 4 would also contribute toward attainment of these objectives; however, since this alternative would be implemented over a six-year period, progress toward meeting these objectives would be extended over an estimated 6 year time period. In addition, since tui chub would not be eliminated under Alternative 4, there would be a higher risk of not meeting improved water quality in the long-term. A reduction in the peak rate of phytoplankton primary production during the summer would allow light penetration deeper into the lake and would likely promote a macrophyte distribution that more closely resembled the distribution of these species under natural conditions.

SURFACE WATER – STREAM ECOLOGY

Streams are relevant to three issues identified in scoping and described in Chapter 1: water quality (significant), wetlands (significant), and water rights (other). Scoping identified a concern that rotenone treated water would escape Diamond Lake through Lake Creek and negatively impact water quality and fish and wildlife species in Lake Creek and the North Umpqua River System. This issue is tracked under the title streamflow regime and is also discussed in fish and wildlife sections of this chapter. There is a concern that a lake draw down would negatively affect water quality in Lake Creek and downstream water bodies. This issue is tracked under the title water quality. Scoping identified a concern that drawing down Diamond Lake would have a negative impact on wetlands adjacent to the lake and Lake Creek. This issue is tracked under the title streamflow regime and is also discussed in the groundwater and terrestrial and wetland plant sections of this chapter. There is also a concern that a draw down and lake refill period would impact the physical integrity of Lake Creek and holders of water rights around and downstream of Diamond Lake. These issues are tracked under the titles channel morphology and streamflow regime respectively.

[34] ACS Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.
[35] ACS Objective 9 – Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian dependent species.
[36] An ecologically-based index for guiding fish stocking decisions in Diamond Lake has been developed (Eilers 2003a); components include water chemistry, phytoplankton, zooplankton, benthos.

STREAMFLOW REGIME

AFFECTED ENVIRONMENT

The streamflow regime for the project area is uniquely influenced by the High Cascade geology and spring snowmelt (Diamond Lake and Lemolo Lake Watershed Analysis, 1998). This underlying geology is the controlling factor in the development of the High Cascade aquifer (Diamond Lake and Lemolo Lake Watershed Analysis, 1998; Sherrod, 1995; Ingebritsen, 1994). Streamflow is dominated by groundwater input. The geologic characteristics influence a high volume and storage capacity of groundwater that slowly releases to channels. The pumice soil of the area allows rapid water infiltration that generally drains to deeply fractured basalt bedrock with an abundance of joints and fracture patterns allowing rapid infiltration and migration of water vertically as well as horizontally over a wide area. Low stream density is common in this geology with higher infiltration rates and less tendency for surface water to concentrate.

The resulting streamflow regime is not only slow to respond to rain, but also persistent with small annual flow fluctuations (i.e., difference between summer to winter flow). This flow condition provides cool and consistent summer flow while producing less winter runoff[37]. Annual river flow in the North Umpqua River below the Lemolo Reservoir is approximately half of the annual precipitation for the watershed, which is typical of High Cascade streams. In contrast, streams in the Western Cascade geologic sub-province tend to runoff over 70% of the precipitation because of much less storage ability in the older geology.

Precipitation

Precipitation in the project area is predominantly winter rain and snow. Summer precipitation is limited while about 60% of the total annual precipitation occurs in December to February at Diamond Lake[38]. Winter precipitation is influenced by marine weather patterns, which usually occur as storm fronts with warmer storms (rain, not snow) out of the southwest. The snowpack tends to be "warm" with an internal snow temperature near 0ºC or 32º F (Harr and Coffin, 1992), which requires little heat energy to initiate snowmelt. Summer rainfall can be a result of thunderstorms that have intense rainfall, but for short durations. Thunderstorms have produced up to 0.5 inches over about a 2-4 hour period during 1981 to 2002 (USDA, Natural Resource Conservation Service, 2003). However, direct rainfall to the lake from these summer storms amounts to less than 1% of the lake volume.

Snowpack in the Diamond Lake area historically has exceeded 100 inches in February and March. See the Hydrology report for additional details on snowpack and air temperature.

The total mean annual precipitation (that is total inches of water from rain + snow) for the years 1981-2002 as recorded at the NRCS SNOTEL station at Diamond Lake is 49 inches. Mount

[37] This streamflow regime is a direct contrast to the warmer and lower summer flow and more responsive winter runoff of downstream Western Cascade sub-province geology.
[38] Data collected by the Natural Resource Conservation Service (NRCS) at the Diamond Lake SNOwpack TELemetry (SNOTEL) Station #22F18 from 1981 to 2002.

Bailey, which is west of Diamond Lake, appears to create a precipitation rain shadow[39] east of the mountain, which includes Diamond Lake and part of this project area. The precipitation modeling by the Oregon Climate Service (State Climatologist Office[40]) also identifies this situation. General winter observations around the lake have noted that the snowpack tends to be greater in the south to southwest than the north area of Diamond Lake. This varying precipitation pattern around the lake results in an uneven spatial water input to the surface and groundwater hydrology of Diamond Lake.

Streams and Streamflow

The snowpack influences the streamflow regime during the spring period. Figure 17 displays the historical mean monthly streamflow (U.S. Geological Survey, 2003) for the Lake Creek gaging station immediately downstream of the Diamond Lake outlet. The second rise in the hydrograph commonly occurs in June as the result of warm weather causing snowmelt and a spring runoff; however, earlier snowmelt has been observed.

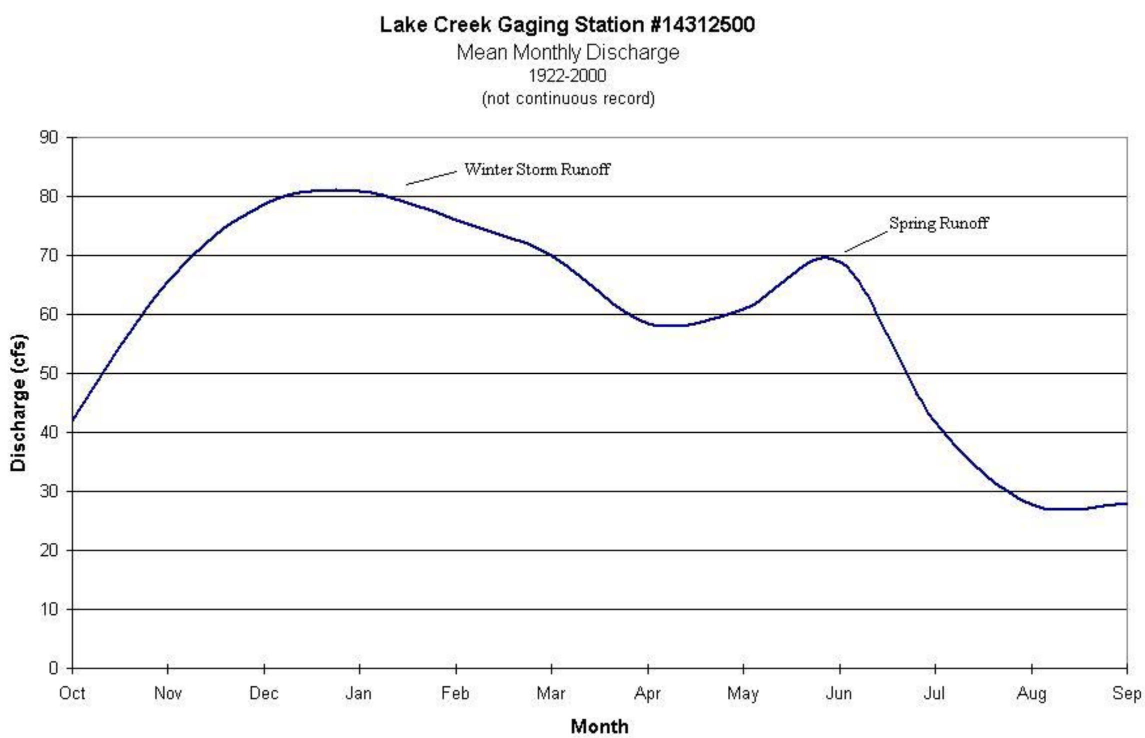

Figure 17. Lake Creek Historical Hydrograph for Mean Monthly Streamflow[41].

[39] Rain shadow is where precipitation is suppressed because of a topographic feature. As a moisture-laden air mass passes over mountains, the existing moisture in clouds tends to evaporate on the leeward side and is less available for precipitation.

[40] State Climatologist Office, Oregon Climate Service, Oregon State University's College of Oceanic and Atmospheric Sciences, Corvallis, OR 97331-2209.

[41] Streamflow data collected and published by the U. S. Geological Survey.

The flow at bankfull level is the "channel-forming discharge" (Leopold, 1994) when flow is the most effective at maintaining the channel's physical form under the current climate regime. Bankfull flows for the greater Umpqua Basin occur about every 1.5 years on average. The bankfull flow for Lake Creek is approximately 110 cubic feet per second (cfs) or about 2 cfs per square mile (cfsm) at the US Geological Survey (USGS) gaging station (#14312500). The streamflow statistics for the Lake Creek Gaging Station show that streamflow can peak above bankfull level as a result of winter storms and spring melt. High Cascade streams like Lake Creek are influenced by groundwater and do not respond quickly to precipitation input through rapid runoff. These streams have less streamflow energy at bankfull or other flood levels. High Cascade streams in the basin generally have bankfull flows that are less than 10 cfsm while streams draining similar size areas in the older Western Cascades geologic sub-province to the west of the project generally have bankfull flows that can be 35 to 50 cfsm[42].

The mean-daily streamflow for the period of record at the Lake Creek Gaging Station is displayed in Figure 18 in comparison to the approximate 1.5-year bankfull flow. Based on the historical data displayed in Figure 3, Lake Creek's mean daily streamflow has frequently exceeded the 1.5-year bankfull flow (110 cfs) during some years. For the period of record, there were 875 occurrences (14,328 mean daily flows in total record) when mean-daily flow was greater than bankfull flow, which represents about 6% of the total record (more than 35 years plus some partial years). These peak streamflow events have occurred both in the winter and spring runoff periods. The duration of these runoff events have lasted from a single day to an average of two weeks, with the larger and longer events during the winter.

[42] Western Cascade streams used for comparison were Susan Creek, Rock Creek, and Cavitt Creek from the crest gage study on or near the Forest. High Cascade streams also evaluated were Thielsen Creek and Clearwater River from the same study (Friday, 1972).

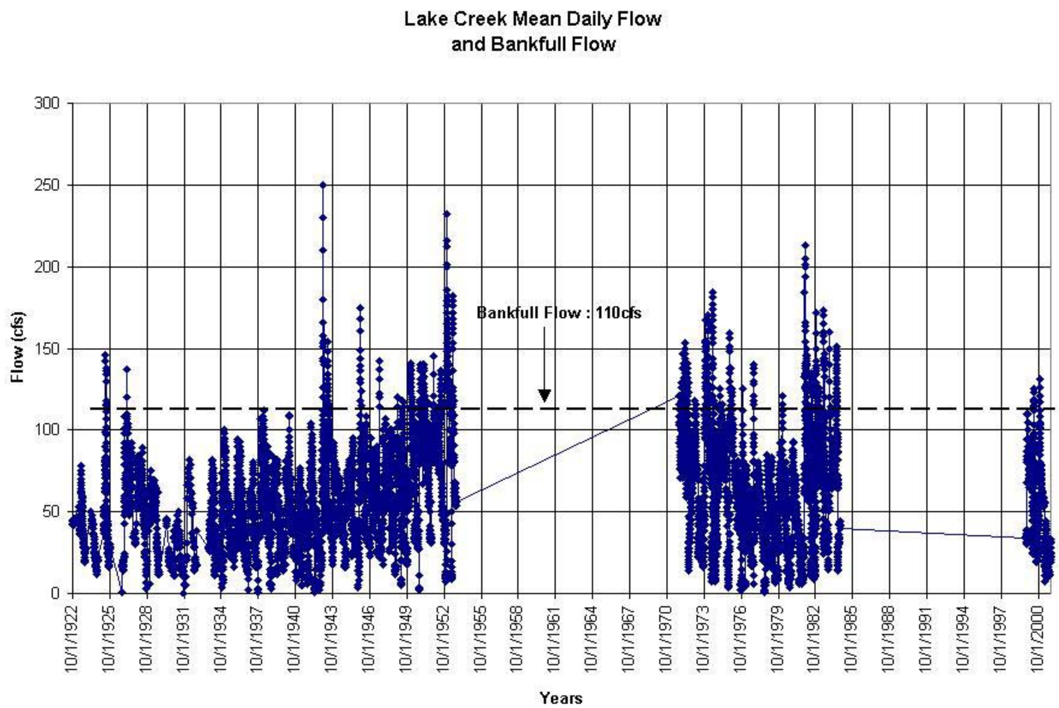

Figure 18. Lake Creek Mean-Daily Streamflow for the Period of Record in Comparison to the 1.5 Year Bankfull Flow of 110 Cubic Feet per Second.

The surface water hydrology of Diamond Lake is strongly influenced by groundwater and snowmelt. The primary surface inflow to the lake is from Silent Creek (about 30 cfs in summer) in the southwest and Short Creek (about 10 cfs in summer) in the southeast (Figure 4). Other surface channels are Two-Bear Creek, Spruce Creek, Porcupine Creek, Dry Creek, Camp Creek, Discovery Creek, Hemlock Creek, and at least three unnamed streams. Most of these streams appear to be seasonal and are influenced by snowmelt. However, Two-Bear Creek and Spruce Creek are more strongly influenced by groundwater through springs. The spring area for Two-Bear Creek has been developed as a water source for the Diamond Lake Resort under the State water right appropriation process. The surface water connection for Two-Bear Creek from its source to the lake appears to exist under the boathouse at Diamond Lake Lodge. The only surface outflow of Diamond Lake is Lake Creek. Oregon Department of Fish and Wildlife (ODFW) regulates the outflow in accordance with a water right to store water above the normal lake surface.

The surface water inflow and outflow for Diamond Lake appears to account for much of the water movement. However, groundwater movement is an important factor for streamflow in the High Cascades.

Oregon Department of Fish and Wildlife (ODFW) has the right to store a maximum of 5,800 acre-feet in Diamond Lake. The stored water is released during the dry season to supplement the flow in the North Umpqua River for downstream diversion and use at the Rock Creek Fish Hatchery (approximately 70 river miles downstream). This becomes critical during below average, low flow periods when the 1974 instream water right[43] is not met. ODFW's water right is junior in time to the instream water right and would be required to stop water use when the instream water right is not met. The release of stored water from Diamond Lake allows ODFW to continue using water from the North Umpqua River during very dry years.

The Oregon Department of Transportation (ODOT) also has a water right. This water use is limited to 0.01 cfs from Lake Creek near the Road 4700-710 crossing (intake upstream of Thielsen Creek and downstream of Sheep Creek) for their truck equipment repair shop which includes shop uses and sanitary facilities.

Wetlands Hydrology
Two primary wetland locations are adjacent to Diamond Lake and identified by the U.S. Fish and Wildlife Service in the National Wetlands Inventory. The larger location is along the southwestern shore (immediately west of South Shore Picnic Area) and is approximately 140 acres. The smaller location is along the northwestern shore (north of Thielsen View Campground) and is approximately 6 acres (mapped as two distinct but adjacent units) (Figure 40).

Local groundwater movement toward the lake during the driest period of the year has been observed in the vicinity of the larger wetland. The water table appears to slope toward the lake along the south shore (Breeden, 2003). The smaller wetland appears to be more influenced by the lake level.

Other wetland locations are along Lake Creek. Between Diamond Lake and the Highway 138 crossing of Lake Creek, there are a number of scattered, but small wetlands (less than 5 acres). However, North of Highway 138 wetlands are more abundant and generally larger than those south of the highway. The wetland locations appear to be influenced by both Lake Creek and upslope groundwater moving toward these sites. Where Lake Creek flows through or immediately adjacent to the wetlands, it was assumed that the stream has some direct influence on the water table, creating the wetland. The remaining wetland locations are at least slightly upslope from Lake Creek where a direct influence was not assumed. Lake Creek appears to have some influence on about 70% of the mapped wetland locations between Diamond Lake and Lemolo Reservoir.

ENVIRONMENTAL EFFECTS

Figure 19 provides a reference for locations on Lake Creek referred to throughout this section.

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[43] "Instream water right" as defined in Oregon Revised Statutes 537.332, means a water right held in trust by the Water Resources Department for the benefit of the people of the state of Oregon to maintain water instream for public use. An instream water right does not require a diversion or any other means of physical control over the water (Oregon Administrative Rules 690-077-0010, Instream Water Rights - Definitions).

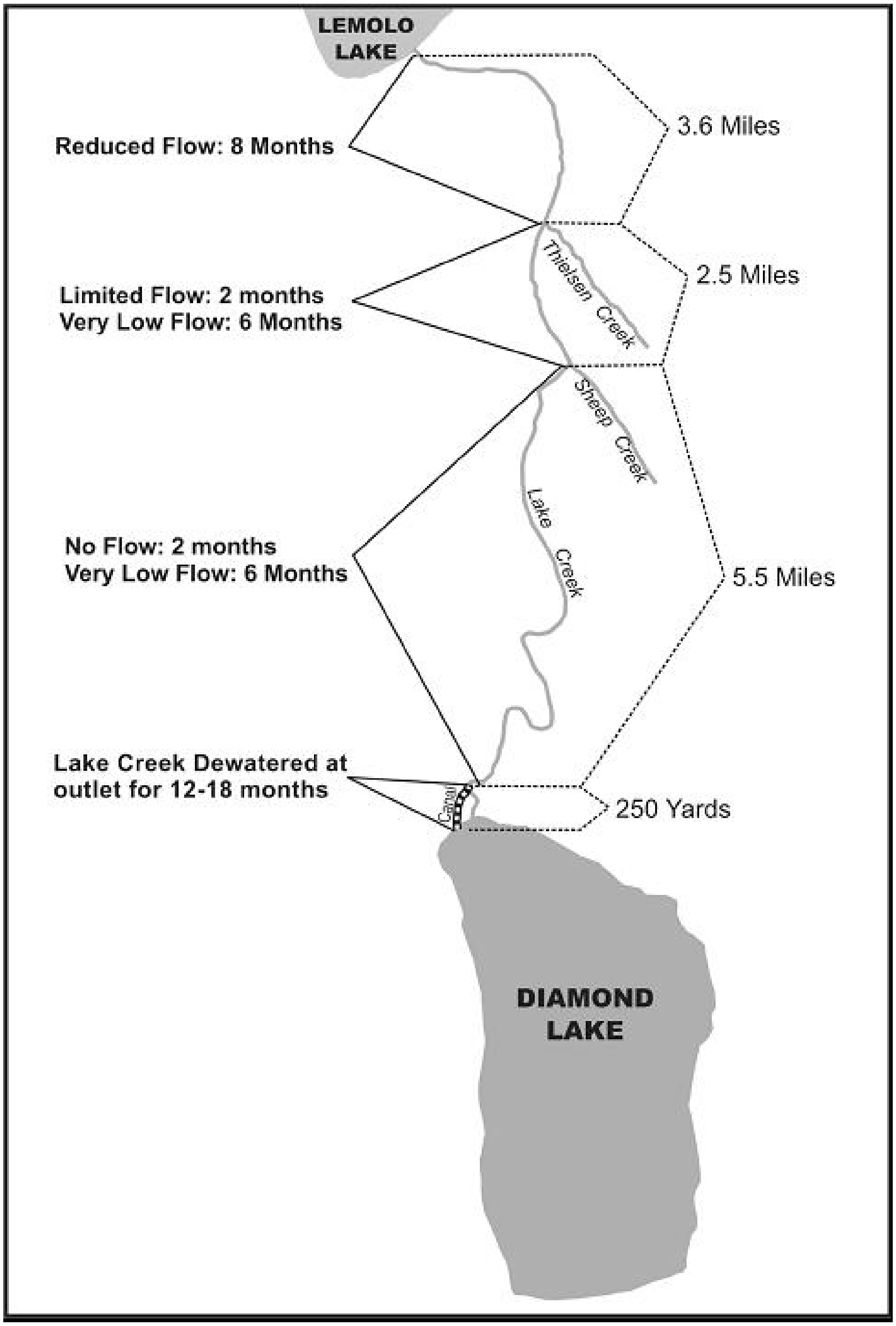

Figure 19. Referenced locations on Lake Creek and the environmental effects of a lake draw down.

Direct Effects: (Lake Creek at the Diamond Lake Outlet)
Alternatives 2 and 3 would directly affect the streamflow regime for Lake Creek at the Diamond Lake outlet through the lake draw down. During the draw down, Lake Creek flow would be at bankfull and periodically higher during winter or spring runoff events. The

streamflow would be released at a quantity that is typical of historic high water streamflow as documented at the gaging station immediately below the outlet of Diamond Lake. However, because of the duration of flow, a similar condition has only occurred once before in 1954 when the lake was also drawn down, at a much higher flow but for the same purpose.

Under Alternatives 2 and 3, Lake Creek would experience extended bankfull flow (or higher during storm or snowmelt runoff periods) for about eight months in order to drain Diamond Lake eight feet (Figure 20). Runoff events would be passed through the canal and down Lake Creek to Lemolo Reservoir, which would simulate winter runoff. The lake outlet would become dewatered when about 2-3 feet of draw down is reached. Lake Creek would remain dewatered from the outlet to where the canal enters the channel (approximately 250 yards) for about 2 months.

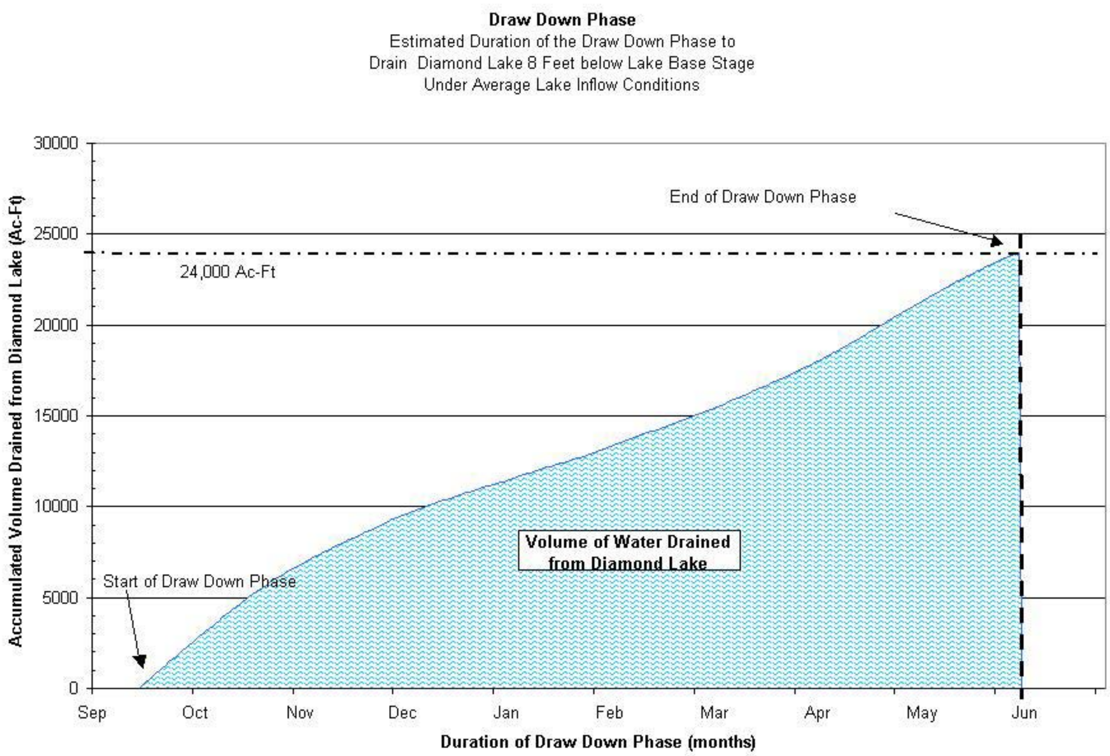

Figure 20. Estimated Duration of the Draw Down Phase with Higher Streamflow in Lake Creek to Drain Diamond Lake (curve does not include likely runoff events).

Figure 21 is a simulated hydrograph that was developed to contrast a worse case scenario of the effects of Alternatives 2 and 3 on streamflow with the actual mean daily flows from the Lake Creek stream gaging record for an extremely wet year (1953). This simulated hydrograph assumes a very wet climatic condition during the draw down phase. The actual flow would probably be less; however, unknown weather conditions during the draw down would determine the actual hydrograph.

The overall effect of the draw down would be higher daily flows in Lake Creek than for a normal winter. The atypical duration of high flow in Lake Creek would be a short-term impact to the streamflow regime only for the draw down phase. For the long-term, streamflow would return to the pre-treatment level.

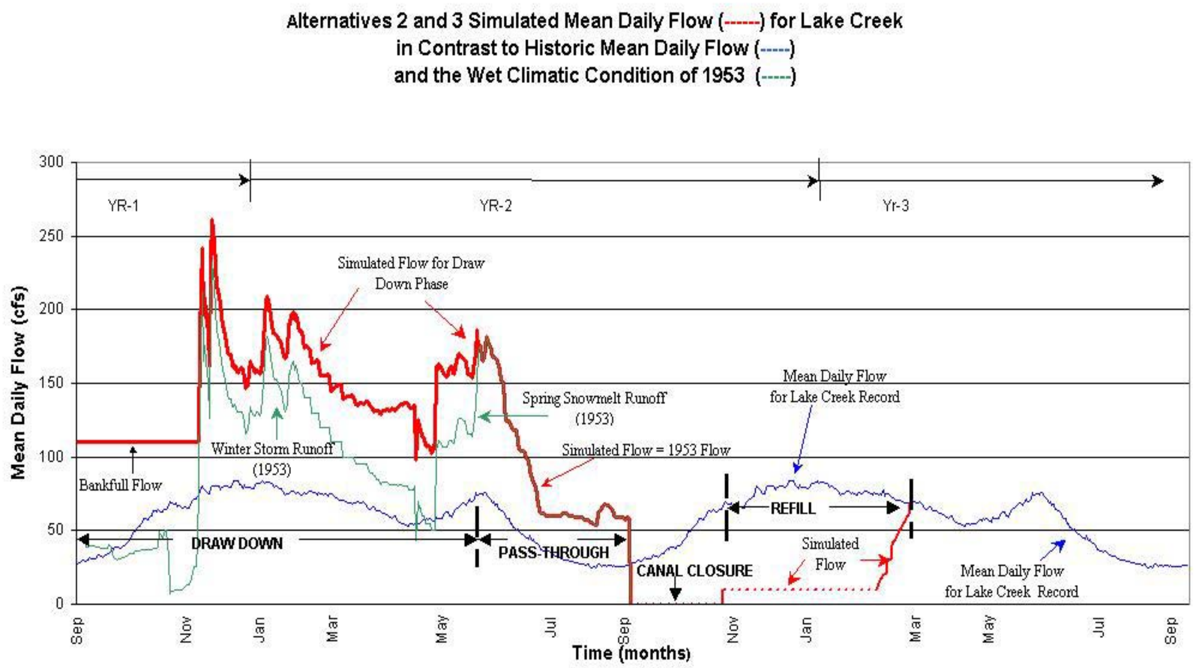

Figure 21. Simulated Mean Daily Flow for Alternatives 2 and 3 over the Project Period in Comparison to Actual Mean Daily Flow from the Lake Creek Gaging Station.

Connected actions by Diamond Lake Resort associated with these alternatives as described in Chapter 2, would have no impact on streamflow regime.

Alternatives 1 and 4 do not involve lake draw down and would not affect the streamflow regime of Lake Creek. These alternatives would maintain the existing streamflow regime; therefore no direct, indirect, or cumulative effects would occur.

Indirect Effects: (Lake Creek Downstream)

Alternatives 2 and 3 are the only alternatives that would have indirect effects on streamflow. Under Alternatives 2 and 3, Lake Creek would flow at bankfull from the canal entry into the channel to Lemolo Reservoir. The bankfull flow would maintain a larger wetted perimeter and wetter soils adjacent to the channel. The immediate riparian areas along the channel would have greater potential for a persistent water table, since groundwater normally draining toward the channel would experience a flatter gradient between groundwater and stream elevation. However, these affects may be very slight since the draw down period occurs during the winter and spring months when greater precipitation would also affect upslope moisture draining to the channel.

Once the draw down flow reaches Lemolo Reservoir, it would be absorbed through reservoir operations. PacifiCorp is a partner in this project and would work with the draw down operation to avoid large changes in reservoir storage and release. Therefore, no major changes in the seasonal streamflow regime below Lemolo Dam in the North Umpqua River would be expected.

After the draw down period, the canal outflow would equal inflow to Diamond Lake, in order to maintain the 8-foot draw down from late spring to the end of the summer. During this period, the flow in Lake Creek would be natural streamflow and reflect the natural watershed responses.

Just prior to chemical treatment of the lake under Alternatives 2 and 3, lake outflow through the canal would be closed and the only flow in Lake Creek would be from groundwater and tributaries. Since there would be little accretion of flow from groundwater or tributaries (Breeden 2003), there would likely be little to no flow, with only some pooled water, in the first 5.5 miles of Lake Creek for about 2 months (Figure19). The largest flow contribution to Lake Creek would be from Thielsen Creek, about 8 miles downstream of the outlet. Thielsen Creek may contribute as much as 5 cfs during this dry channel phase. The limited to no-flow condition for this 8-mile segment of Lake Creek would not change until lake water becomes safe to be released through the canal after treatment. Flow would be gradually released from Diamond Lake about 2 months after closing the canal. The initial release would be about 10 cfs in the spring when flows historically have been 5-7 times greater as measured at the USGS gaging station on Lake Creek.

Following rotenone treatment, the risk of precipitation refilling Diamond Lake and spilling chemically treated lake water into Lake Creek before it is determined to be safe is very low. Assuming that the canal closure would be from September 15 to November 15, the largest rainfall total for this period over the past twenty-two years was about 16 inches (Diamond Lake SNOTEL station 22F18). It would take over 20 inches of rainfall to raise the lake to the elevation that treated water would begin flowing out of Diamond Lake into Lake Creek. The average rainfall for this time period was 7.5 inches and the probability of getting even 16 inches of rain was less than five percent.

In the unlikely situation of the lake refilling during this time, a safety contingency plan would be in-place. The head gate control structures on the canal and natural channel outlet would be designed to ensure that chemically treated lake water would not enter Lake Creek before it is determined to be safe (see Chapter 2).

The refill of Diamond Lake would depend on climatic input, which would allow outflow into Lake Creek to be ramped up as the lake fills. The February-March average monthly snowpack is about 40 inches, which has about an average of 12 inches[44] of water content[45]. Considering

[44] NRCS SNOTEL data from Diamond Lake site 22F18, 1981-2003.
[45] The water content of the snow is referred to as the snow water equivalent (swe) or the depth of water in the snowpack, if the snowpack would melt in inches (NRCS).

that Lake Creek's annual runoff is about thirty percent of the upstream annual precipitation, the snowmelt alone would likely create 10,500 ac-ft of water, in addition to direct precipitation input to the lake that would also occur. However, a mild winter would prolong the refill time.

Effects to streamflow under Alternatives 2 and 3 would last about 16-18 months and then return to pre-treatment condition after the lake refills; effects would not carry into future years.

Alternatives 2 and 3 would affect downstream water rights. ODFW would not be able to store water for one season when the lake is drawn down and treated. The hatchery operation at Rock Creek would depend on the natural flows of the North Umpqua River that are above the 1974 instream water right and be operationally at risk if flow regulation occurs. Lack of water at the hatchery would likely cause ODFW to release fish earlier than scheduled.

ODOT would not likely be able to use water from Lake Creek after the draw down when the canal is closed and this stream segment would have limited flow. Although Sheep Creek contributes flow to Lake Creek, the amount of flow would not likely provide enough depth across the channel to maintain the intake operation. The release of 10 cfs, about 2 months after treatment when lake water is determined safe, would likely provide enough water for this water use. Because very little water is used by ODOT, the impacts to their operations from this short-term restriction of use would be minor.

Alternatives 2 and 3 would potentially influence the water table of the adjacent ground along Lake Creek during draw down, canal closure, and refill phases. The draw down phase would have greater potential for a persistent water table in the adjacent wetlands, because groundwater that would normally drain toward the channel would experience a higher stream surface elevation, causing less groundwater flow from Lake Creek wetlands to the channel. This effect would be similar to winter conditions when marine storms move into the High Cascades creating very wet soils and runoff. However, it would last much longer than under normal conditions.

On the other hand, during the canal closure phase, when Lake Creek would likely have little to no flow from Diamond Lake to Thielsen Creek, wetlands in this area would likely experience a drier condition. The groundwater table would have a steeper gradient between wetlands and channel, which would encourage more rapid water movement toward the channel. Although Sheep Creek does contribute flow to Lake Creek, it only represents about 5% or less of the low flow. Therefore, Sheep Creek flow would not be expected to lessen the potential drying effect to the wetlands downstream. However, in this segment of stream, there are very localized tributary inputs that would provide some moisture at these specific sites. This unnaturally dry condition would last about 2 months.

The release of flow after treatment during the early refill phase would be smaller than the average historic flow in Lake Creek and would tend to encourage groundwater movement to the channel and a lower wetland water table. If the winter months were wet with rain and snowmelt, the weather would help to locally recharge wetlands. Wetland moisture in the Lake Creek area would not likely recover until well into the refill phase.

Cumulative Effects: (Lake Creek Combined with Other Actions)
Alternatives 2 and 3 are the only alternatives that would potentially combine with other past, present, and reasonably foreseeable future actions downstream of Diamond Lake to influence the streamflow regime. Several other activities are proposed within the downstream analysis area that have the potential to influence the processes of streamflow.

Within the Lemolo Lake Watershed, other reasonably foreseeable actions include pre-commercial thinning over the next five years, natural fuels treatments under Lemolo Fire Hazard Reduction CE, Bear Paw timber sale (9 acres), and Lemolo Watersheds Projects (timber harvest and natural fuel treatments). These activities would affect rain-on-snow response to canopy removal. However, since the combined canopy removal from these proposed activities would not reduce the hydrologic recovery to a level of concern that would cause greater rain-on-snow runoff (Lemolo Watershed Projects Supplemental DEIS – water resource analysis, 2003), the additional streamflow from the combined proposed projects would not be expected to incrementally add to the draw down flow during the winter months.

No other projects are proposed or planned that would further reduce Lake Creek flows or wetland moisture. Therefore, no cumulative effectives associated with low flow conditions are expected.

PacifiCorp's hydropower operation exists within the analysis area and can potentially affect streamflow because of flow regulation at storage structures. PacifiCorp would pass the additional flow during the draw down phase when higher flows (winter runoff) would likely occur. Figure 22 displays the historic monthly flow in the North Umpqua River before Lemolo Dam in contrast to the post dam construction and operation period. Bankfull flow from Lake Creek would likely be proportionately higher to current flow releases from Lemolo Reservoir, but less than historic flows that have developed the downstream channel of the North Umpqua River. Winter storm runoffs, which would be greater than bankfull in Lake Creek, would continue to combine with upper North Umpqua River runoff in Lemolo Reservoir. A comparison of historic peak flows (actual paired peak dates) for Lake Creek and North Umpqua River (at the dam site and before construction) illustrated that Lake Creek contributed about 15 percent of average peak flow at the present dam site. Mean annual stream flow showed a similar relationship. Lake Creek is only 14% of the mean annual flow in the upper North Umpqua River and thus, is not considered to be a major influence on the river.

Since PacifiCorp operations of Lemolo Dam would pass additional draw down flow, there would be a short-term higher flow below the dam for this phase in comparison to the post dam regulated flow. Overall, only this short-term cumulative flow effect would be expected immediately downstream of the Lemolo Dam. Below the last PacifiCorp structure (Soda Springs Dam) where the upper reach of the North Umpqua River Wild and Scenic starts, increased flows would not be detectable.

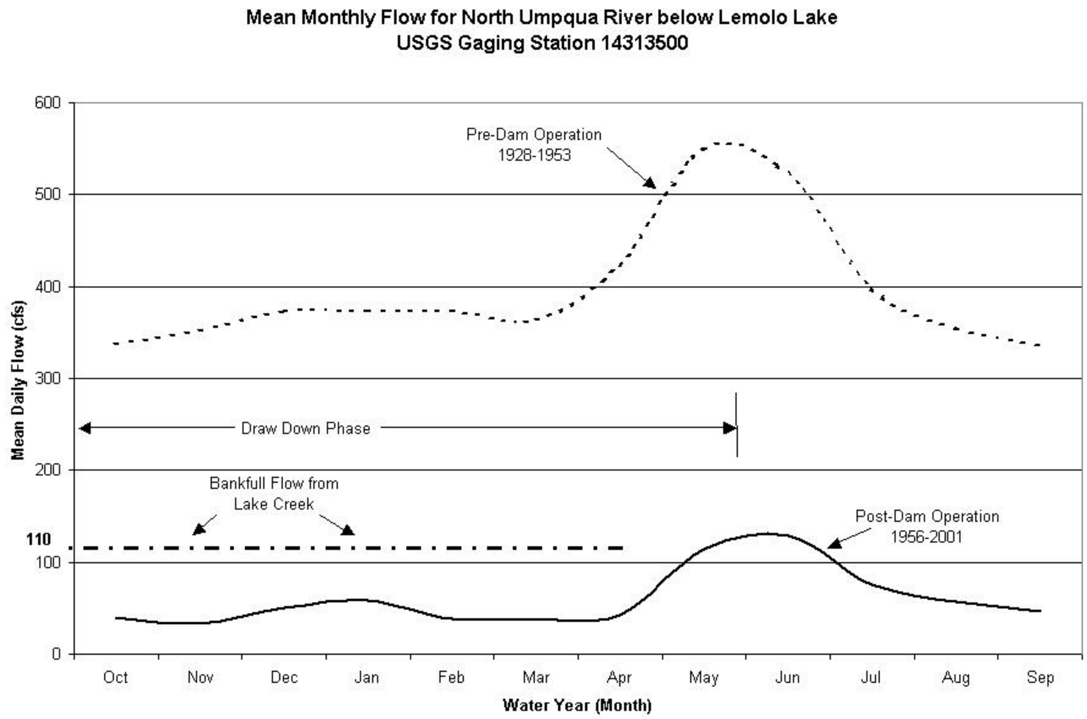

Figure 22. Mean Monthly Flow at North Umpqua River below Lemolo Dam, USGS Gaging Station 14313500 Before and After Dam Operation.

Conclusions:
Alternatives 2 and 3 would have the only impact on the streamflow regime of Lake Creek. During the draw down period, Lake Creek would have at least bankfull flow (110 cfs). Although this amount of flow is not unusual, the proposed duration of bankfull flow is unusual and would not occur under a normal hydrologic cycle.

A short segment of stream (from the outlet to where the canal enters the channel of Lake Creek), would be dewatered for more than 12 months. Not until the lake is nearly refilled would this segment of Lake Creek have appreciable streamflow. When the canal is closed, the hydrologic cycle would be at low flow for all sections of Lake Creek. About 5.5 miles of Lake Creek would not have connectivity of flow. Thielsen Creek would be the only meaningful contribution to Lake Creek at about eight miles downstream. Loss of flow would also temporarily affect two water rights and the moisture regime in the wetlands in the vicinity of Lake Creek.

Alternatives 1 and 4 would not affect the existing streamflow regime.

Aquatic Conservation Strategy:
Aquatic Conservation Strategy (ACS) Objectives 6[46] and 7[47] address in-stream flow, floodplain inundation and wetland water table. Since Alternatives 1 and 4 would not affect streamflow,

[46] ACS objective 6: “Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.”

the attainment of these ACS objectives would occur. Therefore, objectives 6 and 7 would be maintained under these alternatives.

Alternatives 2 and 3 would alter the streamflow regime during the implementation of these actions. Both alternatives would result in bankfull flow for about eight months over the length of Lake Creek and little to no flow from the outlet to Sheep Creek for 2 months. These represent local, short-term impacts; however, for the long-term, streamflow would return to the pre-action level, which would allow attainment of ACS objective 6. Wetlands adjacent to Diamond Lake and along Lake Creek also would likely dry during the short-term. However, this temporary effect would not prevent the long-term attainment of ACS objective 7 once the project is complete and streamflow returns to pre-action levels. The higher flows of winter and spring would be passed through the canal similar to historic flows. Therefore, objective 7 would be met.

WATER QUALITY

The water quality of streams affected by the project is characterized by water temperature and nutrients. Dissolved Oxygen (DO) and pH do not appear to be a concern for Lake Creek, but the situation is potentially different in Lemolo Reservoir and below the Lemolo Dam. There is also the potential for algal toxin to enter Lake Creek from Diamond Lake (see toxin discussion in Limnological section) and move downstream.

Stream Temperature

AFFECTED ENVIRONMENT

Lake Creek is a water quality limited stream on the State 303(d) List as defined in the federal Clean Water Act for elevated water temperatures. The specific concern identified is the warm temperatures during the spawning (year round) and rearing (summer) periods[48] for resident fish and aquatic life.

Lake Creek flow at the outlet is lake surface water running out of Diamond Lake. Because of the direct exposure to sunlight (solar radiation input), the surface water and outflow is naturally warm in the summer. Lake Creek maximum summer water temperatures closely parallel summer daytime temperatures. The warm water condition is not typical for High Cascade streams that are usually influenced by groundwater through seeps and springs. For example, the maximum summer temperature for Lake Creek at the outlet has been measured at greater than 75 degrees Fahrenheit (ºF) (23.9 ºC) while the maximum temperature of Thielsen Creek, a tributary, was 52º F (Diamond and Lemolo Lakes Watershed Analysis, 1998). Across the lake, Silent Creek's maximum temperature was less than 50º F (10º C) for the summer of 2003 (Eilers 2003). However, over the stream distance from Diamond Lake to Lemolo Reservoir, exchange of cool groundwater with surface water as well as tributary flow help to reduce Lake Creek's temperature. The maximum summer temperature for the mouth

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[47] ACS objective 7: "Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands."
[48] Oregon Department of Fish and Wildlife District Offices determine the spawning and rearing periods.

of Lake Creek at Lemolo Reservoir is about 10 degrees cooler than at Diamond Lake outlet[49] (Diamond and Lemolo Lakes Watershed Analysis 1998). Shade also contributes to the cooler stream temperature in the downstream direction.

The current water temperatures in Lake Creek are likely similar to pre-management activity. Vegetation disturbance from timber harvest, road construction, and recreational management activities has been limited along Lake Creek over the past 60 years (Lemolo and Diamond Lakes Watershed Analysis, 1998) and temperatures are likely to have improved since the 1940's, when sheep grazing ended.

ENVIRONMENTAL EFFECTS

Direct Effects: (Lake Creek at the Diamond Lake Outlet)
Alternatives 1 and 4 would maintain the existing stream temperature regime, as no draw down or reduction of flows in Lake Creek would occur; thus, there would be no direct, indirect or cumulative effects associated with these alternatives.

Alternatives 2 and 3 involve lake draw down and no outlet flow to Lake Creek. The pass-through flow and canal closure phases would occur during the time of warmer stream temperatures, while the other phases are during the cooler months. Since the pass-through flow phase would be similar to the existing condition, no stream temperature changes would be expected.

During the canal closure phase, Lake Creek would not have flow immediately below the outlet during the summer, when stream temperature peaks. Any water in the immediate channel, such as in pools, would be susceptible to atmospheric warming and possible direct solar radiation over the period that the outlet is dewatered. However, this segment of channel would not transfer warm water downstream. Therefore, the direct effect of warming would be limited and would not contribute to any downstream warming.

None of the connected actions proposed by Diamond Lake Resort would have any direct, indirect, or cumulative effects on stream temperature.

Indirect Effects: (Lake Creek and Downstream)

As discussed under direct effects for Alternatives 2 and 3, the critical phase would be during the canal closure when there would be little to no flow for about 5.5 miles of stream until Sheep Creek. Any water in the channel would be expected to pool and not likely to flow. The water that is pooled would warm with atmospheric conditions and possibly direct solar radiation. However, the amount of flow from Sheep Creek during this time of year would only provide very shallow flow that would easily warm where stream shade does not exist. At the confluence with Thielsen Creek, cool water would dominate the limited streamflow in Lake Creek from this confluence to Lemolo Reservoir (about 3.5 miles). Although volume of flow would be reduced, Lake Creek's stream temperature would likely be cooler downstream than typical since Thielsen Creek would dominate the flow, and it is a cooler groundwater system.

[49] Diamond Lake Ranger District temperature monitoring that occurred in 1997.

Any stream temperature changes in Lake Creek during any part of these alternatives would be offset once flow reaches Lemolo Reservoir where Lake Creek normally represents less than 20% (Anderson and Carpenter, 1998) of the total flow entering the reservoir during summer and a smaller percentage during canal closure. The cooler and higher volume flow of the upper North Umpqua River that flows into Lemolo Reservoir dominates the reservoir volume. Therefore, the reservoir would be the downstream extent that possible stream temperature influences would occur.

Cumulative Effects: (Lake Creek Combined with Other Actions)

For Alternatives 2 and 3, there are no ongoing or planned actions that would reduce riparian shade along Lake Creek or tributaries. The Riparian Reserve land allocation under the Northwest Forest Plan provides for water quality protection and is applied to all activities near streams, which would protect effective shade. Therefore, the temporary impacts associated with these two alternatives are not expected to cause consequential cumulative effects to the Lake Creek stream temperature within or downstream of the project area.

Conclusions:
Under Alternatives 2 and 3, Lake Creek would essentially quit flowing from the outlet downstream for 5.5 miles until Sheep Creek during the critical summer period when streams warm. Pooling of water would likely occur, which would warm with atmospheric conditions and direct solar radiation, but lack connectivity downstream. As such, warm water would not be delivered to downstream areas. The cool water of Thielsen Creek would dominate Lake Creek stream temperature from the confluence to Lemolo. Lake Creek temperature would be cooler than typical in this segment where Thielsen Creek would dominate the flow.

Alternatives 2 and 3 would temporarily create a cooler, but smaller flow segment of Lake Creek from Thielsen Creek to Lemolo Reservoir. However, the natural stream warming and conveyance would not be permanently altered through these alternatives, but would return to pre-treatment levels after the lake is refilled.

Alternatives 1 and 4 would have no effects on stream temperature.

<u>Nutrients and Algal Toxins</u>

AFFECTED ENVIRONMENT

Phosphorus and nitrogen are the two primary nutrients that enhance algal growth in streams. High concentrations of phosphorus in streams are associated with the volcanic soils of the High Cascades geology that is found in the project area. In contrast, the scarcity of nitrogen in the waters of the greater North Umpqua River Sub-Basin (within and beyond the project boundaries) implies that the algae are potentially "nitrogen limited," making plant-available nitrogen (inorganic nitrogen) difficult to detect[50] (Anderson and Carpenter, 1998). Phosphorus

[50] In nitrogen limited streams, algae and other plants rapidly use up inorganic nitrogen (nitrogen that is in solution or dissolved in the water) as soon as it becomes available in the water column. High inputs of inorganic nitrogen into these types of streams can result in algae blooms.

and nitrogen are exported from the surface water of Diamond Lake down Lake Creek to Lemolo Reservoir.

Phosphorus is delivered to Diamond Lake through surface water, groundwater, and precipitation; however, only a small portion leaves the lake through Lake Creek (see Lake Ecology and Water Quality section). During 1992-2000, the total phosphorus concentration was approximately 4 times greater coming into the lake than measured in Lake Creek below the outlet (Salinas, 2001). The US Geological Survey also sampled the mouth of Lake Creek (Anderson and Carpenter, 1998) within the same time period (1995) and found that total phosphorus and orthophosphate[51] were similar in concentration to the outlet. Phosphorus concentrations measured by Eilers (2001b) were also similar over the length of Lake Creek. It appears there is no meaningful change in phosphorus over the length of Lake Creek.

Inorganic nitrogen (readily available for use by plants) is the primary form of nitrogen externally delivered to Diamond Lake at low concentrations through the groundwater (see Lake Ecology and Water Quality section). With the phytoplankton active on the lake surface, outflow into Lake Creek is higher in organic nitrogen (not readily available for use by plants) than inorganic. However, organic nitrogen is converted (nitrification) to inorganic nitrogen as water flows down Lake Creek, reducing the concentration of the organic form at the mouth. Inorganic nitrogen was found to be as much as 70 times greater at the mouth of Lake Creek compared to the concentration at the lake outlet. Figure 23 displays the nitrogen and phosphorus characteristics of Lake Creek at the outlet and mouth that were sampled by Eilers in 2001.

Recent algal blooms in Diamond Lake have resulted in the production of toxins that are a concern to human health. Toxin sampling at the time of peak algal blooms in Diamond Lake during the summers of 2001, 2002, and 2003 detected levels of both anatoxin-a and microcystins. The concern for toxin is where algal mats or blooms concentrate. These bloom concentrations are not evenly distributed on the lake, but tend to gather in open water and along the shore. Anatoxin-a concentrations ranged from "no detection" to two samples at 300 µg/L in 2001. Microcystin concentrations were less that 1 µg/L except for one sample in 2003 (2.54 µg/L). The presence of toxin during these three summers prompted lake closures for part of each summer for public safety.

A level of concern for anatoxin-a has not been established by the USEPA. However, Dr. Wayne Carmichael of the Department of Biological Sciences at Wright State University suggested to the Umpqua National Forest that 100 micrograms per liter (µg/L) "would be an acute lethal risk to animals (pets) drinking from inshore areas where the bloom would be more concentrated (and hence the toxin as well)" (2001). The World Health Organization has established a guideline value for microcystins at 1 µg/L in drinking water (Chorus and Bartram, 1999).

Toxins delivered to Lake Creek from Diamond Lake are available to be transported downstream. However, the increased streamflow in Lake Creek from groundwater and

[51] Orthophosphate is one of three classes of dissolved phosphorus that can be found in natural waters, but the only form readily available for biotic uptake (MacDonald, Smart, and Wissmar, 1991).

tributary inflow would dilute any original lake concentration downstream. If toxins reach Lemolo Reservoir, it would be further diluted and undergo photo-degradation.

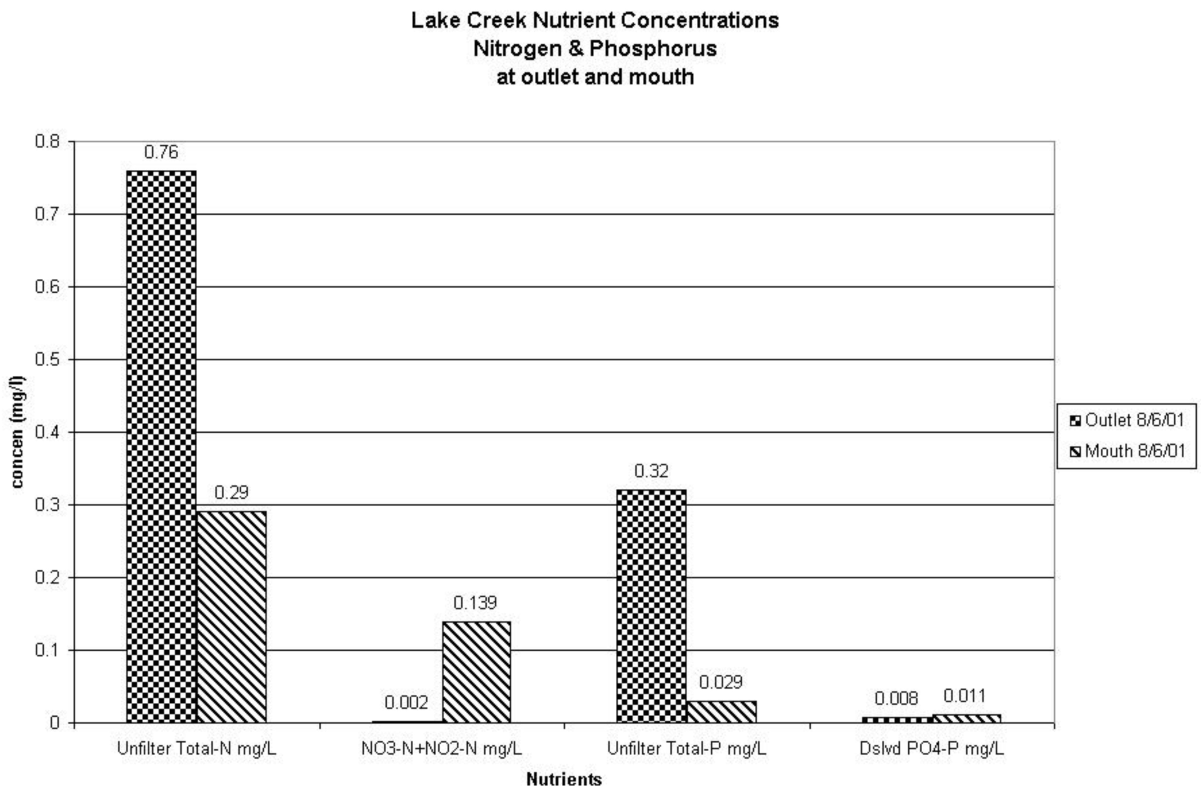

Figure 23. Nitrogen (Unfiltered Total-N and NO_3-N + NO_2-N) and Phosphorus (Unfiltered Total-P and Dissolved PO_4-P) Concentrations (mg/L) in Lake Creek at Outlet and Mouth (Eilers, 2001).

ENVIRONMENTAL EFFECTS

Direct Effects: (Lake Creek at the Diamond Lake Outlet)
Alternative 1 would maintain the existing phosphorus and nitrogen profiles as described in the affected environment. Blue-green algae blooms would continue to occur and produce anatoxin-a and microcystin, which reduce the summer water quality and raise public health concerns.

Under Alternatives 2 and 3, the draw down and refill phases would not occur during the summer when primary production would influence nutrient occurrence and movement through Lake Creek and downstream. Canal closure would potentially dewater Lake Creek to the confluence of Sheep Creek and eliminate nutrient conveyance. Therefore, the consequences of these two phases are minor.

Alternatives 2 and 3 have the greatest potential to influence phosphorus and nitrogen movement during the pass-through flow of the summer. During the pass-through flow, Lake Creek at the outlet would be dewatered and lack any connection to phosphorus and nitrogen from Diamond Lake. The canal would carry the flow and nutrients downstream to a lower segment of Lake Creek. Therefore, the outlet segment would not be able to convey or respond to local nutrients.

The presence of toxins under Alternatives 2 and 3 would also occur during the pass-through flow phase of the summer. Toxin that is produced in Diamond Lake would be available to enter Lake Creek through the canal and carry downstream. As mentioned for nutrients, the outlet would be dewatered and not able to convey toxins.

None of the connected actions proposed by Diamond Lake Resort would have any direct, indirect, or cumulative effects on stream nutrients or toxins.

Alternative 4 would maintain the existing phosphorus and nitrogen profiles (supporting algae populations) as described in the affected environment for about six years of treatment. After six years, some lake improvement would be expected, resulting in a temporary reduction of phytoplankton and nutrient delivery to Lake Creek at the outlet. However, this alternative would not completely remove the tui chub and the remaining chub would continue to feed on the lake zooplankton, allowing phytoplankton activity to continue, but at a lower level than currently exists. This condition would result in the continued delivery of organic nitrogen into Lake Creek, but again, at a somewhat lower level than the existing condition for a period of time.

Toxins would likely remain present at the outlet under Alternative 4 with some possible improvement because of mechanical treatment disrupting algal activity during blooms. As discussed above for nutrients, a reduction of blue-green algae would be expected after six years, which would also result in toxin reduction. However, the remaining tui chub would continue to restrict the ability of zooplankton to control the phytoplankton. Therefore, there would be the risk of future algal blooms and the presence of toxins at the outlet under this alternative.

Indirect Effects: (Lake Creek and Downstream)
Alternative 1 would maintain the existing phosphorus and nitrogen profiles as described in the affected environment in the downstream channel segments. Since the North Umpqua River is a nitrogen-limited system, passage of even small amounts of nitrogen downstream would likely encourage algal growth, which would represent a potential negative impact on water quality.

For Alternative 1, potential toxins from algal bloom concentrations in Diamond Lake would continue to be delivered to Lake Creek and downstream. Groundwater and tributary inflow to Lake Creek would dilute the already low toxin concentrations between Diamond Lake and Lemolo Reservoir. If toxin enters Lemolo Reservoir, it would be further diluted because of the volume of the reservoir in comparison to Lake Creek flow. The resident time of reservoir water is about two weeks, which would not allow continued toxin input to concentrate to a level of concern. The open setting of the reservoir would allow photo degradation to reduce remaining toxin concentrations well below the original Diamond Lake values. Any toxins below Lemolo Reservoir in the North Umpqua River would not likely be detectable.

The ODOT water right on Lake Creek is not for drinking water. However, if diluted concentration of toxins from Diamond Lake were present at the intake of this water right, it probably would be below the suggested level of concern for toxin concentration published by the World Health Organization. This condition would be similar for all the action alternatives during the summer when algal blooms occur.

Eilers and Raymond (2001) investigated the existing movement of nitrogen and phosphorous through the PacifiCorp hydropower project. From Lemolo Reservoir to below the last PacifiCorp dam on the North Umpqua River, they found that overall some phosphorus is retained in sediments in the reservoirs and forebays. Total nitrogen indicated slight gains downstream. Nitrogen gains from fixation by blue-green algae appear to be balanced by retention and storage in sediments.

For Alternative 2 and 3, as described under the direct effects, the pass-through flow phase (using the canal not the lake outlet) would be the primary phase of concern. During this phase, the existing nutrient process would be generally unchanged. Lake Creek's profile for phosphorus and nitrogen would likely follow the existing condition. Therefore, nutrients would continue to be conveyed downstream through the hydropower project and down the North Umpqua River. In three years, phytoplankton density in Diamond Lake would be expected to reduce because of the removal of tui chub. Lower concentrations of organic nitrogen and total nitrogen would be delivered to Lake Creek. The shift would be a result of lower phytoplankton densities in Diamond Lake that would fix less atmospheric nitrogen into organic nitrogen as algal cells. This represents a long-term beneficial effect to the aquatic system and water quality.

Toxins delivered to Lake Creek during the pass-through flow phase would respond similarly to the existing condition as discussed under the indirect effect for Alternative 1.

Under Alternatives 2 and 3, the draw down phase would release nutrient rich water from Diamond Lake down Lake Creek to Lemolo Reservoir. During the time of release, primary productivity would be low because of the cooler water temperatures and limited light of the fall through spring period. It would be important for PacifiCorp to release the draw down flow to the North Umpqua River and not store this water; this would allow the nutrient rich water from Diamond Lake to pass through the hydropower system and down the North Umpqua River before summer when algal productivity would utilize nutrients in PacifiCorp impoundments or the river.

Total nitrogen would be elevated in Lake Creek and downstream during at least the early half of the refill phase and immediately after the canal is opened. The increase in total nitrogen would be in organic nitrogen from the dead aquatic life after chemical treatment. Because of the time of year, organic nitrogen would not be converted to inorganic nitrogen as readily as in the summer. Streamflow would be increasing with cooler water temperatures and less available light in this final phase. As identified for the draw down phase, it would also be important that PacifiCorp release the early refill flow to the North Umpqua River and not store this water. Downstream nitrogen levels would become diluted with increasing flow. Therefore, the higher total nitrogen would be expected to pass through the North Umpqua system before aquatic life would effectively utilize it during the following summer. Inorganic nitrogen (nitrate; NO_3) would remain at low concentrations downstream, which would likely be less than observed during the summer (see Figure 23).

Alternative 4 would show little to no improvement over the existing nutrient profile for about six years. After six years, some reduction in phytoplankton would be expected in Diamond Lake, which would lower organic nitrogen and total nitrogen concentrations exported down Lake Creek. However, this alternative would not completely remove the tui chub (see Aquatic Biology section). The presence of tui chub would continue to influence the amount of organic nitrogen exported from the lake. This alternative would likely export more total nitrogen than Alternatives 2 and 3, but less than Alternative 1.

Toxins would likely remain present at the outlet and carry downstream under Alternative 4. The downstream toxin transport and processes would be similar to the existing situation and described under Alternative 1. However, some possible improvement would likely occur in the short-term because of the mechanical treatment, which would indirectly reduce the potential for high density blooms to develop. As described in the direct effects, a downstream improvement would be expected after six years with a noticeable reduction of phytoplankton (blue-green algae). However, the remaining tui chub would continue to restrict the ability of zooplankton to control the phytoplankton. Therefore, there would be the risk of future algal blooms and the presence of toxins downstream of the outlet.

Cumulative Effects: (Lake Creek Combined with Other Actions)
All the alternatives would have the potential to cumulatively add nitrogen to Lake Creek when combined with other planned and proposed activities that also have potential nitrogen input to Lake Creek. Within the Lemolo Lake Watershed, other planned and proposed activities include various intensities of timber harvest and forest fuel treatments. These types of activities would release nitrogen with the potential to be transported through the groundwater to Lake Creek.

There are no other situations downstream of Diamond Lake that are existing, proposed, or planned that would input toxins to the Lake Creek system and accumulate downstream. Although Lemolo Reservoir is water quality limited for pH because of algal activity, toxins have not been identified in the reservoir in association with the existing phytoplankton blooms.

Alternative 1 would maintain the existing nutrient profiles as described in the affected environment. This alternative would have the greatest opportunity to incrementally add to other planned and proposed activities because of the lack of corrective measures and the indefinite time frame to allow cumulative effects to develop.

Alternatives 2 and 3 would have the potential to add inorganic nitrogen to Lake Creek that potentially would incrementally add to other planned and proposed activities with nitrogen output in the short-term. However, in three years, algae activity would be expected to reduce, which would lower the total nitrogen concentration and organic nitrogen in Diamond

Lake and delivered to Lake Creek. There would also be less organic nitrogen to undergo nitrification in Lake Creek. Overall, less inorganic nitrogen would be available for plant growth in Lake Creek, resulting in a long-term beneficial improvement.

Alternative 4, in six years, would also result in a reduction in phytoplankton activity, which would lower the total nitrogen that Diamond Lake would deliver to Lake Creek. A similar response as in Alternatives 2 and 3 would be expected for this alternative, except it would take six years instead of three years for potential incremental effects to occur and it would likely export more total nitrogen than Alternatives 2 and 3, but less than Alternative 1. Therefore, a beneficial response in nutrients would be expected, but less than Alternatives 2 and 3.

Conclusions:
Under Alternative 1, high concentrations of organic nitrogen would continue to be delivered to Lake Creek. Over the length of Lake Creek, the organic nitrogen would be converted to inorganic nitrogen and thus available to promote algal growth in Lemolo Reservoir, where elevated pH would continue to affect reservoir water quality. Toxin produced by blue-green algae in Diamond Lake would continue to be delivered to the Lake Creek outlet and possibly downstream in a very dilute concentration. Downstream effects of toxins would dissipate completely once Lake Creek mixes with Lemolo Reservoir.

Under Alternatives 2 and 3, phytoplankton (algae) density in Diamond Lake would reduce three years after treatment, lowering nitrogen output into Lake Creek. Nitrogen delivered to Lemolo Reservoir would also be reduced, which would help to reduce planktonic activity and pH in Lemolo.

Under Alterative 4, the same type of improvements as described under Alternatives 2 and 3 would be expected to occur after 6 years, but to a lesser degree. Because some lower number of tui chub would still be present, nutrient cycling would still occur, but at a reduced level from that of Alternative 1.

Dissolved Oxygen and pH

AFFECTED ENVIRONMENT

Lake Creek naturally aerates[52] between Diamond Lake and Lemolo Reservoir in fast water segments. The U. S. Geological Survey did a synoptic[53] study of the water quality and algal conditions in the North Umpqua River, which included Lake Creek at the mouth and the North Umpqua River at the inlet to Lemolo Reservoir (Anderson and Carpenter, 1998). The Dissolved Oxygen (DO) at the Lake Creek site was 97% saturated[54] in the morning and 110% in the afternoon, in late July. DO concentrations can be a concern during the summer months when stream temperatures are the warmest and natural solubility[55] of oxygen is lower. Lake Creek at the lake outlet re-aerates as the water moves quickly out of the lake. The lake surface water that moves out of the lake also has high levels of DO because of wind-induced aeration of the lake surface water and photosynthetic activity of phytoplankton and macrophytes in the summer. Winter DO may also be saturated, because water temperature is low, solubility of oxygen is higher, and higher flow incorporates more oxygen into the water from the atmosphere.

From the same USGS study, pH at the mouth of Lake Creek ranged from 7.2 to 7.6 over a twelve-hour period in late July, which is when higher pH has been measured in other Forest streams and water bodies. The pH for the surface water of Diamond Lake during the summer is usually above 8.0 and driven by phytoplankton primary production. Salinas (2001) found that over a 6-year sampling period during the summers of 1992-2000 that Lake Creek's average pH was 8.5 at the outlet. Because of lower water temperature and light, the winter primary productivity is greatly reduced and pH is also lower.

Downstream summer DO and pH in Lemolo Reservoir have responded to algal activity in the upper 13-19 feet of the water column of Lemolo Reservoir (ODEQ, 2002). The pH has exceeded the water quality standard (pH >8.5) and Lemolo Reservoir has been listed as a Water Quality Limited Water Body (ODEQ 303d List, Table 12). DO has shown daily swings because of algal photosynthesis (elevated DO) and respiration (depressed DO). Nitrogen-rich water from Diamond Lake that is carried by Lake Creek has been identified as a source of concern for Lemolo Reservoir.

[52] A stream naturally aerates when atmospheric oxygen becomes mixed into the water because of turbulence caused by the channel profile.
[53] A type of water-quality sampling that occurs during one short time period to provide a snapshot of conditions (Anderson and Carpenter, 1998).
[54] Percent saturation refers to the amount of dissolved oxygen in water in comparison to the amount the water can potentially hold (higher the percent for a certain temperature and atmospheric pressure the more oxygen dissolved in water).
[55] The solubility refers to the ability of oxygen to dissolve in the water.

ENVIRONMENTAL EFFECTS

pH

Direct Effects: (Lake Creek at the Diamond Lake Outlet)
Under Alternative 1, there would be no change or improvement in the pH of Lake Creek at the outlet. Phytoplankton (algae) blooms would continue on the lake surface in the summer months, driving pH above the water quality standard (>8.5) and conveying this high pH water to the lake outflow and Lake Creek.

Alternatives 2 and 3 would dewater Lake Creek at the outlet during the draw down phase. Flow at the outlet would not return until the lake refills to an elevation that allows surface outflow to connect Lake Creek. This phase of these alternatives would occur during winter when primary productivity is reduced along with water temperature and light. The lower winter primary productivity would result in lower pH (<8.0) for the lake surface water flowing out the canal.

During the pass-through flow phase of the summer months, phytoplankton blooms would likely occur while the lake is drawn down. Therefore, high pH in the lake would be expected, which would be conveyed through the canal to Lake Creek.

The canal closure phase would dewater the canal outlet segment and most of Lake Creek to the confluence with Sheep Creek for 2 months (late summer-early fall period). There would be no flow connectivity between Diamond Lake and Lake Creek to convey water with high pH. However, when flow is again released during refill phase, it would occur during the winter months of low primary productivity and potentially lower pH.

After chemical treatment, the pH of the lake surface water and Lake Creek outlet would probably continue to be high in the summer for approximately three years because of phytoplankton blooms. However, noticeable improvement is expected to occur after this time period with lower planktonic activity resulting in lower pH outflow from the lake surface to Lake Creek.

The connected actions proposed by Diamond Lake Resort under Alternatives 2 and 3 would have no direct, indirect, or cumulative effects on stream pH.

Under Alternative 4, the high planktonic activity and elevated pH would likely continue for about six years similar to the existing condition while annual mechanical fish harvest and predacious fish stocking gradually take effect. After six years, lake improvement would be expected, resulting in a noticeable reduction of phytoplankton and pH in the lake surface water and outflow to Lake Creek. However, this alternative would not completely remove the tui chub and remaining tui chub would continue to prey on lake zooplankton, which would likely allow phytoplankton activity and pH response to continue. This pH response would be conveyed to Lake Creek at the outlet.

Indirect Effects: (Lake Creek and Downstream)
Under Alternative 1, there would be no change or improvement in the pH of Lake Creek and downstream waters.

Under Alternatives 2 and 3, the draw down, canal closure, and refill phases would occur during either the time period (winter) when there is reduced phytoplankton productivity in water bodies and streams or loss of flow connectivity to downstream channel segments. Therefore, pH response in Lake Creek would not be expected during these phases.

After the draw down period, Lake Creek would receive a pass-through flow. Planktonic activity would likely occur in Diamond Lake as is currently happening and discussed under direct effects. The pH from the outlet to the mouth of Lake Creek would continue the existing pattern. At the outlet, pH would be greater than 8.0 (Salinas, 2001) compared to a high range of 7.6 to 7.9 (Anderson and Carpenter, 1998; Eilers, 2001b) at the mouth of Lake Creek. The pH level in Lemolo Lake and further downstream is not necessarily tied to Lake Creek at the outlet, but is more closely associated with local processes and nutrient transport. Therefore, changes in pH in Lake Creek near the outlet would not be expected to result in pH changes in downstream channel segments.

After treatment, the same response described under the direct effects would be expected. In three years, the pH at the outlet and mouth of Lake Creek would be more similar and lower than the existing condition.

Alternative 4 response would be the same as discussed under the direct effect. Downstream responses would be similar to the existing condition until the treatments take effect. As discussed under Alternatives 2 and 3, pH levels would not carry below Lake Creek at the mouth.

Cumulative Effects: (Lake Creek Combined with Other Actions)
There are no other planned or proposed actives that currently or in the foreseeable future would elevate Lake Creek's pH. Under Alternative 1, there would be no change or improvement in the pH of Lake Creek and downstream.

As discussed under indirect effects, the pass-through flow phase for Alternatives 2 and 3 is the treatment phase that would have the greatest influence downstream as high pH lake outflow moves down Lake Creek. However, pH would not increase additively downstream. As described earlier, pH decreases downstream as groundwater exchange and water from tributaries such as Thielsen Creek enter and dilute Lake Creek's pH. The high pH of Lemolo Reservoir is a product of local surface water planktonic activity.

Under Alternative 4, the pH in Lake Creek would operate as described above for Alternatives 2 and 3. No change to Lake Creek pH would be expected until after six years of mechanical fish removal. Because this alternative would not completely remove the tui chub, and remaining chub would continue prey on lake zooplankton, some increased level of phytoplankton activity and pH response would be expected to occur in the future (i.e. high pH's would likely recur.)

Conclusions:
Lake Creek's pH in the upper reaches is influenced by the planktonic activity in Diamond Lake. The outflow from the lake surface water into Lake Creek is at a high pH level in the summer (>8.0). This effect decreases downstream as streamflow aerates water and groundwater exchange and tributary inflow dilutes the water and results in a lower stream pH.

Alternative 1 would not change the existing condition, where Lake Creek at the outlet would continue to experience high pH levels in the summer as a result of lake planktonic activity. Alternatives 2, 3, and 4 would reduce the pH in Lake Creek at the outlet, but in different time frames and possibly to different potential levels. Alternatives 2 and 3 would reduce pH in three years by initially eliminating the tui chub and its effect on the zooplankton, which would result in increased grazing on phytoplankton. Alternative 4 would take about six years, but would only reduce the tui chub, which would likely result in less control on the phytoplankton and pH. The overall result would be that pH throughout Lake Creek would be lower and more equal from Diamond Lake to Lemolo Reservoir. Alternative 4 would likely result in a smaller pH improvement with the risk of tui chub population returning in the long-term.

Table 17 provides a summary of important conclusions and a comparison of the alternatives effects on pH.

Table 17. Comparison of Alternatives Effects on pH Delivered from and a By-product of Primary Productivity of Diamond Lake.

Water Body	Alternative 1 - No Action		Alternative 2 - Rotenone with Put, Grow, and Take Fishery		Alternative 3 - Rotenone with Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time period	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**
Lake Creek (near outlet)	pH would remain high and continue to degrade water quality	pH would remain high and continue to degrade water quality	From years 1-3 after treatment, pH expected to remain high and continue to degrade water quality	After 3 years, pH expected to decrease and result in noticeable improve-ment in water quality over time	From years 1-3 after treatment, pH expected to remain high and continue to degrade water quality	After 3 years, pH expected to decrease and result in noticeable improve-ment in water quality over time	From years 1-6 after treatment, pH expected to remain high but show slight improve-ment over time	After 6 years, presence of tui chub expected to reduce level and duration of pH and water quality improve-ment over time
Lake Creek (down-stream)	pH in upper reaches would	pH in upper reaches would remain high	From years 1-3 after treatment, pH in upper	After 3 years, pH in upper reaches expected to	From years 1-3 after treatment, pH in upper	After 3 years, pH in upper reaches expected to	From years 1-6 after treatment, pH in upper	After 6 years, pH in upper reaches

Water Body	Alternative 1 - No Action		Alternative 2 - Rotenone with Put, Grow, and Take Fishery		Alternative 3 - Rotenone with Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time period	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**
	remain high and continue to lower water quality but in down-stream reaches pH would continue to be lower	and continue to lower water quality but in down-stream reaches pH would continue to be lower	reaches expected to remain high and continue to lower water quality but in down-stream reaches pH would continue to be lower	decrease and result in noticeable improve-ment in water quality over time while downstream would remain unchanged	reaches expected to remain high and continue to lower water quality but down-stream reaches pH would continue to be lower	decrease and result in noticeable improve-ment in water quality over time while downstream would remain unchanged	reaches expected to slightly reduce over time while down-stream would remain unchanged	expected to improve but remaining tui chub expected to reduce level and duration of water quality improve-ment over time
Lemolo	pH would remain high and continue to degrade water quality near the surface with nutrient contribu-tion from Diamond Lake and delivered by Lake Creek	pH would remain high and continue to degrade water quality near the surface with nutrient contribution from Diamond Lake and delivered by Lake Creek	From years 1-3 after treatment, pH would remain high and continue to degrade water quality near the surface with nutrient contribu-tion from Diamond Lake and delivered by Lake Creek	After 3 years, pH expected to decrease near the surface with reduced nutrient from Diamond Lake and result in noticeable improve-ment in water quality over time	From years 1-3 after treatment, pH would remain high and continue to degrade water quality near the surface with nutrient contribu-tion from Diamond Lake and delivered by Lake Creek	After 3 years, pH expected to decrease near the surface with reduced nutrient from Diamond Lake and result in noticeable improve-ment in water quality over time	From years 1-6 after treatment, pH near the surface expected to remain high and lower water quality with nutrient contribu-tion from Diamond Lake and delivered by Lake Creek	After 6 years, pH near the surface expected to improve but remaining tui chub expected to reduce level and duration of water quality improve-ment over time
North Umpqua River	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir	Alternative would have no effect on pH below Lemolo Reservoir

Dissolved Oxygen (DO)

Direct Effects: (Lake Creek at the Diamond Lake Outlet)
Alternatives 1 and 4 would not manipulate the flow in such a way that stream aeration would be changed. Therefore, the existing DO level would not be affected. The DO in Lake Creek is primarily influenced by the natural aeration process.

Alternatives 2 and 3 are the only proposed alternatives that would alter stream aeration through flow manipulation. The treatment phases that would change the DO of Lake Creek at the outlet are the draw down and canal closure. Lake Creek at the outlet would be dewatered during both of these phases. DO would not be a measurable parameter at the outlet until the lake refills to an elevation that allows surface outflow into the Lake Creek channel.

The DO for the post-treatment time would likely return to pre-treatment levels as streamflow returns and aerates in the fast segments at the outlet. Natural stream aeration would affect DO more than the treatment in Diamond Lake.

Under Alternatives 2 and 3, connected actions proposed by Diamond Lake Resort would have no impact on stream DO because they would not involve in-water work.

Indirect Effects: (Lake Creek and Downstream)
Alternatives 1 and 4 would not have indirect effects on the DO in Lake Creek, because no stream flow manipulations would occur.

The phase of Alternatives 2 and 3 that would have the greatest influence on downstream Lake Creek DO would be the canal closure. When the canal is closed while stream temperatures are warm and water has lower ability to retain DO, there would be little to no flow for about 5.5 stream miles to the Sheep Creek confluence. The very limited flow from Sheep Creek would potentially have lower DO concentrations. The cool water of Thielsen Creek and the natural aeration would allow high and continuous concentrations of DO in Lake Creek below this confluence to Lemolo Reservoir. Lake Creek would not influence the DO of Lemolo Reservoir. Where there would be little to no flow in Lake Creek, any pooled water would likely warm during the summer and cause local DO levels to drop. This would be a local effect. However, this situation would occur in most pools from the outlet to the Thielsen Creek confluence.

Cumulative Effects: (Lake Creek Combined with Other Actions)
There would not be a cumulative effect for DO under any of the alternatives. Stream re-aeration would quickly restore any DO reduction in short stream distances of fast water.

Conclusions:
Alternatives 1 and 4 would maintain the existing condition.

The DO of Lake Creek is most influenced by the ability of the stream to aerate, but warm stream temperatures are also a factor. During the summer when streams warm, a pass-through flow would be maintained and Lake Creek would continue to naturally aerate through the fast water segments throughout the stream length. The canal closure phase would dewater about 5.5 stream miles and forgo aeration and DO processes. DO would not be degraded by Alternatives 2 and 3 in the long-term.

Aquatic Conservation Strategy – Water Quality

Aquatic Conservation Strategy (ACS) objective 4[56] addresses water quality. Alternative 1 would not address the existing deteriorated water quality condition for pH, algae, and algal

[56] ACS objective 4: "Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity

toxins in Diamond Lake. This alternative would retard the attainment of meeting objective 4 for both the short- and long-term in Lake Creek at the outlet and would continue to influence the downstream condition in Lemolo Reservoir.

Under Alternatives 2 and 3, the water quality of Lake Creek at the outlet would have short-term impacts after implementation for about three years. Following this period of time, nutrient, pH and toxin improvements would be expected, which would lead to improved water quality in the long-term and the attainment of objective 4.

Alternative 4 would also contribute toward attainment of objective 4; however, progress toward meeting this objective would be extended during the six-year treatment period. Water quality of Lake Creek at the outlet would continue to reflect the lake condition during this time. After the six-year treatment, tui chub would not be completely removed, which would likely allow a reduced level of nutrient cycling, pH and toxin response to continue. Although there would be an expected trend toward water quality improvement, the presence of tui chub would create less certainty for long-term effectiveness.

CHANNEL MORPHOLOGY AND FLUVIAL EROSION

AFFECTED ENVIRONMENT

Inventories of Lake Creek have revealed that, for the most part, channel stability is moderate to high, with some evidence of significant slope failure or mass wasting but with minimal amounts of excessive stream bank erosion or deposition of fine sediment.

Channel adjustment from heavy grazing by sheep in the watershed during the late 1800's and early 1900's may still be occurring to riparian areas (soil compaction) and stream channels (width/depth ratio). Significant adjustment in channel morphology following elimination of grazing disturbance has occurred over decades. Additionally, Diamond Lake was drawn down via Lake Creek in 1954 when about 20,000 acre-feet of water or 29% of the volume of Diamond Lake flowed down Lake Creek from July 15 through September 21, a period of 69 days in 1954 (U.S. Geological Survey, 1963).

Stream flows in Lake Creek during the time of the 1954 draw down were greater than a 100-year flood event (Wellman, 1993). Yet, observations of Lake Creek by the Diamond/Lemolo Lake Watershed Analysis hydrologist and geologist and results from fisheries surveys indicate that the draw down flow in 1954 did not appear to cause significant slope failures or channel adjustment (Diamond Lake and Lemolo Lake Watershed Analysis, 1998). Lake Creek has relatively gentle stream gradients and enough large in-stream wood to help maintain the stability of its bank (Table 18).

Table 18. Lake Creek stream channel characteristics by reach.

of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities."

Stream Channel Reach	**Survey Length** (miles)	**Channel Gradient** (%)	**Large Woody Debris** (per mile)
1*	1.79	2	24
2	1.25	2	21
3	0.35	1	23
4	2.72	2	40
5	2.31	1	62
6	0.63	4	147
7	1.25	3	59
8	1.29	2	33

*Reach 1 begins at the mouth of Lake Creek (where it flows into Lemolo), and reach 8 is the upper-most reach of Lake Creek ending at the outlet of Diamond Lake.

Additionally, Lake Creek appears to be inherently stable due to the nature of the streamflow regime, which is characterized by peak flows that generally are not high energy, but rise and fall gradually in response to both snowmelt and rainfall events.

Since the massive eruption of Mt. Mazama some 7,500 years ago, Lake Creek has carved through a 40-meter thick layer of highly erodible Mazama ash-flow, exposing the underlying glacial deposits that have been, in places, reworked by stream processes. Between Elbow Butte and Highway 138, Lake Creek is characterized as a broad alluvial valley floor bounded by a series of stepped-terraces. From Highway 138 to Lemolo Lake, Lake Creek meanders through a wide alluvial valley floor that is punctuated with extensive meadows. Floodplains are generally wider and channel banks are less confined between Lemolo Lake and Highway 138. Between Highway 138 and Diamond Lake, floodplains are generally narrow and channel banks become more restrictive.

A 1.25-mile long segment of Lake Creek beginning at a point roughly one mile below the Lake Creek outlet is highly entrenched and is characterized by a narrow floodplain, confining valley walls, and steeper channel gradient making it distinctive from all the other reaches of Lake Creek. Here, the inner gorge section has been slowly down cutting through a broad ridge formed of highly resistant lavas. This ridge has helped influence geomorphic development of Lake Creek. Furthermore, erosion of the glacial deposits over geologic time has left large boulders that provide armoring of channel banks.

Lake Creek is currently eroding the toe of the mid-level terrace at three closely spaced sites situated about one-half mile north of the Pit Lake No. 2. Two of the three sites are landslides, the third site is developing into a mass wasting feature. All three sites occur along outcurve reaches. Fine sediment (sand) is being delivered into Lake Creek during low base level flow conditions at both landslide sites.

A total of eight streamside slope failures (landslides) were identified from examination of the 1997 aerial photos that span the length of Lake Creek. Neither the 1946 or 1957 aerial photos provide coverage of Lake Creek, so a before/after photo assessment of the 1954 draw down on the erosion processes in Lake Creek could not be established.

Three of the eight identified landslide features can be expected to deliver some sediment into the channel during bankfull stage flow. The volume of deliverable sediment attributed to further activity of these landslides cannot be quantified.

There are four locations where roads cross Lake Creek within the project boundary. Starting at Diamond Lake, there is a double-culvert crossing of Forest road 4795-000 at the outlet. Roads 4700-710 and 4700-000 (Highway 138) also have double culverts downstream of the outlet about 6.6 and 6.7 miles respectively. The last crossing is a pipe-arch at road 2614-000 near the mouth of Lake Creek at Lemolo Reservoir.

Double culverts serve as the stream crossings both at Road 4700-710 and at Highway 138. In both cases, these crossings are undersized. The crossing of Road 4700-710 exhibits an over-steepened fill slope, fill sloughing, and undercutting of the toe of the fill between the double culverts. This crossing likely experiences annual fill erosion, which indicates a risk of failure. The crossing of Highway 138 has better fill integrity and likely less risk of fill failure.

The fourth crossing is on Road 2614-000 just upstream of Lemolo Reservoir. This crossing is a pipe-arch with a span that is about 50% of bankfull width. This crossing is less likely to impede the flow and is closer to natural channel width allowing natural flows.

ENVIRONMENTAL EFFECTS

Direct Effects:
Alternatives 1 and 4 would not affect channel morphology since streamflow is not altered; therefore no effects would occur.

No effect to stream erosion processes is expected at road crossings 4795-000 because this stream crossing would not experience the prolonged draw down flow as the canal would carry most of the flow, relieving this crossing of any potential erosion or risk of failure. There would also be no effect to erosion processes associated with the 2614-000 stream crossing because this crossing is adequately sized to pass the draw down flows.

On the other hand, flow restriction at the under-sized 4700-710 and 4700-000 crossings would occur for the duration of the draw down period. Under bankfull flow, it is likely that fluvial erosion of the fill and floatable wood could block the inlet at the road 4700-710 crossing. Road 4700-000 crossing would have less concern for fill erosion, but floatable blockage of this crossing is possible at this public highway stream crossing. These potential effects would be reduced through monitoring of the crossings especially when additional flow above bankfull would occur during winter storms and spring runoff. Equipment capable of removing mobile wood that would lodge at the culvert inlets would be available. These mitigation measures would reduce the risk of culvert failure.

Under Alternatives 2 and 3, the direct effects associated with sustained bankfull flows in Lake Creek during the draw down period is likely to result in the delivery of relatively small volumes of fine-textured sediment into Lake Creek due to bank undercutting. Much of the fine sediment would come from three existing landslide sites. Bankfull stage flow is not anticipated to undercut the banks of the other five in-stream bank failures (landslides) or trigger new slope mass-movements in localities where the stream channel presently impinges on adjacent steep valley walls. The small volume of sediment predicted to be delivered into Lake Creek during sustained bankfull stage flow is not considered to be of sufficient volume to cause widespread adjustments to stream channel shape, form, and function.

Bankfull stage flows within Lake Creek lack the energy to transport large amounts of woody debris significant distances. Woody debris is more likely to be transported short distances and reorganized into numerous debris dams. Smaller size woody debris may possibly become mobilized and accumulate in existing debris dams or at other points of constriction along Lake Creek such as culvert inlets.

The 1996 stream survey of Lake Creek revealed that large instream wood (Table 18) is currently within an expected range of natural variability in high-gradient reaches 6 through 8 that would otherwise be prone to channel scour and woody material transport. The 1998 Diamond Lake/Lemolo Lake watershed analysis did not document compelling evidence of widespread slope failures (landslides) or channel adjustments within Lake Creek in the aftermath of the 1954 draw down of Diamond Lake. Anecdotal comments indicated that Lake Creek appeared to be functioning properly with respect to flow and sediment transport, and that the stream channel did not display adverse impacts following the 1954 draw down event (U.S. Forest Service, 1998).

Since the substantially greater 1954 draw down flow did not change the channel location, the bankfull flow proposed in Alternatives 2 and 3 would not be expected to either. Persistent stream energy would have the potential to sort finer substrate and improve pool depth where large wood directs flows to scour. This process appears to be absent per the Diamond Lake/Lemolo Lake Watershed Analysis (1998) and would be a benefit, but would not last indefinitely.

Indirect Effects:
Under Alternatives 2 and 3, no indirect effects are expected to occur downstream of Lake Creek in Lemolo Lake or in the North Umpqua River. This is because the amount of fluvial erosion in Lake Creek is expected to be limited in extent and duration such that the delivery of sediment or silt into Lemolo Lake would be also very limited. Likewise, delivery of sediments into the North Umpqua River below Lemolo Lake is not expected. This is because any suspended sediment that may enter Lemolo as a result of fluvial erosion in Lake Creek during the draw down would settle out in the reservoir and not be available in the water column to flow into the North Umpqua River.

No indirect effects to areas downstream of Lake Creek would occur under either Alternatives 1 or 4 because no draw down is proposed that could cause any fluvial erosion.

Cumulative Effects:
Past management activities that had potential to influence the sediment regime and stream channel morphology of Lake Creek generally correspond to a period of road construction and

logging activities that took place within the Lake Creek watershed beginning in the early 1950's. Road density within the Lake Creek watershed is 1.13 miles per square mile; however, most of the roads are concentrated along a narrow corridor that extends between Diamond Lake and Lemolo Lake.

Some 949 acres of regeneration timber harvest has taken place within the Lake Creek watershed, with most of the harvest being concentrated along a narrow corridor that extends between Diamond Lake and Lemolo Lake. Only four percent of the total area of the Lake Creek watershed has been impacted by timber harvest. Little sediment flux attributable to logging activities or roading within the Lake Creek watershed is thought to have entered Lake Creek due to the gently sloping to flat topography, very low drainage density, and highly porous and permeable soils. The limited amount of timber harvest that has taken place within areas close to Lake Creek (including past riparian harvest) is considered to have had a negligible effect on the volume and timing of peak flows within Lake Creek due to lack of a well developed drainage network. Lake Creek does contain substantial amounts of large woody material that functions effectively to dissipate stream flow energy and turbulence, store sediment bed load, and maintain channel complexity.

Other past management activities in the Lake Creek watershed that contribute to cumulative effects include the 69-day draw down period of Diamond Lake in 1954. That draw down event was comparable to a 100-year peak flow flood.

There are three Forest designated rock pits situated in close proximity to Lake Creek, and include Pit Lake No. 1 (#3112010), Pit Lake No. 2 (#311202), and Sheep Creek (#321301). Both Pit Lake No. 1 and 2 are currently filled with water from groundwater recharge and their water levels are said to fluctuate from 5 to 25 feet below the level of Lake Creek (Jones 1990). At present there is no surface connectivity between Lake Creek and either of the Pit Lake sources. A concern exists in that natural channel movements and migration of Lake Creek have been slowly encroaching towards the earthen berm that forms the eastern limit of Pit Lake No. 1. Sustained bank full flow conditions may possibly breach the dike and flow into Pit Lake No. 1. However, any sediment delivered from this source would be minor.

Reasonably foreseeable natural disturbance patterns may cause impacts to Lake Creek, such as rain-on-snow storms that could trigger flood events. Stream flows at flood stage have the potential for triggering streamside slope failures and causing channel adjustments. However, these events are not predictable and when they occur, are expected to be within the range of natural variability. Moreover, one of the reasons Lake Creek has been so stable is the low stream energy that is characteristic of the high Cascades; peak flows typically rise and fall gradually in response to both snowmelt and rainfall events.

Overall, when combining the minimal effects from past, present, and reasonably foreseeable activities, and the lack of significant direct and indirect effects to Lake Creek, no cumulative effects are anticipated to occur.

Conclusions:
Only under Alternatives 2 and 3 would there be any potential affect on channel morphology. Since the higher flows from the 1954 lake draw down did not appear to impact the channel

integrity, the lower proposed flows for Alternatives 2 and 3 also would not be expected to impact Lake Creek or the area downstream. Lemolo Reservoir would absorb and transfer the additional flow downstream within the existing streamflow regime.

Road crossings 4700-000 and 4700-710 would have some risk of plugging because of small size culverts and potential floatable wood. Road crossing 4700-710 also would have the risk of fill failure with the prolonged bankfull flow. Both of these potential conditions would be addressed through project monitoring and mitigation included in these alternatives and described in Chapter 2.

Aquatic Conservation Strategy:

Under Alternatives 1 and 4, Lake Creek and downstream areas would not experience short-or long-term effects that would alter physical channel integrity or sediment regime. These two alternatives would meet the Aquatic Conservation Strategy (ACS) objectives 3[57] and 5[58].

Alternatives 2 and 3 would have a short-term affect on the channel. Short-term accelerated bank erosion along Lake Creek would likely occur at three distinct locations during the draw down phase. However, the amount of erosion would be limited in amount and duration. Within a few years following draw down, the bank erosion rate would return to the pre-draw down rate. Therefore, the long-term physical channel integrity and sediment regime would be maintained and ACS objective 3 and 5 would be met. Table 19 provides a summary of important conclusions and a comparison of the alternatives effects on stream morphology.

[57] ACS objective 3: "Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations."
[58] ACS objective 5: "Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport."

Table 19. Comparison of Alternatives Effects on Stream Channel Morphology

Water Body	Alternative 1 - No Action		Alternative 2 - Rotenone with Put, Grow, and Take Fishery		Alternative 3 - Rotenone with Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time period	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Lake Creek (near outlet)	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because most of draw down bypasses the outlet	No effect on channel morphology because most of draw down bypasses the outlet	No effect on channel morphology because most of draw down bypasses the outlet	No effect on channel morphology because most of draw down bypasses the outlet	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed
Lake Creek (down-stream)	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed	During the draw down phase, bank erosion at specific identified sites would likely occur with continuous bankfull flow or higher	After draw down, no effect on channel morphology because streamflow is not changed	During the draw down phase, bank erosion at specific identified sites would like occur with continuous bankfull flow or higher	After draw down, no effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed
North Umpqua River	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed	During the draw down phase, higher flow would only occur in the upper reach but no effect on channel morphology would be expected	After draw down, no effect on channel morphology because streamflow is not changed	During the draw down phase, higher flow would only occur in the upper reach but no effect on channel morphology would be expected	After draw down, no effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed	No effect on channel morphology because streamflow is not changed

AQUATIC BIOLOGY

PHYTOPLANKTON AND PRIMARY PRODUCTION

Phytoplankton and primary production are most relevant to the issue of water quality. Scoping identified a concern that both rotenone and fish restocking could affect water quality through effects on Diamond Lake's food chain, or the fish-zooplankton-phytoplankton relationship. Scoping also identified a concern about the immediate and long-term effects of a rotenone treatment on water quality in Diamond Lake. These aspects of the water quality issue, as they relate to phytoplankton and primary production, are tracked under environmental effects in this section.

AFFECTED ENVIRONMENT

PHYTOPLANKTON

Phytoplankton are floating plants, usually microscopic, comprised primarily of algae that live suspended in the water. The composition and abundance of the phytoplankton population of Diamond Lake varies seasonally. A shift in the phytoplankton population can be influenced by a variety of physical and biological factors. Increased abundance generally occurs during periods of rapid growth (algae blooms) during which different algal types can dominate. There are five phytoplankton groups typically found in Diamond Lake: (1) Bacillariophyta (diatoms); (2) Cyanobacteria (blue-green algae); (3) Cryptophtya (cryptomonads); (4) Chlorophyta (green algae); and, (5) Chrysophyta (golden-brown algae) along with low densities of other types of algae.

The phytoplankton abundance in Diamond Lake is at a minimum during the winter when light conditions and temperatures are low. During the fall and winter, the phytoplankton population is generally dominated by diatoms, cryptomonads, and golden-brown algae (Lauer et al. 1979, Aquatic Analysts 1990). As the days lengthen and temperatures warm in the spring, the growth of the phytoplankton population increases and diatom blooms typically develop shortly after the lake ice cover melts. After the initial growth period dominated by diatoms, other types of algae become more common including green algae, golden-brown algae and other types of diatoms. By mid to late-summer, the phytoplankton species composition shifts to a population dominated by blue-green algae (Figures 24 and 25). Historic and recent data from Diamond Lake indicates that during the summer the phytoplankton population is frequently dominated by blue-green algae from the genus *Anabaena*.

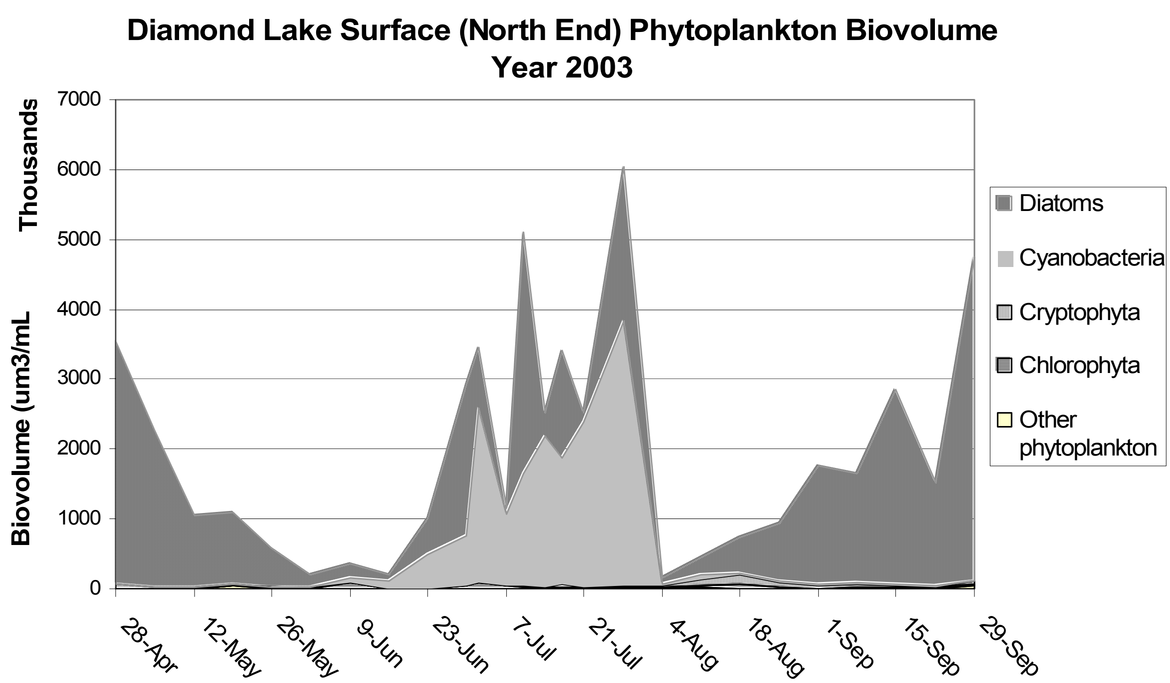

Figure 24. Phytoplankton biovolume during 2003.

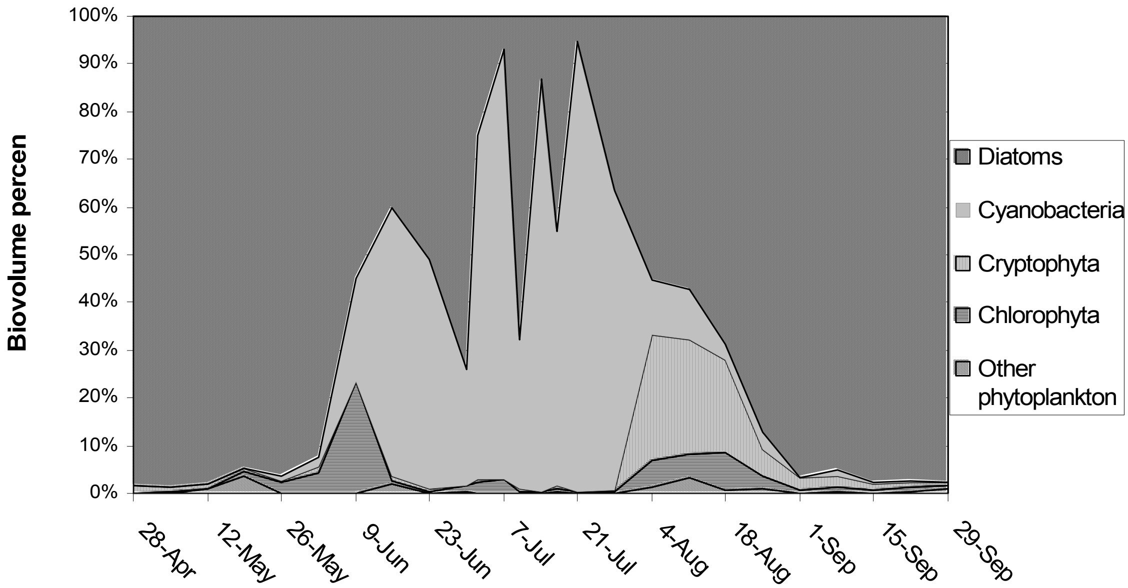

Figure 25. Phytoplankton percent composition during 2003.

Several studies have documented changes over time in the phytoplankton community composition in Diamond Lake[59]. Lauer et al. (1979) reported *Anabaena circinalis* to be the dominant blue-green alga (cyanobacterium). The earliest date that *Anabaena circinalis* dominated the phytoplankton community was June 18, 1973. It was reported to have typically reached high numbers by July or August of each year during the study and frequently was the most numerous type of phytoplankton during September and October. Sanville and Powers (1971) reported 15,000 *Anabaena* cells/mL from a surface sample collected on September 27, 1971.

Based on analysis of sediment cores from Diamond Lake, Eilers et al. (2001b) reported that a shift in the planktonic diatom community of Diamond Lake occurred with the species *Fragilaria crotonensis* becoming much more abundant after approximately 1920 and remaining abundant through the 1950s, indicating more productive conditions in the lake. Although Eilers et al. (2001b) were not able to precisely date changes in the phytoplankton composition

[59]Lauer et al. (1979) recorded high numbers of the diatom *Asterionella formosa* during the spring of each year from 1971 through 1977. Green algae (chlorophytes) were reported to dominate the phytoplankton on only a few occasions. Lauer et al. (1979) observed that the golden-brown algae *Chromulina* sp. appeared to be a much larger part of the phytoplankton community after 1973, although this observation could have been due to a change in counting techniques. This species was the dominant alga in approximately one-half of the samples from 1973 through 1977 and was dominant in all of the 1977 samples, excluding one sample on August 18, 1977 when it was second to *Anabaena*. Salinas and Larson (1995) reported 55 phytoplankton taxa collected during 1992 through 1994. Similar to the results reported by Lauer et al. (1979), Salinas and Larson observed *Chromulina* sp. to be the most dominant taxon. Eilers (2003) reported that since 1999, golden-brown algae (chrysophytes) are the most numerically abundant phytoplankton group in Diamond Lake. Due to their small size, they were found to comprise a small portion of the phytoplankton biovolume however in recent years this group was reported to have become an important part of the phytoplankton assemblage particularly in the spring and fall.

of the lake, these investigators found the diatom *Asterionella formosa* became somewhat more abundant near the year 1980 and that increase in the abundance of both *F. crotonensis* and *A. formosa* indicates a shift to more productive conditions in the lake. Sediment core analysis also indicated a 15-fold increase in the planktonic blue-green algae population during the 20th century (Eilers et al. 2001a). One type of filamentous blue-green algae, *Gloeotrichea*, was reported to have shown two major population increases first appearing in large numbers around 1920, following the introduction of trout in 1910 and another large increase near the time of the first rotenone treatment of Diamond Lake in 1954. The blue-green algae species *Anabaena flos-aquae* and *Anabaena circinalis* were found at low densities prior to the introduction of fish in Diamond Lake. However, their abundance increased greatly around 1954 followed by a decrease to relatively low levels during the 1960s and 1970s with another large increase observed beginning in the 1990s. Peak concentrations of *Anabaena flos-aquae* found in samples during the summers of 2001 and 2002 were estimated to be approximately 1 million cells/mL. During the summer of 2003, the peak measured concentration of 255,567 cells/mL occurred on July 28. The high concentrations of *Anabaena* that have been recorded under bloom conditions in recent years correspond to periods of high tui chub abundance. In addition, during the summer of 2003, Jim Sweet (Aquatic Analysts, unpublished data) noted the rare occurrence of the blue-green alga *Microcystis aeruginosa* in six samples. This species of algae was at much lower concentrations than *Anabaena,* however.

Evidence from the remains of the phytoplankton assemblage in the sediments was consistent with other data indicating a decline in the water quality of Diamond Lake particularly over the last several decades (Eilers et al. 2001a). This decline is consistent with the idea that fish stocking and high populations of tui chub have contributed to this changed condition.

Blue-green algae frequently dominate the phytoplankton of productive lakes during the summer season. Environmental factors that contribute to the dominance of blue-green include: (1) a stable water column; (2) warm water temperatures; (3) high nutrient concentrations near the surface (particularly phosphorus); (4) high pH; (5) relatively low concentrations of carbon dioxide; and, (6) low grazing pressure from large zooplankton (Zurawell 2000-01). Many kinds of blue-green algae (including *Anabaena*) withstand periods of adverse environmental conditions by the production of a resting stage (akinetes) or as vegetative cells that remain in the sediment until conditions are favorable for growth. Studies have shown that the rapid increase in the blue-green algae population of a lake can result, in part, from recruitment of blue-green algae from the sediments (Head et al. 1999).

All phytoplankton require nitrogen in relatively high amounts for optimal growth. Some blue-green algae however, have an advantage over other kinds of phytoplankton under conditions of high phosphorus and low nitrogen. Before nitrogen can be used in the synthesis of biological molecules it must be in the "fixed" (combined) form of ammonia or nitrate. Unlike other kinds of phytoplankton, many species of blue-green algae, including *Anabeana*, have the ability to fix nitrogen gas dissolved in the water. When the total nitrogen to total phosphorus ratio falls below approximately 14 to 1 by weight, the low availability of nitrogen generally favors the growth of nitrogen fixing blue-green algae over other kinds of phytoplankton (Smith and Bennett 1999).

During the summer when phytoplankton abundance is high, densities are typically greatest near the surface where sufficient sunlight for photosynthesis is available and water temperatures are warm. Some species of blue-green algae can gain a competitive advantage over other types of phytoplankton by their ability to regulate buoyancy through the production of intracellular gas vesicles. These gas vesicles allow the cells or colonies to migrate vertically through the water column and occupy a position with optimal light and nutrient concentrations. If calm wind conditions develop over a short period of time however, excess gas vesicles can cause the cells or colonies to rise to the surface where dense surface accumulations can develop. Once on the surface, exposure to high intensity light and possibly depletion of inorganic carbon can inhibit photosynthesis in the blue-green algae cells and interfere with their ability to regulate their buoyancy. Winds can blow surface accumulations toward shore where dense surface scums can develop. Due to their buoyant nature, blue-green algae concentrations in the water can change rapidly over a brief period of time. The rapid death and decay of blue-green algae blooms under conditions of high surface concentrations can lead to the release of ammonia and depletion of dissolved oxygen in the water. Although these factors can be severe enough to result in fish kills, there are no known reports of this occurring in Diamond Lake.

Blooms of blue-green algae are frequently associated with a development of undesirable conditions. In addition to imparting an unpleasant taste and odor to water, many kinds of blue-green algae are known to produce potent nerve or liver toxins and blooms have caused illness and death in wildlife and livestock in many regions of the world. In addition, blue-green algae toxins have been found to cause adverse health effects for humans (Falconer 1996). Studies have also shown that toxins from blue-green algae have the potential for adverse effects on macrophytes, zooplankton and other aquatic species (Christoffersen 1996). These toxins have also been shown to suppress the growth of other types of algae possibly giving the blue-green algae a competitive advantage.

The blue-green algae *Anabaena flos-aquae*, *Anabaena circinalis* and *Microcystis aeruginosa* are known to be potentially toxin-producing species. Analysis results from samples taken from Diamond Lake during periods of high *Anabaena flos-aquae* abundance have been found to contain the neurotoxin anatoxin-a. Human health guidance from Yoo et al. (1995) and Chorus and Bartram (1999) indicate that lake users should avoid water contact at blue-green algae densities above 15,000 cells/mL. The buoyant characteristic of *Anabaena* cells can lead to the formation of high densities on the lake surface or along shorelines where during bloom conditions concentrations can increase greater than 1,000 fold (Chorus and Bartram 1999). As mentioned previously, samples taken in Diamond Lake during blooms of *Anabaena* exceeded this concentration at times during the summer seasons during the 1970s. However during the recent summers of 2001, 2002, and 2003, *Anabaena* cell densities have been dramatically higher, greatly exceeding the threshold of 15,000 cells/mL. Due to the risk to public health, the Umpqua National Forest in cooperation with the Oregon Health Division and Douglas County Health Department restricted water contact activities in Diamond Lake during periods of high Anabaena abundance in each of these summers.

Studies have shown that the presence of fish that feed on zooplankton have a major influence on phytoplankton biomass and phytoplankton community structure (Lynch and Shapiro 1981). Shapiro et al. (1975) introduced the concept of "biomanipulation" as a management tool referring to manipulations of predator/prey relationships at the top trophic levels[60] to influence aspects of a lake's productivity including reducing undesirable algae blooms. Biomanipulation is based on the idea that when the number of fish feeding on herbivore zooplankton are reduced, the abundance of large zooplankton species increases, resulting in an increase in the effectiveness of grazing on phytoplankton. This can reduce the density of phytoplankton and lead to improved water quality. Also, manipulations resulting in an increase in the number of fish that prey on fish that consume zooplankton can decrease predation on large zooplankton and result in an increase in the effectiveness of grazing on phytoplankton. Carpenter et al. (1985) used the term "trophic cascade" to describe trophic level interactions including fish or invertebrate predation that can lead to changes in the structure of zooplankton communities and alter the effectiveness of zooplankton grazing on phytoplankton. Based on numerous investigations, Wetzel (2001) concluded that the concept of cascading trophic interactions frequently fail in natural systems due to multiple compensatory mechanisms[61] that occur rapidly after predator alterations. When aquatic ecosystems are altered, productivity is displaced and is not largely reduced or lost. However, an important management consideration is that the shifts in productivity can potentially be manipulated to a more desirable type viewed as beneficial for human uses of water (Wetzel).

Drenner and Hambright (1999) reviewed the results from 41 biomanipulation experiments from 39 different lakes to determine if biomanipulation succeeded in improving water quality parameters including increased clarity, reduced phytoplankton biomass, and lower blue-green algae density. However, due to the small number of biomanipulation techniques evaluated and the variation in the fish and plankton communities of different lakes, these investigators were not able to identify the best biomanipulation approach for a particular lake. Predacious fish stocking as a biomanipulation approach was reported to have the lowest success and partial fish removal was the most successful. Although they found differences in the results depending on different strategies, overall they found 61 percent of all biomanipulation approaches were consistently successful and that water quality was most likely to be improved and maintained where manipulations increased the abundance of *Daphnia* (a type of large bodied filter feeding zooplankton) and macrophytes.

Meronek et al. (1996) reviewed the results of 250 fish control projects contained in 131 papers. These researchers concluded that total elimination of the targeted fish species was more successful than partial reduction of the targeted species in the majority of the projects. Combined chemical and physical methods were reported to be successful in 66 percent of the projects evaluated. Stocking after combined chemical and physical control methods may have resulted in additional benefits to improve the rate of success for some projects. Meronek et al. found that the success rate for projects that used only physical control methods (e.g. nets, traps, electro-fishing, or a combination of physical treatments) ranged from 33 to 57 percent. Stocking a type of fish to control the population of another fish species was found to be the least successful.

[60] Trophic levels refer to parts of a food chain. For example, fish (predators) represent a high trophic level on the Diamond Lake aquatic food chain and zooplankton (prey) represent a lower level on the food chain.
[61] An example of a compensatory mechanism is if half of the tui chub population in the lake is removed the remaining tui chub "compensate" for this population decline by increasing egg production.

Studies have shown the important role of zooplankton in the regulation of phytoplankton biomass while at the same time encouraging its growth through phosphorus recycling (Villar-Argaiz et al. 2001). Sanni and Wærvågen (1990) reported significant increases in water quality and reduced summer blue-green algae abundance following a rotenone treatment of a eutrophic lake in Norway. Lower nutrient concentrations and increased transparency were reported the first summer after the rotenone treatment and preliminary results from the second summer indicated further improvements. These investigators reported a 30 percent decrease in total phosphate concentrations the first summer after treatment compared to the mean of the preceding eight years without reductions in external loading. Sanni and Wærvågen concluded important factors in the decline of blue-green algae abundance in the summer was not only increased grazing by *Daphnia,* but also an increase in the rate of phosphate cycling benefiting phytoplankton species better able to utilize the nutrient supply from zooplankton excretion.

Despite a large number of studies investigating the suitability of filamentous blue-green algae (e.g. *Anabaena*) as a food source for zooplankton herbivores, the results of these studies remain largely inconclusive. Different studies have produced contradictory results even when the same blue-green algae species were considered (Gliwicz 1990). Even though blue-green algae have often been considered an unsuitable food for zooplankton grazers, in productive lakes where fish that fed on zooplankton (planktivores) died or were removed, it has been observed in many cases that the absence of these fish results in an increase in the size and number of filter feeding zooplankton and this increase is associated with a decline in blue-green algae density (de Bernardi and Giussani 1990).

The blue-green algae-zooplankton interactions in lakes are likely the result of a combination of factors including: the concentration, edibility, toxicity, and nutritional value of the blue-green algae along with the degree the blue-green algae mechanically interfere with filtering and the availability and nutritional value of other food sources (Gilbert and Durand 1990). In their review of numerous studies concerning the suitability of blue-green algae as a food source for zooplankton, de Bernardi and Giussani (1990) concluded that even when blue-green algae alone are not an adequate food source for zooplankton they can be an important complementary source of nutrition and when combined with other environmental factors zooplankton grazing can affect blue-green algae density. Based on a number of short-term grazing trials, Epp (1996) concluded that zooplankton grazing by the large bodied cladoceran *Daphnia* promoted or maintained blue-green algae dominance while decreasing the absolute abundance of blue-green algae and phytoplankton as a whole. Based on these results and a review of other studies, Epp concluded that filamentous blue-green algae should not be assumed to be resistant to zooplankton grazing until it has been evaluated for a particular lake. In Diamond Lake large populations of *Anabaena* over the past decade have coincided with a period of high tui chub abundance suggesting that increased predation of large zooplankton by tui chub has contributed to the severity of blue-green algae blooms in Diamond Lake.

PRIMARY PRODUCTION

Primary production is the rate new organic matter (plant material) is formed through photosynthesis. Primary production occurs in the water column by phytoplankton and on the bottom of the lake by attached plants. Estimates of phytoplankton primary production have been obtained for Diamond Lake.[62] No known studies have investigated primary production of macrophytes or other attached photosynthetic organisms.

Phytoplankton primary production in Diamond Lake is typically highest during July and August and corresponds with the peak in phytoplankton abundance as measured by chlorophyll *a*. Peak productivity during this time period occurs near the surface at approximately 6½ feet in depth (2 m). Phytoplankton primary production is lower at other times of the year and is more uniformly distributed through the water column. Figure 26 displays typical profile data showing the variation in productivity.

Although many studies have focused on the availability of nutrients as a regulator of productivity in lakes, the concept of cascading trophic interactions as proposed by Carpenter et al. (1985) has been suggested to account for the differences in primary productivity between lakes with similar nutrient availability but different food webs. Management activities that alter the food web structure may result in changes to the abundance or type of phytoplankton; however, this change is primarily a temporary shift of nutrients to other components of the ecosystem (Wetzel 2001).

Phytoplankton Primary Production - Year 2002

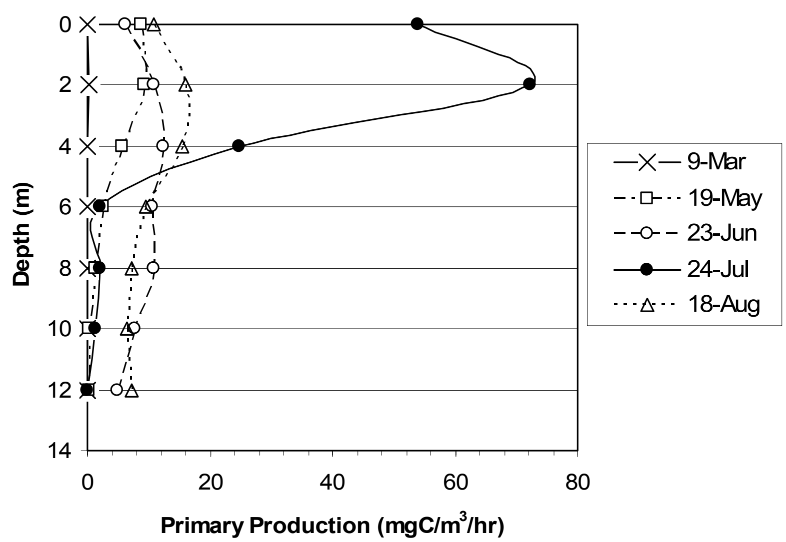

Figure 26. Phytoplankton primary production variation over time and depth (data from Salinas 2002).

ENVIRONMENTAL EFFECTS ON PHYTOPLANKTON AND PRIMARY PRODUCTION

[62] Estimates were obtained by measuring the rate of inorganic carbon assimilation using a carbon-14 radioisotope.

Direct Effects:

Alternatives 1 and 4 would have no direct effects on the phytoplankton of Diamond Lake. Direct effects[63] from a rotenone treatment or other activities proposed under Alternatives 2 and 3 would likely have small to negligible effects on the phytoplankton of the lake. In a review of numerous studies of the direct effects of rotenone on phytoplankton, Bradbury (1986) found that most investigations showed that phytoplankton is not directly affected by rotenone at concentrations of up to 3 parts per million (ppm) of the 5 percent powdered form. Exceptions were one study where the chrysophyte, *Dinobyron,* was absent for a period of two weeks following rotenone treatment in a Montana pond treated with 0.7 ppm Pro-Noxfish®. Additionally, concentrations of 5 percent rotenone above 2 ppm killed all of the chlorophyte *Volvox* and 1 ppm killed the dinoflagellate *Ceratium*. However, none of these algae types comprise a large portion of the phytoplankton community of Diamond Lake.

Under either Alternative 2 or 3, the connected actions proposed by Diamond Lake Resort (described in Chapter 2) would occur only after the affected areas are above the water level of the lake and would have no direct, indirect, or cumulative effects on the phytoplankton or primary productivity of the lake.

Indirect Effects:

Under Alternative 1 no change in the abundance or species composition of the phytoplankton assemblage or primary production would occur. Summer phytoplankton primary production would continue to be high and severe summer blooms of potentially toxic blue-green algae would likely continue. During the summer blooms of toxin producing blue-green algae, adverse effects could occur to wildlife and domestic animals and could also result in adverse effects to other aquatic organisms.

Alternatives 2, and 3 would have indirect effects on phytoplankton potentially a short period of time after mechanical fish removal begins. As the tui chub population is reduced by mechanical removal, it is likely the zooplankton population would increase, including large bodied species. The extent to which predation on zooplankton would be reduced depends on the degree that mechanical removal was successful at reducing the tui chub population. If mechanical removal successfully removes a significant portion of the fish population during the spring and early summer prior to rotenone treatment, the relatively large bodied zooplankton species could rapidly increase in number potentially reducing the phytoplankton density. High rates of zooplankton grazing could reduce the phytoplankton biomass to levels below average values observed over the last decade with a corresponding increase in water clarity and reduced epilimnetic pH values; this represents a positive indirect effect.

Under Alternatives 2 and 3, a short time after rotenone application, there would be a severe reduction or elimination of the zooplankton population in Diamond Lake (see Zooplankton section). As is common following rotenone application, an algae bloom would be expected to occur and the bloom would most likely be dominated by blue-green algae and/or diatoms. The cause of the bloom would be a result of reduced grazing on phytoplankton and the release of nutrients from fish carcasses and possibly sediments. Studies of other lakes have

[63] In this discussion “direct effects” refer to the immediate, short-term effects on phytoplankton that would occur during and immediately following the rotenone treatment.

shown that algae levels typically increase 4 to 6 fold shortly after rotenone treatment compared to levels in years without treatment (Bradbury 1986). The bloom would most likely last for one or two months before subsiding with the onset of winter. The increase in phytoplankton biomass would result in decreased water quality, including a decrease in clarity and elevated pH values during the fall algae bloom.

Generally, zooplankton will return to a lake in large number within 2 to 10 weeks following rotenone treatment (Bradbury 1986). Under alternatives 2 and 3 in the spring following the rotenone treatment, it is likely that a large diatom bloom would occur as would be expected to occur in a normal year[64]. If the recovery of the zooplankton population is delayed, phytoplankton density would likely be greater than normal the following spring. However, it is likely the zooplankton population would rapidly increase in the spring following the spring algae bloom as a response to the abundant food resources and no predation pressure from fish. Since large bodied zooplankton species are most susceptible to predation by fish, the relative number of large bodied zooplankton would be favored under the fishless condition of the lake. The high numbers of zooplankton could significantly graze down the phytoplankton population resulting in a significant reduction in phytoplankton biomass during the summer season. Large-bodied zooplankton are capable of grazing on the relatively large colonies of *Anabaena* and may reduce the density of blue-green algae, along with a reduction in total algal biomass. However, it is possible recovery of the zooplankton population (from the rotenone treatment) could be delayed resulting in water quality improvements occurring gradually over a 3 year period as zooplankton increase.

Differences in fish stocking strategies implemented under Alternatives 2 and 3 could result in different indirect effects to phytoplankton. If the number of fish stocked under Alternative 2 resulted in heavy zooplankton losses due to predation, an increase in phytoplankton density and possibly increased summer blue-green algae blooms would be more likely to occur. Under Alternative 3, zooplankton populations would not be expected to be severely impacted by the stocking of large numbers of the type of domesticated trout proposed for stocking because these fish are not likely to prey significantly on zooplankton and therefore predation pressure on large bodied zooplankton would remain relatively low. Under both alternatives, salmonid stocking would be monitored to ensure that the number of fish stocked would not result in severe predation on the zooplankton population[65]. Therefore, fish stocking under either alternative would not be likely to result in a decline in water quality, however Alternative 3 may have a slightly lower risk of a decline in water quality due to fish stocking.

Because Alternative 4 would be implemented over a six year period, the effects on phytoplankton would occur over an extended time period. Following the initiation of mechanical fish removal, predation pressure on zooplankton would be reduced resulting in increased grazing on phytoplankton over the summer. Similar to Alternatives 2 and 3, the degree to which the zooplankton would be able to reduce phytoplankton densities would depend on the extent mechanical fish removal significantly lowers predation on zooplankton by fish. No toxicants would be used under this alternative and as a result the zooplankton population would not be killed. Consequently, zooplankton grazing pressure on phytoplankton

[64] Diatom blooms in the spring are a natural phenomenon and are expected even when the lake ecosystem is healthy.
[65] An ecologically-based index for guiding fish stocking decisions in Diamond Lake has been developed (Eilers 2003a); components include water chemistry, phytoplankton, zooplankton, and benthos.

would be maintained and expected to gradually increase over several years as the tui chub population is reduced. However, since the tui chub population of the lake would not be eliminated under Alternative 4, compare to the other action alternatives, in the long-term there is a higher risk of the tui chub population increasing in the future to a level where heavy predation on zooplankton would lead to a decline in water quality including reduced clarity, high pH, and increased abundance of blue-green algae.

Alternatives 2 and 3 would lower the lake level beginning with the fall/winter draw down period and the water level would remain low through the following summer, the lowered level along with increased phytoplankton grazing (resulting in a reduction in phytoplankton abundance as an indirect effect of mechanical fish removal) would potentially allow light to be transmitted to portions of the lake bottom that typically would be beyond the range where sufficient light would be available for photosynthesis. Although this could increase the area receiving sufficient light for photosynthesis by macrophytes and bottom dwelling algae, total primary production in the lake would be offset by the potential loss in primary production from the macrophytes in the areas de-watered during the summer draw down. Under Alternative 1, primary production by macrophytes would remain unchanged. Implementation of Alternative 4 would likely result in a slight gain in primary production of macrophytes after a period of approximately 6 years. There would be the possibility that this increase could not be maintained over time because under Alternative 4, there would be a higher probability that the tui chub population would increase significantly over time indirectly leading to an increase in phytoplankton abundance.

Cumulative Effects:
The composition of the phytoplankton population in Diamond Lake to some extent results from the cumulative effects of activities in the watershed that have the potential to be a source of nutrients to the lake. Although past developments within the watershed have likely contributed to nutrient enrichment of the lake to some extent, the majority of the nutrients in the lake originate from natural sources. Ongoing and past projects including fish stocking, installation and operation of the waste water diversion system and erosion control activities, have cumulatively impacted lake conditions and influenced the abundance and species composition of the phytoplankton population. Under Alternative 1, these projects would continue to influence the phytoplankton community composition of the lake resulting in negative cumulative effects on water quality. Any of the action alternatives in combination with ongoing, past projects, and reasonably foreseeable actions have the potential to cumulatively lead to changes in the phytoplankton composition and primary productivity with positive influences on lake water quality. See cumulative effects tables 9-11for a complete list of projects.

Conclusions:
Under Alternative 1, the tui chub population would remain high, resulting in fewer filter feeding zooplankton and a corresponding high rate of phytoplankton production. Summer eplimnetic pH values would remain high and likely above state water quality standards. A high biomass of phytoplankton during summer algae blooms would continue to reduce water clarity and toxin producing blue-green algae blooms would be expected to be more frequent and severe than would occur under any of the action alternatives.

All action alternatives have the potential to affect the abundance and species composition of the phytoplankton population. Implementation of either Alternative 2 or 3 would result in changes to the phytoplankton assemblage in the shortest time period due to the elimination of fish followed by an increase in the zooplankton population. Water quality would be expected to improve within a 3 year time period under these alternatives. The long-term effects on the phytoplankton under Alternatives 2 and 3 would depend on the fish stocking strategy adopted. Monitoring of lake conditions under Alternative 2 would ensure fish stocking levels that do not result in severe predation pressure on zooplankton. The fish stocking strategy proposed under Alternative 3 would likely have small effects on the zooplankton population and therefore phytoplankton densities may have a slightly higher probability of being controlled by zooplankton grazing.

Under Alternative 4, changes to the phytoplankton assemblage would likely occur over time as the tui chub population is reduced and predation on zooplankton is reduced. Water quality would be expected to improve after the 6 year period of mechanical tui chub removal. Since the tui chub population would not be eliminated under this alternative, there would be a higher probability in the long-term that the population could increase in the future resulting in a return to severe blue-green algae blooms and an associated decline in water quality.

Implementation of any of the action alternatives would be consistent with Aquatic Conservation Strategy Objectives and specifically contribute toward meeting Objective 4[66], to maintain and restore water quality. Improvements in water quality would include lower phytoplankton biomass, lower epilimnetic pH values, and increased clarity.

Table 3 in Chapter 2 provides a summary of important conclusions from this section and a comparison of the alternatives effects on water quality.

Aquatic Macrophytes

There were no issues identified in scoping related to aquatic macrophytes. However, information of this subject is provided because of the important for role aquatic macrophytes play in the nutrient cycling and the food chain of Diamond Lake.

[66] ACS Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic riparian communities.

AFFECTED ENVIRONMENT

As is typical of shallow, soft-bottomed lakes, Diamond Lake has a broad zone of aquatic macrophytes, which are primarily vascular aquatic plants[67]. Macrophytes in Diamond Lake are concentrated on the broad, gently sloping bottoms along the south and northwest shore, with fewer populations along the western shore and in the cove by the Lodge (see Figure 27). Most of the eastern shoreline is too rocky and steep to support macrophytes. Light penetration into the lake limits macrophytes to a depth of about 19.7 feet (6 m)(Eilers & Gubala 2003). Total macrophyte cover was estimated at 30-50% of the lake's bottom in a 1979 study (Lauer et al.) which is supported by hydroacoustic[68] sampling in 2002 (Eilers & Gubala 2003). Macrophytes are commonly grouped by their life-forms, which play different ecological roles within the lake. These life forms include: emergent species, floating leaved rooted species, submersed rooted species, and submersed free-floating species.

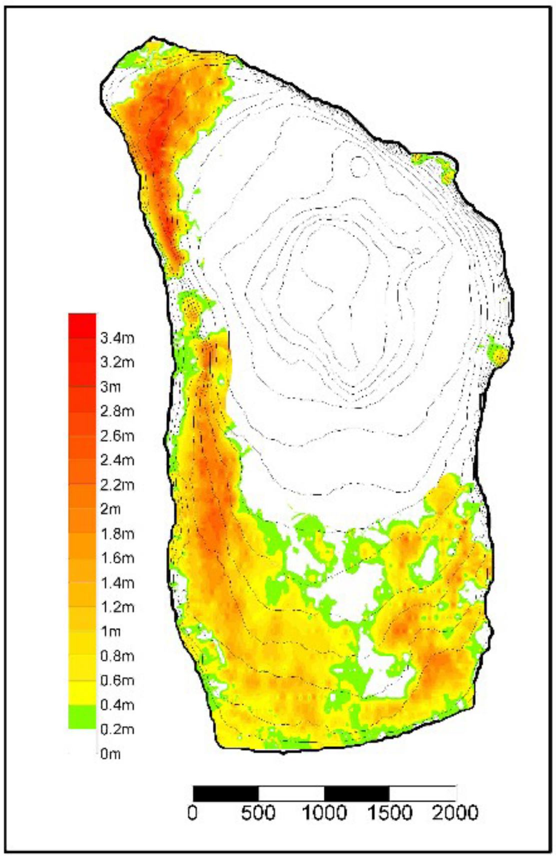

Figure 27. Distribution of aquatic macrophytes in Diamond Lake based upon hydroacoustic sampling in 2002 (Eilers and Gubala 2003).

[67] Vascular plants are plants in which the structure is made up in part of vascular tissue or vessels. They include the flowering plants, cone-bearing plants, and ferns and fern allies. Nonvascular plants include fungi, algae, lichens, mosses, and liverworts. Although the Diamond Lake macrophyte community does include nonvascular plants the majority of the biomass is vascular.

[68] Hydroacoustic sampling utilizes high frequency sound waves to identify bottom features, fish, aquatic vegetation, and zooplankton within water bodies.

Emergent Species: These plants are rooted in shallow water, but have stalks that grow up out of the water. Diamond Lake has a loosely defined community of emergent species in the northwest corner of the lake. There is a large assemblage of the emergent species common cattail (*Typha latifolia*) and hardstem bulrush (*Scirpus acutus*) along the shoreline north of the Thielsen View Campground. Interspersed within this community is yellow pond-lily (*Nuphar lutea* ssp. *polysepala*), which is a rooted plant with floating leaves. The only other emergent species that occurs within the lake itself are several small patches of common spike-rush (*Eleochaeris palustris*) and a single patch of inflated sedge(*Carex vesicaria*). All of the emergent species in the lake are rhizomatous[69], so they tend to occur in dense patches.

One species that was consistently located in shallow water during the macrophyte inventory in 2002 (Helliwell et al. 2003) is what appears to be an aquatic, juvenile form of water bulrush, which should be an emergent species. For some reason, it evidently remains in a juvenile state without ever producing adult leaves or reproductive structures. It is possible that water bulrush (*Scirpus subterminalis*) is a remnant from the former shoreline community at Diamond Lake.

Floating Leaved Rooted Species: The other rooted species with free-floating leaves in the lake is water smartweed (*Polygonum amphibium*). There are scattered plants of this species near the outlet of the lake.

Submersed Rooted Species: Species that are rooted in the bottom of the lake, but have submersed leaves make up the overwhelming bulk of the macrophyte biomass within the lake. The principle submersed rooted species include: white-stalked pondweed (*Potamogeton praelongus*), water-milfoil (*Myriophyllum verticillatum*), and Canadian waterweed (*Elodea canadensis*). Helliwell et al. (2003) found water-milfoil to be the most commonly encountered macrophyte in the lake during an inventory of the shallow depths (<6.5 feet or 2 m) in 2002. However, white-stalked pondweed extends to much greater depths and almost certainly is the most abundant macrophyte in the lake. It is also the tallest with plants in excess of 13 feet (4 m) observed (Helliwell et al. 2003). Canadian waterweed is perhaps the most broadly distributed of the submersed species. It was observed growing at depths less than 3.3 feet (1 m), but is also reported to be associated with white-stalked pondweed between depths of 6.6 - 13.1 feet (2-4 m) (Lauer et al. 1979). Lauer et al. (1979) also reported stonewort, a large, coarse algae with whorled branches, growing at the deepest vegetated areas of the lake at 13.1 – 19.7 feet (4-6 m).

Submersed Free-Floating Species: The only other common macrophytes in Diamond Lake are the submersed free-floating species coontail (*Ceratophyllum demersum*) and quillwort (*Isoetes echinospora*) which is a tiny submersed plant that is rooted in very shallow water. The former species is widely scattered, primarily amongst the water-milfoil, but is never abundant. The later species is a tiny, grass-like plant that is actually more closely related to ferns because it reproduces by spores from sacs at the base of the leaves. See the Aquatic Macrophyte report for a complete species list for Diamond Lake.

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[69] Rhizomatous plants have rhizomes which are horizontally creeping underground stems which bear roots and leaves and usually persist from season to season.

The only non-native macrophyte currently known to occur in Diamond Lake is curly pondweed (*Potamogeton crispus*), which was first reported by Salinas (1998) at the south shore dock. It was also discovered along the western shore during the 2002 inventory (Helliwell et al. 2003). This species is not well-established at present, but has been known to take over some lakes.

The Oregon State Game Commission Annual Report (OSGC 1953) noted that the white-stalked pondweed had all but disappeared in 1952. This coincided with the tui chub proliferation of that time and the pondweed was reported to have recovered by 1955 following lake draw down and rotenone treatment the previous year (OSGC 1956). Although this may simply be the direct result of light limitation from algal blooms, a reduction of this magnitude may involve more complex interactions. It is possible that this condition involved cascading trophic interactions[70] initiated by tui chub introduction and proliferation. The most significant[71] direct impact to the macrophytes may actually have been periphyton[72] increase resulting from reduction in grazing zooplankton (Jones & Sayer 2003, Martin et al. 1992).

McHugh (1972) considered the presence of large beds of aquatic plants in Diamond Lake to be a direct result of eutrophication, which he assumed to be caused by sewage and other man-caused inputs of contaminants. As stated previously the principle source of nutrient inputs is natural although the introduced fisheries, specifically tui chub, have resulted in increased productivity of the lake (Eilers et al. 2001b). The size and morphology of Diamond Lake suggests that even under a mesotrophic[73] nutrient regime there would be a significant macrophyte component to the lake. Macrophyte diversity reaches its peak in moderately productive systems and declines in highly eutrophic systems (Dodson et al. 2000). There is no quantitative means to assess how closely the current macrophyte communities resemble conditions prior to the 1950's. However, anecdotal observations over the last half century indicate significant alteration of macrophyte communities resulting from changes in water quality and the biotic composition of the lake.

Other than white-stemmed pondweed, the only other species recorded as occurring in the lake prior to 1979 are Canada waterweed and water-milfoil. Water-milfoil had previously been reported by McHugh in 1972 and is currently ubiquitous. It seems unlikely that the species could have disappeared completely from the lake only to reappear later, although invertebrate herbivores have been implicated in the decline of the invasive European milfoil (*Myriophyllum spicatum*)(Johnson et al. 1998). Moreover, it is likely that there have been significant shifts in species dominance over time resulting from changes in competition, herbivory, lake productivity, weather, and trophic interactions.

There are no known records available for historic emergent communities in Diamond Lake, but it should be noted that the level of the lake has been maintained at artificially high levels

[70] Cascading trophic interactions refers to effects that work their way through the aquatic foodchain; i.e. increases in tui chub leads to lower numbers of zooplankton which leads to increases in phytoplankton/periphyton which leads to decreases in macrophytes.

[71] It is also possible that direct feeding from crustaceans or mollusks may have contributed to the decline, but this is only rarely a significant cause of macrophyte reductions.

[72] Periphyton refers to algae, protozoa, fungi and bacteria that are attached to macrophytes.

[73] A mesotrophic nutrient regime refers to a "moderate level" of nutrients and biological productivity. A mesotrophic lake is capable of producing and supporting moderate populations of living organisms.

during the summer months by control of the outflow at Lake Creek, since at least the 1950's. It is also maintained at artificially constant levels, since the lake would naturally draw down slightly over the course of the summer. This has resulted in year-round inundation of shoreline areas that may previously have supported emergent rather than aquatic vegetation. Water level management has probably also resulted in unnaturally steep, stable banks that were augmented by planting of reed canary grass (*Phalaris arundinaceae*), a non-native species that was widely planted in riparian areas throughout North America for soil stabilization. It now represents the dominant shoreline species around the lake.

ENVIRONMENTAL EFFECTS

Direct Effects:
Alternatives 2 and 3 would both involve short-term impacts to the macrophyte flora through lake draw down. The draw down itself would expose all macrophytes that are rooted within the top eight feet of the current lake level. This is about a third of the total rooting depth and probably less than a third of the total area covered by macrophytes (see Figure 27). Because the macrophyte flora grows along a depth gradient, most of the species would be affected because more species occur in shallow water than in deep water. Of the rooted species, only white-stem pondweed and Canada waterweed currently appear to have significant biomass below eight feet. Free-floating species, such as coontail, are expected to simply float to the new habitat. Some species, particularly the abundant water-milfoil, would likely adapt to the new water level through colonization by stem fragments, rhizomes, seeds, and winter buds. The rooted submersed species would be beginning to senesce and die back naturally about the time the lake level would be dropped. Therefore, there would be little direct mortality to above ground biomass from desiccation during the draw down itself.

Other rooted species, including yellow pond lily, quillwort, and all of the emergent species would be drained and would have to survive the summer through stored reserves in their roots. There may be mortality to exposed plants due to freezing incurred by beginning the draw down prior to the onset of winter. The severity of the winter may be significant in survival of rooted macrophytes in exposed areas. Application of Rotenone in the 1950's was preceded by a draw down period from mid-July to September, rather than over the winter; therefore, macrophyte recovery at that time may not be a good predictor of present recovery.

The proposed application of rotenone under Alternatives 2 and 3 would have no discernable affect on the macrophyte flora because rotenone formulations are not toxic to plants (U.S. EPA as cited in CDFG 1994). There would likely be some damage to macrophyte beds from mechanical fish harvest proposed under Alternative 4. Since aquatic plants provide hiding cover for fish, especially small fish, the macrophyte beds would pose a challenge to efficient fish harvest. However, the proposal is to use gill nets rather than seines in the vicinity of the dense macrophyte beds, which would result in minimal damage to the plants. It is also possible that there may be damage to macrophytes resulting from carcass recovery in Alternatives 2 and 3. However, this activity would occur when submersed rooted macrophytes would be dying back for the winter. There could be incidental collection of species which do not die back during the winter, but this is not expected to be significant.

Excavation of the canal and deposition of the spoils to augment an existing wetland under Alternatives 2 and 3 would also have short-term impacts to macrophytes. The existing canal has partially filled with sediments and has had some reestablishment of macrophytes within its confines. The limited numbers of plants within this man-made feature are considered insignificant relative to the populations beyond the canal. Deposition of the dredged material near the shoreline would bury submersed aquatic plants in that vicinity of the shoreline which are comprised principally of quillwort, Canadian waterweed, and water-milfoil. Emergent species with suitable root structures[74] would be planted in this area in order to increase the likelihood that sediments would stay in place once the silt fence is removed (see mitigation in Chapter 2 and planting prescription in the Botany report). Overall, the direct effect of this activity is considered to be minor to the macrophytes in the area.

Alternative 1 proposes no activity; therefore, there would be no direct effects to macrophytes from this alternative.

Indirect Effects:
Indirect effects to macrophytes under all of the alternatives would principally be from the trophic cascades, which are the feeding levels within the lake's food web. For example, the introduced tui chub and young rainbow trout feed upon zooplankton which in turn feed upon phytoplankton. The relationships with macrophytes are more complicated. Increases in phytoplankton compete with macrophytes, to a degree, for nutrients. Large numbers of phytoplankton also reduces light penetration into the lake which limits the depth to which submersed macrophytes can grow. Periphyton, which refers to algae together with protozoa, fungi and bacteria that are attached to macrophytes, may also increase indirectly because of large numbers of fish. Excessive periphyton growth suppresses macrophytes and generally results in a shift towards phytoplankton.

Alternative 1 has the potential to result in a crash of white-stem pondweed, and possibly other macrophytes, much as it occurred in the early 1950's (Loomis 2002). As long as tui chub populations remain high, there will be predation upon zooplankton, with cascading trophic effects that may result in alteration of the current macrophyte community (Jones & Sayer 2003, Lodge et al. 1994, Martin et al. 1992). On the other hand, past history is no guarantee that similar results would necessarily follow. The tui chub have been expanding in Diamond Lake since the early 1990's and severe blooms of *Anabaena flos-aquae* have occurred from 2000-2003, but it is noteworthy that the macrophyte community has not crashed in similar fashion as to what evidently occurred in the early 1950's. Other than the hydroacoustic sampling of the lake in 2002, there is no repeatable, quantitative data on macrophytes that would allow for more in-depth analysis on community trends.

Recovery of the macrophyte flora subsequent to rotenone treatment and refilling of the lake is difficult to assess under Alternatives 2 and 3. Because lake systems are comprised of complex, connected, interdependent biota that can be highly dynamic, precise determination of the indirect consequences of biomanipulation are speculative[75]. There is anticipated to be

[74] Maintenance of the water level at full pool through the summer growing season limits the potential diversity of colonizers for this created wetland.
[75] Jones and Sayer (2003), in discussing alternative equilibrium states in lake systems declare that "[o]nce a change has been precipitated, restoring pre-change conditions is insufficient to reinstate the previous community".

rapid expansion of zooplankton populations under Alternative 2 and possibly even more so with Alternative 3 due to their differing fish stocking strategies. Specifically, this should result in recovery of large-bodied Daphnia which have the potential to reduce phytoplankton and decrease turbidity. This should provide excellent conditions for recovery of macrophytes by improving clarity of the water.

There is, however, the potential that there could be substantial damage to plants rooted in the draw down zone of the lake due to freezing over winter and/or desiccation during the summer. This wouldn't necessarily preclude recovery of the macrophytes in this zone, but it may slow the recovery rate if the area needs to be recolonized. There is also the potential that stress to deep water-adapted species that would be subjected the previous summer to shallow water, would not recover as vigorously. If there is a significant lag in macrophyte recovery this could result in repartitioning of the nutrient balance within the lake to phytoplankton. However, since the dominant submersed macrophyte species in the lake would have much or most of their habitat remaining, this should provide sufficient means for revival of at least this portion of the macrophyte flora. Therefore, there is a reasonable expectation that something resembling the current macrophyte communities would reestablish under Alternatives 2 and 3 and possibly even extend to deeper depths, but there is considerable uncertainty surrounding in what manner and how quickly. Both Alternatives 2 and 3 are considered to be very similar in their indirect effects upon macrophytes. Alternative 3 may have a slightly greater likelihood of resulting in conditions favorable for macrophyte communities realizing their potential. However, it is likely that the draw down conditions (which are the same in both alternatives) would be far more significant to macrophyte conditions than fish-stocking strategies.

It is unknown how the single, non-native, weedy species would respond to the treatments in Alternatives 2 and 3. The two known locations of curly pondweed are within the proposed draw down zone and could succumb to harsh conditions that the draw down may result in. There is also the potential that it could respond more rapidly to the unstable conditions likely to ensue as the lake refills and the biota recovers.

Alternative 4 lacks the negative affects of the lake draw down while providing at least partial reduction of tui chub and whatever consequent affect this has on the rest of the lake's ecosystem. Because it is the least disruptive proposal over the short run, this alternative is most likely to retain the current macrophyte populations in something resembling their present condition for the foreseeable future. Long-term consequences to macrophyte assemblages under this alternative would be subject to the effects of the tui chub populations and distributions over time, along with the populations and distributions of the other organisms within the lake.

Cumulative Effects:
Salinas (1998) noted an increase in nutrient inputs to the lake over time, particularly since the 1960's. Increased nutrient inputs typically result in an increase in phytoplankton, although the pathways and interactions between biota are exceedingly complex (Wetzel 2001). Submersed macrophytes decline at very high levels of nutrient loading, but are tolerant of a broad range of nutrient loads. Productivity of emergent macrophytes, on the other hand, would continue to increase with increased nutrients. Alternatives 2 and 3 would presumably result in a short-term increase in nutrients from decaying fish that would be partially mitigated through mechanical collection of carcasses. The nutrient increases are not expected to result in a decline of the macrophytes, but there is no quantitative data to base this assumption upon.

Other past and ongoing actions, primarily related to recreation, provide a slight increase in sedimentation. Suspended sediment in the water column reduces light penetration which in turn restricts photosynthesis in submersed macrophytes. Improvements to the campgrounds and especially paving of the Diamond Lake loop road has limited sediment inputs from these sources such that shoreline inputs represent the principle input to the lake. Nothing in any of the proposed alternatives would directly affect overall sedimentation rates over time. However, if the proposed draw down were to adversely impact macrophyte populations, the reduction in macrophytes, which buffer shorelines from wave erosion, would likely result in an increase in suspended sediments.

Conclusions:
Macrophyte populations have the potential to change under all of the alternatives (including the no-action alternative). The greatest potential for an abrupt change to macrophytes is from the draw down schedule proposed in Alternatives 2 and 3. The combination of exposing rooted species to freezing temperatures in the winter and drought during the summer could result in significant mortality to much of the macrophyte flora. However, because the majority of submersed macrophyte beds would remain aquatic throughout the draw down, it is reasonable to expect the rapid and substantial recovery of at least the dominant submersed species. Because of the lack of empirical data on macrophytes in Diamond Lake and the complexity of lake ecosystems in general, there is considerable uncertainty about the fate of macrophyte diversity, distribution, and biomass over time. This is true of all alternatives, but particularly true of Alternatives 2 and 3 because the draw down schedule is anticipated to be the most significant variable for macrophyte conditions.

Zooplankton

The status of Zooplankton populations is important to the issue of water quality. Scoping identified a concern about the immediate and long-term effects of a rotenone treatment on water quality in Diamond Lake and the long-term effects on the future food chain and ecology of Diamond Lake (fish-zooplankton-phytoplankton-water quality relationships). This issue, as it relates to zooplankton populations, is tracked in this section.

AFFECTED ENVIRONMENT

Zooplankton are tiny animals living within the water column of a given body of water. In freshwater lakes, zooplankton are dominated by three major groups: the rotifers, and two subclasses of the Crustacea, the Cladocera and Copepoda (Wetzel 1983) (Figure 28). Zooplankton feed upon plant materials (phytoplankton, plant detritus[76], and filamentous algae) and other zooplankton, and are in turn fed upon by larger insects and fish. As a result, zooplankton populations are of critical importance to water quality, fish, and wildlife populations in the Diamond Lake system and ultimately the water quality of the lake.

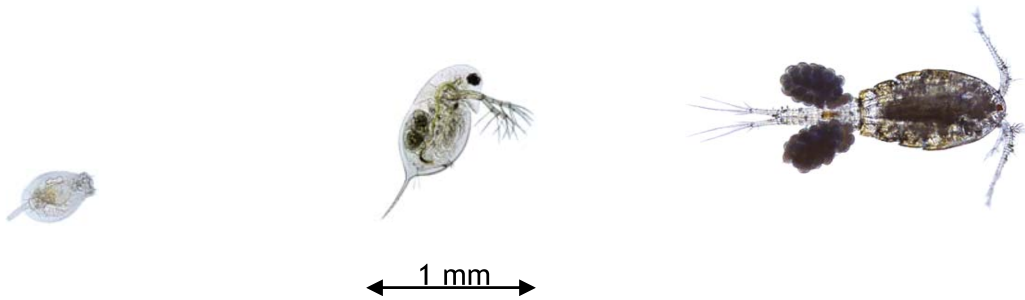

Figure 28. Representative examples (and relative sizes) of the three major groups of zooplankton in freshwaters – from left to right - rotifers, cladoceran (often called Daphnia), and copepods.

DIAMOND LAKE

Based on recent sediment cores[77] taken from the bottom of Diamond Lake (Eilers 2001b), zooplankton populations are believed to have shifted over time. Prior to the introduction of fish into Diamond Lake around 1910, zooplankton populations were likely very abundant (Eilers, 2001b). Literature and data suggests that pre-fish zooplankton populations in Diamond Lake were dominated by large copepods prior to fish introductions. In support of this theory, Liss et al. (1995) found that other fishless lakes in the Cascades were commonly dominated by large copepods. At some point after fish were stocked in Diamond Lake, the zooplankton community shifted from one formerly dominated by copepods to one dominated by large-bodied[78] cladocerans.

Currently, populations of zooplankton in Diamond Lake are dominated by smaller-bodied animals, like small cladocerans (mostly Bosmina species) and numerous rotifers (Vogel 2002, as cited in Salinas). The majority of these species are less than 0.029 inches (0.75 mm) in length (Vogel, personal communication, 2003). This dominance by smaller-bodied zooplankton is likely a result of heavy predation on larger-bodied zooplankton by tui chub.

[76]Plant detritus is composed of tiny, loose particles of living and dead plant matter.

[77] Sediment cores taken from lake bottoms consist of cylindrical samples of the bottom materials that have been deposited there over time. These cores possess compounds that allow scientists to date when material was deposited at any given layer in the core sample. Zooplankton and benthic organism body parts, as well as algae cell walls and spores are often preserved in these sediment layers. As a result, lake managers are able to use sediment core data to determine when changes in zooplankton, benthic organism, and algae populations occurred in the past.

[78] Large-bodied zooplankton are those >1.0 mm in length, Medium-bodied are those between 0.75-1.0 mm, and small-bodied zooplankton are those <0.75 mm (Allen Vogel, personal communication, 2003).

O'Brien (1979) found that ". . . the presence of planktivorous fish[79] in large numbers has unequivocally resulted in the elimination or reduction of large-sized species of zooplankton." Numerous other studies (Galbraith 1967; O'Brien 1979; Post and McQueen 1987; Northcote 1988) have also shown that large populations of plankton eating fish, like the tui chub in Diamond Lake, often result in a zooplankton population structure that is dominated by smaller-bodied individuals.

Importance of Zooplankton to Fish Populations

In addition to tui chub, smaller rainbow trout and other salmonids also feed on larger-bodied forms of zooplankton. Numerous studies (Galbraith 1967; Baldwin et al, 2000) indicate that salmonids prey upon zooplankton 0.051 inches (1.3 mm) in size or larger. Below this size threshold, zooplankton are generally too small to be heavily utilized by salmonids as a food source. As trout grow, studies have shown that they shift from an exclusively zooplankton diet to one with a much larger component of aquatic insects and other benthic organisms (Luecke 1986). In cutthroat trout for instance, this shift occurred when the fish attained a size of around 2¾ inches (7 cm). In Diamond Lake, the majority of the rainbow trout were stocked as 3 inch (7.6 cm) fingerlings between 1962 and 1990. Although no stomach content data are available for these fish, it is likely that they switched from an exclusively zooplankton diet to one with a larger portion of aquatic insects and benthic organisms[80] shortly after being stocked in the lake.

In most lake ecosystems, salmonids do not generally reach the high densities quickly achieved by minnows like the tui chub. In Diamond Lake, there is very little successful trout reproduction that occurs (see fisheries section). As a result, the majority of the trout biomass in the lake at any given time is closely correlated to the number and size of fish stocked in previous years. Diamond Lake stocking records indicate that an average of around 400,000 fingerling rainbow trout, roughly 3 inches (7.6 cm) in length, were stocked annually from 1962 to 1990. When this number is compared to the current population estimate for tui chub in this same rough size range, approximately 24 million (Loomis and Eilers, personal communication), the relative difference in potential impact on the zooplankton population is apparent.

In a study by Bird (1975) tui chub in East Lake (near La Pine, Oregon) showed a preference for zooplankton, with 39% of the total food organisms consumed being cladocerans (daphnia). In addition, the same study documented that three of the four food items (cladocerans, amphipods[81], and dipterans[82]) eaten in greatest quantities by the tui chub were also the most preferred food items of trout in East Lake, Oregon. Therefore, there was considerable diet overlap between the two species. Assuming 3 inch trout and 3 inch chub consume zooplankton at approximately the same rate and amount in Diamond Lake, the average population of 7.6 million tui chub in this size range (see Fish Section) could have a 19 times greater impact on zooplankton populations than the 400,000 rainbow trout fingerlings that had been stocked annually in Diamond Lake for 30 years prior to the discovery of tui chub. In

[79] Planktivorous fish are those that prey upon plankton.
[80] Benthic organisms are those that live on or near the bottom of a given water body.
[81] Amphipods, also known as scuds, are small shrimp-like crustaceans living on or near a lake or stream bottom.
[82] Dipterans are an insect group that include common flies, midges, and mosquitoes.

addition, there are also an estimated 94.5 million tui chub in younger age classes (young of the year, 1 and 2 year old fish), ranging in size from ¼ to 2½ inches (6 to 65 mm) in length. These smaller fish also feed heavily upon zooplankton (Bird 1975), and are likely exacerbating impacts to zooplankton populations in the lake.

While trout fingerlings and similar-sized tui chub are in direct competition for large-bodied zooplankton, tui chub are likely consuming smaller zooplankton as well[83]. Figure 29 below (courtesy of J. Eilers) represents an empirical model[84] of the likely relationship between fish and zooplankton size that has occurred in Diamond Lake over the past 90+ years.

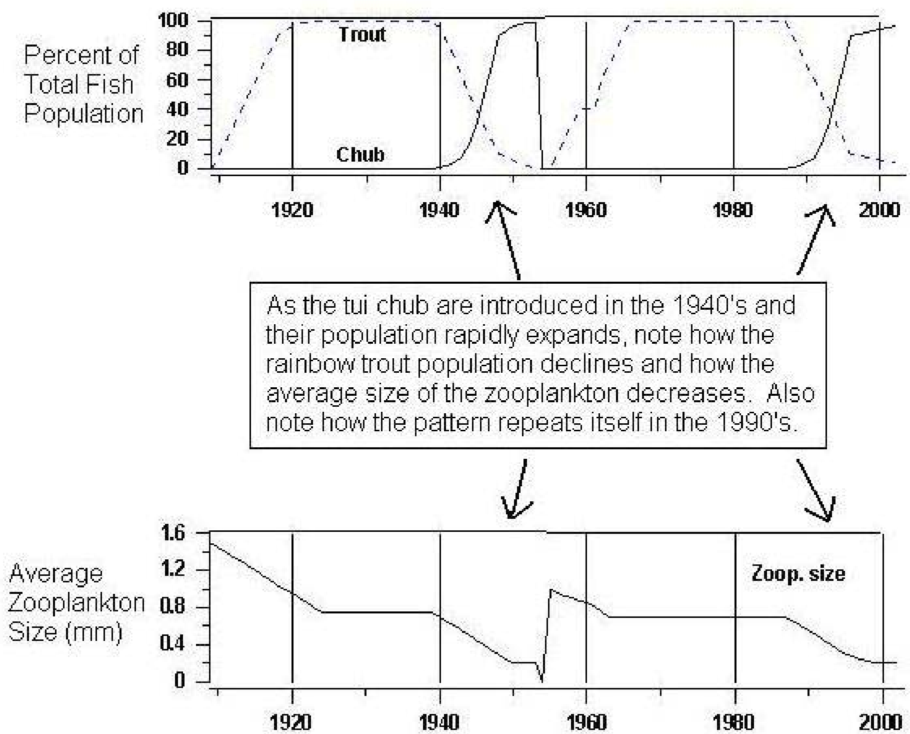

Figure 29. The relationship between zooplankton and fish in Diamond Lake (modeled from data collected at Diamond Lake).

Importance of Zooplankton to Water Quality

Zooplankton can influence water quality in a lake by feeding upon the phytoplankton populations found there. These tiny animals are essentially removing plant particles from the water column to use as food. As a result, zooplankton can have a dramatic effect on water clarity. In general, larger zooplankton individuals are able to capture and utilize larger food particles. Numerous studies reported by Wetzel (1983), have shown that when large-bodied

[83] In a study by Schneidervin (1987) in lakes where both trout and minnows were present, results indicated that the minnows preyed heavily upon small, medium, and large bodied zooplankton, effectively removing this potential trout food source before it had a chance to grow to a large enough size for trout to eat.
[84] An empirical model is one that relies upon or is gained from experiment or observation (Webster, 1988).

zooplankton are removed from a lake or pond, water transparency decreased as algae populations were able to grow relatively unchecked. The lack of large-bodied zooplankton in Diamond Lake is likely one of the contributing factors responsible for decreasing water clarity and the unusually large blooms of blue-green algae seen in recent years in the lake.

Another important aspect of the zooplankton's contribution to lake water quality is the type of food they tend to feed on. Certain zooplankton feed on a wide variety of algae of different sizes and shapes, while other zooplankton are highly selective in the algal types ingested. Circumstantial evidence suggests that toxin-releasing algae, such as blue-green algae, are selected against (i.e. not eaten as readily) by zooplankton, regardless of food size and shape. The majority of studies regarding zooplankton feeding rates on toxic blue-green algae indicate that most species of zooplankton reduce their feeding rates when they are feeding in waters with high concentrations of toxin-producing algae (Wetzel 1983). The blue-green algae *Anabaena flos-aquae*, that bloom in Diamond Lake, often form large strands that are difficult for smaller-bodied zooplankton to utilize as food. In addition, this algae has been known to produce toxins in the lake. Therefore, the combination of a zooplankton population dominated by smaller-bodied individuals and an algae population dominated by large, toxin producing species may be serving to reduce the overall extent and effect of zooplankton grazing on phytoplankton in Diamond Lake. This reduction in grazing potential is primarily a result of the shift from a larger-bodied zooplankton population, to one dominated by smaller-bodied organisms, caused by heavy tui chub predation.

In Diamond Lake, it is apparent that blue-green algae populations vary in terms of population size, species abundance, and whether those species produce toxins in any given year (see Phytoplankton section). A complete understanding of these variables in the lake has not been attained, and will continue to be a source of uncertainty regarding future trends of blue-green algae growth. Regardless of the zooplankton relationship with blue-green algae blooms in Diamond Lake, many lake studies have consistently shown that smaller-bodied zooplankton are not as readily able to consume larger-sized colonies of phytoplankton, such as the blue-green algae, *Anabaena flos-aquae*. As a result, the potential for the existing, mostly small-bodied zooplankton in Diamond Lake to effectively graze upon large blooms of blue-green algae has been greatly reduced by tui chub predation on zooplankton.

Zooplankton Reproduction and Resilience

The reproductive rates and life histories of zooplankton are extremely diverse. Water temperature and food supply are critically important to the rate of zooplankton population development. In general, as water temperature and suitable food supplies increase, the rate of population development also increases (Wetzel, 1983). Environmental stress in the form of decreasing water temperature, shortened day-length, reduced food availability, lack of dissolved oxygen, and increases in predation often trigger zooplankton populations to produce resting eggs[85]. Certain types of resting eggs are typically encased in a heavy cell wall, and are resistant to freezing, drying, and other environmental stresses. In some cases, these resting eggs may float and form large accumulations along windward shorelines, where they may

[85] The production of resting eggs is an adaptation that zooplankton have developed to allow their populations to persist in spite of future environmental uncertainties. These eggs can be produced asexually (by an individual female) or by fertilization between a male and a female.

become entangled in vegetation and transported by birds to other water bodies (Wetzel, 1983). In many cases, these eggs will not hatch until conditions are more favorable (sometimes months or years later). As a result, many species of zooplankton are highly resilient in spite of environmental extremes. Some species can repopulate nearby water bodies through transport by waterfowl, and others can rebound quickly after the complete drying of small lakes or ponds. In Diamond Lake, it is likely that the existing stresses on zooplankton populations induced by extreme predation from tui chub, a large proportion of less palatable blue-green algae (i.e. less food), and poor water quality conditions have, together, served to increase the development of resting eggs. Theoretically, if the existing environmental stresses in Diamond Lake are removed or reduced, zooplankton populations are likely to rebound strongly, due to a large number of resting eggs. No specific zooplankton data is available for Diamond Lake immediately following the rotenone treatment in 1954, but the highly successful results of fingerling stocking following this treatment tend to support the theory that zooplankton rebound strongly.

TRIBUTARY STREAMS AND LAKE CREEK

In stream systems, such as Short Creek, Silent Creek, and Lake Creek, zooplankton communities are much smaller relative to lakes. Experiments in streams found that zooplankton prefer low flow areas such as backwaters, pools and the bottom boundary layer (Richardson 1992). Very little information is available regarding zooplankton in the streams adjacent to Diamond Lake. Both Richardson (1992) and Shiozawa (1986) found that zooplankton are more abundant in streams where the climate and the stream type promote the formation of pools and the water in the pools is warmed. Habitat surveys in Short, Silent, and Lake Creeks indicated a lack of large quantities of deeper pool habitat. In addition, water temperatures in Short and Silent Creeks are consistently very cold. Therefore, zooplankton populations in these streams are likely to be relatively small, and not a major component of the aquatic organisms living there[86].

LEMOLO LAKE

Samples taken in 1992 from Lemolo Lake indicated that the zooplankton population consisted mainly of cladocerans, copepods, and rotifers. Total zooplankton densities were considered to be quite low; however, the species composition was characteristic of a mesotrophic[87] lake with moderate amounts of organic material (A. Vogel, as cited in PacifiCorp 1995). A likely factor causing the low densities was reduced food quality due to the dominance of blue-green algae. The large cladocerans *Daphnia galeata mendotae* and *D. pulicaria* were relatively abundant; their presence in moderately high numbers was indicative of low feeding pressure by the fish community (PacifiCorp 1995).

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[86] An exception to this general lack of zooplankton occurs in the upper section of Lake Creek, near Diamond Lake. In this area, relatively large numbers of zooplankton are typically carried into Lake Creek by the outflowing waters of Diamond Lake. It is not likely that these lake-adapted zooplankton species would persist for long periods of time in this turbulent stream environment. In addition, the filter feeding component of the aquatic insect community in this area is relatively large, and has presumably adapted to utilize the abundant food resource of zooplankton provided by the lake.

[87] A mesotrophic lake is one with a moderate level of biological productivity. A mesotrophic lake is capable of producing and supporting moderate populations of living organisms.

Although tui chub are also present in Lemolo Lake, they do not reach the high densities found in Diamond Lake (see Fish section). Therefore, in Lemolo Lake, tui chub apparently do not impact zooplankton populations to the extent seen in Diamond Lake.

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK)

As mentioned above, zooplankton are not thought to be a major component of invertebrate populations in stream systems. In the free-flowing sections of the North Umpqua River below Lemolo Lake, the consistently cold water is likely one of the key factors limiting stream-adapted zooplankton populations.

In the larger reservoirs below Lemolo, such as Toketee Reservoir and Soda Springs Reservoir, it is likely that zooplankton populations represent a larger component of the overall aquatic invertebrate populations found in those areas similar to the populations seen in Lemolo Lake.

ENVIRONMENTAL EFFECTS

BACKGROUND: TOXICITY OF ROTENONE TO ZOOPLANKTON

Based on laboratory bioassays performed on various zooplankton, it is expected that at least 50% of the cladocerans and copepods would die from exposure to the rotenone concentrations commonly used in fisheries work (0.5 ppm and up) (Bradbury 1986). Alternatives 2 and 3 would result in concentrations of 2 ppm. Kiser (as cited in Bradbury 1986) found that the greatest reduction in total zooplankton counts came between 15 minutes and one hour after treatment began. During this time, mid-water zooplankton numbers dropped by 70%. In 16 of 19 studies reviewed by Bradbury (1986), zooplankton numbers were reduced by 95-100% shortly after rotenone treatment.

Although zooplankton populations are drastically reduced immediately following rotenone treatment, these communities recover in almost all cases. The chemicals contained in the rotenone formulations proposed for use do not persist in the environment for long periods of time, and would not be expected to impact zooplankton in future years (Bradbury 1986; Finlayson et al. 2000). Even in those lakes where not a single living zooplankton appeared in the post-rotenone samples, enough escaped or survived treatment to eventually repopulate the lake (Bradbury 1986). Some zooplankton escape treatment in densely weeded areas where rotenone is quickly detoxified (Almquist 1959, Kiser et al. 1963 – as cited in Bradbury 1986). Others may survive simply by virtue of their tolerance to rotenone. Certain zooplankton may survive by means of tough resting eggs which are unaffected by rotenone (Bandow 1980; Anderson 1970; Kiser et al 1963 – as cited in Bradbury 1986).

There is normally a period of 2 to 12 weeks following rotenone treatment during which there are no crustacean zooplankton in the open water. Rotifers, although reduced in number, were never absent in the 19 studies reviewed. Following this period, zooplankton populations rebuild quickly. Zooplankton communities in most lakes eventually return to their pre-rotenone levels of abundance and diversity. During the period where no fish are present, the zooplankton community structure often shifts to one dominated by larger-sized cladocerans (daphnia). This complete recovery typically takes between two and twelve months after rotenone treatment (Bradbury 1986).

DIAMOND LAKE

Direct Effects:

The direct effects are those that occur during and shortly after implementation of the alternatives for a period of several months.

Alternatives 1 and 4 are not likely to have any direct effects on zooplankton populations in Diamond Lake. Under these alternatives, there are no alterations of lake water levels and no additions of rotenone to the system. Stocking of trout under these alternatives is not expected to directly impact zooplankton populations over and above the heavy impact of tui chub. Due to the heavy predation on zooplankton by tui chub, there is virtually no zooplankton in the lake of a large enough size to be utilized by salmonids.

Alternatives 2 and 3 would each directly affect zooplankton populations. In each case, the primary impact would be a result of lake draw down and rotenone. The actions of canal reconstruction and wetland expansion are not expected to measurably impact zooplankton populations due to the relatively small size and short-term nature of these actions (2-3 weeks). The draw down portion of the project would result in an approximate 30% reduction in total water volume in the lake. As this water is drawn down, a portion of the existing zooplankton population would be carried downstream with it, thereby removing a portion of zooplankton biomass from the lake. Of more importance, the direct effect of rotenone addition to Diamond Lake would result in a relatively quick decline in mid-water zooplankton numbers, with populations being severely reduced by as much as 95-100%. However, this dramatic population decline is not expected to last more than a year as populations would rebound rapidly.

Indirect Effects:

Over the long-term under Alternative 1, zooplankton populations would continue to be preyed upon by the large population of tui chub. This would result in the continued suppression of average zooplankton body size and overall species diversity for years or decades.

Following the draw down and chemical treatment associated with Alternatives 2 and 3, zooplankton populations would rebound strongly during the brief period without fish in the lake. In succeeding years zooplankton populations would be primarily influenced by the fish stocking strategies used. After the complete eradication of all fish from Diamond Lake and the period of time allowed for recovery of the base aquatic ecosystem (i.e. zooplankton, aquatic insects, etc.), zooplankton populations would be expected to return to a state similar to that assumed prior to fish introductions in the lake (i.e. large proportion of large-bodied cladocerans and copepods). In numerous studies of zooplankton populations in lakes following rotenone treatment, most of these populations were considered to be completely recovered (to pre-treatment conditions) in less than one year (Bradbury 1986; Finlayson personal communication, 2003). Of the studies reviewed, the lakes that required more than one year for zooplankton recovery to occur were oligotrophic[88] alpine systems, unlike Diamond Lake. In addition, under Alternatives 2 and 3, zooplankton population recovery would be further enhanced in the spring months due to the presence of ample nutrients resulting from natural sources, as well as nutrients derived from decaying aquatic organisms (zooplankton and benthic organisms) and fish carcasses not collected during carcass recovery efforts.

In the absence of fish predation, populations would recover in terms of total numbers, general species diversity, and a dramatic increase in the average size of zooplankton. (Bradbury 1986; CDFG 1994). Once salmonids are stocked back into the lake, they would become the primary predator on zooplankton.

Salmonid stocking under Alternative 2 would be conservative at first, with relatively small numbers of fish stocked (estimated to be 50,000-150,000 fingerlings, and 10,000 legal sized rainbow for the first year following chemical treatment). Close monitoring of zooplankton numbers and size indices would be carried out annually to ensure that the stocked fish are not overgrazing zooplankton populations[89]. Under Alternative 2, zooplankton populations would likely show the pattern in Figure 29, with a slight decrease in the average size of individual zooplankton, but not the dramatic shift that has contributed to recent blooms of blue-green algae and corresponding water quality problems in the lake.

Under Alternative 3, zooplankton populations are not expected to be much influenced by the large numbers of catchable-sized fish stocked in the lake. The fish proposed for use in this alternative would be domesticated rainbow trout from the Washington State Trout Lodge stock (a mix of Kamloops and other rainbow stocks). Trout from this broodstock would not reproduce successfully in Diamond Lake, would not prey significantly on available food organisms, and the majority would not survive through the winter (D. Loomis, ODFW, personal communication). Therefore, in the absence of any substantial predation on zooplankton, it is likely that zooplankton populations would experience a dramatic recovery in terms of species diversity, numbers, and average size.

Under Alternatives 2 and 3, if monitoring reveals a slow recovery of zooplankton numbers and diversity, recovery would be facilitated by adding species of zooplankton from appropriate sources.

Under Alternative 4, zooplankton populations would be influenced primarily by the remaining portion of the tui chub population, and to a lesser extent, the larger salmonids that would be stocked. The effect on zooplankton populations is highly dependent upon the proportion of the existing tui chub population removed in each of the successive years of mechanical chub harvest. Assuming mechanical harvest is successful in reducing the numbers of reproductive age chub by 85-95% annually, it is likely that zooplankton populations would respond positively, with a gradual increase in the relative proportion of cladocerans and an increase in the average size of individual zooplankton. This improvement would be slow at first, due to the continued presence of millions of younger tui chub in the 0, 1, and 2 year age classes that would not be initially impacted by the mechanical removal methods. Over a 4 to 6 year

[88] Oligotrophic systems are those that are low in nutrient inputs, and have low productivity.
[89] Eilers (2003a) created an ecologically based index for guiding salmonid-stocking decisions in Diamond Lake.

period, as these young fish grow to the sizes targeted for removal, and overall reproduction rates (and juvenile fish numbers) are reduced as a result of these continued mechanical removal efforts, their predation impact on zooplankton is likely to lessen accordingly.

The extent of potential improvements associated with Alternative 4 is difficult to predict. Past efforts utilizing commercial fishing gear to remove tui chub in Diamond Lake were not considered to be effective. Only small numbers of chub were captured relative to the amount of effort expended. These efforts were not carried out during the peak of the chub spawning season, when the fish would be most concentrated and most vulnerable to mechanical removal.

Similar mechanical removal efforts have been conducted annually in Lava Lake (near Sunriver, Oregon) for the last several years. During this time, intensive netting of tui chub has taken place each summer in this 368 acre lake in an effort to control chub populations, and improve water quality and the recreational trout fishery. Tui chub only spawn in a small portion of the lake (roughly 5% of the area) where macrophytes are present. Overall, these efforts have not been considered to be very successful, as Lava Lake continues to experience depressed trout populations, and blooms of blue-green algae (Ted Fies, Personal Communication, 2003). This lake was recently listed on the State's 303(d) list of impaired water bodies as a result of low levels of dissolved oxygen.

Cumulative Effects:
The 1954 rotenone treatment and past, present, and future fish stocking strategies are the primary management activities that contribute to a potential cumulative effect on zooplankton populations (see cumulative effects tables 9-11 for details). However, as described above with the existing suppressed population of zooplankton, the relative contributions of these management activities to future zooplankton populations are considered to be minor. Under Alternative 1, zooplankton populations would continue on their present course as a result of the large population of tui chub. Actual numbers and species diversity of zooplankton would likely vary on an annual basis, corresponding to environmental changes or other factors associated with interspecific competition[90]. Under Alternative 1, zooplankton populations would remain dominated by small-bodied cladocerans and rotifers into the future. Past, ongoing, and reasonably foreseeable management activities would have no meaningful contribution to a cumulative effect on zooplankton populations in Diamond Lake.

Overall, Alternative 2 represents a short-term contribution to the cumulative negative effect of management on zooplankton, with a predicted long-term beneficial impact. Future fish stocking strategies under this alternative would result in increased cumulative impacts on zooplankton, but due to the required monitoring and adaptive management stocking strategies under this alternative, the consequences of these cumulative impacts to zooplankton are considered to be minor. Alternative 3 only differs from Alternative 2 in that its potential contribution to negative cumulative effects is further reduced by stocking with fish not expected to prey heavily on zooplankton.

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[90] Interspecific competition is the natural process of similar organisms competing with one another for available food and habitat resources.

The cumulative effect of Alternative 4 is more difficult to predict based on the uncertainty associated with mechanical methods of chub removal, and the need to consistently remove a large proportion of the spawning chub population for at least 6 consecutive years in order for this alternative to be successful. As mentioned in the indirect effects discussion, predation pressure from tui chub would likely decline gradually if mechanical removal methods are successful. However, if mechanical methods are discontinued after 6 years, or are not successful during any of these years, there is a chance that tui chub populations would rapidly expand again. Based on the inability of predacious fish (i.e. Brown trout) to control the tui chub in the 1950's after partial chub removal efforts (see Fish section), it is unlikely that piscivorous fish (Eagle Lake rainbow or brown trout) would be able to control chub populations in this instance.

Based upon past experiences from the early 1950's, the likely cumulative impact of Alternative 4 would be similar to that of Alternative 1. As demonstrated in the past, the high fecundity[91] of tui chub virtually ensures their rapid future population expansion in Diamond Lake (see Fish section). Thus, Alternative 4 represents a primarily neutral or potentially limited positive contribution to the beneficial cumulative effects of management activities on future zooplankton populations.

Connected Actions:
Dock cleanup activities proposed by the Diamond Lake Resort and described as connected actions for Alternatives 2 and 3 in Chapter 2, would have no direct, indirect, or cumulative impacts to zooplankton. Impacts are not expected because of the small size and lack of in-water work associated with these activities.

TRIBUTARY STREAMS AND LAKE CREEK

Direct, Indirect, and Cumulative Effects:
Since zooplankton are not a major component of the invertebrate populations living in those streams, Alternatives 1 and 4 would not result in any detectable short-term effects to zooplankton populations in the tributaries to Diamond Lake or Lake Creek. These alternatives may result in artificially small zooplankton populations in Lake Creek in the long-term as a result of elevated predation pressure on zooplankton by the continued presence of tui chub in pools and slow water areas of Lake Creek.

Alternatives 2 and 3 would likely result in direct short-term decreases in stream zooplankton populations, followed by short-term increases. In Short and Silent Creeks, the decreases would come as a direct result of rotenone, which would kill the relatively small populations of zooplankton found in those systems below the chemical drip stations. However, it should be noted that these drip stations would be located within the streams that flow through the drawn down portion of the de-watered lake bed.

In Lake Creek, the zooplankton decreases would be an indirect result of the lake draw down, which would result in above average high flows for an extended duration, followed by a short period of channel dewatering in the upper 6 miles of Lake Creek. Following this decrease,

[91] Fecundity is a measure of reproductive potential.

slight short-term increases in zooplankton may occur in Lake Creek as a result of improved habitat caused by high flows during draw down. This increase would likely last for several years until habitat conditions gradually returned to pre-draw down conditions.

The long-term cumulative effects of Alternatives 2 and 3 would be an eventual stabilization of zooplankton populations in Lake Creek as flow and habitat conditions return to their natural state. This stabilization may be followed by slight population increases. In the absence of tui chub in Lake Creek[92], it is likely that stream-adapted zooplankton populations would increase due to an overall decrease in predation pressure from these fish.

LEMOLO LAKE

Direct, Indirect, and Cumulative Effects:
None of the actions proposed in the alternatives are located in Lemolo Lake. As a result, there are not likely to be any direct effects to zooplankton populations in Lemolo Lake from any of the alternatives.

Over the long-term, Alternatives 1 and 4 would result in continued tui chub presence in Diamond Lake, and the continued contribution of nutrient enriched waters to Lemolo Lake via Lake Creek. This would likely result in increased algal production in the warmer surface waters of Lemolo Lake (Eilers, 2001c). If the dominant phytoplankton species are those preferred by zooplankton, an increase in algal production may be followed by increases in zooplankton populations as well.

Alternatives 2 and 3 would result in reductions in the amount of nitrogen enriched water entering Lemolo Lake via Lake Creek (see water quality sections). As a result, algal productivity in Lemolo Lake would likely be reduced slightly from current conditions, and zooplankton populations in Lemolo Lake may decrease slightly as their primary food resource decreases.

The cumulative effects of Alternatives 1 and 4, in combination with activities that might potentially deliver sediment to Lemolo such as timber sales and road work listed in Tables 9-11, would be the continued contribution of nitrogen enriched waters to Lemolo Lake, potentially leading to small increases in zooplankton populations[93]. If Alternative 4 is successful in reducing chub populations in Diamond Lake in the long-term, the relative nutrient contribution to Lemolo Lake would be expected to be somewhat smaller than that in Alternative 1.

The cumulative effects of Alternatives 2 and 3, would be a reduction in the amount of nitrogen in the waters entering Lemolo Lake via Lake Creek. This may result in slight

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[92] Tui chub are currently present in Lake Creek.

[93] The relative increase is difficult to predict due to other controlling factors, such as the species of phytoplankton dominating the reservoir, the extent of fish predation on zooplankton populations, the extent of fish stocking, and other environmental conditions.

decreases in phytoplankton production and consequently, small reductions in zooplankton populations as well[94].

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK)

Direct, Indirect, and Cumulative Effects:
Zooplankton populations in these areas are likely small, and controlled primarily by cold water and other physical habitat limitations. In addition, the reservoirs associated with the hydropower system in the upper North Umpqua River are considered to be nutrient sinks[95] (Eilers 2001c). Therefore, the majority of the nutrients entering the North Umpqua River are quickly utilized by local plants, and not transferred in the water column to downstream areas. As a result, none of the alternatives are likely to result in any detectable direct, indirect, or cumulative effects on zooplankton populations in the North Umpqua system below Lemolo Lake.

Conclusions and ACS Consistency:
Alternative 1 would result in continued suppression of zooplankton populations in the short and long-term (Table 20), and it would prevent attainment of Aquatic Conservation Strategy Objective 9[96]. Alternatives 2 and 3 would result in dramatic and immediate decreases in zooplankton populations due to the addition of rotenone. However, these population declines would be short-term, and not expected to last for more than a few months. The three action alternatives would result in varying levels of zooplankton population recovery in the long-term, and would not prevent attainment of ACS Objective 9. Based upon past history at Diamond Lake, alternatives that propose to completely remove tui chub (Alternatives 2 and 3) are more likely to achieve desired zooplankton population recovery suitable to support stocked salmonids and contribute to improved water quality conditions. Alternative 4, which does not completely eradicate tui chub, may be the least effective of the action alternatives at movement toward ACS Objective 9, due to the potential for continued expansion of the remaining tui chub population, and uncertainty regarding the efficacy of mechanical and biological methods to remove chub over a multiple-year timeframe. Also in the long-term, Alternatives 2 and 3, which result in the most robust populations of zooplankton (in terms of species diversity and size indices), are likely to provide the greatest contribution to water quality recovery and attainment of ACS Objective 4[97].

In summary, based on zooplankton's ecological role in Diamond Lake, the relative ACS ranking of each alternative would be as follows (from best to worst):

Alternative 3 – Most effective at moving toward attainment of ACS objectives

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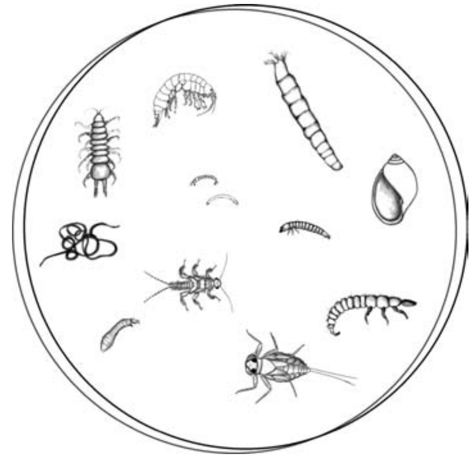
[94] The relative decrease is difficult to predict due to other controlling factors, such as the species of phytoplankton dominating the reservoir, the extent of fish predation on zooplankton populations, the extent of fish stocking, and other environmental conditions.
[95] Nutrient sinks are locations where nutrients are lost or unavailable.
[96] ACS Objective 9 – Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.
[97] ACS Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

Alternative 2 – Effective at moving toward attainment of ACS objectives
Alternative 4 – Least effective of the action alternatives at moving toward attainment of ACS objectives
Alternative 1 – Retards attainment of ACS objectives

Table 20. Summary of Alternative Effects on Zooplankton Populations.

Factor	Alternative 1 – No Action	Alternative 2 – rotenone & put- grow- take fishery	Alternative 3 – rotenone & put and take fishery	Alternative 4 – mechanical & biological control of chub
Average Zooplankton Body Size **(Indicator for Key Issue 4 - Water Quality)**	Continued high short and long-term negative impacts to zooplankton body size due to high predation by tui chub. Results in an ecological condition that continues degraded water quality.	High short-term negative impacts to zooplankton due to rotenone treatment. Moderate to High mid and long-term beneficial impacts to zooplankton size due to lack of intense tui chub predation, and only low to moderate predation by trout fingerlings. Results in an ecological condition that supports improved water quality in the long-term.	High short-term negative impacts to zooplankton due to rotenone treatment. High mid and long-term beneficial impacts to zooplankton size due to lack of intense tui chub predation, and low or no predation by stocked domesticated trout. Results in an ecological condition that supports improved water quality in the long-term.	Continued moderate to high short-term negative impacts to zooplankton size due to continued moderate to high predation levels. High long-term negative impacts to zooplankton body size due to high predation by tui chub. Results in an ecological condition that continues degraded water quality.
Zooplankton Species Diversity	Species diversity relatively low compared to pre tui chub conditions. Zooplankton population continues to be dominated by small rotifers and small cladocerans.	Species diversity increases over time. Large daphnia and copepods increase in numbers, and replace rotifers as the dominant zooplankton.	Species diversity increases over time. Large daphnia and copepods increase in numbers, and replace rotifers as the dominant zooplankton.	Species diversity relatively low compared to pre tui chub conditions. Zooplankton population continues to be dominated by small rotifers and small daphnia.

Benthic Organisms



There were no issues identified in scoping concerning benthic organisms. However, information on this subject is provided because of the important role benthic organisms play in the food chain of Diamond Lake.

AFFECTED ENVIRONMENT

Benthic organisms are those that live on or near the bottom of a lake or stream. In Diamond Lake, benthic organisms include aquatic insects like mosquito and midge larvae, mayfly larvae, caddisfly larvae, damselfly larvae, dragonfly larvae, and others. In addition, other bottom-dwelling aquatic invertebrates[98] such as leeches, snails, amphipods (or scuds), worms, and crayfish also form an important component of the benthic community. In many lakes, benthic organisms are of primary importance to fish and other aquatic predators.

DIAMOND LAKE

No historic information regarding benthic organism community structure or overall numbers is available prior to the introduction of fish into Diamond Lake. However, insect body parts preserved in lake-bottom sediment cores collected by Eilers in 2003 indicate that there was a large component of midge larvae (chironomids) present in the lake prior to fish introductions. During this pre-fish timeframe, sediment core samples contained approximately 460 midge heads per gram of sediment. Sediment layers evaluated from 2002 contained roughly 250 midge heads per gram of sediment (Eilers, 2003c). The analysis of core samples found a substantial decrease in midge population size and a shift in species diversity coincident with the introduction of fish, and especially the rapid expansion of the tui chub population.

Benthic life at the bottom of the lake during a 1946 study indicated that benthic productivity appeared to be considerably above average when compared to other Oregon lakes (OSGC, 1947). This study reported an average standing crop of roughly 292 pounds of benthic organisms per acre of lake-bottom. Scuds, leeches, snails, and midge-larvae comprised a large percentage of this standing crop, and were also found in large numbers in areas with aquatic vegetation. This value declined rapidly as the chub population expanded in the late 1940’s and early 1950’s. Populations of benthic organisms appeared to rebound quickly following the rotenone treatment in 1954 (Figure 30).

[98] Animals without a spine or backbone.

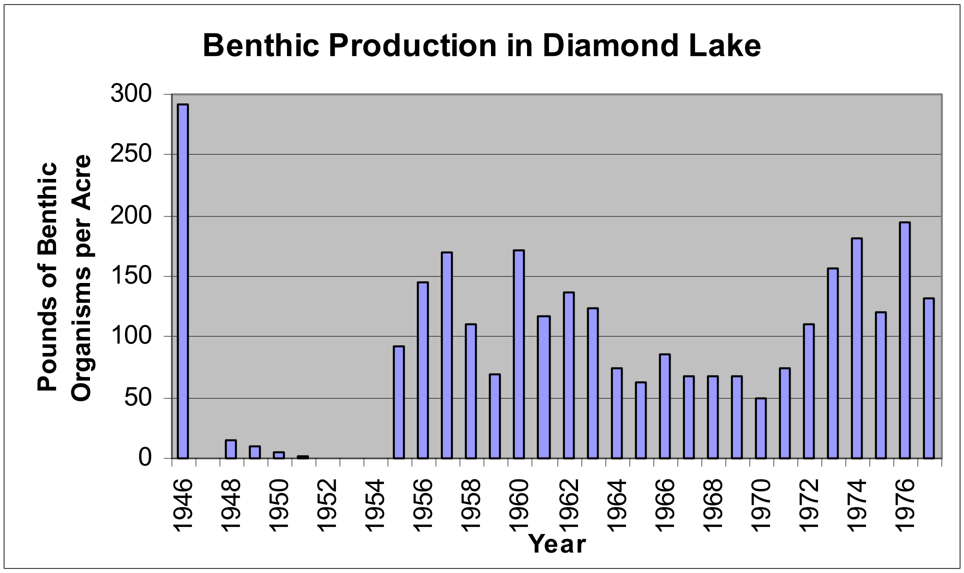


Figure 30. Benthic production in Diamond Lake from 1946 to 1977.

No estimate of past crayfish abundance is available due to the fact that none of the past benthic samples reported capture of any crayfish in Diamond Lake. This may be a result of the crayfish's ability to move quickly and avoid capture in the sampling equipment, or an indication that they weren't present in the lake in great abundance. Regardless, recent anecdotal evidence indicates that the current crayfish populations are quite large. In support of this, fish trapping efforts in Lake Creek also resulted in the capture of over 4,000 crayfish during the summer months. Since 2003 was the first year of fish trapping efforts in Lake Creek, it is not known whether this is an annual occurrence or an isolated migration event[99].

Anecdotal information from long-time residents and recreationists in the area indicate that large hatches of mosquitoes, flies, and midges were common throughout the spring and summer months prior to the introduction of tui chub. These individuals also noted that large hatches of aquatic insects are virtually non-existent today. Other insect life reported in the area included sporadic large hatches of damsel flies, dragon flies, caddis flies, and mayflies—all of which are also depressed at the present time.

Currently, aquatic insect communities and other invertebrates in the lake are believed to be severely limited by the presence of millions of tui chub, directly through consumption and indirectly through impacts on water quality. Based on the recent bottom samples, scuds have been virtually eliminated from Diamond Lake. In the 1957-60 period, they represented over 60 percent of the organisms sampled, but by 2002, only 3 individuals were found in the 66 bottom samples collected. In addition, recent benthic samples indicated that the only invertebrates present in large numbers are those that are tolerant of extremely low dissolved oxygen levels (Eilers, 2003c). This is likely an indication that water quality near the bottom of the lake is poor, and currently not capable of supporting diverse assemblages of aquatic insects and other bottom dwelling organisms.

[99] This outmigration may also coincide with the period when dissolved oxygen decreased to extremely low levels in the bottom waters of Diamond Lake, perhaps forcing the crayfish to find suitable habitat elsewhere.

TRIBUTARY STREAMS AND LAKE CREEK

The Umpqua National Forest has conducted aquatic insect monitoring at three sites on Lake Creek on an intermittent basis from 1990 to 2001. In general, aquatic insect populations in Lake Creek appear to be moderately healthy and typical of lake outlet stream types. These insect communities appear to be somewhat limited by a lack of overall habitat complexity and warm water conditions (Wisseman 2001). The lack of habitat complexity and the warm water conditions in Lake Creek are both naturally occurring situations, and not due to human-induced management actions upstream.

The uppermost monitoring site in Lake Creek is located near Diamond Lake. The aquatic insect community at this site is substantially different than the two sites located further downstream. In this area, the insect community is dominated by filter feeders (i.e. black fly larvae) and net spinners (i.e. certain caddisfly species), with overall densities being 2 to 3 times higher than those at the lower sites. These differences are likely the result of localized adaptations that have allowed the insect community to take full advantage of the large quantity of food resources coming out of Diamond Lake (i.e. live zooplankton, plant particles, etc.).

There is no evidence that the severe *Anabaena* bloom in 2001 affected aquatic insect communities in Lake Creek (Wisseman 2001). This corresponds well with information reported by Eilers (personal communication 2003) that indicates fairly rapid decreases in blue-green algae levels once water from Diamond Lake enters Lake Creek. This rapid decline in algae abundance is a result of algae cells being physically disrupted and ruptured as water in Lake Creek tumbles through several steep, boulder dominated sections (cascades).

Less is known about aquatic insect populations in Short and Silent Creeks. However, based on the very cold water in these streams and the presence of large amounts of highly angular sands embedding the larger pumice bed materials, it is not likely that they are highly productive in terms of aquatic insects.

LEMOLO LAKE

Predation levels on benthic organisms in Lemolo Lake are believed to be relatively low based on limited sampling. Water quality in the deeper portions of Lemolo Lake is considered to be much better than in Diamond Lake (see Water Quality section). These cooler bottom waters contain ample amounts of dissolved oxygen capable of supporting a diverse assemblage of benthic species. Therefore, it is assumed that benthic organism populations in Lemolo Lake are relatively healthy.

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK)

The Umpqua National Forest has conducted aquatic insect monitoring on an intermittent basis at several sites along the main stem of the North Umpqua River for several years. In general, from Lemolo Lake downstream to the National Forest boundary (over 47 miles), these samples show a slight downward trend in insect population diversity and abundance. It is not known whether this is a result of aquatic impacts from past land management actions, changes to nutrients and water quality induced by actions associated with the hydropower project, or simply a natural occurrence associated with increasing river size.

ENVIRONMENTAL EFFECTS

BACKGROUND: TOXICITY OF ROTENONE TO BENTHIC ORGANISMS

Regardless of the organism, rotenone's primary toxic action is at the cellular level, where it inhibits the cell's ability to utilize oxygen (Bradbury 1986). As in fish, the high susceptibility of insects to rotenone is primarily due to easy entry via the gill-like tracheae and the cuticle, although rotenone can also enter effectively through the mid-gut (Tischler 1935; Fukami et al 1970 – as cited in Bradbury 1986). Once in the bloodstream, rotenone is quickly carried to vital organs (such as the brain), where it inhibits cellular respiration (Oberg 1964 – as cited in Bradbury).

Some field studies indicate little or no changes in invertebrate populations following rotenone treatments[100]. Burress (1982) found that benthic communities were seriously reduced by a 2 mg/L formulated rotenone treatment, but recovered to higher than pre-treatment levels in 69 days. More recent studies (Mangum and Madrigal 1999) indicate that rotenone treatments in streams can result in a substantial loss of more sensitive species, (primarily mayflies, caddisflies, and stoneflies) which were still missing five years after the initial rotenone treatment.

In both aquatic insects and fish, rotenone tolerance tends to vary inversely with oxygen requirements. Simply put, aquatic organisms that are tolerant of low dissolved oxygen are more resistant to the toxic effects of rotenone. A large portion of the aquatic insects and other benthic organisms currently living in Diamond Lake are tolerant of low dissolved oxygen or are able to burrow into the soft mud (Eilers, personal communication). As a result, these organisms may be able to survive a rotenone treatment. In addition, as noted above, the vast majority of invertebrates that would be considered as sensitive to the effects of rotenone have already been virtually eliminated from Diamond Lake by extensive predation by tui chub and poor water quality conditions.

[100] Two year studies by Houf and Hughey (1973) and Houf (1974) found no short-term or long-term effects on population abundance, relative number of dominant species, or species diversity of either zooplankton or benthos in ponds following treatments of 0.5 to 2 mg/L formulated rotenone (CDFG, 1994).

DIAMOND LAKE

Direct Effects:
Alternatives 1 and 4 are not likely to have any detectable direct effects on populations of benthic organisms in Diamond Lake. Under these alternatives, there are no alterations of lake water levels and no additions of chemicals to the system, which would be the primary source of a direct effect on the benthos[101]. The addition of fish also has the potential to directly impact benthic populations. However, in the presence of much larger tui chub populations and severely depressed populations of benthic organisms, these impacts would be non-detectable.

Alternatives 2 and 3 would each be likely to directly affect benthic populations to some extent. In each case, the impact would be a result of canal reconstruction, wetland expansion, lake draw down, chemical additions to the lake, and stocking of fish. The canal reconstruction portion of the project would result in approximately 1,000 cubic yards of sand, silt, and aquatic plants being removed from the existing canal area within the perimeter of the lake. This material would be utilized to increase the size of an existing wetland in the northwest corner of the lake. Any benthic organisms living within the canal sediments or in the area of wetland expansion would likely be killed. However, based upon the small size of the area disturbed, these impacts are expected to be minor and short-term.

The draw down would result in an approximate 30% reduction in total water volume in the lake. As this water is drawn down, a portion of the lake bottom along the near-shore zone would be dewatered, thereby temporarily reducing the amount of suitable habitat for benthic organisms. In addition, small areas of gravel may be added in several areas in order to create low-water roadbeds that would allow boats to be launched and chemicals to be loaded onto those boats.

Of more importance to benthic populations, the direct effect of rotenone addition under Alternatives 2 and 3 would result in a relatively quick decline in benthic organism numbers. According to Bradbury (1986), the immediate effect of rotenone on benthic organisms in lakes and ponds varies, but it does not affect them as drastically as it does zooplankton. In a review of 13 studies, Bradbury (1986) reported that immediate reduction in total numbers of benthic animals ranged from a low of 0% to a high of 71%, with a mean of 25%. It is important to note that the current benthic population in Diamond Lake is considered to be severely depressed and simplified as a result of tui chub predation and secondarily to poor water quality conditions that render much of the lake uninhabitable to many benthic organisms.

Indirect Effects:
Alternative 1 would result in the continued long-term suppression of benthic populations by the large population of tui chub. The benthic community in deeper parts of the lake would remain depressed and simplified, with only a few species capable of tolerating the low dissolved oxygen conditions found there (see water quality section). The benthic community around the remainder of the lake would likely persist at extremely low levels, due to the intense predation on those populations by the tui chub.

[101] Benthos is defined as "the organisms living on sea or lake bottoms" (Webster, 1988).

The indirect effects of Alternative 4 would be similar to those of Alternative 1, with slight improvements to benthic species diversity and overall numbers. These improvements would be a result of the partial removal of a portion of the tui chub biomass, and the consequent reduction in overall predation levels on benthic populations. The chub targeted for removal under this alternative are the larger-sized reproductive-aged fish (from 3 to 10 inches in length) that are likely to be highly efficient and effective predators on benthic organisms. It is not possible to quantify the expected improvement in the benthos, due to the potential for continued expansion of the remaining tui chub population, and uncertainty regarding the efficacy of mechanical methods to remove chub over a multiple-year timeframe.

Portions of the indirect effects of Alternatives 2 and 3 would be identical to each other, and are considered to be beneficial effects. Following chemical treatment and complete removal of tui chub, the lake would be left fishless for a period of time. During this time, the lake would refill to full summer pool, and a large portion of the former benthic diversity and abundance that was present prior to the establishment of tui chub would return. The areas of exposed shoreline, including areas where gravel was added for low-water access, are likely to be quickly recolonized by recovering benthic populations. In addition, high levels of nutrients originating from decaying aquatic organisms (zooplankton and benthic organisms) and fish carcasses missed during carcass recovery efforts would also fuel a relatively rapid recovery. In numerous studies cited in Bradbury (1986), populations of benthic organisms returned relatively rapidly following removal of various fish species using rotenone. Based on benthic population recovery following rotenone treatment in Diamond Lake in 1954, it is estimated that virtually all of the major benthic groups that were present in substantial numbers prior to tui chub establishment would again return to Diamond Lake following rotenone treatment. However, if monitoring reveals that benthic population and species diversity recovery are not occurring naturally, recovery would be facilitated by adding benthic organisms from appropriate sources.

The indirect effects of Alternative 2 would differ slightly from those of Alternative 3 with respect to fish stocking. While each alternative proposes the complete removal of tui chub, Alternative 2 proposes to restock the lake with rainbow trout fingerlings. The size and number of fish stocked would have an influence on benthic invertebrate populations. Since juvenile salmonids often shift from a diet dominated by zooplankton to one with a larger component of aquatic invertebrates when trout reach a length of around 2¾ inches (7 cm), these fish would immediately begin to prey upon zooplankton and benthic organisms. Based upon past fingerling stocking and benthic production data in Diamond Lake, the stocking of 50,000 to 150,000 fingerling rainbow trout under Alternative 2 would not be expected to dramatically affect those invertebrate populations. Over time, benthic invertebrate indices would be developed from extensive annual monitoring of those populations in order to help define a fish stocking regime that would not significantly impair benthic invertebrate populations[102].

Alternative 3 proposes to restock Diamond Lake with a large number of domesticated rainbow trout. These highly domesticated fish would not be expected to prey significantly on

[102] Eilers (2003a) created an ecologically based index for guiding salmonid-stocking decisions in Diamond Lake.

available food organisms like benthic invertebrates, and would not be expected to survive through the winter months. In the absence of substantial fish predation, populations of benthic invertebrates would be expected to recover to near pre-fish levels.

Connected Actions:
Dock cleanup activities proposed by the Diamond Lake Resort and described as connected actions for Alternatives 2 and 3 in Chapter 2, would have no direct, indirect, or cumulative impacts to benthic organisms. Impacts are not expected because of the small size and lack of in-water work associated with these activities.

Cumulative Effects:
The 1954 rotenone treatment and past, present, and future fish stocking strategies are the primary management activities that contribute to a potential cumulative effect on benthic populations (as detailed in Tables 9- 11). However, given the existing suppressed populations of benthos, the relative contributions of these potential cumulative management activities to future benthic populations are considered to be minor. The cumulative effect of Alternative 1 would be severely truncated benthic invertebrate populations for years to come. Large populations of tui chub would continue to consume the majority of aquatic invertebrates produced in the lake. In addition, poor water quality conditions would continue, further limiting the size and diversity of the benthic organism populations in the future.

Alternative 2 would result in a long-term cumulative improvement in benthic invertebrate species diversity and total abundance. The complete eradication of tui chub along with water quality improvements associated with chub removal, and an ecological approach to trout stocking would likely result in a dramatic improvement in benthic populations, diversity, and numbers when compared to the existing condition. Past evidence in Diamond Lake indicates that benthic populations rebounded strongly following the rotenone treatment in 1954 (Figure 30).

Alternative 2 represents a short-term contribution to the negative cumulative effect of management on benthic organisms, with a predicted long-term beneficial impact. Future fish stocking strategies under this alternative would have increased cumulative impacts on benthic organisms, but due to the proposed monitoring and adaptive management, consequences of these impacts to this aquatic resource are considered to be minor and short in duration given that stocking will be managed to minimize impacts.

Alternative 3 would likely result in the largest improvements to benthic organism population of the alternatives. The combination of chub eradication and stocking with domesticated rainbow trout would essentially remove any significant fish predation on those organisms. As a result, benthic invertebrate populations would be expected to flourish. The lack of predation coupled with water quality improvements and inherent species resilience would lead to an invertebrate population that is somewhat similar to that believed to be present prior to the introduction of fish. The historic occurrence of large hatches of mayflies, caddisflies, midges, mosquitoes, dragonflies, and damselflies during the spring and summer months would likely return over time. Thus, Alternative 3 only differs from Alternative 2 in that its potential contribution to cumulative effects is further reduced by stocking with fish not expected to prey heavily on benthic organisms.

Alternative 4 represents the alternative with the greatest amount of uncertainty regarding affects to the aquatic community. This alternative would attempt to remove roughly 85-95% of the reproductive age chub from Diamond Lake on an annual basis for 6 years. If successful, the end result would be a much smaller population of tui chub that is considered manageable by stocking of piscivorous fish to control them. Assuming this alternative is successful at dramatically reducing tui chub populations, it is likely that benthic invertebrate populations would respond in a positive manner. There would be a decrease in benthic predation by tui chubs, along with an increase in benthic predation by salmonids. The total number of tui chub predicted in Diamond Lake following treatment is unknown, but is anticipated to be significantly less than the current population of tui chub. There is a risk that the process of adjusting salmonid stocking regimes in response to changes in aquatic invertebrate indices may have little effect in terms of stabilizing those populations. Since tui chub are able to out-compete trout for food in Diamond Lake, the continued presence of a variable tui chub population is likely to result in continued suppression of benthic organism populations in the lake. Given the long-term delay before impacts to benthic organisms would potentially subside and the risk that improvements may not even occur, Alternative 4 is expected to result in continued cumulative effects to benthic organisms. These cumulative effects would occur for at least six years and would likely continue indefinitely into the future.

TRIBUTARY STREAMS AND LAKE CREEK

Direct, Indirect, and Cumulative Effects:
Alternatives 1 and 4 would have no direct effect on benthic organism populations in tributary streams or Lake Creek because no treatments would occur to these streams in these alternatives. In addition, based upon macroinvertebrate sampling data, there have been no detectable impacts to benthic organisms to date in Lake Creek resulting from the existing, poor water quality conditions in Diamond Lake. Therefore, no indirect or cumulative impacts to Lake Creek invertebrate communities would be expected under Alternatives 1 and 4 as a result of existing or future water quality conditions under either alternative. However, there is the possibility of small indirect and cumulative impacts to benthic populations resulting from tui chub predation as a result of these alternatives.

The direct effects of Alternatives 2 and 3 would be a short-term, dramatic decline in benthic organisms below rotenone drip stations in Short and Silent Creeks. However, the rotenone drip stations would actually be located on the area of these streams that flow through the drawn down portion of the de-watered lake bed.

Benthic populations in Lake Creek would also experience a dramatic decline. This decline would result from the extended duration of high flows, followed by a period of no or extremely low flows in all or portions of Lake Creek. No rotenone would be released into Lake Creek.

An indirect result of extended high flows in Lake Creek associated with Alternatives 2 and 3, is an increase in habitat complexity and the amount of pool habitat in that stream. This would likely result in an increase in the diversity and abundance of benthic organisms as they take advantage of this new habitat.

From a cumulative perspective, this increase in habitat during the draw down would only last for several years. As physical habitat in Lake Creek returns to the relatively simplified pre-draw down conditions (i.e. pools fill in), the benthic organism community size and structure is also likely to return to one representative of a stable, simple-habitat stream channel. The 1954 rotenone treatment and associated activities, and fish stocking are the primary activities contributing to a cumulative effect. Based on the recovery of the benthos following the 1954 treatment and the long-term neutral impacts to habitat, cumulative impacts associated with Alternatives 2 and 3 are expected to have minor consequences to benthic organisms in Lake Creek.

LEMOLO LAKE

Direct, Indirect, and Cumulative Effects:

None of the alternatives are likely to result in direct effects to benthic communities in Lemolo Lake. Under Alternatives 2 and 3, this is primarily due to the fact that no chemicals would be added to Lemolo Lake, and the draw down of Diamond Lake would occur gradually during the fall, winter, and early spring months during a period of low biological activity. Under Alternatives 1 and 4, none of the associated activities would be experienced as far downstream as Lemolo. Therefore, no direct effects would occur in Lemolo from any of the alternatives.

From an indirect and cumulative effects standpoint, Alternatives 1 and 4 may result in minor beneficial impacts to benthic communities in Lemolo Lake as a result of continued inputs of nitrogen enriched waters flowing out of Diamond Lake via Lake Creek. This nutrient enriched water is currently resulting in increased algal productivity in the warmer surface waters of Lemolo Lake, and would continue to do so over time. The combination of increased algal production and cool, well oxygenated waters near the bottom of the reservoir would likely result in the production and maintenance of moderate to large populations of benthic organisms (relative to the potential in Lemolo Lake in the absence of additional nutrients)[103].

Alternatives 2 and 3 would likely result in a general long-term decrease in the amount of nitrogen enriched water coming out of Diamond Lake. This reduction in nitrogen may result in small decreases in algal production, and consequently, reductions in benthic production as well[104]. The indirect effects of Alternative 2 and 3 are small and not considered substantial enough to lead to a cumulative effect on aquatic invertebrates in Lemolo Lake.

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK):

Direct, Indirect, and Cumulative Effects:

[103] The extent of these increases is difficult to quantify due to other controlling factors, such as the species of phytoplankton dominating the reservoir, the extent of fish predation on benthic populations, the extent of fish stocking, and other environmental conditions.

[104] The extent of these reductions is difficult to quantify due to other controlling factors, such as the species of phytoplankton dominating the reservoir, the extent of fish predation on benthic populations, the extent of fish stocking, and other environmental conditions.

None of the alternatives are likely to result in direct effects to benthic communities in the North Umpqua River below Lemolo Lake. This is primarily due to the fact that no chemicals would enter Lake Creek, Lemolo, or the North Umpqua River, and the draw down of Diamond Lake would occur gradually during the fall, winter, and early spring months during a period of low biological activity. No direct effects would occur under Alternatives 1 and 4 because the conditions or activities associated with these alternatives would not be experienced as far downstream as this section of the North Umpqua River.

Under Alternatives 1 and 4, indirect impacts to benthic populations in the North Umpqua River downstream of Lemolo Lake are unlikely due to the rapid biological uptake of nutrients in Lemolo. The cumulative nutrient impacts potentially associated with these alternatives, timber harvest and other activities in the upper North Umpqua River area (e.g. fish stocking, fishing, fuels reduction projects, horse camping, and use of dispersed recreation sites) may be contributing to slight impacts to benthic communities downstream of Lemolo. These impacts are evident as shifts in benthic organism communities that have likely developed to take advantage of increased algal production in certain downstream areas (Anderson 1998). The extent of Diamond Lake's relative contribution to this situation has not been quantified.

Alternatives 2 and 3 are not likely to indirectly impact benthic populations in the North Umpqua River downstream of Lemolo Lake. This is primarily due to the fact that no chemicals would enter Lake Creek, Lemolo, or the North Umpqua River, and the draw down of Diamond Lake would occur gradually during the fall, winter, and early spring months during a period of low biological activity. From a cumulative impact standpoint, however, the long-term decrease in nitrogen inputs originating from Diamond Lake may result in decreased algal production in downstream areas such as the North Umpqua River. Should this occur, benthic populations in these areas may shift slightly, moving back towards an assemblage more representative of the natural, nutrient-limited river system.

Conclusions and ACS Consistency:

Based on the above discussions, Alternative 1 would result in continued suppression of benthic organism populations in Diamond Lake in the short and long-term (Table 21), and it would prevent attainment of Aquatic Conservation Strategy Objective 9[105]. Benthic populations downstream in Lake Creek, Lemolo Lake, and the North Umpqua River would likely remain unchanged. Alternatives 2 and 3 would likely result in immediate reductions in benthic organism populations due to the addition of rotenone. However, these population declines would be short-term, and not expected to last for more than a few months. The three action alternatives would result in varying levels of benthic organism recovery in the short and long-term, and would not prevent attainment of ACS Objective 9. Alternatives 2 and 3 that propose to completely remove tui chub are more likely to achieve desired benthic organism population recovery suitable to partially support stocked salmonids. Alternative 4, which does not completely eradicate tui chub, may be the least effective of the action alternatives at movement toward ACS objectives, due to the potential for continued expansion of the

[105] ACS Objective 9 – Maintain and restore habitat to support well-distributed populations of native plant, invertebrate and vertebrate riparian-dependent species.

remaining tui chub population, and uncertainty regarding the efficacy of mechanical methods to remove chub over a multiple-year timeframe. Also in the long-term, alternatives that result in the most robust populations of benthic organisms (in terms of species diversity and abundance) are likely to provide the greatest contribution to aquatic ecosystem recovery.

In summary, based on the ecological role of benthic organism, the relative ACS ranking of each alternative would be as follows (from best to worst):

Alternative 3 – Most effective at moving toward attainment of ACS objectives
Alternative 2 – Effective at moving toward attainment of ACS objectives
Alternative 4 – Least effective at moving toward attainment of ACS objectives
Alternative 1 – Retards attainment of ACS objectives

Table 21. Summary of Alternative Effects on Benthic Organism Populations.

Factor	Alternative 1 – No Action	Alternative 2 – rotenone & put- grow- take fishery	Alternative 3 – rotenone & put and take fishery	Alternative 4 – mechanical & biological control of chub
Benthic Organism Production	Benthic organism production would continue to be suppressed by high predation from tui chub, and poor water quality conditions.	Benthic organism production would increase dramatically due to increasing water quality and relatively light predation from stocked fingerling trout.	Benthic organism production would increase dramatically due to increasing water quality and virtually no predation from highly domesticated stocked fish.	Benthic organism production would continue to be suppressed by high predation from tui chub, and poor water quality conditions.
Benthic Organism Species Diversity	Benthic organism communities would remain simplified, and dominated by species that are tolerant of high predation and poor water quality conditions.	In the presence of improving water quality, and relatively light predation, benthic organism communities would likely regain their former complexity over time.	In the presence of improving water quality, and virtually no predation, benthic organism communities would likely regain their former complexity over time.	Benthic organism communities would remain simplified, and dominated by species that are tolerant of poor water quality conditions.

Fish and Fish Habitat

This section focuses on information pertaining to the issues of fish stocking, the role fish play in water quality, fish habitat, and non-target species. Scoping identified a concern that past and proposed fish stocking in Diamond Lake may negatively affect water quality and that different fish species might serve as more effective predators against tui chub. This issue is tracked in this section by displaying alternative fish stocking strategies, the expected effects of the stocking strategies on tui chub, and how fish indirectly affect water quality through modifications of the aquatic food chain.

There was also a concern raised during scoping over the effects of a rotenone treatment on fish downstream of the project area (non-target species). This issue is tracked under the titles Lake Creek, Lemolo Lake, and the North Umpqua River in this section.

Two other issues, effects on indigenous fish and likelihood of tui chub reintroductions are addressed in this section under the title potential cumulative effects common to all alternatives in this section.

Finally, this section includes a discussion of the effect to the riparian environments of Short and Silent Creeks and Diamond Lake with respect to Umpqua Forest Plan prescriptions C2-I and C2-IV. These prescriptions states that no pesticide use is permitted in riparian units. A site-specific Forest Plan amendment is proposed in this DEIS to allow the one-time use of rotenone within these riparian units of Silent and Short Creeks and Diamond Lake itself. The disclosure of the effects of implementing this is covered under this section.

AFFECTED ENVIRONMENT

Historically, all waters above Toketee Falls, located roughly 28 miles downstream from Diamond Lake on the North Umpqua River, were believed to be naturally fishless (USDA 1998). Therefore, Diamond Lake and its tributaries were also likely fishless (USDA 1998). It is likely that numerous large waterfalls on the upper North Umpqua River (i.e. Lemolo Falls, Toketee Falls, and others) would have blocked the upstream migration of fish from the lower areas of the basin. As reported in the Lemolo and Diamond Lake Watershed Analysis (USDA, 1998), if fish had made it upstream past Toketee and Lemolo Falls and successfully established populations, they would have had to endure several periods of glacial activity and periodic pyroclastic[106] ash flows from Mt. Mazama to have survived to current times. No record of fish in Diamond Lake or the surrounding streams prior to stocking with trout (circa 1910) by the Oregon Department of Fish and Wildlife has been found (ODFW 1996).

Oregon Coast coho salmon, a federally listed threatened species under the Endangered Species Act, are present in the North Umpqua River subbasin. The nearest habitat for coho salmon is below Soda Springs dam, which is located approximately 33 miles downstream from Diamond Lake, 23 miles downstream of Lemolo Lake, and 5 miles downstream of Toketee Reservoir. Umpqua River cutthroat trout, Oregon Coast Chinook salmon and the Umpqua chub are on the USDA Forest Service Region 6 sensitive species list[107]. The nearest habitat for cutthroat trout and Chinook salmon is also located below Soda Springs dam. The nearest habitat for the Umpqua chub is located approximately 105 miles downstream, in the main stem Umpqua River.

SILENT AND SHORT CREEKS

Of the six named tributaries to Diamond Lake, only Silent and Short Creeks (Figure 4, in Chapter 1) are believed to be capable of supporting fish populations. The other streams are considered to be too small, or are intermittent, and would not be capable of supporting fish. Anecdotal observations have indicated that small numbers of tui chub and rainbow trout periodically enter the lower segment of Silent Creek from Diamond Lake. However, cold water temperatures (40˚to 45˚F) found year round likely limit the stream's use by fish. Results from a recent habitat inventory conducted in Silent Creek in 1997 support this assessment. During the entire 1.8 mile survey, only one fish (a rainbow trout) was seen by experienced snorkel surveyors looking for fish.

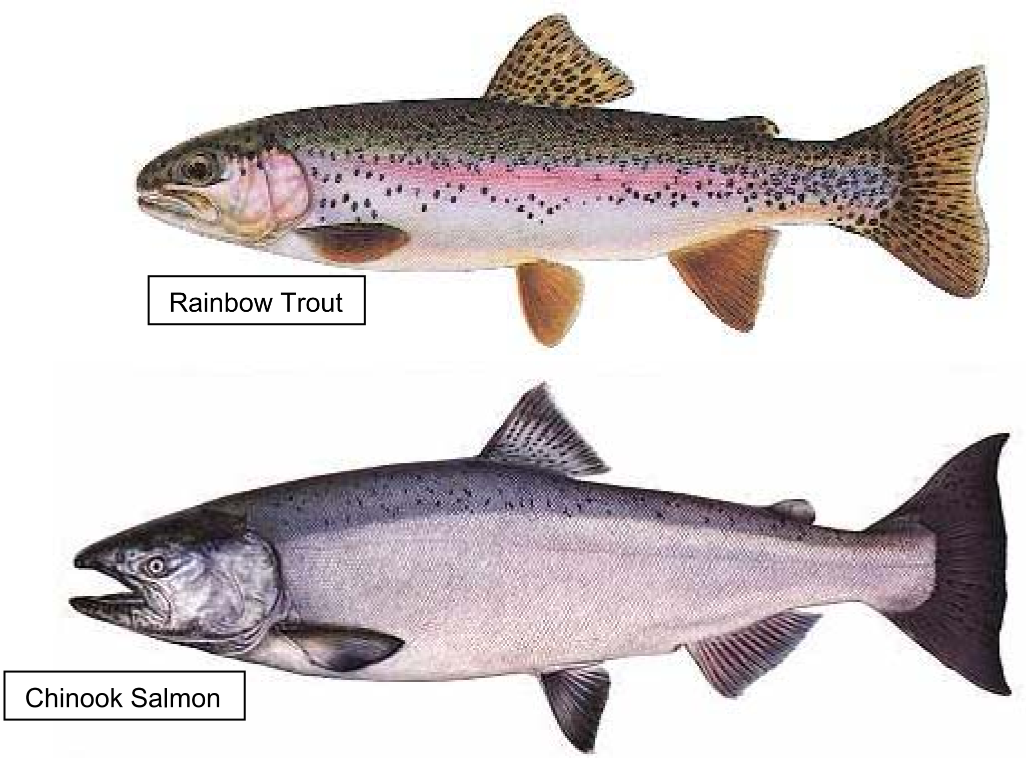
[106] Resulting from volcanic eruption.
[107] Sensitive species are managed by the Forest Service to prevent the likelihood that these species would need to be listed under the Endangered Species Act.

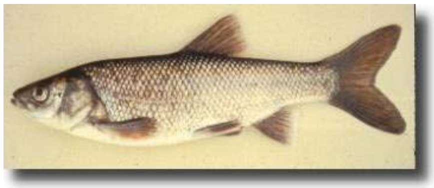
The 1947 Diamond Lake Study prepared by the Oregon State Game Commission reported that the mouths of Silent Creek and Short Creek were closed to angling until July 15th in order to protect spawning fish. During this time, trout would concentrate in these areas before and after spawning, and would be highly vulnerable to angling.

Silent Creek is a relatively short stream (approximately 1.8 miles long) with stable flows due to the spring fed nature of the headwaters. Sediments in this stream are primarily comprised of fine, highly angular sands, and small pumice gravels. Recent spawning surveys conducted in Silent Creek during the spring of 2003 detected no fish, but numerous redds (gravel nests) within the lower 0.7 mile stretch of stream channel. The redds were relatively large and were likely constructed by fish greater than 15 inches in length. However, the success of this spawning activity is believed to be low due to high egg mortality. Fine, angular sands (observed in all redds) can abrade eggs and limit intragravel flow of oxygenated water to the eggs. In addition, consistently cold water in Silent Creek would result in a prolonged incubation period for fish eggs within the streambed. No redds were observed in Short Creek during these surveys (C. Street, personal communication, 2003).

DIAMOND LAKE

Currently, rainbow trout, spring chinook salmon, tui chub, and golden shiner are found in Diamond Lake (Figure 31).




Tui chub

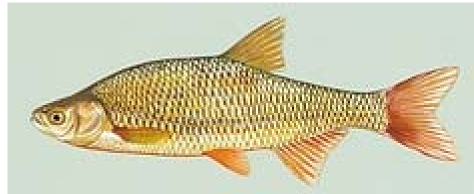

Golden Shiner

Figure 31. Fish species currently in Diamond Lake.

Salmonid Spawning Habitat
Salmonid reproduction in Diamond Lake proper does occur, but it is believed to be limited (Locke 1947; Loomis, personal communication, 2003). Rainbow trout have repeatedly been observed spawning on a gravel shoal area on the northeast shore of the lake, but few efforts[108] have been made to investigate the relative success of this spawning.

Overall, there are very few areas in the littoral zone[109] that have gravel substrates suitable for salmonid spawning. In addition, the high productivity of the lake has resulted in bottom substrates that are covered by layers of silt and organic detritus. Even if the salmonid population in Diamond Lake was prone to margin spawning in lake environments, it is likely that the success of this spawning would be limited by the lack of habitat and the relatively poor quality of this habitat.

Tui Chub Spawning Habitat
Diamond Lake provides ample habitat for successful tui chub reproduction. As cited in Bird (1975), Kimsey found that tui chub must spawn upon vegetation and away from the influence of the bottom muck in order for their eggs to survive. The littoral zone of Diamond Lake supports a robust population of emergent aquatic vegetation, especially at the southern and northwestern ends (Eilers 2003d). Roughly 35-40% of the lake's surface area supports populations of emergent aquatic vegetation. In addition, the relatively warm waters of Diamond Lake are also conducive to successful chub spawning.

Rearing Habitat
Recent studies looking at sediments in Diamond Lake (Eilers 2001b) suggest that the lake has always been relatively productive in terms of nutrients and primary production, but that overall productivity has increased substantially following the introduction of fish[110].

This naturally high productivity is one of the primary reasons why trout stocking in the lake has been so successful over the years. The high productivity results in large amounts of

[108] Locke (1947) placed fertilized trout eggs in wire screen baskets containing gravel, and then placed those baskets at varying depths along the gravel shoal in the northeast corner of the lake. He found live fry at each of the depths tested, and determined that successful spawning could occur in the lake.
[109] The littoral zone is the relatively shallow near-shore area.
[110] Sediment accumulation rates (SAR) have increased substantially since fish were introduced. The periods of greatest SAR increases coincide with the periods when tui chub populations were very large in the lake.

phytoplankton, which in turn fueled a healthy, diverse population of larger zooplankton and aquatic insects. When fish were added into this pre-existing food web, they quickly took advantage of the abundant food source. When trout were the dominant fish in the lake, Diamond Lake was renowned for its ability to produce large fish in only one year. It was not uncommon for the 3-4 inch fish, typically stocked in June, to grow to lengths of 12-14 inches by the following June or July. This put-grow-and take fishery gained a large following, eventually providing one of the largest recreational fisheries in the state of Oregon (ODFW 1996). Juvenile tui chub generally utilize the same food resources as salmonids and thus were also able to thrive in habitat provided by Diamond Lake.

Current habitat conditions are not considered optimal for fish or other aquatic life. As mentioned in the Water Quality section, in the summer months Diamond Lake routinely experiences pH values in violation of State standards, depletion of dissolved oxygen in deeper portions of the lake, and large blooms of toxic blue-green algae. These conditions result in depressed populations of zooplankton and benthic organisms, which are the primary prey items for fish in the lake.

Past Management History (1910 to 1954)

Rainbow trout of Spencer Creek origin (Klamath basin) were first put into Diamond Lake in 1910 (ODFW 1996). Annual stocking efforts[111] were necessary in order to sustain the fish population due to limited natural fish reproduction in the lake and its tributaries (USDA 1998). Excellent trout fishing was reported by the early twenties, with six to eight pound trout common, and a reported record trout of 27½ pounds (Locke 1947). Rainbow trout were stocked into Diamond Lake at increasing levels up until 1946, when the numbers of fish began to be reduced. Table 22 displays rainbow trout stocking data for Diamond Lake through 1954.

[111] This stocking was so successful that an egg-taking facility was established in 1919 by the Oregon Fish Commission. This station operated for 33 years, utilizing rainbow trout eggs to restock the lake and as a supply source for other hatcheries.

Table 22. Early stocking in Diamond Lake (ODFW,1996a).

Diamond Lake Fish Stocking Data from 1910 through 1954			
Date	**Strain**	**Number Stocked/yr.**	**Size**
1910-1938	Spencer Creek	1.0 million	fry (1 inch, 2.5 cm)
1938-1945	Spencer Creek	2.0 million	fry
1946	Spencer Creek	4.0 million	fry
1947	Spencer Creek	3.3 million	fry
1948	Spencer Creek	2.0 million	fry
1949		None	
1950	Spencer Creek	49,000	Legal sized
1951	Spencer Creek	47,000	Legal sized
1952	Spencer Creek	49,000	Legal sized
1953	Spencer Creek	32,000	Legal sized
1954		None	

Sometime in the 1940's tui chub, a minnow native to the Klamath basin, was introduced into Diamond Lake. Most local fisheries professionals believe these fish were introduced by an unwitting fisherman who had been using them as live bait, and dumped the remaining bait overboard at the end of the day. However, there are several other possibilities[112].

By 1946, the decline in angling success, decreasing size of rainbow trout, and drop in fishing pressure triggered a preliminary biological investigation of Diamond Lake. This study found populations of rainbow trout, brown trout, and tui chub present in the lake (Locke 1947). It is important to note that brown trout were likely present in Diamond Lake at the time when tui chub were first introduced. Although these fish were not routinely taken in the recreational fishery, Locke (1947) reported that three overnight gillnet sets in October of 1946 resulted in the capture of five brown trout weighing from 1.5 to 7 pounds (0.7 to 3.2 kgs). In comparison, 15 rainbow trout, ranging from 1.5 to 3.5 pounds (0.7 to 1.6 kgs), were also caught in these same gillnet sets. An additional 30 brown trout were collected in upper Lake Creek through angling and use of poison. Brown trout are known to be voracious predators, often feeding primarily on other small fish if they are available. While there is no direct evidence to confirm that the brown trout in Diamond Lake preyed upon the tui chub, it is highly likely that the chub would have provided an ample food source for these aggressive fish. However, these trout were apparently not able to keep the rapidly expanding chub population in check.

By 1946, enormous schools of tui chub were beginning to show up in the shallow shoreline waters. Efforts to control the tui chub population included seining and partial chemical treatment in the shallow areas of the lake where they were observed spawning. These methods are believed to have eliminated over 68 million chub between 1946 and 1950, but the tui chub continued to flourish while rainbow trout populations continued to decline

[112] Based on the biology of the tui chub, and its presence in many other lakes within a one hour drive radius of Diamond Lake, it is also possible that these fish were accidentally transported to the lake as eggs attached to aquatic weeds, or perhaps larvae or small juveniles trapped in bilge water, or live wells (Frank Bird, personal communication). Regardless of the source, the tui chub population grew quickly while the rainbow trout population and angling pressure declined.

(ODFW 1996). In 1954 the entire lake was treated with rotenone to eliminate all fish. The biologist coordinating the operation estimated that 32 million tui chub were killed, or around 400 tons of fish representing a complete fish kill.

One year after this treatment, a spring-spawning strain of rainbow trout originating from British Columbia, Canada (the Kamloops stock) was introduced into the lake. Although not native to Oregon, it was presumed that this "pure" stock (i.e. not mixed with other strains of rainbow) would perform better than stocks used previously in the lake (ODFW, 1996). However, stocking of Kamloops rainbow was discontinued after 1961 due to their relatively low fry-to-adult survival, and their poor body condition in the spring when the fishing season opened (during and immediately after the trout spawning season).

From 1962 through 1969 a mixed stock[113] of rainbow trout was used in Diamond Lake. These trout originated from Oregon in the Willamette River, the Roaring River, and Oak Springs areas. Stocked as fingerlings in June, these fish had an exceptional survival rate, with approximately 70% surviving to a catchable size. A typical 3 inch (7.6 cm) fingerling stocked in June would grow to a 12 to 14 inch (30.5 to 35.6 cm) fish by the following summer. From 1962 to 1990, roughly 400,000 fingerlings (primarily Oak Springs strain) were stocked on an annual basis. Table 23 below displays fish stocking data from 1955-1990.

Table 23. Diamond Lake Fish Stocking Data from 1955-1990.

Date	Strain	Number Stocked	Size
1955	Kamloops	530,000	Fry (1 inch)
1956	Kamloops	250,000	Fry
1957	Kamloops	300,000	Fry
1958	Kamloops	1,014,000	Fry
1959	Kamloops	1,000,000	Fry
1960	Kamloops	1,063,000	Fry
1961	Kamloops	1,175,000	Fry
1962-1969	Mixed Strain	400,000-500,000	Fingerlings (3 inches)
1970-1990	Oak Springs	300,000-400,000	Fingerlings

Recent Management History

In the recent past, Diamond Lake has been managed under a formal management plan that was adopted in 1990 by the Oregon Fish and Wildlife Commission. This management plan includes the objectives of 100,000 angler trips[114] per year, harvest of 2.7 fish per angler trip (or 270,000 trout), with an average fish length of 12 inches (30.5 cm). It is important to note that these figures were developed from data collected during the peak of Diamond Lake's angling success, 1963 to 1978 (see recreation section for annual angler trips over time).

In 1992, tui chub were discovered again in Diamond Lake. As tui chub populations expanded exponentially, the success of the fingerling rainbow trout stocking program at the lake began

[113] Unlike the majority of other rainbow trout stocks that tend to spawn in the spring, these stocks were developed to spawn in the fall. As a result, juveniles of this fall spawning stock were able to attain a larger size than their spring-spawning counterparts by the time they were stocked in the various lake systems (Loomis, personal communication).
[114] An angler trip is defined as a person angling for any period during a day

to decline substantially (ODFW, 1996). This situation closely paralleled the fishing declines seen in the early 1950's, when tui chub were first introduced into Diamond Lake.

Current Conditions
Based on hydroacoustic surveys[115] and trap netting data over the last several years, the estimated yearly tui chub population from 1995 to 2003 has averaged around 7.6 million chub greater than 2½ inches (>6.4 cm.) in length with a range of 1.7 to 23.7 million (Loomis and Eilers, personal communication). Based upon life history and fecundity tables generated by Bird (1975) and population modeling by ODFW (Jackson and Loomis 2004), the large average population of spawning-age tui chub in Diamond Lake would be capable of producing approximately 6.9 billion eggs in a single year. In addition, during this same time frame, there was also an estimated average of 94.5 million tui chub in younger age classes present in Diamond Lake on an annual basis. These fish represent young-of-the-year, 1 year, and 2 year old fish, ranging in size from ¼ to 2½ inches (6 to 65 mm) in length. As Bird (1975) indicated in his work with tui chub, the food preferences of tui chub and trout in lake environments are very similar. Therefore, tui chub and stocked rainbow trout are in direct competition for available food resources in Diamond Lake.

The population of tui chub in Diamond Lake is currently exhibiting characteristics of a stressed population. The number of larger chub greater than 6 inches (>15.2 cm) is declining, and the number of fish considered to be in the catchable size range using nets (greater than 2.5 inches or 6.4 cm) has also declined recently. The age and size when sexual maturity is reached has also likely declined. In summary, this is an indication that population stressors have resulted in more fish spawning at younger ages and smaller sizes.

The actual number of chub present in any given year is dependant upon a number of factors, including food availability, competition, weather, water quality conditions, over-winter survival, and overall habitat limitations induced by the large size of the chub population as a whole. While the chub population in Diamond Lake is variable from year to year, there is virtually no chance that the entire population would crash naturally, thereby eliminating tui chub from the lake. As chub populations decline as a result of natural causes, previously utilized food and habitat resources become available, thereby increasing the growth and productivity of the remaining chub. As these remaining fish grow larger, they are also able to produce a greater number of eggs, ultimately leading to more tui chub. Therefore, due to the cyclic nature (i.e. rise and fall) of the population, tui chub are likely to persist in Diamond Lake indefinitely without some form of management intervention.

Based on the inability of Diamond Lake to meet formal management plan basic yield fish numbers, ODFW is currently managing Diamond Lake using modified fish management guidelines. For the last several years, stocking of fingerling rainbow trout has been dramatically reduced due to their poor survival, and stocking of legal size rainbow trout and other experimental species has been initiated. While this strategy provides a small recreational fishery, it is viewed as a temporary measure due to the high cost. Recent efforts to identify a salmonid that can successfully compete with or prey upon tui chub in Diamond Lake has led to an increasingly complicated experimental stocking program (Table 24).

[115] Hydroacoustic surveys utilize high frequency sound waves to identify bottom features, fish, aquatic vegetation, and zooplankton within waterbodies. These surveys are capable of estimating fish numbers and the relative sizes of fish.

As an example: In 2003, Diamond Lake opened for trout fishing on April 26, and a total of nearly 100,000 legal-sized fish were stocked periodically throughout the fishing season. Of these fish, roughly 60,000 were catchable-sized hatchery spring chinook, approximately 24,000 were catchable-sized Eagle Lake rainbow trout (sterile triploid stock), and 15,000 were two-pound (0.9 kg) Kamloops rainbow trout. In addition to catchable-sized fish, 50,000 Oak Springs rainbow trout fingerlings and 40,000 spring Chinook fingerlings were also stocked. This fish stocking cost approximately $184,000. Table 24 below displays recent fish stocking data associated with the experimental stocking program.

Table 24. Recent fish stocking information for Diamond Lake.

Diamond Lake Fish Stocking Data from 1991-2003			
Date	**Strain**	**Number Stocked**	**Size**
1991	Oak Springs rainbow	350,000	Fingerlings
1992	Oak Springs rainbow	425,000	Fingerlings
	Cape Cod rainbow	5,000	Legal sized
1993	Oak Springs rainbow	350,000	Fingerlings
	Cape Cod rainbow	14,000	Legal sized
1994	Oak Springs rainbow	425,000	Fingerlings
	Cape Cod rainbow	5,000	Legal sized
1995	Oak Springs rainbow	400,000	Fingerlings
	Cape Cod rainbow	7,500	Legal sized
	Williamson rainbow	12,000	Fingerlings
1996	Oak Springs rainbow	350,000	Fingerlings
	Cape Cod rainbow	10,000	Legal sized
1997	Oak Springs rainbow	350,000	Fingerlings
	Cape Cod rainbow	7,700	Legal sized
	Williamson rainbow	50,000	Fingerlings
1998	Oak Springs rainbow	345,000	Fingerlings
	Cape Cod rainbow	7,500	Legal sized
	Williamson rainbow	50,000	Fingerlings
1999	Oak Springs rainbow	380,000	Fingerlings
	Cape Cod rainbow	8,000	Legal sized
	Williamson rainbow	50,000	Fingerlings
	Kamloops rainbow	5,000	Trophy sized
2000	Oak Springs rainbow	60,000	Fingerlings
	Cape Cod rainbow	38,000	Legal sized
	Kamloops rainbow	15,000	Trophy sized
2001	Oak Springs rainbow	50,000	Fingerlings
	Cape Cod rainbow	31,000	Legal sized
	Kamloops rainbow	15,000	Trophy sized
2002	Oak Springs rainbow	50,000	Fingerlings
	Cape Cod rainbow	26,000	Legal sized
	Spring Chinook salmon	40,000	Fingerlings
	Spring Chinook salmon	24,000	Legal sized
	Kamloops rainbow	15,000	Trophy sized

Diamond Lake Fish Stocking Data from 1991-2003			
Date	**Strain**	**Number Stocked**	**Size**
2003	Oak Springs rainbow	50,000	Fingerlings
	Spring Chinook salmon	40,000	Fingerlings
	Spring Chinook salmon	60,000	Legal sized
	Kamloops rainbow	15,000	Trophy sized
	Eagle Lake rainbow	24,000	Legal sized

LAKE CREEK

Lake Creek is the only outlet stream from Diamond Lake. It is approximately 11.6 miles in length and drains into Lemolo Lake. Lake Creek currently supports populations of rainbow trout, brook trout, brown trout, and tui chub. There is also a small component of the kokanee population from Lemolo Lake that enters the lower portion of Lake Creek in the fall to spawn. Formerly, golden shiner were formerly only known to occur in Diamond Lake (USDA, 1998). However, fish trapping efforts in Lake Creek during 2003 documented 16 golden shiner migrating out of Diamond Lake and into Lake Creek.

The existing fish population in Lake Creek is believed to have migrated upstream from Lemolo Lake, and downstream, from Diamond Lake. Lake Creek is capable of supporting successful spawning, and the existing salmonid populations are generally self-sustaining.

Lake Creek was surveyed in 1996 using Forest Service protocols[116]. These surveys indicate that large wood is abundant throughout most of the stream, but there are few deep pools present. The presence of large quantities of wood, but lack of pool habitat is likely the result of the extremely stable stream flow patterns in Lake Creek. As a result, annual stream energy is relatively low, and Lake Creek is not able to scour and maintain large quantities of deep pool habitat. The Diamond Lake and Lemolo Watershed Analysis (1998) indicate that there was no evidence that past lake draw down activities in 1954 destabilized stream banks or aquatic habitat in this system. Lake Creek is considered to be healthy and near its reference condition, with habitat attributes well within the range of natural variability for a stable, lake outlet stream system.

No fish stocking is known to take place in Lake Creek. No estimates of fish population size have been conducted in the eleven mile length of Lake Creek between Diamond Lake and Lemolo Lake. However, there is a modest recreational trout fishery that occurs at either end of this stream, near the respective lake or reservoir water bodies (Loomis, personal communication).

While no population estimate of tui chub in Lake Creek has been made, data collected in 2003 from a fish trap located in Lake Creek near Diamond Lake indicates that large numbers of tui chub enter this system in late spring and early summer. Almost 7,000 tui chub were caught in this trap over the spring and summer months. Since this trap only captures a portion of the

[116] A copy of the Lake Creek stream survey report is located in the Analysis File for this project.

fish moving past it each day, this figure only represents a partial count of chub that outmigrated from Diamond Lake into Lake Creek. Throughout the summer months, chub were observed occupying habitats in slow moving pools and backwater areas of Lake Creek. However, based on the chub's preference for slow water habitat, it is likely that the majority of these fish moved through the system, and into Lemolo Lake. Those chub that remain in Lake Creek are likely washed downstream during the high, cold flows that routinely occur during the spring snowmelt runoff period. The occurrence of large numbers of tui chub leaving Diamond Lake has been observed since 1994 (Loomis, personal communication).

It should be noted that a 6 foot waterfall (human constructed) is located in Lake Creek approximately 1,000 feet downstream from Diamond Lake. This structure likely prevents upstream migration by all fish species inhabiting Lake Creek. This migration barrier was likely constructed as part of the 1954 rotenone treatment in order to prevent tui chub and brown trout from re-entering Diamond Lake. Based on its height, it is highly unlikely that tui chub could ever make it over the falls. This constructed barrier, which is still in stable condition, apparently functions as planned in 1954 and is expected to continue to block upstream tui chub passage in the future.

LEMOLO LAKE

Lemolo Lake was created in 1954 when Lemolo Dam was constructed, damming the North Umpqua River at the confluence of Lake Creek and Poole Creek. Fish management in Lemolo Lake began shortly afterward in 1955. Lemolo Lake currently supports populations of rainbow trout, kokanee salmon, brook trout, brown trout, and tui chub. The kokanee population mainly occurs in Lemolo Lake, entering Lake Creek and the upper North Umpqua River only to spawn.

From 1955 to 1972, various trout were stocked in the lake, until brown trout became the dominant species (DEA, 1998). Today, the majority of the fish population in Lemolo Lake is self sustaining, with naturally spawning populations of brown trout, kokanee salmon, and brook trout[117]. Tui chub are also present in the lake. It is likely that some golden shiner are also present in Lemolo Lake based upon the discovery of shiner migrating out of Diamond Lake.

Currently, Lemolo Lake is primarily managed for brown trout and kokanee salmon, with 10,500 angler trips recorded in 1997 (DEA 1998). Studies of brown trout in Lemolo Lake in 1992 revealed that populations were healthy, attaining a length of 8 inches (20.3 cm) by age 2, and 12 inches (30.5 cm) by age 3 (FERC 1994).

The tui chub population in Lemolo Lake has not expanded as rapidly as the population in Diamond Lake (Loomis, pers. comm. 2003). There are several likely reasons for the apparent inability of the tui chub to dominate Lemolo Lake. With an average depth of around 29 feet (8.8 meters), Lemolo Lake is deeper than Diamond Lake (22.5 ft. average depth, or 6.9 meters), and doesn't contain the large shallow areas that are common at Diamond Lake. In addition, Lemolo Lake is routinely lowered in the winter, exposing the limited shallow areas

[117] Some limited annual stocking of catchable-sized rainbow trout does occur in Lemolo in order to provide a fishery in the late summer months, when brown trout are typically harder to catch (Loomis, personal communication).

to harsh winter conditions. As a result, Lemolo Lake does not contain an abundance of aquatic macrophytes, which are essential to the successful reproduction of tui chub. In addition, the relative amount of warmer surface waters in Lemolo Lake is substantially less than that seen in Diamond Lake. In Lemolo Lake, warmer surface water temperatures usually extended to depths of 9.8 to 16.4 feet (3 to 5 meters) (USDA 1998), whereas in Diamond Lake, warmer surface water temperatures usually extend to depths of around 26.2 feet (8 meters). This relative lack of extensive warm surface waters in Lemolo Lake may also be a potential limiting factor on chub populations. From a predator standpoint, there is a healthy population of brown trout in Lemolo Lake, which may be preying on the tui chub. All of these factors are apparently leading to a relatively stable tui chub population in Lemolo Lake.

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK)

Downstream from Lemolo Lake, the North Umpqua River flows for roughly 16 miles before entering Toketee Reservoir. From Toketee Reservoir, the river flows for another 4.5 miles before entering Soda Springs Reservoir. From Soda Springs, the river flows for another 70 miles before entering the main stem Umpqua River. From Soda Springs Dam, downstream to the confluence with Rock Creek, (a distance of 33.8 miles) the North Umpqua River is classified as a Wild and Scenic River[118].

The portion of the North Umpqua River between Soda Springs Dam and Lemolo Dam is dominated by resident trout. Rainbow trout, brown trout, and brook trout are the primary species living in this section of the river. Rainbow trout found in Fish Creek, and below Toketee Falls are believed to be of local origin. However, all brown trout and brook trout in this area are naturally reproducing descendants of non-native fish stocked in the Umpqua system decades ago.

The majority of this area is characterized by swift flowing segments of river, divided by several reservoirs created for hydropower use. In addition to the larger reservoirs, there are several canal systems and forebays (water holding areas) that also support populations of resident trout. Soda Springs Dam is a complete barrier to upstream fish passage, and consequently, represents the upper extent of anadromous fish in the North Umpqua system.

One of the Outstandingly Remarkable Values (ORV's) that led to the wild and scenic designation is the fishery. This segment of the North Umpqua River (below the hydropower dams) supports populations of summer and winter steelhead trout, spring chinook salmon, coho salmon, resident and migratory cutthroat trout, resident rainbow trout, brown trout, Pacific lamprey, several sculpin species, speckled dace, Umpqua dace, and redside shiner. Other species, such as brook trout and tui chub have been encountered occasionally.

[118]This segment of the North Umpqua River was designated a recreational river under the National Wild and Scenic Rivers Act of 1988. Roseburg BLM manages the lower 8.4 miles and the Forest Service manages the upper 25.4 miles. As defined by the Act, a National Wild and Scenic River must be undammed and must have at least one outstandingly remarkable value (ORV). The established ORV's for the North Umpqua Wild and Scenic River are: fisheries, water quality and quantity, recreation, scenic, and cultural. The underlying principles of the Act are to keep the designated River in a free flowing condition and to recognize the River's importance to our natural and cultural heritage.

However, these fish are believed to be moving through the area from upstream populations due to their small numbers and sporadic presence. It is not likely that tui chub could establish a reproducing population in this portion of the North Umpqua River due the consistently cold water and abundance of fast-water habitat found here.

The North Umpqua River between Soda Springs dam and the confluence with Steamboat Creek is confined and is largely characterized by boulder and bedrock morphology. Channel gradients are predominantly less than 1 percent, with 1 to 2 percent gradients present in a portion of the reach between Soda Springs powerhouse and Boulder Creek. Large boulders and abundant bedrock outcrops create pools and provide channel complexity. From Steamboat Creek downstream to Rock Creek, many reaches contain bedrock ledges divided by a deep trough through which most bedload is carried and stored. More cobble and gravel bars can be found in this reach having a heterogeneous mix, with the median diameter in the cobble range.

Due to the inherent resiliency of the mainstem channel in this reach, the gross appearance (and resultant habitat elements) of the river is likely to be very similar today to what it was in reference conditions (Middle North Umpqua WA, USDA 2001). In brief, the North Umpqua River is considered to be healthy, supporting viable native fish populations and maintaining the outstandingly remarkable values of the river.

ENVIRONMENTAL EFFECTS

BACKGROUND: TOXICITY OF ROTENONE TO FISH

Rotenone's primary toxic action is at the cellular level, where it inhibits the cell's ability to utilize oxygen (Bradbury 1986). The high susceptibility of fish to rotenone is mostly due to its efficient entry through the gills. Once in the bloodstream, rotenone is quickly carried to vital organs (such as the brain), where it inhibits cellular respiration (Oberg 1964 – as cited in Bradbury).

A treatment concentration of 2 mg/L formulated rotenone mixed into the lake water is anticipated to remain toxic long enough to kill most, if not all, of the fish species present in target waters (CDFG 1994). Fish eggs are resistant to rotenone treatments because of an impervious chorion[119] (CDFG 1994), however treatment is proposed in September after all eggs have hatched.

In Diamond Lake, approximately 238,000 pounds of powdered rotenone, and roughly 375 gallons of the liquid formulation Noxfish would be used. The powdered form of rotenone is comprised only of ground plant roots, and therefore only contains rotenone and rotenolone compounds. The chemicals associated with liquid Noxfish® include rotenone, and other inert ingredients that act as emulsifiers and solvents. The four primary inert ingredients include xylene, trichloroethylene, naphthalene, and 2-methylnaphthalene. These inert ingredients make up roughly 85-90% of the liquid formulation, and are considered to be volatile or semi-volatile organic compounds that are expected to evaporate within several weeks. These

[119] The chorion is the outer membrane of an egg or embryo.

chemical compounds do not contribute to the lethality of the formulation, but are important to ensure the solubility and dispersion of rotenone in the water (CDFG, 1994).

SHORT AND SILENT CREEKS

Direct Effects:
With the lack of a lake draw down and no chemical treatment, Alternatives 1 and 4 would have no direct, indirect or cumulative effects to fish or fish habitat in Short or Silent Creeks.

The effects of Alternatives 2 and 3 would be extremely limited as well. The direct effect of the rotenone drip stations proposed for Short and Silent Creeks (located within the actual lake perimeter) would be to render the downstream waters toxic to fish. Any fish present downstream of these sites would likely move down into Diamond Lake upon contact with rotenone treated waters. Based upon the overall lack of fish presence in Short and Silent Creeks, it is unlikely that any fish would be killed or displaced in these areas. Following cessation of rotenone drip stations, aquatic habitat conditions would return to normal within a matter of hours, as the remaining rotenone and the other formulation constituents are flushed downstream into Diamond Lake. All of the chemicals associated with these drip stations would break down and/or evaporate relatively quickly, or be transported to Diamond Lake, where they would evaporate over a relatively short period of time.

As a result of the draw down under Alternatives 2 and 3, aquatic habitat conditions in Silent Creek and Short Creek may change slightly. These changes would include stream channel down-cutting and incision through soft lake bottom sediments as the lake is drawn down by 8 feet. Based upon review of recent aerial photos, evidence of this occurrence appears to be present from the first draw down in the 1950's; a deeper, sinuous channel extending out into the lake is visible on photos and was likely formed during the 1954 draw down of Diamond Lake.

Indirect Effects:
Upon cessation of the rotenone drip stations, rotenone and the other formulation ingredients would be quickly flushed downstream and out of these respective stream systems. It is uncommon to find rotenone in stream sediments (CDFG 1994). The VOC's (volatile organic compounds) do not accumulate in the sediment, and only naphthalene and the methyl napthalenes temporarily (less than 8 weeks) accumulate in the sediments (Finlayson et al. 2000). Rotenone dissipates in flowing waters relatively quickly (less than 24 hours) due to dilution and increased rates of hydrolysis (Finlayson et al. 2000). Based on the continuation of the drip stations for 17 days in these two streams, an estimated total of 375 gallons of liquid rotenone (Noxfish® formulation) would be utilized. All of the chemicals associated with these drip stations would break down and/or evaporate relatively quickly, or be transported to Diamond Lake, where they would evaporate over a short period of time.

Cumulative Effects:
The 1954 draw down is the primary past management activity that impacted these creeks. There are no ongoing or reasonably foreseeable actions that contribute meaningfully to a cumulative effect on these aquatic habitats. For Alternatives 1 and 4, there would be no

actions associated with these alternatives that would contribute to cumulative impacts to aquatic habitat conditions in Silent Creek or Short Creek.

As mentioned above, Alternatives 2 and 3 may result in stream channel downcutting within the perimeter of the lake. Upstream of this point, there was no visible evidence of aquatic habitat change in these streams as a result of the 1950's treatment of Diamond Lake. Recent field review of channel and habitat conditions within the lower portions of these streams indicates that both channels contain adequate substrate and large woody material roughness to prevent significant channel downcutting and incision from migrating in an up-stream direction for more than 0.25 mile. Therefore, no cumulative change would be anticipated as a result of these alternatives in Short and Silent Creeks.

DIAMOND LAKE

Direct Effects:
Alternative 1 would result in status quo management of the fisheries at Diamond Lake. No physical or chemical treatments would occur in the lake. A direct effect to fish from this alternative would be that the Oregon Department of Fish and Wildlife would continue with the existing experimental fish stocking program (~100,000 fish/year).

Alternative 2 would have a direct impact on aquatic habitat conditions and current fish populations in Diamond Lake as a result of the canal reconstruction, lake draw down, mechanical removal of tui chub (netting), the addition of rotenone, and the addition of salmonids back into the lake. Canal reconstruction would result in minor short-term (2-3 week) disturbance and displacement of fish as sediments are removed from the canal and placed in the northwest corner of the lake as part of the wetland expansion. The draw down portion of the proposed action would result in lowering the lake level by 8 feet (2.4 meters). This would result in a 10% reduction in total surface area and a 30% reduction in water volume, and would expose a large percentage of the near-shore zone that supports abundant growth of aquatic vegetation. As the lake is drawn down, tui chub would be forced out of this preferred habitat into interior portions of the lake. In addition, during the draw-down it is likely that numerous tui chub would enter the Lake Creek system, and be transported to downstream areas. In order to minimize tui chub movement out of Diamond Lake, a fish trap would be installed (see mitigation in Chapter 2).

Under Alternative 2, the mechanical removal of tui chub utilizing trap nets and other commercial fishing techniques would likely reduce chub population numbers to some unknown extent. These activities are proposed for a duration of up to one month prior to the application of rotenone. Based upon past chub removal efforts utilizing these techniques and the fact that a large percentage of the existing chub biomass is comprised of fish too small to be effectively netted, this effort would likely result in a low to moderate reduction in total fish biomass in Diamond Lake.

Based upon the results of the rotenone treatment in 1954, the addition of rotenone in the fall would result in the eradication of all fish living in Diamond Lake, Short Creek, and the lower mile of Silent Creek. While the original rotenone treatment in 1954 was apparently successful in removing all tui chub from the lake, it should be noted that some of the literature reviewed indicates that it is rare to kill all fish with a single rotenone treatment (Bradbury 1986). Yet, only one treatment is proposed for Diamond Lake based upon the past success of the single treatment in 1954.

In the spring following rotenone treatment, a relatively small number of trout would be stocked in Diamond Lake. Based on preliminary estimates by ODFW biologists, a range of 50,000 to 150,000 Oak Springs rainbow trout fingerlings, and roughly 10,000 legal-sized Eagle Lake rainbow trout would be stocked. These fish would provide a small recreational fishery while still allowing for recovery of zooplankton and benthic invertebrate populations (the biological indicators).

The direct effects of Alternative 3 would be similar to those of Alternative 2. Alternative 3 differs from Alternative 2 only in the proposed fish stocking regime it would utilize. Under this alternative, up to 400,000 domesticated rainbow trout would be stocked throughout the fishing season in Diamond Lake annually. This would likely provide a large recreational fishery similar to that in the 1970's and 1980's.

The direct effects of Alternative 4 differ substantially from those of the other action alternatives. Alternative 4 does not include the actions of canal reconstruction, lake draw down, chemical treatment, and lake refill. As a result, none of the direct effects associated with those treatment components would apply to Alternative 4. This alternative would result in the direct mechanical removal of a substantial portion of the tui chub biomass from the lake in each of six consecutive years. Mechanical removal methods would have a goal of removing 85-95% of the spawning population of tui chub. Immediately following mechanical chub removal efforts, up to 250,000 predatory salmonids would be stocked in the lake. These fish would be larger-sized Eagle Lake rainbow trout capable of feeding on the remaining tui chub prey base, and would provide a moderate recreational fishery. The extent and effectiveness of chub predation by these fish is unknown.

Although the numbers of fish stocked in Alternatives 3 and 4 are somewhat similar, the recreational fishery under Alternative 4 is expected to be slightly smaller than that under Alternative 3. This difference would be a result of special angler harvest regulations implemented under Alternative 4 that may limit the harvest of large fish in an effort to maintain the predatory controls on the tui chub population[120].

Indirect Effects:
Under Alternative 1, indirect effects on aquatic habitat quality would continue to occur in several areas. In Diamond Lake, the continued presence of a large tui chub population would continue to impact water quality (high pH, low DO, toxic algae blooms), rendering a large portion of the habitat uninhabitable to salmonids during the late spring and summer months.

Continued high levels of algal productivity would likely result in anoxic conditions throughout much of the lake during the spring and summer months, and could result in fish kills under certain environmental conditions. When these large algae blooms produce toxins, it is also possible that fish kills could occur as a result of these toxins (Christoffersen 1996)

[120] Special harvest limits must be approved by the Oregon Fish and Wildlife Commission.

Under Alternative 2, a conservative number of trout would be stocked in the lake once biological indices indicate it is ecologically acceptable to do so. Indirectly, this alternative would result in high growth and survival rates of these stocked fish. The stocked fish are likely to thrive due to the expected recovery of large-bodied zooplankton and other benthic organisms. As a result, a small recreational fishery would likely return to Diamond Lake within a few years. The average fish caught would be of excellent size and body condition due to the abundant forage base and the presence of multiple age classes of trout (resulting in the potential for larger fish being available to the angler).

The indirect effects of Alternative 3 would be similar to those of Alternative 2. The primary difference with this alternative would be the size of the recreational fishery, as well as the condition of the fish caught. Under this scenario, up to 400,000 domesticated rainbow trout would be stocked in the lake throughout the angling season. Based on past experience with this stock, these fish would not be expected to take advantage of the available food resources. As a result, fish would gradually start to lose body condition and size over time until they were caught, or die with the onset of harsher winter conditions. Stocking at these levels would likely provide a large recreational fishery at Diamond Lake. The average fish caught would be of modest size and body condition. Very few of these fish would be expected to survive through the winter or attain larger sizes. Thus large fish would not be a strong component of the recreational fishery under Alternative 3.

Alternative 4 would have a different suite of indirect effects than the other action alternatives due to the lack of a lake draw down, no chemical treatment, and no period of Lake Creek de-watering. Under this alternative, up to 400,000 larger sized, predatory trout would be stocked in the lake. It is anticipated that these larger fish would take advantage of the abundant tui chub food source, and grow to relatively large sizes. Stocking of these large trout would likely result in a moderate recreational fishery returning to the lake, with the potential for anglers to catch trophy sized fish. The potential use of angler harvest restrictions in order to limit the removal of large predatory fish (to maintain a predatory control on the chub) may reduce the desirability of this fishery.

The addition of larger-sized piscivorous trout (Eagle Lake rainbow trout, or brown trout, or Kamloops rainbow trout) under Alternative 3, may result in a further reduction in tui chub numbers as a result of predation. However, preliminary stomach content data from Eagle Lake rainbow trout recently stocked in Diamond Lake indicates that very few tui chub are being consumed by these fish (Loomis, personal communication). Based on information contained in a report by the Oregon State Game Commission (Locke 1947), large brown trout were likely present in Diamond Lake when tui chub were first introduced. These trout were apparently not able to prevent the rapid expansion of the tui chub population. Therefore, the addition of piscivorous fish may result in a further reduction in tui chub numbers, but the extent of that reduction is unknown.

Under Alternative 4, the successful removal of a large portion of the spawning tui chub population in Diamond Lake on a yearly basis (over a span of 6 years) would reduce the annual spawning success of the chub population in the short-term and lead to relatively small numbers of juvenile tui chub produced each year (millions instead of billions). Assuming an average population of 7.6 million reproductive chub in Diamond Lake at the time of treatment, the successful removal of 90% of the spawning tui chub population in the first year of mechanical treatment would result in roughly 760,000 reproductive chub remaining in the lake. Assuming all of these remaining chub were in the 2.4-3.7 inch range (6.0-9.4 cm) and that 50% were female, they would be capable of producing roughly 127,300,000 eggs. For more information on tui chub population and egg production estimates associated with Alternative's 1 and 4, refer to Appendix X, Population Model Predictions for Tui Chub Removal at Diamond Lake (Jackson and Loomis 2004).

A potential complicating factor associated with the partial removal of the chub population under Alternative 4 is that of a compensatory response[121]. As large numbers of tui chub are removed through mechanical harvest or predation, the stunted population would have increases in food and habitat availability. Remaining fish would likely respond positively to this increase in available resources, with increases in average length and weight of individual chub. Bird (1975) indicated that as tui chub length and weight increase, the number of eggs produced also increases. As an example, a 5 inch (12.7 cm) chub could produce an average of around 5,000 eggs per spawning cycle, while a 7 inch (17.8 cm) chub could produce an average of around 28,000 eggs per spawning cycle. Therefore, as large numbers of chub are removed from the lake, the remaining population would likely respond indirectly by increases in body size and number of eggs produced by each individual fish. It is unknown to what extent this potential increase in egg production may offset the population reductions achieved by mechanical and/or predatory removal of tui chub.

Connected Actions:
Dock cleanup activities proposed by the Diamond Lake Resort and described as connected actions for Alternatives 2 and 3 in Chapter 2, would have no direct, indirect, or cumulative impacts to fish. Impacts to fish are not expected because of the small size and lack of in-water work associated with these activities.

[121] A compensatory response occurs when a given population adjusts (compensates) to changes in its environment.

Cumulative Effects:
Past, present, and future fish stocking strategies, as well as the 1954 rotenone treatment and a variety of in-water facility developments (i.e. boat docks, boat launch ramps, etc.) represent the primary management activities that would contribute to cumulative effects on aquatic habitat and the fishery resources in Diamond Lake. Alternative 1 would result in a long-term continuation of tui chub as the dominant fish species in Diamond Lake. Tui chub populations would eventually reach some unknown maximum sustainable level. Once this point is reached, chub populations would vary from year to year due to density-induced food shortages, disease, or water-quality induced mortality. Salmonids would continue to be stocked on a limited basis in order to maintain a recreational fishery in Diamond Lake. It is likely that most stocked salmonids would be caught in the recreational fishery, or would starve to death over time due to the lack of an exploitable prey base. Very few salmon or trout would survive over the winter due to the lack of a food source.

Alternatives 1 and 4 would result in the continued presence of tui chub in Diamond Lake. If recreational fishing results in the removal of a large portion of the predacious Eagle Lake rainbow trout population (under Alternative 4), this may inadvertently remove the majority of the predation control on the tui chub population, potentially allowing their populations to rapidly expand. In addition, if the predacious fish stocked into the lake do not prey upon the chub to the extent expected, it is likely that chub populations would quickly expand, eventually exceeding the capability of the piscivorous fish predation controls. If this occurred, conditions similar to current conditions (i.e. poor water quality and trout survival) would reappear. Thus, it is uncertain whether Alternative 4 would result in a meaningful positive cumulative impact on the fishery beyond the six-year lifetime of the project.

Alternative 2 would likely result in the complete eradication of tui chub, and the reestablishment of the put-grow-and take fishery that formerly existed at the lake. Fish stocking levels would likely be modified annually over the first several years based on the monitoring of zooplankton and benthic invertebrate indices. Over the long-term, the number of fish stocked would likely stabilize as fisheries managers utilized the biological indicators to adapt stocking levels to maximize the attainment of water quality and recreational fishery goals. Based upon the numbers of fish stocked in the past, and the relative effects that stocking apparently has on water quality, it is likely that the future fish stocking levels would be somewhat similar to experienced in the past. Thus, Alternative 2 is expected to result in a positive cumulative impact on the fishery beyond the lifetime of the project. For more information on tui chub population and egg production estimates associated with Alternative's 1 and 4, refer to DEIS Appendices, Population Model Predictions for Tui Chub Removal at Diamond Lake (Jackson and Loomis 2004).

Alternative 3 would also result in the complete eradication of tui chub, but the fishery would change to a put-and-take scenario. Up to 400,000 domesticated rainbow trout would be stocked annually. The majority of these fish would be caught each year, with very few expected to survive through the winter months. As a result, recreational fishery levels may be similar to those seen in the past, but there is also a chance that these levels would decrease due to the lack of opportunities to catch larger-sized fish, which may result in a less desirable fishing experience overall. Thus, a positive cumulative impact is expected under this alternative, but it may be somewhat less than that seen under Alternative 2.

The long-term effects to fish habitat under Alternatives 2 and 3 would be beneficial and would likely include an improvement in dissolved oxygen content, water clarity, a decrease in pH, and a decrease in the frequency, duration, and intensity of toxic blooms of blue-green algae. These physical changes would be a cumulative result of changes to biological processes occurring in Diamond Lake, as well as improved fish stocking practices over time.

Riparian Unit of Silent and Short Creeks and Diamond Lake and Forest Plan Riparian Prescriptions (C2-I and C2-IV) under Alternatives 2 and 3:

Alternatives 2 and 3 would both apply rotenone to Silent and Short Creeks and to Diamond Lake, which would be in conflict with two riparian prescriptions in the Umpqua National Forest Land and Resource Management Plan (LRMP). These prescriptions state that pesticides will not be applied in such riparian units of fish bearing stream, lakes, and ponds. Therefore, a one-time, project-specific Forest Plan amendment would be necessary in order to implement either Alternative 2 or 3.

The rotenone application to Silent and Short Creeks under Alternatives 2 and 3 would occur within the channels that would flow through the drawn down lake bed, rather than in upstream areas where the creeks flow through a vegetated riparian area. As disclosed above in this section, the impacts from the rotenone would be a fish kill in these channels which are expected to contain very few fish. The impact to fish and the aquatic ecosystem of these streams would be of limited extent and duration, as the pesticide is not expected to persist in either in water or in sediments for any significant length of time. Moreover, the native populations of aquatic life killed by the rotenone are expected to return to a healthy state within about 1 year.

The impacts from the rotenone application within Diamond Lake would be a complete fish kill and a substantial kill of the other aquatic organisms in the lake such as zooplankton and benthic invertebrates. These biological impacts would be of limited extent and duration, as the pesticide is not expected to persist in either the lake water or in lake sediments for any more than a few months. Moreover, the populations of native zooplankton and benthic invertebrates are expected to rebound rapidly, attaining species diversity and populations superior to the existing condition prior to treatment.

In the case of both Silent and Short Creeks (located within the perimeter of the existing lake), and Diamond Lake itself, the short-term impacts of using the pesticide rotenone would be outweighed in both aquatic/riparian ecosystems by the long-term beneficial effects to these ecosystems. This is especially true in light of the existing condition of these ecosystems as a result of the tui chub infestation. Since riparian prescriptions C2-I And C2-IV have the intent of meeting riparian, fisheries, and water quality objective of the Forest Plan, and since these Forest Plan objectives are highly compromised by the existing infestation of tui chub, this one-time use of rotenone is consistent with over-all Forest Plan objectives under the circumstances of the tui chub problem. Since the issuance of the Umpqua National Forest LRMP in 1990, the tui chub population has reached extreme levels, compromising water quality in the vicinity of the mouths of both stream and lake ecosystems as a whole.

LAKE CREEK

Direct Effects:
Alternatives 1 and 4 are not likely to result in any direct effects to fish populations in Lake Creek, due to the lack of the lake draw down and no period of Lake Creek de-watering. Under Alternatives 1 and 4, physical aquatic habitat and stream bank conditions in Lake Creek would remain unchanged, due to the lack of a lake draw down component. Therefore no direct effects on the physical habitat in would occur in Lake Creek under either Alternative 1 or 4.

Alternatives 2 and 3 would result in removal of the flashboards[122] at the outlet of the lake (beginning of Lake Creek) to initiate the lake draw down. Once the lake is lowered by approximately 2-3 feet (0.6 to 0.9 meter) by removal of these flashboards, water will no longer exit the lake via this route. At this point, water would be routed out of the Lake by use of the reconstructed canal, which is at a lower elevation, and capable of draining additional water out of the lake. The section of Lake Creek located between the lake and the canal outlet (roughly 1,200 feet, or 366 meters) would then dry up due to a lack of surface flow, displacing fish and eliminating aquatic habitat. This portion of the Lake Creek channel would remain dry for a period of approximately 1½ years. Surface flows would most likely return to this stream segment in the spring following chemical treatment, when the lake level has risen by at least 5 feet (1.5 meters).

In the portion of Lake Creek below the canal confluence, the draw down phase of the project would result in relatively high stream flows for a period of 4 to 6 months. This extended duration of bankfull flows during the fall, winter and spring months would likely require fish in Lake Creek to expend substantial amounts of energy to survive. As a result, fish mortality may be higher than the natural mortality rates seen under normal flow conditions.

Under Alternatives 2 and 3, immediately prior to chemical treatments in the lake, the headgates controlling flows in the canal (and Lake Creek) would be closed. This would result in the drying up of a portion of Lake Creek below the confluence of the canal for approximately 1-2 months until lake water was determined to be free of rotenone. Recent flow and groundwater investigations in Lake Creek (refer to groundwater hydrology section) indicate that there is very little accretion of flow in the upper 6 miles of Lake Creek, from tributary or groundwater sources. As a result, when surface flow is cut off from Lake Creek immediately prior to chemical treatment, it is likely that this stream would virtually dry up in this 6 mile stretch. Below this segment, stream flow conditions would improve dramatically due to the flow added by Thielsen Creek.

During this period of no-flow in the upper 6 miles of Lake Creek, it is likely that a large portion of the fish in this area would perish as a result of channel dewatering. An unknown portion of the fish population would likely persist in some small residual pools. These pools are not likely to completely dry up due to sub-gravel flow[123] and localized contributions of

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[122] There are several boards placed across a concrete channel located at the beginning of Lake Creek, the outlet stream of Diamond Lake. These boards serve the purpose of raising the surface water elevation of Diamond Lake by two feet.

[123] Sub-gravel flow is the portion of water that actually flows through the substrates of a channel, rather than on top of them as the surface flow we most commonly recognize as a stream.

groundwater that were encountered during the flow investigations. Flow conditions would improve at stream mile 6 due to the stream flow added by Thielsen Creek, which would not be affected by the Diamond Lake Project.

Indirect Effects:
Under Alternatives 1 and 4 tui chub would continue to move out of Diamond Lake and into Lake Creek, leading to the indirect effect of chub competition with resident trout for food and habitat resources.

For Alternatives 2 and 3, the extended period of high flow along the entire length of Lake Creek during the draw down, and an extended period of very low (or no) flow in the upper 6 miles of Lake Creek before and after chemical treatment would likely result in a dramatic decline in trout populations within this stream. Fish populations would be expected to return to pretreatment levels within two to four years, as other trout move in to occupy available habitat from downstream areas, as well as Diamond Lake. The lack of habitat and food resource competition from tui chub in Lake Creek may also result in slight increases in trout populations in the long-term.

Large wood amounts and stability would not be expected to change substantially in Lake Creek as a result of the lake draw down. The majority of the complex aquatic habitat in Lake Creek is in close association with stable large wood. The majority of this large wood appears to have originated from adjacent riparian stands, and is often found in the exact location where it originally fell (as a result of relatively stable flow patterns and low stream energy). Many of the stable large wood pieces have remained in place for decades or more, as evidenced by surrounding vegetation growth and/or channel features. Lake Creek is not prone to severe high flows or debris torrents. Therefore, the large wood found in this system is extremely stable when compared to other streams in western Oregon. Any pieces of wood that might be mobilized during draw down activities would likely be captured and retained on the next wood accumulation or channel bend downstream.

Areas of stream bank erosion currently present in the Lake Creek channel may be exacerbated by the extended duration of bankfull flows. The majority of these naturally eroding areas are located downstream of Thielsen Creek. This increased erosion is likely to be temporary in nature, with erosion from these naturally unstable areas returning to pre-treatment levels within a 3 to 5 year period after the draw down. The high level of channel complexity provided by ample quantities of large wood and boulders would result in deposition of a large portion of these sediments in gravel bars and other smaller depositional areas. As mentioned in the existing condition for Lake Creek, there was no evidence that past lake draw down activities in 1954 destabilized streambanks or aquatic habitat in this system. The estimated stream flow of 180 cfs during the 1954 draw down (USDA, 1998) also indicates that streamflows during that time period were likely significantly higher than those proposed in these alternatives (i.e. 110 cfs).

Cumulative Effects:
The 1954 rotenone treatment, past, present, and future water rights and fish stocking are the primary management activities that contribute to cumulative effects in Lake Creek. In this context under Alternatives 1 and 4, fish populations in Lake Creek would be expected to remain relatively unchanged over time (as stated under indirect effects). Although tui chub

would continue to move out of Diamond Lake and into Lake Creek under these alternatives, it is unlikely that tui chub could out-compete trout in the majority of this fast water stream environment. Thus, cumulative impacts are considered to be minor.

Under Alternatives 2 and 3, there would likely be a short term reduction in trout populations, followed by a longer term recovery of these fish. No tui chub would be present to compete with resident trout. Physical habitat conditions may increase in quality for several years following treatment, but would return to pre-treatment levels within a few years of the action. Thus, cumulative effects to the Lake Creek fishery are considered to be minor.

LEMOLO LAKE

Direct, Indirect, and Cumulative Effects:
It is unlikely that any of the alternatives would result in direct effects to fish populations or physical aquatic habitat in Lemolo Lake, due in large part to the relatively large distance from Diamond Lake to this lake system (11 miles).

Alternatives 1 and 4 would result in the continued contribution of nutrient enriched waters entering Lemolo Lake, potentially having an indirect and cumulative impact on trophic interactions in that system. The slight increases in zooplankton and benthic organism production may result in small beneficial impacts to trout and kokanee populations in Lemolo Lake, due to the increased availability of food resources. However, these benefits may be counteracted by the thousands of additional tui chub that would also move into Lemolo Lake annually from Diamond Lake.

Alternatives 2 and 3 would likely result in a dramatic reduction of nutrient enriched waters entering Lemolo Lake. Indirectly, this may result in slight decreases in zooplankton and benthic organism populations in that system, and consequent decreases in the amount of food resources available to trout and kokanee populations. It is also likely that the lake draw down phase of these alternatives could result in a large pulse of tui chub being carried out of Diamond Lake and into Lemolo Lake. However, installation of a trap to prevent fish movement out of Diamond Lake (as described earlier) would minimize this potential impact. In the short-term, this would likely have a small to moderate indirect negative impact on these salmonid populations due to increased competition for food resources. Cumulatively however, no further outmigration of tui chub from Diamond Lake would be expected in future years due to their eradication with rotenone. The number of tui chub competing with trout and kokanee for food resources would gradually lessen, and eventually reach a stable level. This would likely result in small beneficial impacts to salmonid populations in the long-term. Cumulative effects under all alternatives are considered to be minor.

The lake draw down associated with Alternatives 2 and 3 is likely to result in localized increases in stream-bank erosion in Lake Creek. It is likely that a portion of the gravel and fine sediment generated from this erosion would be deposited in Lemolo Lake. Based upon preliminary analysis from the project Hydrologist and Geologist, it is unlikely that the amount of material deposited in Lemolo Lake would be large enough to form a noticeable depositional feature (fan, delta, bar, etc.). Based upon the large size of the reservoir, this small amount of material would be inconsequential to the aquatic habitat found there.

NORTH UMPQUA RIVER (FROM LEMOLO LAKE TO ROCK CREEK)

Direct, Indirect, and Cumulative Effects:
It is unlikely that any of the alternatives would result in direct or indirect effects to fish populations in the North Umpqua River below Lemolo Lake, due in large part to the relatively large distances from Diamond Lake to this portion of the North Umpqua River (Diamond Lake is located 11 and 33 miles upstream of Lemolo Lake and Soda Springs dam, respectively). In addition, the series of reservoirs in this portion of the North Umpqua River have a moderating influence, virtually eliminating potential impacts associated with flow increases during lake draw down, as well as nutrient and sediment contributions to downstream areas. The amount of additional flow generated by the proposed lake draw down activities is small relative to the North Umpqua system, and is within the standard of measurement error for the streamflow gauging station located in the North Umpqua River near Copeland Creek. Numerous project design criteria were also developed to specifically eliminate the potential for negative aquatic impacts to occur.

Alternatives 1 and 4 would result in the continued contribution of nutrient enriched waters entering Lemolo Lake, and ultimately the North Umpqua system. In combination with other activities in the basin (i.e. recreation, timber harvest, fertilization, and hydropower activities, this could result in a cumulative negative impact on trophic interactions in that system (i.e. shifts in aquatic insect populations). Conversely, Alternatives 2 and 3, would likely result in slight reductions of nutrient enriched waters entering Lemolo Lake and the North Umpqua system. This may ultimately lead to slight beneficial impacts to downstream populations of aquatic insects.

The extent of the potential negative or beneficial impacts to the trophic structures downstream (from all alternatives) is likely to be relatively small when considered in context with all of the other activities in the watershed (tables 9-11). Therefore, it is highly unlikely that any of the alternatives would result in detectable impacts to fish species living in the North Umpqua River below Lemolo Lake.

Potential Cumulative Effects Common to All Alternatives:
There is the possibility of introducing non-indigenous fish genetics into the indigenous fish populations in the Umpqua Basin living downstream as a result of stocking Eagle Lake rainbow trout and Kamloops rainbow trout. Even though all non-endemic fish proposed for stocking in the various alternatives would be artificially sterilized (triploid), the procedures used to obtain sterile fish are not 100% effective. In a report by the Idaho Fish and Game (Megargle and Teuscher 2001), roughly 5-35% of rainbow and cutthroat trout strains sterilized using heat shock techniques were found to be capable of successful reproduction. This report demonstrates that different strains of fish often have differing susceptibilities to heat, pressure, or chemical sterilization techniques. If a portion of the non-indigenous stocks of trout proposed for use in Diamond Lake are reproductively viable, there is a remote chance that these fish could interbreed with fish from the Umpqua basin.

This risk is considered to be relatively minor however, due to the improbability of this actually occurring. Spawning habitat in Diamond Lake, and Short and Silent Creeks, is marginal at best, and has not resulted in substantial trout production in the past. Furthermore, Eagle Lake rainbow trout are adapted to a closed lake environment, and they are not considered to be migratory in nature (Paul Chappel, Personal Communication, 2003). Non-sterilized Kamloops rainbow trout have been used in Diamond Lake for a number of years; To date, no self-sustaining spawning populations of these fish have been detected in the rivers, streams, or lakes within the analysis area.

Although Alternatives 1 and 4 would result in the continued presence of tui chub in Diamond Lake, Alternatives 2 and 3 would likely eradicate tui chub from the lake for an unknown period of time. Based on history and the cumulative activities listed in tables 9-11, such as future recreational fishing and boating, it is reasonably foreseeable to predict that tui chub may be reintroduced (accidentally or intentionally) at some point in the future. As pointed out in the Diamond Lake/Lemolo Lake Watershed Analysis (1998), "given that two introductions of tui chub have occurred, and that one introduction occurred approximately 30 years after the original trout stocking in 1910 and the other approximately 30 years after rotenone treatment in 1954, it seems reasonable to assume that this is an appropriate timeframe until the next reintroduction of a nuisance fish will once again require a major management intervention." If history is an accurate measure of this likelihood, then the 30 year timeframe would be an appropriate estimate. If tui chub remain or are reintroduced, it is reasonable to assume that negative impacts to the recreational fishery would again occur.

Conclusions[124]**:**
Based on the above discussion, Alternative 1 (no action) would continue to result in poor physical habitat conditions in Diamond Lake, and contribute to nutrient and water quality problems in Lake Creek and Lemolo Lake in the short and long-term. Alternative 1 would result in the maintenance of large populations of tui chub, with a much smaller component of catchable-sized salmonids that are stocked annually in the lake to maintain a small recreational fishery (Table 25).

Alternatives 2 and 3 which would completely remove tui chub are more likely to result in aquatic habitat quality improvements in Diamond Lake and Lemolo Lake. There would be short-term impacts to Short, Silent, and Lake Creeks under these alternatives, but the extent and duration of these impacts would be relatively minor. Physical habitat would likely return to pre-project conditions within a week in Short and Silent Creeks, and within a few years in Lake Creek.

In Alternative 2, a mix of salmonids would be stocked, including relatively small numbers of fingerling rainbow trout (Fishwich or Oak Springs stock), and legal or trophy-sized predacious fish species (Eagle Lake rainbow trout, brown trout, or spring chinook salmon). In the absence of tui chub, these fish would be expected to thrive as they take advantage of the abundant prey items available to them. Alternative 2 would result in multiple age classes of trout being present in Diamond Lake at any given time.

[124] All general discussions pertaining to the recreational fishery in Diamond Lake are in relation to the 1990 OFWC management plan objectives of 100,000 angler trips per year, harvest of 2.7 fish per angler trip (or 270,000 trout), with an average fish length of 12 inches.

In Alternative 3, large numbers of domesticated rainbow trout would be stocked into the lake, providing a relatively large recreational fishery. These fish would not be expected to utilize available food sources to the extent seen in other strains of fish, and would not be expected to survive through the winter months. As a result, substantial numbers of trout would be present in the lake on a seasonal basis, and would be comprised of one general size and age range of fish.

Alternative 4 would result in the maintenance of a reduced population of tui chub, and a population of larger-sized predacious salmonids. Even though the numbers of fish stocked in Alternatives 3 and 4 are similar, Alternative 4 proposes to use special angler harvest regulations that limit the removal of large predatory trout in order maintain the predation control effect on chub populations. This reduced ability to catch and keep larger fish may decrease the desirability of the recreational fishery. Therefore, this alternative would likely provide a moderate fishery when compared to Alternative 3. There are many additional uncertainties associated with this alternative, including whether piscivorous salmonids would prey upon tui chub, whether these salmonids would be able to prevent the expansion of the remaining tui chub population, and whether mechanical chub removal methods would be able to successfully remove 85-95% of the spawning chub population. Table 25 summarizes alternatives effects on fish populations.

Table 25. Summary of Alternative Effects on Fish Populations.

Element Measure or Issue Indicator	Alternative 1 – No Action	Alternative 2 – rotenone & put- grow- take fishery	Alternative 3 – rotenone & put and take fishery	Alternative 4 – mechanical & biological control of chub
Expected Tui Chub Populations (A Measure for Element 2 - Recreational Fishery)	Tui chub populations would remain high, limited only by available food and habitat resources.	Based upon the past rotenone treatment, tui chub would likely be eradicated from Diamond Lake	Based upon the past rotenone treatment, tui chub would likely be eradicated from Diamond Lake	Tui chub populations may decrease slightly in the short-term as a result of commercial harvest, but would likely increase substantially over time as remaining fish compensate for this by increasing body size and egg production.
Trout body condition (A Measure for Element 2 - Recreational Fishery)	Stocked legal-sized fish would continue to lose body mass due to lack of food resources	Stocked fingerlings would grow quickly due to utilization of the abundant food resources (i.e. zooplankton and benthic organisms).	Stocked legal-sized fish would continue to lose body mass due to their highly domesticated nature and lack of tendency to feed upon available food resources.	An unknown portion of the stocked larger-sized fish would likely gain body mass as they prey upon chub populations.

Element Measure or Issue Indicator	Alternative 1 – No Action	Alternative 2 – rotenone & put- grow- take fishery	Alternative 3 – rotenone & put and take fishery	Alternative 4 – mechanical & biological control of chub
Recreational Fishery And Estimated Annual Angler Catch* (A Measure for Element 2 - Recreational Fishery)	Recreational fishery would remain relatively small due to small numbers of legal-sized fish stocked and continued low desirability of fishery (induced by lake closures, algae blooms, and low potential for capture of large, high quality fish). Annual catch estimated to be 10,000 fish/year in long-term (2007 and beyond).	Recreational fishery would likely be relatively large over time as stocked fingerlings grow to large sizes. Numbers of fish stocked may vary based upon biological indices. Fishery would likely regain the former high desirability due to the potential to capture numerous large sized, high quality fish. Annual catch estimated to be between 100,000-200,000 fish/year in long-term.	Recreational fishery would likely be relatively large due to stocking of large numbers of legal-sized fish. Fishery may not regain the former high desirability due to presence of only one size-class of fish, and put-and-take nature of fishery. Annual catch estimated to be between 80,000-160,000 fish/year in long-term.	Recreational fishery would likely be moderate due to stocking of large numbers of larger-sized predacious trout. Fishery may not regain former high desirability due to angler harvest restrictions that limit the harvest of larger fish, and continued lake closures associated with toxic algae blooms. Annual catch estimated to be between 50,000-70,000 fish/year in long-term.
Fish Stocking Manage-ment Strategy (An indicator for Issue 1 – Fish Stocking)	<u>Experimental Fish Stocking Program</u> in the short-term, followed by stocking of 24,000 legal-sized fish annually in the long-term (small put-and-take fishery).	<u>Basic Yield Alternative</u>, using ecological indices to determine appropriate numbers of fish to stock. (moderate to large put-grow-and-take fishery).	<u>Intensive Use Alternative</u>, large numbers of legal-sized fish would be stocked annually (large put-and-take fishery). Minimizes potential impacts of fishery on water quality.	<u>Featured Species</u> or <u>Trophy Fish Alternative</u>, large numbers of legal or trophy sized fish would be stocked annually, with special angler harvest regulations (moderate put-and-take fishery, with potential for some catch-and-release size restrictions).
Fish Species Mix Selected for Use (An indicator for Issue 1 – Fish Stocking)	Continued experimentation with legal sized Eagle Lake rainbow trout, brown trout, and/or spring Chinook salmon in the short-term. Small numbers of legal sized Eagle Lake rainbow trout in long-term.	Fishwich or Oak Springs stock rainbow trout fingerlings, and smaller numbers of larger sized Eagle Lake rainbow trout, brown trout, or spring Chinook salmon.	Trout Lodge stock of rainbow trout, with smaller numbers of larger sized Eagle Lake rainbow trout, brown trout, or spring Chinook salmon. Represents a different stocking strategy than Basic Yield.	Eagle Lake rainbow trout (Featured Species Alternative) Or Brown trout or Kamloops Trout (Trophy Fish Alternative). Represents a different strategy than Basic Yield with a focus on larger numbers of different species of predators.

*** Estimated annual angler catch values were developed by the Oregon Department of Fish and Wildlife, 2003.**

ACS Consistency:

As discussed previously throughout this document, large populations of tui chub are directly or indirectly tied to the existing conditions of poor water quality, toxic algae blooms, and suppressed zooplankton and benthic invertebrate populations. Therefore, any alternative that would not improve these conditions would retard attainment of Aquatic Conservation Strategy objectives. The most relevant ACS objectives are those that call for the maintenance and restoration of water quality (objective 4)[125], and habitat (objective 9)[126] in order to support

[125] ACS Objective 9 – Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.

[126] ACS Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity

species and communities. As such, Alternative 1, the no action alternative, would continue to retard attainment of ACS objectives.

Each of the action alternatives has the potential to result in improved aquatic conditions in the long term. Therefore, each of these alternatives would be consistent with the ACS. The degree to which conditions are improved and the longevity of those improvements would likely vary by alternative. Therefore, some alternatives would better meet the long term intent of the ACS than others. Alternative 4 would result in a partial removal of the chub population, and stocking of up to 250,000 larger-sized predacious fish. It is unknown whether the mechanical and predatory controls on tui chub populations would be effective at keeping their populations at a relatively low level. Therefore, this alternative may not be as effective at improving aquatic conditions in the long-term as other alternatives that propose to completely eradicate tui chub.

Alternatives 2 and 3 would result in complete eradication of the tui chub, and restocking of rainbow trout. Alternative 2 would primarily restock rainbow trout fingerlings under a put-grow-and take scenario. Fingerling stocking levels are expected to be relatively conservative (low) at first, and would be modified (increased or decreased) over time based upon biological indicators of aquatic health. Therefore, Alternative 2 would result in substantial improvements to water quality, zooplankton, and benthic organism populations in the long-term (due to the removal of the chub), but there would always be some level of predation pressure exerted on the aquatic organisms because the stocked fingerlings would forage on the zooplankton and benthos (due to the put-grow-and take fish stocking scenario).

Alternative 3 would restock up to 400,000 domesticated rainbow trout annually under a put-and-take stocking strategy. Unlike the fingerling stockings, these highly domesticated fish are not expected to prey upon the available food sources of zooplankton and benthic organisms, and would not be expected to survive through the winter months. As a result, this alternative is likely to result in the largest improvement to water quality, zooplankton, and benthic organism populations in the long term (due to removal of the chub and lack of predation on the other aquatic organisms).

Although there would be no short-term impacts to aquatic habitat, Alternative 4, which does not completely eradicate tui chub, may be the least effective of the action alternatives at movement toward attainment of ACS objectives, due to uncertainties regarding the efficacy of mechanical and biological population control methods. As a result, the extent and duration of improvements to aquatic habitat in Diamond Lake and Lemolo Lake under this alternative are uncertain. Based upon the failure of past efforts to partially control chub populations in Diamond Lake and elsewhere, it is likely that the long-term effects of Alternative 4 would be similar to those of Alternative 1.

In summary, from water quality and aquatic organism standpoint, the relative ACS ranking of each alternative would be as follows (from best to worst):

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of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

Alternative 3 – Most effective at moving toward attainment of ACS objectives
Alternative 2 – Effective at moving toward attainment of ACS objectives
Alternative 4 – Least effective at moving toward attainment of ACS objectives
Alternative 1 – Retards attainment of ACS objectives

Aquatic Biological Evaluation of Proposed, Threatened, Endangered and Sensitive (PETS) Aquatic Species

There are eight aquatic species on the Regional Forester's sensitive species list that are considered in this biological evaluation. Only one species, coho salmon, is listed as Threatened under the Federal Endangered Species Act. The habitat requirements for the sensitive aquatic insects listed in Table 26 is not present and none have been encountered during annual sampling in Lake creek since 1989 (B. Wisseman, personal communication).

The nearest habitat for coho salmon and the three other sensitive salmonids considered here, is located in the North Umpqua River within the Middle North Umpqua 5th field hydrologic unit below Soda Springs dam, a distance of 33 stream miles from the Diamond Lake project. Habitat for the Umpqua chub is found 70 stream miles from Diamond Lake in the main stem of the Umpqua River.

Virtually all of the potential effects to downstream aquatic resources associated with this project would be mitigated and/or eliminated as a result of the development of mitigation measures and best management practices listed in Chapter 2 (also called protective Project Design Criteria in the context of consultation). Moreover, the three large reservoirs downstream of the project (Lemolo, Toketee, and Soda Springs reservoirs) provide water and sediment storage and energy dissipation which lessen the downstream effects of the winter draw down, or partial draining of Diamond Lake.

Table 26. Biological Evaluation and Effects Determinations for PETS Aquatic Species

Review Process	Step #1 Prefield Review	Step #2 Field Recon	Step #3 Effects Determination	Step #4 Conclusion of Effects			
	Habitat Present	Species Present	Effects	Determination by Alternative			
Invertebrates *				1	2	3	4
Mt. Hood primitive caddisfly	no	no	no	NI	NI	NI	NI
Cascades apatanian caddisfly	no	no	no	NI	NI	NI	NI
Tombstone Prairie caddisfly	no	no	no	NI	NI	NI	NI
Alsea micro caddisfly	no	no	no	NI	NI	NI	NI
Fish **							
Oregon Coast coho salmon	no	no	yes	NLAA	NLAA	NLAA	NLAA
Oregon Coast steelhead trout	no	no	yes	MIIH	MIIH	MIIH	MIIH

Review Process	Step #1 Prefield Review	Step #2 Field Recon	Step #3 Effects Determination	Step #4 Conclusion of Effects			
	Habitat Present	Species Present	Effects	Determination by Alternative			
Umpqua chub	no	no	no	NI	NI	NI	NI
Oregon Coast cutthroat trout	no	no	yes	MIIH	MIIH	MIIH	MIIH
Oregon Coast chinook salmon	no	no	yes	MIIH	MIIH	MIIH	MIIH
EFH	no	no	yes	WNAA	WNAA	WNAA	WNAA

*Field review of species presence and habitat was conducted by Bob Wisseman, Aquatic Biology Associates, Inc.

**The nearest habitat for anadromous fish is located approximately 33 miles downstream of Diamond Lake, in the North Umpqua River below Soda Springs Dam.

Key to determinations:

·The threatened coho and EFH determination calls follow the nomenclature established by NOAA Fisheries: NE= No Effect; NLAA= Not Likely to Adversely Affect; and LAA= Likely to Adversely Affect

·For sensitive species including all species in the table except coho, determinations follow the nomenclature established in the Forest Service Handbook:
NI= no Impact; MIIH= May Impact Individuals or Habitat but will not Likely Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species; and WIFV= Will Impact Individuals or Habitat with a Consequence that the Action May Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species.

·For Essential Fish Habitat: WNAA = Would Not Adversely Affect.

Essential Fish Habitat (EFH) Under the Magnuson-Steven Fishery Conservation and Management Act (MSA)

The MSA requires Federal agencies to consult with the Secretary of Commerce regarding any action or proposed action authorized, funded, or undertaken by the agency that may adversely affect essential fish habitat (EFH) identified under this law. The MSA defines adverse effects as any impact, which reduces the quality and/or quantity of essential fish habitat. Adverse effects include direct, indirect, site specific or habitat wide impacts, including individual, cumulative or synergistic consequences of actions. This law deals with commercial fisheries. Coho and Chinook salmon are considered for this project.

The Diamond Lake Restoration project is expected to have an extremely low likelihood of causing an effect upon EFH, the species considered, and their major freshwater prey species. Major prey species are considered to be a variety of aquatic macroinvertebrates, including but not limited to the aquatic and winged adult phase of the following insect groups: stoneflies, mayflies, caddisflies, and midges. No substantial direct, indirect, cumulative, or synergistic effects to EFH are anticipated under the project. Coho and Chinook salmon are not found in the vicinity of the project planning area; and the chances of any effect being realized are so small as to be considered discountable and insignificant. Therefore, the proposed action and its alternatives have been given the following EFH effects determination: "Would Not Adversely Affect" (Table 26).

Habitat and Watershed Indicators used in Endangered Species Act Consultation.

NOAA Fisheries uses a set of 18 indicators to assess conditions for Threatened and Endangered Species during the consultation process done under the Endangered Species Act. This assessment is typically accomplished at the scale of both 5th and 6th field watersheds. The fifth field watershed containing coho and Chinook salmon is the Middle North Umpqua watershed. Since the Diamond Lake project would have no influence on individual 6th field sub-watersheds, this baseline condition evaluation only considers the main stem North Umpqua River. The 18 indicators recognized by NOAA fall under five headings (Table 27) discussed here.

Water Quality

Maximum Water Temperature:
The Diamond Lake Restoration project would have no impact on maximum summer water temperatures in the North Umpqua River below Soda Springs Dam.

Sediment and Turbidity:
The largest potential for streamside erosion, sediment entrainment, and turbidity increases would come during the draw down portion of the project, and would stem from three small areas of stream bank instability along Lake Creek. The majority of the sediments are of volcanic origin, and do not stay in solution for long periods of time. Based on field review of potential erosion areas in Lake Creek, as well as anecdotal accounts of the 1954 draw down, the potential for large sediment and/or turbidity increases associated with this project is low. In addition, based on Lake Creek stream gauge data, the relatively small increase in stream flows during the draw down period (~ 50 cfs), would be well within the range of natural flows that have helped form the current channel of Lake Creek over the past several decades. Therefore, any sediment and/or turbidity increases caused by draw down activities would likely be small, and would settle out in the system of reservoirs prior to reaching anadromous fish bearing waters.

Chemical Contaminants/Nutrients:

Nutrients: Alternatives 1 and 4 would result in the continued contribution of nutrient enriched waters entering Lemolo Reservoir, and ultimately the North Umpqua system. In combination with other activities in the basin (i.e. recreation, timber harvest, fertilization, hydropower activities, and others) this could contribute to a cumulative negative impact on trophic interactions in that system (i.e. shifts in aquatic insect functional feeding groups). Conversely, Alternatives 2 and 3 (in combination with the cumulative activities listed above) would likely result in slight reductions of nutrient enriched waters entering Lemolo Reservoir and the North Umpqua system. This may ultimately lead to slight beneficial impacts to downstream populations of aquatic insects as elevated nutrient levels begin to decrease slightly.

The extent of the potential negative or beneficial impacts to the trophic structures downstream (from all alternatives) is likely to be relatively small when considered in context with all of the other activities in the watershed (Tables 9-11). Therefore, it is highly unlikely that any of the alternatives would result in detectable impacts to aquatic insect populations, or fish species living in those areas.

It is highly unlikely that any of the alternatives would result in direct, indirect, or cumulative effects to fish populations in the North Umpqua River below Soda Springs Reservoir.

Chemical Contaminants: Before chemical treatment of the lake, lake outflow through the canal would be closed and the only flow in Lake Creek would be from groundwater and tributaries. A recent low flow investigation of Lake Creek (September 2003) revealed that there is little accretion of flow from groundwater or tributaries from the outlet to Sheep Creek, about 5.5 miles downstream. This segment of channel would likely have little to no flow with only some pooled water for about 2-3 months. The same investigation measured about 0.84 cfs at the mouth of Sheep Creek. The largest flow contribution to Lake Creek would be from Thielsen Creek, about 8 miles downstream of the outlet. Thielsen Creek may contribute as much as 5 cfs during this dry channel phase. The limited to no-flow condition for this 8-mile segment of Lake Creek would not change until lake water becomes safe to be released through the canal after treatment (i.e. no chemicals detected). Flow would be gradually released from Diamond Lake about 2-3 months after closing the canal. The initial release would be about 10 cfs in the spring when flows historically have been 5-7 times greater as measured at the USGS gaging station on Lake Creek.

The risk of precipitation refilling Diamond Lake and spilling lake water into Lake Creek before it is determined safe during the canal closure phase is very low. Accumulative rainfall after canal closure would have to be greater than 20 inches in order to refill the lake and return flow at the outlet to Lake Creek. The canal closure phase would occur during the last month of the low flow period, which coincides with low precipitation (September), but would possibly extend to the middle of the fall rainy season (early November). Based on historic weather data, the average rain fall for this time period (September 15th to November 15th) was 7.5-inches and the probability of receiving as much as 20 inches is extremely low. However, a mitigation measure is incorporated into both Alternatives 2 and 3 that would reconstruct the outflow structure of Diamond Lake in Lake Creek to an elevation that would contain any unexpectedly large amount of rainfall during this two month period.

<u>Inert Ingredients, Metabolites, and Other Chemicals</u>

None of the chemicals associated with the powdered or liquid forms of rotenone proposed for use would be expected to persist in the environment for more than a few weeks. Therefore, no impacts to downstream aquatic resources would be expected as a result of the proposed chemical treatment. See the Aquatic Biological Evaluation for additional information.

Habitat Elements

Physical Barriers: The Diamond Lake Restoration project would have no impact to physical barriers on the main stem North Umpqua River.

Large Woody Material: As channel size increases, the size required for LWD pieces to remain stable also generally increases. The role and frequency of LWD generally decreases in large, confined channels like the analysis section of the North Umpqua, although accumulations of LWD into large debris jams are locally important. Currently, densities of large wood within the North Umpqua River are very low and believed to be well below that which would exist in a river bordered by the type of late seral forest that is found along the North Umpqua.

The majority of the wood mobilization that occurs in the North Umpqua River coincides with larger storm/stream flow events. Therefore, it is highly unlikely that a 3% increase in stream flow (see FLOW/HYDROLOGY section below) would result in mobilization and flushing of larger wood in the North Umpqua River. Therefore, activities associated with the draw down portion of the Diamond Lake Restoration Project would not impact large wood loading in this system.

Substrate: The majority of the stream bed and banks of the North Umpqua River are considered to be well armored with bedrock, boulders, and cobble substrates. Limited gravel substrates can be found in association with depositional features such as stable large wood, boulder formations, or certain bedrock outcroppings. As a result, these substrates are relatively stable. Based upon the extremely small increases (see FLOW/HYDROLOGY section below) in stream flow that are likely to occur during the draw down portion of the project, it is highly unlikely that any changes in substrate size, amount, or distribution would occur as a result of the Diamond Lake Restoration Project.

Pool Character: The vast majority of the pools in the North Umpqua River main stem are formed as a result of variations in large boulder and bedrock formations, not scour into alluvial substrates. As a result, these pools are inherently stable. It is highly unlikely that any changes in pool character would occur as a result of minor stream flow increases caused by the draw down portion of the Diamond Lake Restoration Project.

Low Velocity Refuge: Low velocity refuge habitat typically occurs in side channels, on floodplains, or in association with complex accumulations of large woody material. In the North Umpqua River, this low velocity refuge habitat is in relatively short supply naturally when compared to other rivers of this size. Overall, side channels are rare habitat features along the North Umpqua River, floodplains are limited in size and extent, and large wood is relatively infrequent. As mentioned below, the relatively small increase in stream flow that would occur during the draw down phase of the Diamond Lake Restoration Project is considered to be insignificant. It would be highly unlikely to negatively impact the amount of low velocity refuge habitat in this system.

Refugia: Based on the consistently large amounts of relatively cold water during the Summer months, the entire main stem portion of the Middle North Umpqua 5th field watershed could be considered as an anadromous fish refuge. The Diamond Lake Restoration Project would have no negative impact on this condition.

<u>**Channel Condition and Dynamics**</u>

Width/Depth Ratio:
The majority of the stream bed and banks of the North Umpqua River are considered to be well armored with bedrock, boulders, and cobble substrates. As a result, channel dimensions in this river are not easily changed. It is highly unlikely that changes in width/depth ratio would occur as a result of the extremely small increases in stream flow that would occur during the draw down portion of this project.

Streambank Condition:
The majority of the stream banks of the North Umpqua River are considered to be well armored with bedrock, boulders, and cobble substrates. As a result, these banks are considered to be inherently stable. Based upon the extremely small increases in streamflow that would be expected during the draw down phase of this project, it is highly unlikely that any change to streambank condition would occur.

Floodplain Connectivity:
No floodplain impacts, or channel incision would be expected along the main stem North Umpqua River as a result of this project. Therefore, the Diamond Lake Restoration Project would have no impact on floodplain connectivity.

<u>**Flow/Hydrology**</u>

Changes in Peak/Base Flows:
Once the draw down flow reaches Lemolo Reservoir, it would be absorbed into the larger reservoir until a flow equilibrium is reached. In addition, a portion of this increased flow would be absorbed through reservoir operations. PacifiCorp is a partner in this project and would work with the draw down operation to avoid large changes in reservoir storage and release. Therefore, no major changes in the seasonal streamflow regime below Lemolo Dam in the North Umpqua River would be expected.

Minor changes to fall, winter and early spring stream flows in the North Umpqua River below Soda Springs Dam are likely to occur as a result of the Diamond Lake draw down. These changes would result in an average stream flow increase of approximately 50 cfs for a 4-7 month period. However, no changes to peak flow levels would be expected from this project due to the fact that naturally occurring storm-generated flows would be allowed to flow through the system, without additional draw down flow volumes added to them. Once these large storm flows recede below the bankfull stage, additional water from the lake would again be added in order to bring stream flows back up to bankfull levels, and continue the draw down process.

The bankfull flow in the North Umpqua River below Soda Springs Dam is approximately 5,500 cfs (as measured at the USGS gauge below Soda Springs dam). The average monthly flow of the North Umpqua River during the draw down period (as measured at the USGS gauge below

Soda Springs dam) is approximately 1,560 cfs. In Water Resources Data publications by USGS, the accuracy of the flow measurements at the North Umpqua River above Copeland Creek gage is described as being within 10 percent of the actual for 95 percent of the flows. While the minor flow increases mentioned above would be likely to occur, the average increase of 50 cfs is within the measurement error of the stream gauge at the Copeland site, and represents roughly 3 percent of the average base flow of the North Umpqua River at this location during the proposed draw down period. Therefore, this minor flow increase meets the definition of an insignificant effect where, "based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects".

In addition, a chronological evaluation of average monthly flows during each of the fall and winter months indicates that yearly variations in same-month flows can range from +/- 4 to over 1,000 cfs for the same month. This high level of monthly flow variation over the years is clearly evident in the 54 years of flow data for this gaging station.

Year	Month	Average Stream Flow (cfs)
1994	November	792
1995	November	1,295
1996	November	2,324
1997	November	1,241
1998	November	1,697
1999	November	1,177
2000	November	934
2001	November	902

Drainage Network:
No roads would be constructed or decommissioned as a result of this project. Therefore, no changes in drainage network would be anticipated as a result of the Diamond Lake Restoration Project.

Watershed Conditions
None of the 4 Indicators for watershed conditions recognized by NOAA Fisheries (Road Density, Disturbance History, Riparian Reserves, or Landslide Rates) within the Middle North Umpqua River 5th field watershed would be affected by any Alternative.

All the Action Alternatives included in the Diamond Lake Restoration project were found to maintain the existing condition of the 18 indicators, (rather than degrade or restore the condition) (Table 27). In this case of the chemical/nutrient indicator, the action alternatives begin a trend toward restoration with a small decrease in the downstream contributions of nutrients to the North Umpqua River where coho salmon are found.

Table 27. Matrix of Pathways and Indicators for the Middle North Umpqua 5th field watershed.

Environmental Baseline	Effects of Alternatives 2, 3, and 4

Relevant Indicators	Properly Functioning	At Risk	Not Prop. Functioning	Restore	Maintain	Degrade
Water Quality						
Maximum Temp			X (1,3)		All alts.	
Sediment & Turbidity		X (1,2,3)			All alts.	
Chemical/ Nutrients		X (3)			All alts. (trend toward restore)	
Habitat Elements						
Physical Barriers	X (1,3)				All alts.	
Large Woody Material			X (1,2,3)		All alts.	
Substrate			X (1,3)		All alts.	
Pool Character		X (1,3)			All alts.	
Low Velocity Refuge		X (1,3)			All alts.	
Refugia		X (1,3)			All alts.	
Channel Condition and Dynamics						
Width/Depth Ratio	X (1)				All alts.	
Streambank Condition	X (1,2,3)				All alts.	
Floodplain Connectivity		X (1,2)			All alts.	
Flow/ Hydrology						
Changes in Peak/Base Flows			X (1,3)		All alts.	
Drainage Network			X (1)		All alts.	
Watershed Conditions						
Road Density			X (1)		All alts.	
Disturbance History		X (1,2,3)			All alts.	
Riparian Reserves			X (1,2,3)		All alts.	
Landslide Rates		X (1,2)			All alts.	

The relative condition values listed for the indicators in Table 27 were derived from the Middle North Umpqua Watershed Analysis (USDA, 2001), field reviews associated with other projects in the area, and professional judgment.

GROUNDWATER

Groundwater flow patterns in the project area are relevant to three significant issues identified in scoping and described in Chapter 1: water quality, non-target species, and wetlands. Scoping identified a concern that rotenone treated water would escape Diamond Lake through the groundwater and negatively impact water quality and fish and wildlife species in Lake Creek and the North Umpqua River System. This issue is tracked under the title groundwater investigation and is also discussed in the fish and wildlife sections of this chapter. There is also a concern that water containing rotenone would migrate through the groundwater into the drinking water wells of the summer homes on the west side of Diamond Lake. This issue is tracked under the title water quality-water chemistry. Finally, scoping identified a concern that drawing down Diamond Lake would have a negative impact on wetlands adjacent to the lake. This issue is tracked under the title water quantity-groundwater discharge and recharge, and is also discussed in the terrestrial and wetland plant sections of this chapter.

BACKGROUND- AFFECTED ENVIRONMENT

Groundwater can be defined as that subsurface water that occurs beneath the water table in soils and other geologic formations that are fully saturated (Freeze and Cherry 1979). Water enters the groundwater system as precipitation or snow melt infiltrating soil and rock through cracks and pores eventually migrating down to the saturated zone[127] where groundwater actually flows. In some instances recharge areas can be an impoundment such as a lake or pond. After entering the ground it moves through the system to discharge areas, which are areas where subsurface water is discharged to streams or other bodies of surface water, such as lakes or ponds. Storage and flow of groundwater are controlled to a large extent by geology. In the Diamond Lake watershed, the geology is a major factor controlling recharge and discharge to both a shallow and a deep aquifer. The pumice soils generated from volcanic activity have high infiltration rates that allow a high percentage of the precipitation and snow pack to recharge the aquifers.

The principle geologic factors that influence groundwater movement are porosity and permeability of the rock or soil material through which it flows. Porosity, in general terms, is the proportion of a rock or deposit that consists of open space. In a gravel deposit, this would be the space between the individual pebbles and cobbles. Permeability is a measure of the resistance to the movement of water through the rock or deposit. Deposits with large interconnected spaces, such as gravel, have little resistance to groundwater flow and are therefore considered highly permeable. Rock or deposits with few, very small, or poorly connected open spaces offer considerable resistance to groundwater flow and, therefore, have low permeability.

The hydraulic characteristics of geologic materials vary between rock types and within particular rock or soil types. For example, in sedimentary deposits the permeability is a function of grain size and the range of grain sizes (degree of sorting). Coarse, well-sorted gravel has much higher permeability than fine, silty sand deposits. The permeability of lava flows can also vary markedly depending on the degree of fracturing. The highly fractured, rubbly zones at the tops and bottoms of lava flows and in the interflow zones are often highly permeable, while the dense interior parts of lava flows can have very low permeability (Gannet, 2001).

[127] Saturated zone is the depth, below which all of the pores in the soil or geologic matrix are filled with water, thus allowing the water to flow.

Sherrod (1986, 1991) describes the surficial geologic material of the Diamond Lake basin as consisting of glacial drift (Qgd), lacustrine (Ql), and ash (Qaf) deposits resting on top of the basaltic andesite bedrock, see Figure 32. These surficial deposits comprise a shallow unconfined aquifer in the Diamond Lake basin. The glacial deposits consist of stratified and unstratified drift with particle size ranging from silt to boulders. The lacustrine deposits are comprised of well-bedded[128] unconsolidated sand and gravel consisting primarily of medium to coarse grained crystal-lithic-pumice sand that is generally medium to well sorted, thin to medium bedded, and parallel bedded. Some lacustrine deposits are as high as eight meters above the current lake level. The ash deposits are from the Mount Mazama eruption and consist mainly of unsorted, pale-grayish-white ash. At Diamond Lake the ash flows ponded in excess of 12 m, as interpreted from water-well cuttings (Sherrod 1991).

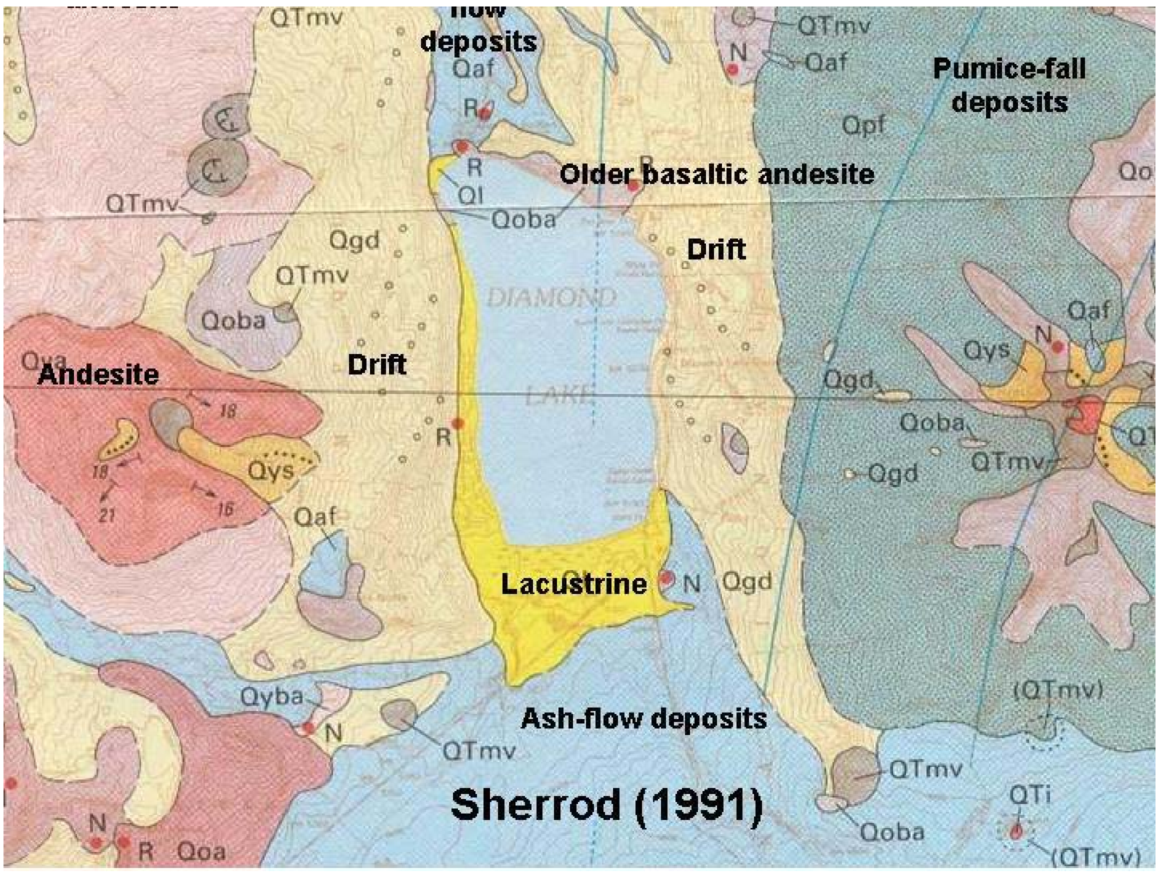

Figure 32. Geologic map of Diamond Lake, showing the Drift, Lacustrine, and Ash flow deposits.

The regional groundwater flow direction in the Diamond Lake watershed follows the typical pattern of a mountainous terrain. Groundwater is recharged via snow melt and rain infiltrating into the soil and bedrock which percolates down, following the pattern of topographic relief until it reaches the lake, where it discharges. In the Diamond Lake area, groundwater recharge occurs mainly at the higher elevation in the mountains above and

[128] Bedded refers to the distinct layering of sediment that accumulates over time in the lake basin and can usually be detected visually.

around the lake. Also, recharge occurs to both, a deep basaltic bedrock aquifer[129], which is typically greater than 100 feet below the ground surface as well as to the shallow aquifer. The shallow groundwater aquifer generally follows the perimeter of the lake until it pinches out along the eastern, western and northern shores. Along the southern boundary of the lake, the shallow aquifer extends south to encompass the lacustrine deposits and some of the ash deposits, shown on Figure 32. The exact extent of the shallow aquifer south of the lake has not been investigated and therefore is not known at this time.

GROUNDWATER INVESTIGATION

Monitoring Wells

Any impacts to the groundwater from contaminated lake water are expected to occur in the shallow aquifer not the deep aquifer. In the Diamond Lake basin, the deep aquifer is confined and exhibits artesian conditions. What this means is that water in the deep aquifer is separated from the shallow aquifer by an impermeable layer of rock and the water in the deep aquifer is confined and under pressure. When a well is installed into the deep aquifer, through the impermeable rock layer, the water level in the well will rise (see Figure 33). If the water level rises above the ground surface, it is referred to as a flowing artesian well. In the Diamond Lake area this artesian flow is evidenced by the springs that form Silent Creek and Short Creek and the water level in the wells of some summer cabins that have deep wells which penetrate into the deep aquifer. The tendency of water to rise out of the deep aquifer will act to inhibit shallow groundwater from infiltrating into the deep aquifer, acting as a barrier restricting the downward migration of water from the shallow aquifer. Therefore, if the shallow aquifer were to become contaminated with rotenone or algal toxins they are not expected to migrate into the deep aquifer.

Though it is not likely that the deep aquifer could become contaminated by toxins from the lake, the shallow aquifer might. Therefore, a groundwater investigation was initiated during the summer of 2003 to determine the characteristics of the shallow aquifer surrounding Diamond Lake. The shallow aquifer is the source of many shallow wells used by summer home residents and one campground. A total of sixteen monitoring wells, installed as pairs, 300 to 600 feet apart, were placed at various locations around the lake (Figure 34).

[129] Aquifers are areas beneath the earth's surface that contain groundwater.

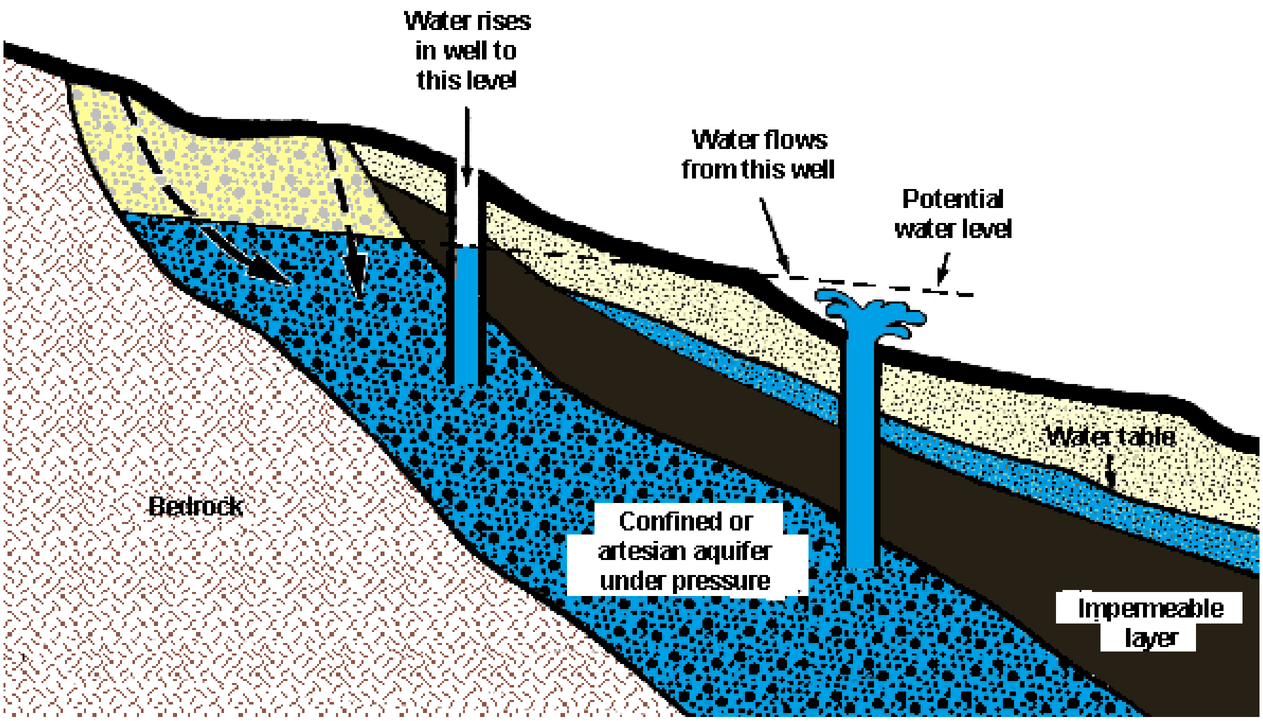

Figure 33. Shallow and Deep Aquifers. In the Diamond Lake area, the deep aquifer is confined by a layer of impermeable bedrock which causes the groundwater to be under pressure. The shallow aquifer (water table) is unconfined and not under pressure.

Groundwater monitoring wells were installed and screened at depths approximately 10 to 15 feet below the level of lake draw down proposed in Alternatives 2 and 3. See the Groundwater report for the depth and screened interval for each well. Having the wells screened at these depths allows for determining changes that may occur in the direction of groundwater flow before, during, and after any manipulations of the lake level.

Installation and development of the wells was completed on July 29, 2003. Groundwater elevation measurements were collected from August 5, through November 5, 2003 and are included in the discussion of the shallow aquifer.

See the Groundwater report for the groundwater elevation data for all of the wells. Additional groundwater elevation measurements will be collected throughout the winter and spring of 2003 -2004. The data will indicate any change to the groundwater flow direction over the period when elevation measurements are collected. Changes in the groundwater flow pattern are expected to occur as the groundwater elevation rises and drops throughout the normal yearly hydrologic cycle. As recharge diminishes over the summer and groundwater elevations drop to below the level of the lake, the direction of groundwater flow can reverse. When this occurs, the lake begins to recharge the groundwater and will continue to do so until the level of groundwater rises above that of the lake, or the lake level is lowered to below that of the groundwater.

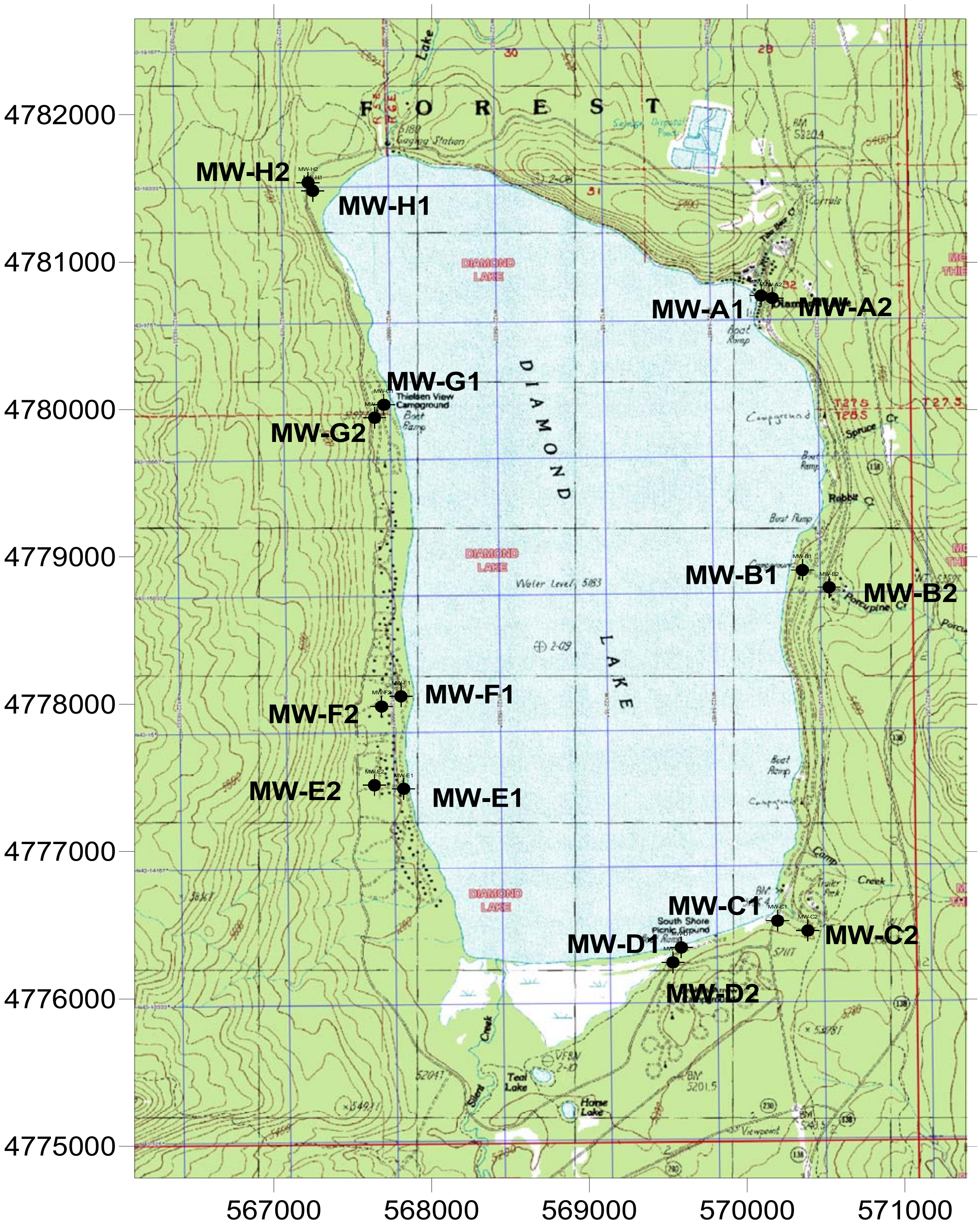

Figure 34. Ground Water Monitoring Well Locations in the Shallow Unconfined Aquifer at Diamond Lake.

During the snowmelt in late spring and early summer it is expected that groundwater elevations will rise and all groundwater will discharge into the lake. Figure 35 shows the various flow patterns that can occur around a lake such as Diamond Lake.

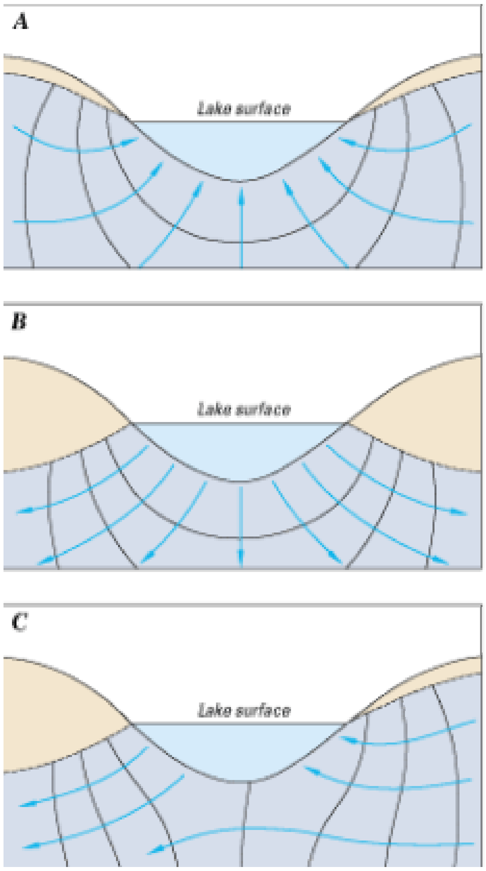

Diagram A illustrates typical groundwater flow patterns in late spring and early summer. Snowmelt and precipitation raise the water table and groundwater moves into the lake.

Diagram B illustrates typical groundwater flow patterns in late summer and fall. Water leaves the lake and enters the groundwater aquifer.

Diagram C illustrates the scenario where ground water is discharging to the lake, the lake is recharging ground water, and a portion of ground water is not interacting with the lake, but flowing beneath it.

Figure 35. Changes in ground water flow patterns around a lake. A - ground water recharge to the lake, B-the lake recharges ground water, C – the lake acts as both recharge and discharge area (U.S.G.S. Circular 1139).

The current groundwater elevation data indicate that during late spring, summer, and early fall, groundwater flow direction is toward the lake. In an area along the east and northeast near wells MW-A1, MW-A2 and MW-B1, (Figure 34) groundwater levels have been at, or slightly lower than that of the lake from the beginning of the data collection period. However, the hydraulic gradient[130] from the outermost wells has been toward the wells located closest to the lake. In other words, throughout the spring, summer, and early fall the groundwater flow direction is toward the lake as determined from the water elevations in all of the outermost wells. There are no drinking water wells in the shallow aquifer in the area of monitoring wells MW-A1, MW-A2, and MW-B1. Therefore, there is no risk of exposure to rotenone or algal toxins from groundwater in this area.

The groundwater flow direction is expected to reverse as the water table continues to drop throughout the year. Once flow reversal has occurred, lake water will recharge the shallow

[130] Hydraulic gradient is the difference in water level between two wells divided by the distance between them and has units of ft/ft. The direction of groundwater flow is from the well with the higher level to that with the lower level.

aquifer and will continue until spring snow melt. The predicted time when flow reversal will occur (for those wells not already exhibiting reversal) was calculated from the hydrographs for those wells. The hydrographs for each monitoring well are shown in Figure 5 of the Groundwater report. Flow reversal is predicted to occur in all monitoring wells except MW-B2 by February 2004. Table 28. shows the actual or predicted time when the groundwater level will drop below that of the lake. MW-B2 is not expected to fall below the level of the lake. Wells MW-E1, MW-E2, MW-F1 and MW-F2 are all located on the western shore in the area of the summer homes, and as such are the wells which are monitored to determine when flow reversal occurs and if contaminated lake water is flowing toward the summer home wells. Table 28 shows that flow reversal occurred at wells MW-E1 and MW-F1 (closest to the lake) by mid August, but that the outer set of wells still showed a gradient toward the lake. However, the predicted time for reversal to occur in the outer wells is mid November (see the Groundwater report for well hydrographs). The data indicates that water from the lake will begin recharging the groundwater in the summer home area by mid August and is expected to continue until the groundwater table rises during spring snowmelt. That is the time period when the summer home wells could potentially become impacted from contaminated lake water.

Table 28. Actual or predicted groundwater flow reversal for Diamond Lake monitoring wells.

Well Number	Inches above lake	Actual or Predicted Time of Reversal
MW-A1	-4.46	08/05/2003
MW-A2	-3.28	08/05/2003
MW-B1	-2.05	08/05/2003
MW-B2	46.73	Not expected to occur
MW-C1	0.26	11/12/2003
MW-C2	4.37	02/18/2004
MW-D1	-0.08	11/05/2003
MW-D2	0.04	11/12/2003
MW-E1	-0.21	08/19/2003
MW-E2	2.87	11/18/2003
MW-F1	-0.93	08/19/2003
MW-F2	1.31	11/12/2003
MW-G1	Dry Well	N/A
MW-G2*	-21.8	08/05/03
MW-H1	Dry Well	N/A
MW-H2	Dry Well	N/A

* The very small amount of water (2 inches) temporarily in MW-G2 may have been from water introduced into the borehole to hydrate the bentonite seal.

Wells installed in Thielsen campground (MW-G1) and in the far northwest corner (MW-H1 and MW-H2) have been dry since data collection began. MW-G2 had two inches of water in the well after completion, but soon became dry. The water in the well may have been from water used to hydrate the bentonite seal and not groundwater. These wells were drilled to a depth of 19 to 24 feet below the current level of the lake and, as with the other wells, were expected to intercept groundwater at those depths. However, since these wells are dry, two things could be occurring: either there is no groundwater in this area, or a steep gradient exists and groundwater is exiting the lake at a depth greater than the screened interval of the wells. In order to answer this question, the U.S. Forest Service will conduct additional hydrogeologic investigation in this area in spring 2004.

Downstream Seepage Study

If groundwater is migrating out of the lake basin at a depth below which the current wells can monitor, it could be discharging into Lake Creek. Therefore, it was necessary to determine if it was surfacing in Lake Creek, downstream of the outlet. In September 2003, the U.S. Forest Service conducted a groundwater seepage study along a six mile length of Lake Creek. The study was conducted while the creek was at base flow. A series of stream gauging transects were completed at intervals along Lake Creek (Breeden 2003). Any increase in flow to Lake Creek at base flow could only come from groundwater discharge (all surface inputs separated out), which could possibly be coming from the northwest area of the lake. The results of this investigation indicate that Lake Creek receives no appreciable increase in flow due to groundwater discharge to the creek. The conclusion drawn from this study was that even if groundwater was migrating from the lake basin in the area of MW-H1 and MW-H2 wells, it is not discharging into Lake Creek within the first six miles of the lake outlet, and therefore, chemical treatment would have no deleterious effects on this reach of Lake Creek.

There is the possibility that groundwater could discharge at a location further downstream. However, given the hydraulic conductivity[131] of the shallow aquifer, the time required for a release to travel that distance, and the propensity for migration of rotenone to be severely retarded due to its strong tendency to attach to sediments, it is very unlikely that rotenone would discharge via the groundwater at a concentration that would negatively affect any receiving body of water.

Groundwater Quantity Study

The quantity of groundwater flowing into the lake varies as the gradient changes and with the permeability of the geologic material. Pumping tests[132] were conducted on six monitoring wells to determine the hydraulic conductivity of the aquifer material.

The quantity of groundwater flowing into the lake was estimated by dividing the lake into different sections and calculating the flow for each section. The differentiation for each section was based upon the hydraulic conductivity of the aquifer material associated with a specific well and extending that area from that well to a point midway between the next set of wells. See the Groundwater report for the map of the sections.

Flow into the lake was calculated in two ways[133]. The conclusion drawn from this flow analysis is that the contribution of groundwater to the total inflow into the lake is substantial so any

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[131] Hydraulic conductivity is a measure of the ability of fluid to move through a porous media and is a function of the fluid properties and physical properties of the media such as the size and shape of pores, and effectiveness of the interconnection between the pores. It has units of L/T, (i.e. cm/sec).

[132] The results of these pumping tests were: the shallow groundwater aquifer at Diamond Lake exhibits a range of hydraulic conductivities of 7.9×10^{-5} cm/sec in the northwestern area of the lake (MW-F2) to 5.92×10^{-2} cm/sec in the southeastern area (MW-C2 and MW-D2). See the Groundwater report for the results of the pumping tests and the logs for all of the wells.

[133] The first method for calculating flow used the well specific values for hydraulic conductivity, hydraulic gradient and the cross sectional areas for a specific well section. This method calculates the flow for each of the defined sections

impacts to groundwater from proposed lake restoration activities could have an impact on the overall groundwater quality of the shallow aquifer

WATER QUALITY – WATER CHEMISTRY

Mixing of groundwater with surface water can have major effects on aquatic environments if factors such as pH, temperature, dissolved oxygen, and nutrients are altered, or the addition of contaminants occurs. Thus, changes in the natural interaction of groundwater and surface water caused by human activities can potentially have a significant effect on aquatic environments. The flow between groundwater and surface water creates a dynamic habitat for aquatic flora and fauna near the interface (hyporheic zone). In most cases, these organisms are part of the food chain that sustains a diverse ecological community. Studies indicate that these organisms may provide important indications of water quality plus adverse changes in aquatic environments. For example, wetlands are dependent on a relatively stable influx of groundwater throughout changing seasonal and annual weather patterns. Therefore, wetlands can be highly sensitive to any change that may impact the groundwater system, such as the lake draw down.

Additionally, it is generally assumed that groundwater is safe for consumption without treatment. The summer cabins along the western shore of the lake depend on groundwater for their source of domestic and potable water supply and have no system to treat or remove contamination if it were to migrate to their wells. Because Alternatives 2 and 3 propose a rotenone treatment in Diamond Lake, it is important to be able to monitor and verify that no chemically treated lake water that enters the groundwater would migrate toward the drinking water wells, nor discharge to Lake Creek. Because Alternative 1 maintains the existing condition, it is also important to know if algal toxins from the lake could be contaminating summer home wells.

AFFECTED ENVIRONMENT

In August 2003, the U.S. Forest Service measured the quality of the groundwater in the shallow aquifer surrounding Diamond Lake. The twelve parameters measured included nutrients, pH, dissolved oxygen, specific ions, conductance, and temperature (see Groundwater report). The results of this analysis indicate that groundwater quality is excellent, with none of the parameters exceeding state or federal water quality standards. However, no tests were completed to determine presence of algal toxins in the groundwater.

ENVIRONMENTAL EFFECTS

Direct Effects:

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described above. Using this method the combined flow into the lake is approximately 6.5 cfs. The second method used the averaged values for hydraulic conductivity and hydraulic gradient, and set the cross sectional area to 2,112,000 ft^2 (this is the equivalent of 8 miles of shoreline with a discharge depth of 50 feet). The groundwater component of flow using the average values is approximately 9 cfs. These values are based on the hydrogeologic conditions that existed at the time the study was conducted and may be either lower or higher depending on climatic conditions and weather patterns that affect the overall snowfall and precipitation, and thus recharge to the aquifer in a given year.

Groundwater quality in the shallow aquifer would be slightly degraded under all alternatives through the transfer of algal toxins from the lake into the groundwater during and following algae blooms. This would occur only if the toxins were present in the lake water when the groundwater flow reversal occurs, (lake water recharging groundwater). Under Alternatives 2 and 3, this effect would be expected to decrease after approximately three years; under Alternative 4 some decrease in the effect is expected after six years; and under Alternatives 1 this effect would continue to occur on annual basis indefinitely. For all alternatives, there is also the potential that groundwater containing algal toxins would migrate and contaminate the water in some of the summer home wells. However, the risk of these potential effects actually occurring is considered to be very low because studies have shown that, due to bank filtration, both algal cells and dissolved toxins are removed very efficiently. The mean rates of removal for cells were 93.7 – 99.7 per cent and 97.5 – 99.5 per cent for extracellular toxins (Chorus and Bartram, 1999).

Under Alternative 2 and 3, this minor risk would be greatly reduced after 3 years because the tui chub population, the primary factor associated with the toxic algae blooms would be eliminated by this time; under Alternative 4, this risk would be reduced after 6 years because the mechanical removal would take at least this long to affect a change in tui chub populations; and under Alternative 1, this risk would be sustained into the future due to lack of action.

Alternatives 1 and 4 would have no other direct effects on the groundwater quality since neither alternative would alter the natural hydrogeological system by lowering the lake level or introducing chemicals to the lake.

Alternatives 2 and 3 would have potential temporary adverse effects to groundwater quality through the addition of rotenone to the surface waters of Diamond Lake. Groundwater may be adversely impacted if chemically treated lake water migrates from the lake into the groundwater. Results of the groundwater studies clearly indicate that the permeability of the shallow aquifer is sufficient to allow chemically treated lake water to recharge the groundwater and potentially migrate at a rate that could impact the overall groundwater quality of the shallow aquifer. Chemically treated lake water would be expected to affect groundwater during the point in the hydrologic cycle where and when the groundwater flow direction shifts from the lake being a groundwater discharge area to a groundwater recharge area (during late summer and fall).

If chemically treated lake water migrated into the groundwater and thus through the hyporheic zone, it would have a direct affect on the fauna living in the hyporheic zone (i.e., zooplankton, bacteria, and other microinvertebrates and macroinvertebrates). It is expected that some of these organisms would be killed by the chemical. The extent of this impact is unknown, however, because the rotenone naturally degrades and dilutes within a relatively short time frame (one to eight weeks), impacts are considered to be temporary. It is expected that fauna associated with the hyporheic zone would recover quickly as water quality returned to normal.

Additionally, if chemically treated lake water migrated into the groundwater, it would have the potential to enter the private wells of the summer cabins along the western shore and temporarily contaminate this water supply. Tolerances for rotenone in potable and irrigation waters have not been established by the U.S. EPA, even though the studies required for setting those tolerances have been completed. This does not mean that rotenone concentrations in drinking waters will create a problem; it just means that U.S. EPA has not established rotenone tolerances at this time. As a result, water containing residues of rotenone cannot be allowed for use as a domestic water source. During the time that rotenone residues are present, alternative water sources must be used for domestic and potable purposes. Depending on the initial rotenone concentration and environmental factors (e.g. temperature), this period can vary from 1 to 8 weeks (CDFG 1994; Finlayson and J. Harrington, unpublished data, presented at Chemical Rehabilitation Projects Symposium, Bozeman, Montana, 1991).

To assess the likelihood that a potential impact to the summer home wells would actually occur, it is necessary to evaluate the mobility of rotenone in the subsurface environment. Dawson et al. (1991) determined that rotenone is not very mobile in sediments. Rotenone leaches vertically less than 2 cm in most soil types, less than 8 cm in sandy soils, and binds readily to most sediments.

Under a worst-case scenario there would be no retardation of the rotenone and it would migrate freely with the groundwater. If this were to occur[134], it would take approximately 11 days to reach a well located 150 feet from the shore. If an attenuation/retardation factor of 10 is applied to the migration, it would take 113 days to reach the same well. Since rotenone shows a strong tendency to adhere to the organic matter in the soil, (Dawson 1991), an attenuation/retardation factor of 10 would be considered conservative, it would more than likely be much greater than 10.

CDFG (1994) reported that the California Department of Pesticide Regulation has determined that rotenone is not a potential groundwater contaminant. The authors site multiple studies where well monitoring of groundwater aquifers adjacent and downstream of rotenone applications were conducted. In all cases, analysis of groundwater samples were unable to detect rotenone, rotenolone, or any other organic compounds found in the formulated rotenone product. Thus, the results of these studies in conjunction with the propensity of rotenone to adsorb to sediment and soil and not migrate coincident with groundwater, support the conclusion that it is unlikely chemically treated water would enter summer home wells. However, in order to minimize any potential risks to homeowner health and safety, groundwater flow patterns would be monitored before and after the rotenone application; if necessary, west shore residents would be advised not to consume the well water; and bottled drinking water would be provided (see mitigation measure in Chapter 2).

Indirect Effects:
Potential effects of algal toxins on groundwater quality described under direct effects above would continue in the long term under some alternatives. For Alternative 1, the minor risk of degraded groundwater quality and contaminated summer home wells would continue indefinitely. For Alternative 4, these risks would be reduced after six years but, there is a

[134] Assumptions are: 1) with groundwater flowing toward the wells of the summer homes; 2) a hydraulic gradient of 0.007 ft/ft; 3) hydraulic conductivity of 2×10^{-2} cm/sec (57.6 ft/day); and 4) effective porosity of 0.03 (unitless).

great degree of uncertainty on how long improved water quality would be sustained under this alternative. For Alternatives 2 and 3, theses risks would be reduced after three years and are expected to remain low to none for many years.

There are no additional anticipated long-term indirect effects to groundwater quality associated with Alternatives 2 or 3 because: 1) all potential effects to the groundwater chemistry from the rotenone treatment would be temporary (one to eight weeks); and based on the seepage study chemically treated water in the groundwater would not be expected to surface in Lake Creek or be transported outside the project area.

Cumulative Effects:
With the exception of annual algal toxin presence, the existing condition of the groundwater at Diamond Lake is considered to be excellent. Implementation of past, present, and future water rights, as well as the 1954 rotenone treatment (described in the cumulative effects table) are the primary activities that contribute to the cumulative effects of management activities on the groundwater resource at Diamond Lake.

Alternatives 1 and 4 would make no measurable contribution to the cumulative effects on the groundwater in the project area, other than those described under direct and indirect effects. Alternatives 2 and 3 represent a temporary potential modification of groundwater chemistry with no anticipated negative long-term impacts and expected long-term improvements through a reduction in algal toxin presence. Thus, cumulative effects on groundwater are considered to be minor.

Conclusions:
Alternative 1 has minor, potential negative short-term and long-term impacts to groundwater through annual contamination with algal toxins. Alternatives 2 and 3 have potential temporary effects to groundwater from the rotenone treatment with no anticipated long-term negative effects and expected improvements in the long-term through reductions in algal toxins. Alternative 4 has limited short-term effects on groundwater quality because no rotenone treatment would occur. Reductions in algal toxins are expected, but it is uncertain how long the reductions would be sustained through time.

GROUNDWATER QUANTITY –GROUNDWATER DISCHARGE AND RECHARGE

AFFECTED ENVIRONMENT

Groundwater interacts with streams and lakes in all types of landscapes in three basic ways: streams and lakes gain water from inflow of groundwater to the streambed or lakebed, they lose water to groundwater by outflow through the streambed or lakebed, or they do both. The natural groundwater flow system around Diamond Lake changes temporally and spatially throughout the yearly hydrologic cycle. During part of the year, the lake is a groundwater discharge area (groundwater moves into the lake) and at other times the lake becomes the recharge area where water from the lake flows into the shallow aquifer immediately surrounding the lake. The timing and length of time in which recharge or discharge to the lake occurs is dependant on the level of water in the lake and of the surrounding groundwater. Any change to the level of the lake will directly affect the discharge and recharge of the shallow aquifer surrounding Diamond Lake, which in turn will affect the water table in the aquifer. The majority of what is known about the groundwater flow patterns at Diamond Lake is summarized in the Groundwater Investigation section of this document.

ENVIRONMENTAL EFFECTS

Direct Effects:
Alternatives 1 and 4 would have no direct effect on the groundwater discharge or recharge since neither alternative implements a draw down that alters the natural hydrogeological system.

Either Alternatives 2 or 3 would have the potential to produce a temporary adverse affect on groundwater discharge and recharge. Both alternatives rely on drawing down the level of the lake approximately 8 feet. By lowering the level of the lake 8 feet, the groundwater would act concomitantly, thus it would continue to discharge into the lake until a new equilibrium level is reached with the new level of the lake. This would effectively lower the groundwater table several feet from the normal groundwater table elevation. Thus, several direct effects would be expected to occur under Alternatives 2 and 3: 1) shallow wells in the summer home area would probably dry up; 2) portions of the wetlands along the southern border of the lake would dewater and become dry; and 3) the water levels in Horse Lake and Teal Lake would lower to the extent that they also could become dry. These potential impacts would be expected to remain until the level of the lake, and thus the groundwater table returns to the pre-draw down level.

The timeframe over which the groundwater table drops enough to stress the flora and fauna would lag behind the lowering of the lake level by several weeks, perhaps even months. The exact timing would depend on several factors such as, the amount of precipitation that falls over the area during the draw down period; the amount of recharge to groundwater from snowmelt and precipitation in the high mountain recharge areas; and other factor such as temperature and wind speed.

Potential dewatering of shallow wells (approximately 80 wells) on the west side of the lake would inconvenience some of the residents, particularly if water was unavailable during the high-use summer months. To help reduce inconvenience to potentially affected summer home owners, drinking water would be provided to cabin owners whose wells go dry.

Dewatering the Silent Creek wetlands would not occur at the same rate as lowering the lake. Since the groundwater must flow through a matrix of rock and soil (the aquifer), it would dewater only as fast as water can flow through it, which is dependent on its permeability and the gradient between the lake and groundwater. Additionally, the wetlands would not dewater to complete dryness, due to the effects of capillary action. Capillary action causes a certain amount of water to be retained in the pore spaces, similar to a wet sponge. For example, only a certain amount of water will freely flow out of a completely wet sponge, the remainder is retained in the sponge; this demonstrates the effects of capillary action. Similarly, the wetlands would only dewater to the point where free water would no longer flow. After that the wetlands would gradually become dryer as a result of evaporation[135] and evapotranspiration[136]. When these evaporating processes have acted on the wetlands for some time, flora and fauna would become stressed and the affects of lowering the water table would become evident.

The surface area of wetlands that may be affected also depends on the factors mentioned above (precipitation, temperature, etc.). However, it is expected that most of the southern wetland area (Figure 40) would be temporarily impacted to some degree, the exact extent is impossible to predict with the available data. For analysis purposes, it is assumed that approximately 135 acres of the Silent Creek wetlands would be temporarily impacted. Areas along Silent Creek would experience less of an impact due to the proximity to the local recharge zone of the creek. Affects would be more pronounced the greater the distance from any recharge area.

Monitoring gauges were installed in Horse and Teal Lakes to determine the extent of drying that normally occurs seasonally. Based on data collected from August 28, 2003 through November 5, 2003 it appears that water levels in Horse and Teal Lakes drop naturally in the late summer and fall and may become completely dry periodically in low precipitation years (Figure 36). Under Alternatives 2 and 3, it is considered likely that by late spring or summer following the draw down, these lakes may have little to no surface water remaining.

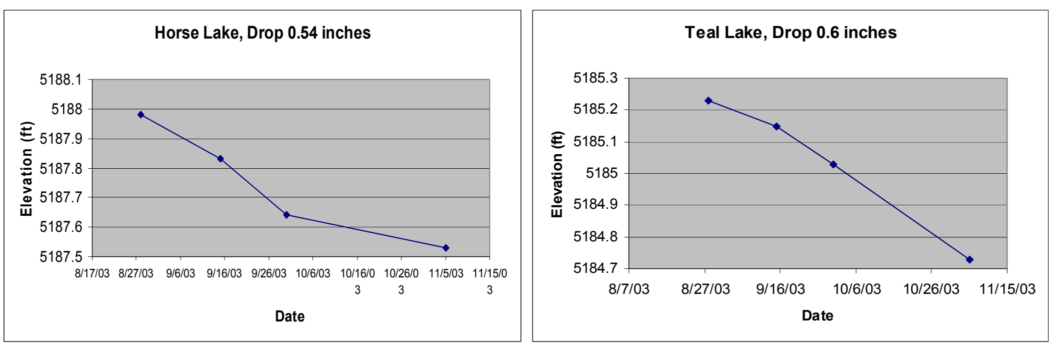

Figure 36. Hydrographs for Teal and Horse Lakes

With the exception of mitigation for one sensitive moss species, there are no recommended measures for mitigating the dewatering of the wetlands or small lakes. However, it should be noted that no long-term deleterious affects to the wetlands are expected because of the temporary lowering of the groundwater table. Most wetland plants can survive short durations of dewatering stress. The groundwater table will rise and return to normal levels as the lake is refilled. Additionally, precipitation during the fall would also help rehydrate exposed plants.

Indirect Effects:

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[135] Evaporation is the process by which liquid water is converted into water vapor.
[136] Evapotranspiration is the combination of evaporation from free water surfaces and transpiration of water from plant surfaces to the atmosphere.

Alternatives 1 and 4 would have no indirect effect on the groundwater discharge or recharge since neither alternative alters the natural hydrogeological system given the lack of any draw downs.

As described above, Alternatives 2 and 3 would not be expected to result in any long-term effects to groundwater, thus they would have no impact on the future groundwater resource. All potential impacts to flora and fauna associated with the temporary dewatering of the Silent Creek wetlands and Horse and Teal Lakes are described in the Wildlife and Botany sections of this chapter.

Cumulative Effects:
Implementation of past, present, and future water rights, as well as the previous lake draw down, (see cumulative effects tables) are the primary activities that contribute to the cumulative effects of management activities on the groundwater resource at Diamond Lake. The existing condition of the groundwater resource is considered to be excellent. Alternatives 2 and 3 represent a temporary, potential modification of the groundwater flow patterns with no anticipated long-term impacts. Based on this information, potential cumulative effects on groundwater associated with these are considered to be minor.

Conclusions:
Alternatives 1 and 4 would have no direct, indirect, or cumulative effects to groundwater levels. Alternatives 2 and 3 have potential temporary effects to groundwater levels with no anticipated long-term negative effects. A summary of important conclusions about groundwater and a comparison of the alternatives are documented in Table 29.

Table 29. Comparison of Alternatives Effects on Groundwater.

Alternatives	Alternative 1 - No Action		Alternative 2 – Rotenone, put, grow, and take		Alternative 3 - Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time Period	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**	**Short-term**	**Long-term**
Indicator **Risk of Well Contamination by Toxins**	No rotenone risks. No meaningful algal toxin risks.	No rotenone risks. No meaningful algal toxin risks.	Rotenone risks low to none with mitigation. No meaningful algal toxin risks.	No rotenone risks. No meaningful algal toxin risks.	Rotenone risks low to none with mitigation. No meaningful algal toxin risks.	No rotenone risks. No meaningful algal toxin risks.	Rotenone risks low to none with mitigation. No meaningful algal toxin risks.	No rotenone risks. No meaningful algal toxin risks.
Indicator **Acres of Wetlands Potentially Dewatered**	0	0	135	0	135	0	0	0

Alternatives	Alternative 1 - No Action		Alternative 2 - Rotenone, put, grow, and take		Alternative 3 - Put and Take Fishery		Alternative 4 - Mechanical & Biological	
Time Period	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Number of Summer Home Wells Potentially Dewatered	0	0	80	0	80	0	0	0

TERRESTRIAL ENVIRONMENT

TERRESTRIAL VEGETATION

Scoping identified a concern that a lake draw down may adversely affect wetlands and the flora (plant life) associated with them. This issue is tracked under the titles TES plants, Survey and Manage Species, and Wetland Plant Ecology in this section.

No issues related to upland vegetation or noxious weeds were identified in scoping. Information on these topics is included to provide a landscape context for the project and enhance understanding of the affected environment.

UPLAND VEGETATION

AFFECTED ENVIRONMENT & EVIRONMENTAL EFFECTS

Upland vegetation types surrounding Diamond Lake and along Lake Creek are dominated by coniferous montane forests heavily influenced by snowpack, geology, fire, soils and topographic relief. In general these forests are typical for elevations of 4,500-5,500 feet in the Southern Cascade Mountains. Four distinct forest types exist within the project, the most abundant being a lodgepole pine (*Pinus contorta*) dominated forest. Lodgepole pine forests occupy flat topography with soils that hold little moisture and have little organic matter. Repeated stand replacing fires can result in large tracts of land being dominated by lodgepole. The lack of a stand replacing fire would usually result in succession leading to a mountain hemlock/mixed fir dominated forest. These forest types are also more common along areas with some topographic relief especially with northeast to northwest aspects. Mountain hemlock (*Tsuga mertensiana*), Shasta red fir (*Abies magnifica var. shastensis*), white fir (*Abies concolor*), western white pine (*Pinus monticola)* and Douglas fir (*Pseudotsuga menziesii*) are the dominate tree species. A third type of forest is fairly limited and occurs in wet depressions and along the edge of wetlands. This vegetation type is dominated by Englemann spruce (*Picea englemannii*) and occurs along the banks of Lake Creek between Diamond Lake and Lemolo Lake. The fourth distinct forest type is dominated by Ponderosa pine (*Pinus ponderosa*) and is mostly confined to a relatively small area around the north end of Diamond Lake.

ENVIRONMENTAL EFFECTS

Direct and Indirect Effects:

Alternatives 1, 2, 3 & 4
The scale at which direct and indirect effects are addressed is the project area boundary. A small amount of ground disturbance would occur as a result of re-constructing the canal on the north end if Alternative 2 or 3 is implemented; however, this low level of disturbance would not produce negative effects. No other ground disturbing activities are proposed that would have any direct or indirect effects on vegetation. The project would not lead to any negative direct or indirect effects with regards to upland vegetation.

Cumulative Effects:

Alternatives 1, 2, 3 & 4

The scale at which cumulative effects are addressed is the 5th field watershed level. Many affects to the upland vegetation from past practices have occurred. Sheep grazing, telephone line installation, construction of campgrounds, road building, Lemolo 1 hydro project construction, construction of cabins, construction of the Dellenback trail, timber harvest, extensive road-building, stockman ignited fires and herbicide use for competition within timber plantations are some examples of actions that have impacted upland vegetation in the past within the vicinity of this project area. (see cumulative effects Table 9 for more detailed information). Fewer activities are currently impacting the upland vegetation environment and include hazard tree removal, fuel reduction projects, fire camp expansion, and herbicide and non-herbicide treatments of noxious weeds. (see cumulative effects Table 10). Foreseeable projects in the future that may impact the upland vegetation include hazard tree removal, Lemolo timber sales, fuels reduction projects and herbicide and non-herbicide treatments of noxious weeds (see cumulative effects Table 11.). Implementing any of the alternatives within this project is not likely to lead to any negative cumulative effects (when combined with the past, present and reasonably foreseeable actions) to upland vegetation because the scope of this project is focused on aquatic systems and does not propose any alteration of upland vegetation systems.

NOXIOUS WEEDS

No issues related to noxious weeds were identified in scoping.

AFFECTED ENVIRONMENT

Two non-native species were found to be occurring in the area that would be affected by this project. Reed canary grass (*Phalaris arundinaceae*) is not listed by the state or the Umpqua National Forest as a noxious weed, but it is a non-native species that can cause displacement of native plants, especially in wetlands and along stream and river corridors. Reed canary grass was found to be growing all around Diamond Lake and along Lake Creek all the way down to Lemolo Lake. This grass is fairly abundant where it is found and forms dense colonies that out compete or displace other vegetation.

Only one very common, nearly naturalized[137], state and forest listed noxious weed was found to be occurring within the project area. St. Johnswort (*Hypericum perforatum*) is a perennial forb introduced from Europe that has become well established on the Diamond Lake Ranger District. It is mostly distributed along roads, but is also known to occur in natural meadows and forests with less than 30% canopy. It was found in the open dry forested area along the southwest corner of the lake as well as in campgrounds and along many roads in the project area.

ENVIRONMENTAL EFFECTS

Direct and Indirect Effects:

<u>Alternatives 1 & 4</u>
The scale at which direct and indirect effects are addressed is the project area boundary for all alternatives. These alternatives would have no direct or indirect effects with regards to the spread of noxious weeds within the planning area. This is because these alternatives do not propose any activities that would spread any of the reed canary grass populations that ring the lake or occur along Lake Creek nor do they propose any activities that would spread or expand any of the St. Johnswort populations within the project area.

<u>Alternatives 2 & 3</u>
Both of these alternatives propose a draw down of the lake and construction related to reforming a canal that exits at the north side of Diamond Lake. These actions have the potential to increase the populations of reed canary grass around the lake and especially at the outlet of Lake Creek. It is not possible to know exactly what would occur due to these actions and it may be that this weedy species would not spread at all or possibly even decrease due to the extended drying that would occur around the edge of the lake as a result of the draw down. In most cases where heavy machinery works and disturbs ground, weeds expand to surrounding disturbed areas. The risk is moderate to likely that the reed canary grass problem would be exacerbated by implementing either of these alternatives. This risk is lessened by mitigation measures incorporated into Alternative 2 and 3, which require the re-vegetation of disturbed areas with native species, the education of work crews regarding this weed, and the washing of equipment to remove seed and plant parts to lessen the potential of spread.

Though not documented yet, a very important weed to keep out of the project area is purple loosestrife (*Lythrum salicaria*). Additionally, there are several aquatic weed species that could potentially be accidentally introduced into the lake during project work. Mitigation measures (included in Chapter 2) that require equipment washing, monitoring of the project area for any new invasive plants, and immediate action to control such invasions would help

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[137] Naturalized - an otherwise non-native plant that is so well established and has inundated so many different types of ecosystems that it is all but adapted to the new continent it was brought to.

to reduce the likelihood of an infestation of purple loosestrife or other weeds occurring as a result of implementing Alternatives 2 and 3.

The mitigation measures and monitoring requirements established for the action alternatives respond to the standards and guidelines from the 2002 Forest Plan amendment for the Integrated Weed Management Strategy (Forest Plan Amendment #5).

Cumulative Effects:

Alternatives 1 & 4

The scale at which cumulative effects are addressed is the 5th field watershed level. Many effects with regards to the spread of noxious weeds from past practices have occurred. Sheep grazing, telephone line installation, construction of campgrounds, road building, Lemolo 1 hydro project construction, construction of cabins, construction of the Dellenback trail, timber harvest and extensive road building are some examples of actions that have led to a spread of noxious weeds in the past within this project area (Table 9). Fewer activities currently have the potential to spread noxious weeds but include hazard tree removal, fuel reduction projects and fire camp expansion. A positive ongoing activity for removing noxious weeds is the treating of spotted knapweed (*Centaurea beibersonii*) with herbicide along highway 138 (Table 10). Foreseeable projects in the future that may impact the spread of noxious weeds include hazard tree removal, Lemolo timber sales and fuels reduction projects (Table 11). The continued use of herbicide and various methods to control noxious weeds is a positive impact. Implementing either of these alternatives is not likely to lead to any negative cumulative effects (when combined with past, present or reasonably foreseeable actions) to noxious weeds as these alternatives do not propose ground disturbing activities or a lake draw down.

Alternatives 2 & 3

Management activities that contribute to cumulative effects to noxious weeds are the same as described under Alternatives 1 and 4. Implementing either of these alternatives has the potential to further the spread of noxious weeds, especially reed canary grass. Disturbing the existing sites of reed canary grass, as these alternatives propose to do, has the potential to combine with past, present and potential future projects to lead to a overall likely increase of this species within the watershed. However, because the species is already well established throughout the project area, the consequences of this cumulative impact would be relatively minor.

Threatened, Endangered and Sensitive (TES) Plants

AFFECTED ENVIRONMENT

No Threatened or Endangered plants are known to occur on the Diamond Lake Ranger District and no habitat exists for any species listed as such. A complete Biological Evaluation (BE) disclosing affects to Regional listed Sensitive plants can be referenced in Appendix X. Also under the section on wetland plants and ecology there is a discussion about rare plants and their communities within the wetland ecosystems.

There are 35 species on the Regional Forester's Sensitive Plant list. Only one species, Kincaid's Lupine, is listed as Threatened throughout its range. This plant occurs in oak savannah habitat in the Willamette valley and is known from one isolated population on the Tiller Ranger District. There is no potential habitat for this plant within this planning area. The following sensitive plants with potential habitat in the project area are displayed in Table 30. All other sensitive species are listed in the botanical Biological Evaluation; no habitat exists for those species within the project area and they will not be discussed further.

Table 30. Sensitive species with potential habitat in the project area.

Latin Name	**Common Name**	**Found During Surveys**
Calamagrostis breweri Thurb.	Brewer's reedgrass	
Carex crawfordii Fern.	Crawford's sedge	
Carex serratodens W. Boott	twotooth sedge	
Schuezeria palustris ssp. americana L.	American Scheuzeria	**x**
Scirpus subtermanalis (Torr.) Sojak	water bulrush	**x**
Utricularia minor L.	lesser bladderwort	**x**
Wolffia columbiana Karst.	Columbian water-meal	
Wolffia borealis (Engelm. Ex Hegelm.) Landolt ex Landolt & Wildi.	northern water-meal	

Potential habitats within the project area were surveyed during June and July of 2003. Potential habitat for sensitive plants was confined to wetlands along the south shore of Diamond Lake, along Lake Creek and along the south shore of Lemolo Lake. Three sensitive plants were found during field surveys.

American Scheuzeria was found in a fen[138] along Lake Creek just south of Highway 138. The population occurs over a three acre area within the fen.

Water bulrush was found growing on the margins of Teal and Horse Lakes as well as on the margins of shallow pools within the south shore wetland complex adjacent to Diamond Lake. Juvenile forms of the plant were also found in Diamond Lake along shallow margins at the south end of the lake. The condition of water bulrush with regard to population size, vigor and overall health is questionable. This is thought, though no quantitative data exists, to be a result of the previous 1954 draw down which likely affected this species' habitat negatively through drying of the wetland environment.

Lesser bladderwort was found growing in the south shore Diamond Lake wetland complex as well as the south shore Lemolo Lake wetland. The sites are very similar with plants occurring in areas with shallow standing water. The plant has small modified leaves that float on the surface of water and trap insects. Lesser bladderwort was found growing near the sites of water bulrush and likely suffered from the same negative effects due to the 1954 draw down and rotenone treatment.

[138] A fen is a wetland ecosystem in which the main source of water is usually nutrient rich groundwater.

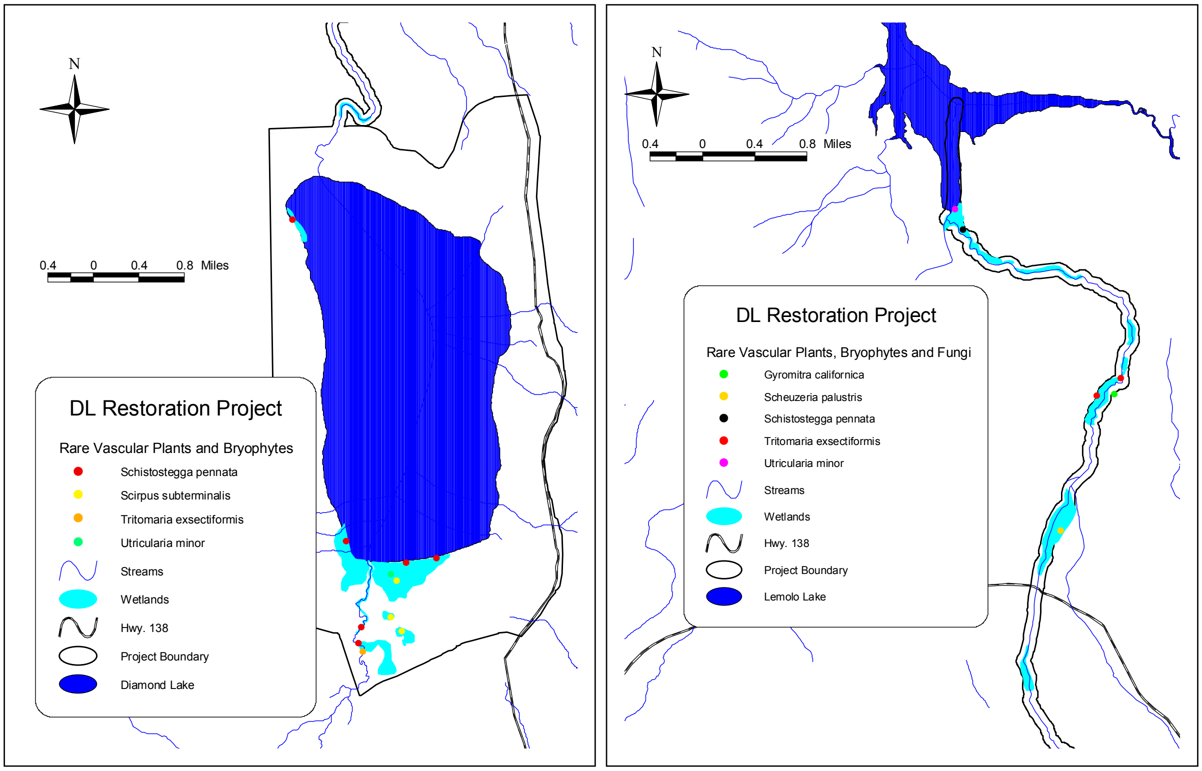

Figure 37. Rare plant sites within the project area.

ENVIRONMENTAL EFFECTS

American Schuezeria

Direct & Indirect Effects:

Alternative 1 & 4

Neither of these alternatives propose activities that would jeopardize this population of American Scheuzeria. This species is a wetland obligate species that is dependent on the fen ecosystem. These alternatives do not plan any alteration of that system; therefore, no direct or indirect effects would occur under these alternatives.

Alternative 2 & 3

None of the actions proposed in these alternatives would cause direct effects to this plant population. Indirect effects may occur if potential flooding and drying would occur in Lake Creek. However it is likely that this fen is dependent upon springs and groundwater (Hofford pers. com., 2003). It is unknown how much this fen depends on water from Lake Creek to keep it wet year round. If significant flooding or drying does occur there is potential for individual plants to be uprooted and washed downstream as well as for individual plants to desiccate. Neither of these scenarios would necessarily lead to extirpation of this population. Flooding is a natural occurrence and may actually help distribute the plant to new locations. Drying is not likely to affect this species or the fen, which is raised a little above the stream terrace. Therefore, no indirect effects are expected to occur. However there is minimal risk that negative effects could occur in a worse case scenario.

Cumulative Effects:

Alternative 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. The only past action that may have had affects on this population would be the 1954 lake draw down and subsequent drying of Lake Creek. This is only speculative, however, and the population seems to be fully recovered, if any negative effects did indeed occur (see Table 9 for past management activities). The only current ongoing activity that may be affecting this population is the water rights that change flow of Lake Creek from natural historic flows (Table 10). The influence of this water manipulation has obviously not been enough to negatively impact this population to date. Under these two alternatives no future foreseeable projects would have any affects on this population of American Scheuzeria (Table 11). When combined with the past, present and reasonably foreseeable projects, implementing either of these alternatives is not likely to lead to any negative cumulative effects to this population of American Scheuzeria, which is the only known population within the entire Umpqua basin.

Alternatives 2 & 3
The past, present and reasonably foreseeable actions contributing to cumulative effects are the same as those described under Alternatives 1 and 4. Under these two alternatives there is minimal risk that this project would have any affects on this population of American Scheuzeria. When combined with the past, present, and reasonably foreseeable actions (Tables 9-11), implementing either of these alternatives is not likely to lead to any negative cumulative effects to this population of American Scheuzeria.

Water bulrush

Direct and Indirect Effects:

Alternatives 1 & 4
Neither of these alternatives proposes activities that would jeopardize these populations of water bulrush. This species is a wetland obligate species that is dependent on lake margins and fen ecosystems with areas of shallow water. These alternatives do not plan any alteration of these systems; therefore, no direct or indirect effects would occur under these alternatives.

Alternatives 2 & 3
No direct effects to water bulrush are expected to occur as a result of implementing either of these alternatives. Indirect effects are likely to occur as a result of lowering Diamond Lake and drying the margins of the lake, the sedge meadow/fen systems along the south shore, and the potential drying of Teal Lake (Breeden pers. com., 2003, Kemmers and Jansen, 1988, Beltman et. al. 2001). This would almost certainly lead to some desiccation of plants from the drying of their habitat. Whether these effects would be long term is unknown, but it is anticipated that the water bulrush would likely return within five years.

Cumulative Effects:

Alternatives 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. Past actions that may have had affects on this plant would be the 1954 draw down and water rights which affect the levels and margins of Diamond Lake (Table 9). The only current ongoing activity that may be affecting this population is the water rights that continue to impact the lake margins of Diamond Lake (Table 10). The influence of this water manipulation has possibly caused populations of water bulrush to stay in a juvenile state, potentially halting reproduction. By keeping the water at a steady high level, the margin of Diamond Lake has not naturally receded, an event which would open habitat for this species. Under these two alternatives, the only future foreseeable action that would have affects on this plant would be maintaining the water rights (Table 11). When combined with the past, present, and reasonably foreseeable effects, implementing either of these alternatives is not likely to lead to any negative cumulative effects to this population of water bulrush.

Alternatives 2 & 3
The past, present and reasonably foreseeable actions contributing to cumulative effects are the same as those described under Alternatives 1 and 4. Under Alternatives 2 and 3, future foreseeable actions that would have affects on this plant would be implementing either of these alternatives and maintaining the water rights (Table 11). When combined with the past, present, and reasonably foreseeable actions (Tables 9-11), implementing either of these alternatives is likely to lead to negative cumulative effects to this population of water bulrush. This is because the extended drying of the plants habitat proposed with these alternatives, as well as the 1954 treatment and the manipulation of lake water levels are affects that have and would continue to negatively impact this sensitive plant by drying its habitat. This effect would lead to some loss of individual plants and may compromise reproductive ability of the species. It is anticipated however, that these plant populations would recover relatively soon because the period of plant desiccation would not occur any longer than one season.

Lesser bladderwort

Direct and Indirect Effects:

Alternatives 1 & 4
Neither of these alternatives propose activities that would jeopardize these populations of lesser bladderwort. This species is a wetland obligate species that is dependent on sedge meadow/fen ecosystems with areas of shallow water. These alternatives do not plan any alteration of these systems; therefore, no direct or indirect effects would occur under these alternatives.

Alternatives 2 & 3
No direct effects are expected to occur as a result of implementing either of these alternatives. Indirect effects are likely to occur as a result of lowering Diamond Lake and

drying the sedge meadow/fen ecosystems along the south shore of Diamond Lake (Breeden, 2003, Kemmers and Jansen, 1988, Beltman et. al. 2001). Desiccation is expected in some plants as a result of prolonged drying of the habitat. Whether these effects will be long term is unknown, but it is anticipated that the lesser bladderwort would likely return in a relatively short amount of time.

Cumulative Effects:

Alternatives 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. Past actions that may have had affects on this plant would be the 1954 draw down Diamond Lake and the implementation of Lemolo 1 hydropower projects (Table 9). The only current ongoing activity that may be affecting this population is the Lemolo 1 hydropower projects which fluctuates water at Lemolo Lake. These actions have not resulted in the complete extirpation of this species from the area, but they have likely significantly reduced the amount of habitat (see Table 10 for present management activities). Under these two alternatives the only future foreseeable action that would have affects on this plant would be the continued operation of the Lemolo 1 hydro project (Table 11). When combined with the past, present, and reasonably foreseeable effects, implementing either of these alternatives is not likely to lead to any negative cumulative effects to these populations of lesser bladderwort since no alteration of the aquatic systems would occur.

Alternatives 2 & 3
The past, present and reasonably foreseeable actions contributing to cumulative effects are the same as those described under Alternatives 1 and 4. When combined with the past, present, and reasonably foreseeable actions, implementing either of these alternatives is likely to lead to negative cumulative effects to some of the populations of lesser bladderwort due to the potential of prolonged drying of their habitat. It is likely that the 1954 draw down combined with the proposed draw down would cause drying and desiccation to lesser bladderwort populations on the south shore of Diamond Lake. A loss of individual plants is expected and there may be a loss of vigor within the entire population along the south shore, which already seems to be only barely holding on. The populations at the south end of Lemolo Lake would likely not be impacted by these alternatives.

SURVEY AND MANAGE SPECIES

AFFECTED ENVIRONMENT

Surveys for rare and little known plants and mushrooms referred to as Survey and Manage species in the Northwest Forest Plan, were completed according to established protocols during the summer of 2003. Three rare Survey and Manage species were discovered within the project area during surveys; two rare bryophytes adapted to wetland conditions that persist around Diamond Lake and along Silent Creek and Lake Creek, and one fungus that seems to prefer wetland meadow edges.

Goblin's gold (*Schistostega pennata*) (Figure 38) is a Survey and Manage category "A" moss requiring management of all known sites. Three sites are known on the Umpqua National

Forest, two of which occur within this project area. The population along Silent Creek is the southern most known site on the west coast of North America. This species grows on the underside of rootwads of lodgepole pine that have tipped over in the wet unstable soils along Diamond Lake and in other wet meadows adjacent to Silent Creek and Lake Creek. The substrate and ecological niche this moss is adapted to is fairly specific and rare across the landscape. The management recommendations for this species state that maintaining micro-climatic conditions and leaving rootwads intact are necessary for the persistence of the moss.

Figure 38. Goblin's gold moss.

Goblin's gold (*Schistostega pennata*) (Figure 38) is a Survey and Manage category "A" moss requiring management of all known sites. Three sites are known on the Umpqua National Forest, two of which occur within this project area.

The population along Silent Creek is the southern most known site on the west coast of North America. This species grows on the underside of rootwads of lodgepole pine that have tipped over in the wet unstable soils along Diamond Lake and in other wet meadows adjacent to Silent Creek and Lake Creek. The substrate and ecological niche this moss is adapted to is fairly specific and rare across the landscape. The management recommendations for this species state that maintaining micro-climatic conditions and leaving rootwads intact are necessary for the persistence of the moss.

Little brownwort (*Tritomaria exsectiformis*) is a Survey and Manage category "B" liverwort requiring management of all known sites. Of the seventeen known sites of this species, five occur on the Umpqua National Forest; two are within this project area. This species forms tiny leafy mats on moist to wet decaying logs that have fallen from the edge of fens[139] and are being decomposed slowly in the fen environment. It also can be found on hummocks of sphagnum[140] on the edge of slow moving streams. This unique wetland environment is fairly rare across the landscape, hence the rareness of this species. No official management recommendations exist for this species. Draft recommendations state that maintaining micro-climatic conditions and maintaining the integrity of substrate are essential with regard to persistence of sites.

[139]Fens are a wetland ecosystem in which the main source of water is usually nutrient rich groundwater.
[140]Sphagnum is a general term for moss forming peat mounds.

Figure 39. California elfin saddle.

California elfin saddle *(Gyromitra californica)* (Figure 39) is a Survey and Manage category "B" fungus. This species has only been found in two locations (including this site) on the Umpqua National Forest and is known from 33 sites in the Pacific Northwest. It seems to prefer edges of wet meadows, at least on the Umpqua National Forest. This species is not covered under the "Management Recommendations for Survey and Manage Fungi" (September, 1997) and there is no other known source to reference for this information. This species is a decomposer, so it is important to keep downed wood moist and intact where the fungus was found growing.

ENVIRONMENTAL EFFECTS

Goblin's gold

Direct and Indirect Effects:

Alternatives 1 & 4
These alternatives do not propose any draw down of Diamond Lake or associated affects to Lake Creek. The habitats for this Survey and Manage moss depends solely on these hydrologic systems and the humidity and habitat they create. These alternatives do not propose to alter any of these systems and would lead to no direct or indirect effects to goblin's gold.

Alternatives 2 & 3
No direct effects are expected to occur as a result of implementing either of these alternatives. Indirect effects are likely to occur as a result of lowering Diamond Lake and drying the margins of the lake and the sedge meadow/fen systems along the south shore (Breeden, 2003, Kemmers and Jansen, 1988, Beltman et. al. 2001). Species of moist habitats (e.g. *Schistostega pennata*) are always killed by even slight drying (Proctor 1982). According to Regional Bryophyte Taxa Expert, Judy Harpel PhD., it is likely that *S. pennata* would return to the south shore sites as long as the populations along Silent and Lake Creeks remain as dispersal sources for future re-colonization (Harpel pers. Comm., 2003).

Therefore, with mitigation, there is a minimal risk that it would be extirpated from the south shore wetlands and populations would continue to persist along Silent Creek, Lake Creek, and near Lemolo Lake, as well as other populations outside of this project in the Kelsay Valley.

Cumulative Effects:

Alternatives 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. Past actions that may have had effects on this moss would be the 1954 lake draw down and water rights which affect the levels and margins of Diamond Lake (Table 9). The only current ongoing activity that may be affecting this population is the water rights that continue to impact the lake level of Diamond Lake (Table 10). This action may actually be a positive effect to this moss because it keeps the habitat wet for longer each year, which seems to be necessary for the moss to persist. Under these two alternatives the only future foreseeable action that would have affects on this plant would be maintaining the water rights (Table 11). Implementing either of these alternatives would not lead to any negative cumulative effects to goblins gold, since no lake manipulation activities would occur.

Alternatives 2 & 3
The past, present and future actions that contribute to cumulative effects would be the same as described under Alternatives 1 and 4 for this species. Implementing Alternatives 2 and 3 may lead to negative cumulative effects, when combined with the past, present, and reasonably foreseeable effects, as continued drying from the lake draw down may impact the habitat for this species. However, it is thought that these populations would re-establish after a few years, as long as there is a source for re-colonization (Harpel pers. com., 2003). The populations up Silent Creek would not be impacted and would provide a source for dispersal and re-colonization. In addition, mitigations detailed in Chapter 2, that require supplying water to about a third of the population, would facilitate maintenance of a portion of the affected individuals throughout the draw period and would promote re-colonization.

Little brownwort

Direct and Indirect Effects:

Alternatives 1 & 4

These alternatives do not propose any draw down of Diamond Lake or associated affects to Lake Creek. The habitats for this Survey and Manage liverwort depend solely on these hydrologic systems and the humidity and habitat they create. These alternatives do not propose to alter any of these systems and would lead to no direct or indirect effects to little brownwort.

Alternatives 2 & 3
No direct effects are expected to occur as a result of implementing either of these alternatives. There is potential for indirect effects to occur if Lake Creek floods or dries significantly enough to dry out the areas where the liverwort is growing. There is minimal risk that this would occur and even if it did there are several sites far enough away from Lake Creek that don't seem to be under any influence from the creek and would continue to persist. These sites would serve as dispersal populations should some of the little brownwort sites be impacted by the project. The proposed effects to this liverworts habitat would be temporary. No long term impacts to habitat conditions are anticipated.

Cumulative Effects:

Alternatives 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. Past actions that may have had affects on this liverwort would be the 1954 lake draw down which may have affected Lake Creek (Table 9). No current activities are affecting the populations of this species (Table 10). Under these two alternatives there are no future foreseeable projects that would affect this species (Table 11). Implementing either of these alternatives would not produce any negative cumulative effects, when combined with past, present or reasonably foreseeable actions for little brownwort.

Alternatives 2 & 3
The past, present and future actions that contribute to cumulative effects would be the same as described under alternatives 1 and 4 for this species. Implementing either of these alternatives may lead to negative cumulative effects when combined with past, present, and reasonably foreseeable effects described for little brownwort. However, there is minimal risk that negative cumulative effects would occur and it is anticipated that it would take a one hundred year flood or severe drying much worse than expected to produce those effects. If these kinds of events do take place, several sites far enough away from Lake Creek would remain and would not be impacted by the project. These sites would serve as dispersal populations if some of the little brownwort sites were impacted.

California elfin saddle

Direct and Indirect Effects:

Alternatives 1 & 4
These alternatives do not propose any draw down of Diamond Lake or associated affects to Lake Creek. The habitats for this Survey and Manage fungus depend on these hydrologic systems and the humidity and habitat they create. These alternatives do not propose to alter any of these systems and would lead to no direct or indirect effects to California elfin saddle.

Alternatives 2 & 3
No direct effects are expected to occur as a result of implementing either of these alternatives. There is potential for indirect effects to occur if Lake Creek floods or dries significantly enough to dry out the areas where the fungus is growing. There is minimal risk that this would occur (Hofford pers. com., 2003). With the minimal risk present, it is likely that no indirect effects would occur to this fungus.

Cumulative Effects:

Alternatives 1 & 4
The scale at which cumulative effects are addressed is the 5th field watershed level for all alternatives. Past actions that may have had affects on this fungus would be the 1954 lake draw down which may have affected Lake Creek (Table 9). No current activities are affecting the populations of this species (Table 10). Under these two alternatives there are no future

foreseeable projects that would affect this species (Table 11). Implementing either of these alternatives is not likely to lead to any negative cumulative effects when combined with past, present, and reasonably foreseeable actions described for California elfin saddle.

<u>Alternatives 2 & 3</u>
The past, present and future actions that contribute to cumulative effects would be the same as described under alternatives 1 and 4 for this species. Implementing either of these alternatives may lead to negative cumulative effects when combined with the past, present, and reasonably foreseeable actions for California elfin saddle. There is minimal risk that negative effects would occur and it would take a one hundred year flood or severe drying much worse than anticipated to produce those effects. However, if this site is extirpated it is the only known site in the watershed and would produce significant cumulative effects at this scale. There is one other known site in the Fish Creek Desert area, 13 miles to the west. However, with the minimal risk associated with these alternatives, it is anticipated that no cumulative effects would occur.

WETLAND PLANT ECOLOGY

AFFECTED ENVIRONMENT

Approximately 300 acres of wetlands occur within the project area (Figure 40). Roughly 140 acres of wetlands border the south shore of Diamond Lake. About 100 acres occur sporadically as small fens and riparian influenced areas along Lake Creek between Diamond Lake and Lemolo Lake. Another fairly large wetland complex borders Lemolo Lake near the mouth of Lake Creek. An emergent wetland area roughly 6 acres in size occurs along the northwest edge of Diamond Lake. An additional 0.6 acres of wetlands would be constructed in this area and planted with emergent wetland species under two action alternatives.

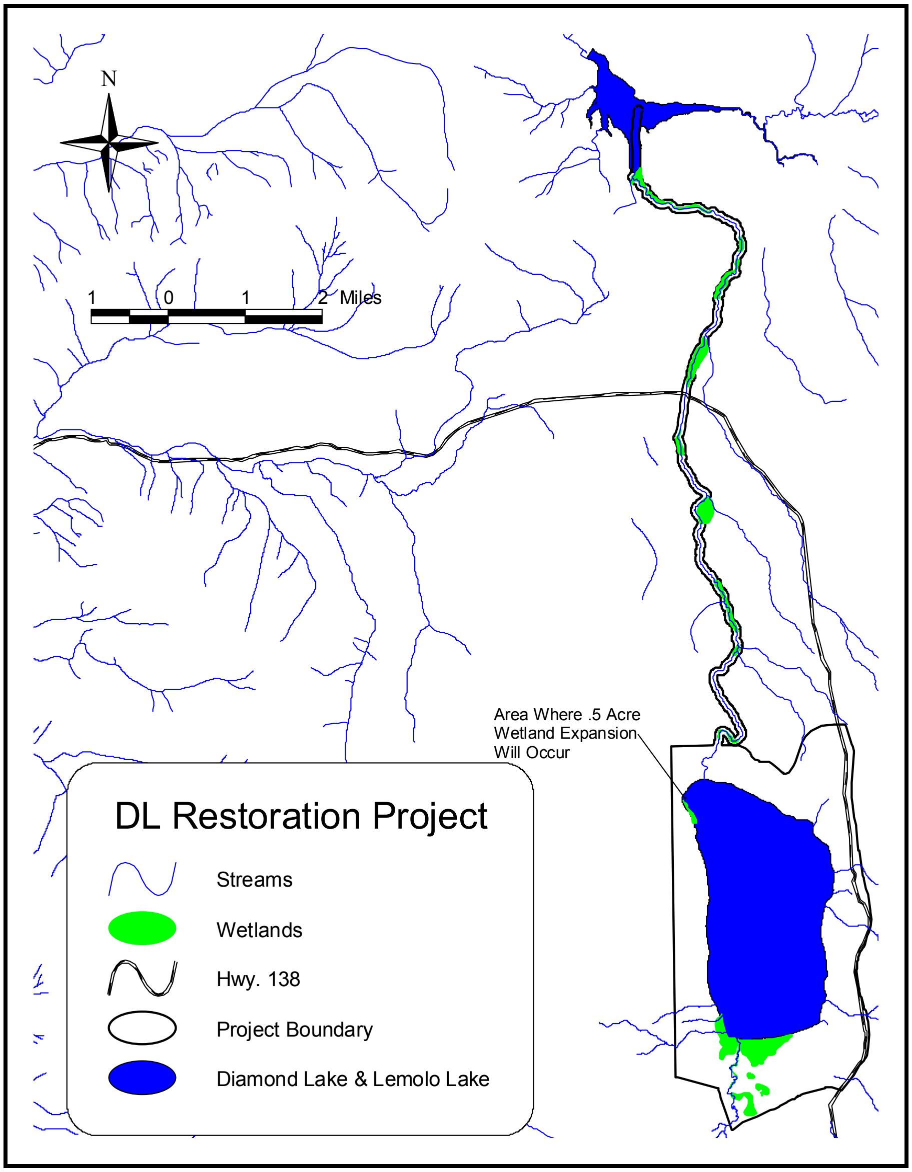

Figure 40. Wetlands Within the Project Area.

These wetlands are classified mostly as "poor fens" or "transitional wetlands" (Crum, 1988; Mitch & Gosselink, 1993; McNamara et. al., 1992; Boeye et. al., 1995) because of the presence of standing water with abundant sedges and grasses along with some areas being dominated by various moss species and *Sphagnum spp*. These are systems that are in a successional state between being a minerotrophic[141] fen and an ombrotrophic[142] bog, a process that is occurring over thousands of years.

[141]Minerotrophic fen- wetland ecosystems rich in nutrients deriving nutrients and water from precipitation and groundwater. Usually with a higher more basic pH.
[142]Ombrotrophic bog- wetland ecosystem that derives nutrients and water solely from the atmosphere because of the large amount of peat accumulation creating an impermeable barrier from groundwater. Usually with a very low acidic pH.

Some areas are in a more minerotrophic stage while some specific areas appear to be advancing more towards an ombrotrophic state. Subtle changes in plant species can be seen that indicate different pH and nutrient levels correlating with the different stages leading to a bog condition. Plants from the *Ericaceae* family such as bog laurel and bog blueberry are tolerant of the more acidic conditions persisting within the more ombrotrophic peat bog areas (Crum, 1988, Beltman et. al., 1996, Boeye et al., 1994).

The plant communities dependent on these wetland systems are fairly uncommon on the Umpqua National Forest and are habitat for three vascular plants listed as Sensitive and two rare bryophytes on the Survey and Manage list; these were described previously.

South Shore Diamond Lake Wetlands

The largest expanse of wetland ecosystems occur on the south shore of Diamond Lake. These wetlands seem to fit the classification of sedge meadows more than that of a fen system (Crum, 1988). However, certain areas within these meadows are showing more of a rich fen type system, as can be attested to by the presence of certain species of peat moss, which are rich fen indicator species. Sedge meadows are similar to marshes, but tend to be a bit drier during the summer months and can tolerate more drying in general. The fen ecosystem differs in that there is a constant supply of water rich in minerals (especially calcium) and by accumulating significant peat. Closer to Silent Creek the sedge meadow wetland gives way to a more classic type of a minerotrophic fen with a higher diversity of forbs. While forb abundance and diversity seem low in the south shore wetland, sedge diversity and especially abundance are fairly high. Table 31 lists the plant species that were found during field surveys in the summer of 2003.

Table 31. Plant Species Occurring in the South Shore Diamond Lake Wetland Complex.

Scientific Name	Common Name
VASCULAR PLANTS	
Carex aquatilis	water sedge
Carex canescens	silvery sedge
Carex echinata	star sedge
Carex utriculata	beaked sedge
Carex simulate	analogue sedge
Cicuta douglasii	western water hemlock
Comarum palustris	purple marshlocks
Drosera anglica	English sundew
Eleocharis pauciflora	fewflower spikerush
Eriophorum gracile	slender cottongrass
Juncus sp.	Rush
Nuphar lutea ssp. polysepala	Rocky Mountain pond lily
Pedicularis groendlandica	elephants head
Pinus contorta var. latifolia	lodgepole pine
Potamogeton sp.	Pondweed
Salix sp.	willow
Scirpus subterminalis	water bulrush
Sparganium natans	small bur-reed

Scientific Name	Common Name
Spiranthes romanzoffiana	hooded ladies'-tresses
Utricularia minor	lesser bladderwort
Vaccinium uliginosum	bog blueberry
MOSSES	
Aulocomnium palustre	ribbed bog moss
Drepanocladus sp.	
Schistostegga pennata	goblins gold
Sphagnum subsecundum	peat moss

Much of the wetlands are covered by sedges of one species or another. Figure 41(left) shows a band (light beige color) of star sedge surrounded by the most common and abundant sedge in the wetlands, beaked sedge. In areas where water is standing, other communities have begun to develop and yellow pond lily is usually present floating on the surface. In the more shallow waters on the margins of standing water, lesser bladderwort and water bulrush were found.

Figure 41. South shore wetland complex at Diamond Lake (left) and cottongrass (right) growing within a meadow complex.

Figure 41 (right) shows slender cottongrass (the white cottony looking plant in the background) and its habit of forming nearly pure stands in certain areas of the wetland. The other plant in this picture is fewflower spikerush and can be seen on the left side of the photo having small brown spike like inflorescences. An interesting aspect to the communities in these wetlands is how different plant species seem to take over and dominate given areas. Very few species were found to be occurring throughout the wetland in every distinct community.

The dependence of these wetlands on lake levels of Diamond Lake and groundwater discharge and recharge is imperative in understanding how these ecosystems have developed and are maintained. Groundwater studies show that these underwater aquifers play important roles in feeding water to Diamond Lake and the wetlands around the lake (Breeden pers. com., 2003).

Wetlands Along Lake Creek and Lemolo Lake

The wetlands along Lake Creek consist of more typical minerotrophic and transitional fens as well as riparian wetlands and floodplains (Crum, 1988; McNamara et. al., 1992). In some of these wetlands, much more peat and bog-type conditions exist as opposed to the wetlands on the south shore of Diamond Lake. A much more diverse array of forb species were documented in these areas. It appears that more mineral rich springs and underground water sources are feeding the wetlands along Lake Creek. The wetlands on the south shore of Lemolo Lake are more similar to those along Diamond Lake, but there is much more diversity in shrub and forb species. Figure 42 shows some of the diverse shrub and forb communities in these areas.

Figure 42. Wetland complex bordering Lemolo Lake illustrates the abundance of Bog Birch.

Shrub species such as bog birch and sitka alder dominate some areas, while diverse forb communities with species like slender cottongrass, hairy arnica, streamside groundsel and Columbian monkshood are interspersed throughout the wetlands.

ENVIRONMENTAL EFFECTS

The draw down of Diamond Lake along with potential flooding and then drying of Lake Creek are the actions in this project which may have impacts on the wetland ecosystems in the project area. No other direct, indirect or any other connected actions proposed would have any effects.

Direct and Indirect Effects:

<u>Alternatives 1 & 4</u>

The scale at which direct and indirect effects are addressed is the project area boundary for all alternatives. These alternatives do not require draining of Diamond Lake and the associated actions necessary to perform the draw down. Alternative 1 does nothing, basically leaving the existing condition as status quo. No adverse effects are currently known to be occurring to the wetland ecosystems. Though the water quality and recreational opportunities at the lake are being negatively affected, there has not been any correlation made that this would eventually affect the wetland ecosystems. Implementing either of these alternatives is expected to have no direct or indirect impacts on the wetland environment or the rare plant species dependent on those environments.

<u>Alternatives 2 & 3</u>

Direct Effects: Both of these alternatives propose an eight foot draw down of Diamond Lake. The change in water table and groundwater recharge expected from this action has the potential to temporarily dewater the south shore wetlands (Breeden pers. com., 2003). Dewatering the south shore wetland would result in some short term negative effects, in that some individual plants may dry and desiccate. Some of the species identified from the area are rhizomatous and are expected to recover from one season of drying. There is minimal risk that the draw down would result in permanent changes to the wetland environment on the south shore of Diamond Lake. There is some uncertainty as to whether the wetlands would incur any permanent changes, potentially changing the rare plant communities that are adapted to them. However, based on professional judgment and the low likelihood of permanent impacts, there is minimal risk that this would occur.

These alternatives also propose to raise the level of Lake Creek to bank full level while Diamond Lake is being drained and then lower the level of Lake Creek to nearly no flow after the eight foot draw down is completed. Most of the wetlands along Lake Creek are fed by localized springs and groundwater. However, there are some uncertainties about raising the creek to bank full during the fall and winter months because of the potential for severe flooding should a large rain or rain on snow event occur. The affects that severe flooding could have on the fen ecosystems adjacent to Lake Creek are unknown. Flooding is a natural disturbance and is within the historic range of variability for the area. But the flooding that may occur would most likely be exacerbated by the actions implemented from these alternatives. Flooding could also lead to positive effects due to increasing diversity of the fens allowing for new species to colonize, or it could lead to negative effects by allowing noxious weeds such as reed canary grass to colonize new areas. Although uncertainty exists, the risk is fairly minimal that negative effects to the fen vegetation would occur over the long term.

The lack of water in the Lake Creek channel after the draw down is complete also has potential to produce negative effects on these ecosystems. Lake Creek is expected to be fairly dry from the outlet at Diamond Lake down to the inlet of Thielsen Creek into Lake Creek (Hofford pers. com., 2003). See Figure 43 for details of where this would potentially occur.

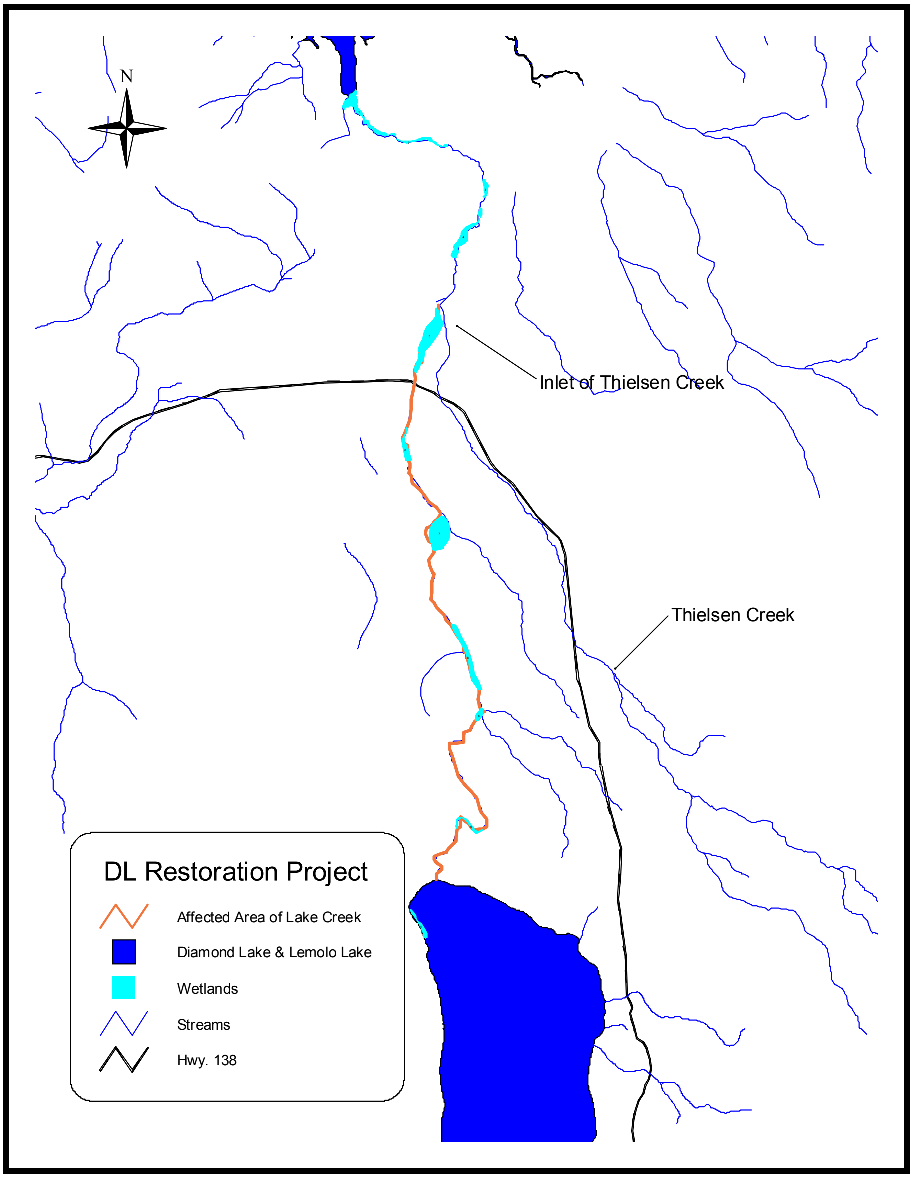

Figure 43. Map Showing Affected Area of Lake Creek From Drying After Draw Down Is Complete.

Most of the fen systems along Lake Creek are supported by localized springs and groundwater that would not be impacted by the draw down. There is uncertainty as to how much the water from Lake Creek affects these fen ecosystems and what would happen when that water is not available for an entire season. Literature does exist stating that manipulating hydrology in given catchment areas can have affects on certain types of minerotrophic fens (Kemmers and Jansen, 1988; Boeye et. al., 1995; Beltman et. al., 2001). However, it is not possible to say what the specific outcome of this temporary impact would be. It is anticipated that a moderate risk of direct negative effects to these fen ecosystems may occur as a result of the prolonged lack of water in Lake Creek under Alternatives 2 and 3.

Indirect Effects: The scale at which indirect effects are addressed is the project area boundary. The effects to hydrochemistry could play a role in what happens to the vegetation in these wetlands (Kemmers and Jensen, 1988). No data is available on the hydrochemistry of the wetlands so it is not possible to assess risk with regards to hydrochemistry. The proposal does not involve any changes in chemistry to Diamond Lake besides adding rotenone, which does not affect plants and would not change the hydrochemistry of the wetlands over the long term. From assessing the vegetation, it appears some areas are high in acidic components as these areas support species tolerant of those chemicals. Other areas appear to be high in various nutrients, especially phosphorous (Johnston pers. com., 2003). Minimal risk of long term changes to the plant communities from hydrochemistry alteration is likely.

The only other potential indirect effect includes the potential for noxious weeds to enter the wetlands. These effects were described previously.

Cumulative Effects:

<u>Alternatives 1 & 4</u>

Many effects to the wetlands from past practices have occurred, and have been described previously (Table 9). Some activities have had minor affects, while others have likely contributed to some severe changes in these ecosystems. For instance, the affects of recreation has probably had little impact with campers and hikers periodically trampling vegetation while the affects of road building directly impacted the wetlands with heavy machinery. The previous rotenone treatment and draw down probably caused some decline in species diversity and may have changed some of the composition of the south shore wetland complex. There is no way to be certain but with the potential for sustained drying under Alternatives 2 and 3 it can be assumed that there was also sustained drying 50 years ago. Sustained drying in wetlands can, and has in other cases, led to lower species richness (Kemmers et. al., 1988). Unfortunately, no quantitative or qualitative data from that era exists that describes the past effects. Fewer activities are currently impacting the wetland environments, but include hazard tree removal, Lemolo 1 hydro project implementation, recreation use and water rights use (Table 10). In particular, existing water rights may be significantly affecting the south shore Diamond Lake by not allowing the natural seasonal fluctuations of water on the lakes margins. This may be having the affect of eliminating certain species that would otherwise be emergent colonizers of the lake's edge. Foreseeable projects in the future that may impact the wetland environment include hazard tree removal, continued use of water rights, continued heavy recreation use and the Lemolo 1 hydro project (Table 11). The implementation of Alternatives 1 or 4 would not further contribute to cumulative effects, because neither alternative proposes a lake draw down.

<u>Alternatives 2 & 3</u>

The scale at which cumulative effects are addressed is the 5th field watershed level. Many effects to the wetlands from past and present practices have occurred and were described under Alternatives 1 and 4. They are the same for these alternatives. Implementing Alternative 2 or 3 of this project would likely contribute to negative cumulative effects to the wetland environments in the project area, especially those along the south shore of Diamond Lake. This is because the combined effects of the previous rotenone treatment and other past actions along with the proposed actions from either Alternative 2 or 3 would lead to an overall negative effect through drying, desiccation and simplification of species richness. However, it is expected that only short term negative effects would occur. There is minimal to moderate risk that long term negative cumulative effects would occur.

SUMMARY OF EFFECTS TO WETLAND PLANTS

Table 32. Summary of effects of each alternative to wetland plants in Diamond Lake.

Comparison Factor	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Effects to rare plant communities within wetland ecosystems	**Short Term**	**Long Term**	**Short Term**	**Long Term**	**Short Term**	**Long Term**	**Short Term**	**Long Term**
	No Effect	No Effect	Likely Negativ e Effects	Minimal Risk of Effects	Likely Negativ e Effects	Minimal Risk of Effects	No Effect	No Effect

WILDLIFE

Scoping identified a concern that the proposed rotenone treatment would kill non-target wildlife (i.e. amphibians) in Diamond Lake and would potentially impact other fauna in the Diamond Lake food chain (i.e. bald eagles, waterfowl, river otters) or downstream of the project area. The bald eagle is used as an indicator for this issue. However, predicted effects of each alternative on: Proposed, Endangered, Threatened, or Sensitive Species (PETS); Survey and Manage Species; and Other Non-Target Species are all relevant to the issue. This issue is tracked in the following section of this chapter.

BACKGROUND: TOXINS AND WILDLIFE

Because Alternative 1 proposes no active management intervention at Diamond Lake, it is assumed that toxic algae blooms would continue to affect the lake ecosystem and likely worsen in the future. Thus, a general description of the effects of toxic algae blooms on wildlife is documented below. Additionally, because Alternatives 2 and 3 involve treatment of Diamond Lake with the chemical rotenone, a general description of the toxicity of rotenone to wildlife is also included below.

Effects of Toxic Algae Blooms on Wildlife

Introduction

Certain species of blue-green algae produce toxins that in high concentrations (such as during and following major blooms) are harmful to wildlife and humans. Toxic algae blooms are known to have caused death in domestic animals (cattle, pigs, sheep, dogs), waterfowl and other wildlife (Government of Alberta 2003).

The two main types of algal toxins are neurotoxins and hepatotoxins. Neurotoxins affect the nervous system, are fast acting (acting on a timescale of minutes to hours), and can cause death by respiratory failure. Heptatoxins are relatively slow acting (acting on a timescale from hours to days), and attack the liver and other internal organs. Acute (short-term) exposure to high doses of heptatoxins can cause death from liver hemorrhage or from liver failure. Chronic (long-term) exposure to low doses may promote the growth of liver, kidney, and other tumors (MRACC 2002).

In 2001-2003, the blue-green algae *Anabaena flos-aquae*, bloomed in Diamond Lake. This species produces the neurotoxin, anatoxin-a. *Anabaena* was present in sufficient densities that closures to protect human health and safety were implemented at the lake for portions of all three summers. In 2003, *Microcystis aeruginosa,* was also detected in water samples at Diamond Lake. This species produces heptatoxins known as microcystins and nodularin.

Mortality and Illness
Toxic algae blooms have been identified as the cause of mortality for a broad spectrum of species world-wide: a human tragedy in Brazil, an alligator die-off in Florida, domestic livestock kills in Australia, Africa, and South America, and waterfowl and other species in Canada and the United States (Government of Alberta 2002; Wright State University 2003; MRACC 2002; NSW 2002; Burgess 2001). Although standards for human drinking water have been established by the World Health Organization, there are no established toxic thresholds for wildlife species (Creekmore 2001). In general, the amount of toxic water that can kill an animal is usually proportional to the size of the animal. Old, very young, sick or weak animals may have lower tolerance levels and can be poisoned with much smaller amounts (Government of Alberta 2003).

Creekmore (2001), in the Field Manual of Wildlife Diseases, provides a table of documented instances of wild bird mortality caused by algal toxins. The following excerpt is relevant to Diamond Lake (Table 33).

Table 33. Bird mortality from algal toxins.

Toxin	Algal species	Toxin type(s)	Migratory bird species affected	Route of exposure
Cyanobacterial	Microcystis sp., Anabaena sp., Aphanizomenon sp., Nodularia sp., and Oscillatoria	Heptatoxins (mycrocystins and nodularin) Neurotoxins (anatoxin-a and anatoxin –a(s)	Unidentified ducks, geese, and songbirds, Franklin's gull, American coot, mallard, American wigeon	Oral (Water)

Creekmore (2001) also notes that cyanobacterial toxicosis (poisoning) has been suspected in mortalities of free-ranging ducks, geese, eared grebes, gulls, and songbirds. Some symptoms of illness in wildlife exposed to toxins are known from clinical testing. Clinical signs in muscovy ducks dosed with anatoxin-a(s) included excessive salivation, regurgitation of algae, diarrhea, tremors, reduced responsiveness and activity, incoordination, difficult breathing, excessive thirst, wing and leg weakness, and recumbency and intermittent seizures prior to death.

To date, there have been no documented wildlife deaths attributed to toxin exposure at Diamond Lake. However, a recreationist at the lake reported that their dog entered the water during a bloom in July 2003, emerged wobbly and vomited for several hours (Graham 2003).

Toxicity of Rotenone to Wildlife

Introduction

The fish piscicide rotenone is a naturally occurring substance derived from the roots of tropical plants in the bean family. Rotenone is commonly used in fisheries management to eradicate undesirable fish populations. Rotenone kills living organisms by inhibiting a biochemical process at the cellular level making it impossible for the organism to use the oxygen absorbed into the blood, which is needed in the release of energy during respiration (Finlayson et al. 2000).

Rotenone has the ability to inhibit cellular respiration in fish, mammals, birds, insects, reptiles, amphibians, and even plants. However, at concentrations used in fisheries management, rotenone is only toxic to gill-breathing organisms such as fish, some forms of amphibians and aquatic invertebrates (Bradbury 1986; Finlayson et al. 2000). Studies determined that the reason rotenone is generally toxic to fish, tadpoles, and aquatic invertebrates and not to other animals is that gills provide an efficient mode of entry of the chemical into the cells and the stomach does not (Bradbury 1986; Finlayson et al. 2000).

Finlayson et al. (2000) describe that all animals (including fish) have natural enzymes in the digestive tract that neutralize rotenone, and that the gastrointestinal absorption of rotenone is inefficient. However, gill-breathing organisms are more susceptible to rotenone because rotenone is readily absorbed directly into their blood through their gills (non-oral route) and thus, digestive enzymes cannot neutralize it.

Attachment 2 of the Wildlife Biological Evaluation (located in the DEIS Appendices) includes excerpts from two documents detailing the toxicity of rotenone to wildlife (Bradbury 1986; CDFG 1994). These documents include median lethal doses (LD50)[143] of rotenone for birds, mammals, amphibians and reptiles and expected impacts to these species groups as described in scientific literature. Important concepts regarding acute and chronic toxicity detailed in Attachment 2 are summarized below. Most laboratory studies[144] have revealed no evidence of carcinogenic activity and the prevailing scientific opinion is that rotenone does not cause cancer, birth defects, or genetic mutations (USEPA, 1981 and 1989); the Human Health section of this chapter identifies limited exceptions to this conclusion. The primary pathways of exposure to rotenone by wildlife would be oral and dermal (through the skin). Wildlife would have negligible inhalation exposure to rotenone because they would not be in close proximity to the concentrated powder.

Although there are exceptions, normal or routine rotenone treatments in fisheries management generally do not exceed rotenone concentrations of 2ppm. Alternatives 2 and 3 would result in rotenone concentrations of approximately 2 ppm.

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[143] LD50 or median lethal dosage is the dosage of a toxin that when fed or injected kills 50% of the test animals. It is usually expressed as mg of toxin per kg of the test animal's body weight (Bradbury 1986).

[144] A recent study (Betaret et al. 2000) reported that rats injected with rotenone at 2 to 3 mg/kg body weight each day in the jugular vein for 5 weeks showed symptoms similar to that of Parkinson's disease. Other chemicals were administered with the rotenone to enhance tissue penetration. None of the other studies that used realistic exposure pathways of rotenone have reported such findings. Rotenone entering the body via the actual exposure pathways is unlikely to enter the brain (Rotenone Stewardship Program 2001).

Mammals

Mammals that live near water bodies treated with rotenone may ingest rotenone either by drinking treated water or by eating dead fish that were killed by the rotenone treatment. However, toxicity data for orally administered rotenone indicate that mammals will not be affected by drinking rotenoned water or eating rotenone-killed fish (Bradbury 1986). As described above, the digestive system is not an efficient mode of rotenone entry into an animal's body, thus limiting potential for harm. Rotenone residues in dead fish are generally very low (< 0.1ppm), unstable, and not readily absorbed through the gut of an animal eating a rotenone-killed fish (Finlayson et al. 2000).

As an example: the lowest LD50 of pure rotenone found in the literature on mammals is 55 mg/kg of body weight for guinea pigs. In order for a small mammal weighing approximately ½ pound to be killed by rotenone, it would have to drink 33 gallons of lake water treated with a 2 ppm dosage. (Bradbury 1986).

Chronic toxicity levels are also described in CDFG (1994). The authors conclude that no chronic toxicity affects to mammalian wildlife are expected under a normal rotenone treatment. For example, to exceed the chronic no-effect level, a 22 pound dog would have to regularly consume 10 gallons of water or over 88 pounds of fish per day. Typically, a 22 pound dog would be expected to consume less than 0.5 gallons of water or 2 pounds of fish per day.

Birds

Birds that live near water bodies treated with rotenone may ingest rotenone either by drinking treated water or by eating aquatic invertebrates or fish killed by the rotenone treatment. However, as with mammals, toxicity data indicate that birds will not be affected by ingesting treated water or consuming rotenone-killed organisms (Bradbury 1986).

As an example: a bird weighing ¼ pound would have to drink 25 gallons of treated water or eat more than 40 pounds of fish and invertebrates within 24 hours to receive a lethal dose. This same bird would normally consume 0.2 ounces of water and 0.32 ounces of food daily (Finlayson et al. 2000).

CDFG (1994) documents the chronic no effect level of rotenone for birds at 50 ppm. To exceed this level, a bird would have to consume water containing 50 ppm of rotenone for 30 days or more (Alternatives 2 and 3 would result in rotenone concentrations of approximately 2 ppm).

Amphibians and Reptiles

Toxicity data indicate that amphibians are more tolerant of rotenone than most fish species, nonetheless, rotenone is generally considered toxic to all gill-breathing life stages of amphibians. At concentrations routinely used in fisheries management, rotenone kills frog tadpoles, salamander larvae and gill-breathing adult salamanders. Laboratory tests also indicate that rotenone can impair cell respiration and normal development in amphibian eggs (Bradbury 1986).

Non-gill breathing adult amphibians are much less susceptible to rotenone than larvae. Bradbury (1986) documents that the median lethal concentration (LC50)[145] of rotenone for adult leopard frogs ranged from 3.2 to 7.9 ppm; Alternatives 2 and 3 would result in rotenone concentrations of approximately 2 ppm. At concentrations typically used in fisheries management, CDFG (1994) concludes that rotenone treatment would have little effect on non-gill breathing amphibians. However, Maxell and Hokit (1999) conclude that adult turtles and tailed frog adults are likely to suffer mortality through the application of piscicides.

Inert Ingredients

Liquid formulations of rotenone (i.e. Noxfish®) contain dispersants and emulsifiers known as "inert ingredients". Finlayson et al. (2000) documents that inert ingredients impart no toxicity to fish, insects, birds, or mammals. CDFG (1994) documents the acute toxicity levels of inert ingredients for fish, amphibians, mammals, and birds and concludes that inert ingredients have little, if any effects, to species in typical rotenone applications. Based on this information, it is assumed that inert ingredients would not have added impacts to species beyond those expected for the active ingredient and they will not be discussed as a separate element in the remainder of this section. All potential effects of inert ingredients are included in the documented effects of the rotenone treatment. Toxicity data on inert ingredients is documented in detail in the Human Health section of this chapter.

PETS SPECIES

A pre-field review was performed to determine which Proposed, Threatened, Endangered, and Sensitive (PETS) species are most likely to be impacted by the proposed action. Table 34 summarizes the presence or absence of sensitive species and/or their habitat within or adjacent (in terms of being potentially impacted – e.g. noise) to the actual proposed project area(s). It is based on the latest documented survey and sighting data, scientific literature review and GIS analysis. Impact or effect determinations[146] are based upon this review. If there is a potential impact or effect to the species, further analysis and discussion is provided in the following section. The results of this review are found in detail in the Wildlife Biological Evaluation in the Project Record and are summarized below. Throughout the rest of the Wildlife section the terms discountable and insignificant are used to characterize potential effects. These terms are defined as follows: Insignificant effects relate to the size of the impact and should never reach the scale where "take" occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to

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[145] LC50 or median lethal concentration is the concentration of a toxin in water that kills 50% of the test animals in the water within a specified time (usually 24, 48, or 96 hours). It is usually expressed as ppm (Bradbury 1986).

[146] Conclusions regarding the consequences of the direct, indirect, and cumulative effects to a Federally listed species or its habitat are defined as: "No effect" – is the appropriate conclusion when a proposed activity will not have any effect on a listed species or critical habitat. "May effect but is not likely to adversely affect" – is the appropriate conclusion when effects on a listed species or critical habitat are expected to be beneficial, discountable, or insignificant. Insignificant effects relate to the size of the impact and should never reach the scale where "take" occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur. "Is likely to adversely affect" – is the appropriate conclusion if any adverse effect to a listed species or critical habitat is expected to occur as a result of the proposed activities. Conclusions regarding the consequences of impacts to Regional Forester sensitive species are self explanatory: "no impact"; or "beneficial impact"; or "may impact individuals or habitat, but will not likely contribute to a trend towards Federal listing or loss of viability to a population or species"; or "will impact individuals or habitat, and would be expected to contribute to a trend towards Federal listing or loss of viability to a population or species".

meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

Table 34. Prefield review and biological evaluation summary table.

Common Name	Species Present		Habitat Present		Impact/Effect Expected		Conservation Strategy or Recovery Plan		Loss of Viability or Trend	Comments
	In	Adj.	In	Adj	Species	Habitat	Type	Consistent		
Northern Spotted Owl		✔	✔	✔	YES	NO	NFP	YES	NO	SEE SPECIES DISCUSSION
Bald Eagle	✔	✔	✔	✔	YES	YES	P Bald Eagle RP	YES	NO	SEE SPECIES DISCUSSION
Peregrine Falcon		✔		✔	NO	NO	Pacific Coast RP	YES	NO	The closest falcon eyrie is approximately 11.6 miles northwest of the project area boundary. No impacts are anticipated.
Harlequin Duck		✔	✔	✔	YES	YES	NONE	N/A	NO	SEE SPECIES DISCUSSION
Bufflehead	✔	✔	✔	✔	YES	YES	NONE	N/A	NO	SEE SPECIES DISCUSSION
Yellow Rail			✔	✔	NO	YES	NONE	N/A	NO	SEE SPECIES DISCUSSION
Oregon Spotted Frog			✔	✔	NO	YES	NONE	N/A	NO	SEE SPECIES DISCUSSION
Foothill Yellow-legged Frog					NO	NO	NONE	N/A	NO	The project area does not contain suitable habitat for this species. The upper elevation range for this frog is about 1,800 feet (Corkran & Thoms 1993). Species was not detected in Hayes surveys (1997 & 1998). No impacts anticipated
Southern Torrent Salamander					NO	NO	NONE	N/A	NO	The project area does not contain suitable habitat for this species. Hunter (1998) documented the species at 4,800 feet, but the upper elevation range on the Umpqua National Forest appears to be about 3,550 feet (local survey data). Species has not been located on the DL Ranger District. Surveys of the best potential habitat on the District (Copeland and Fish Creeks) occurred in 2002 with no detections. No detections occurred during Hayes surveys (1997, 1998). No impacts anticipated.
Western Pond Turtle					NO	NO	NONE	N/A	NO	The project area does not contain suitable habitat for this species. The upper elevation range for pond turtles in Douglas Co is 3,700 feet & most naturally occurring populations occur below 2,500 feet (T. Farrel, 2003). No historical records occur & species was not detected in Hayes surveys (1997 & 1998). No impacts anticipated.
Common Kingsnake					NO	NO	NONE	N/A	NO	The project area does not contain suitable habitat for this species. The upper elevation range for this snake in Oregon is about 1,500 feet (PacifiCorp 1995, Hayes 1996). Species was not detected in Hayes surveys (1997 & 1998). No impacts anticipated.
Canada Lynx					NO	NO	Conservation Strategy & Assessment	N/A	NO	The project area does not contain suitable habitat for this species. Interagency lynx biologists recommended that land management guidelines in the *Canada Lynx Conservation Assessment and Strategy* not be applied west of the Oregon Cascade Crest. These recommendations were finalized in Regional direction (9-19-2000). No impacts anticipated.
California Wolverine	✔	✔	✔	✔	YES	NO	NONE	N/A	NO	SEE SPECIES DISCUSSION
Pacific Fisher	✔	✔	✔	✔	YES	NO	Northwest Forest Plan	YES	NO	SEE SPECIES DISCUSSION
Pacific Fringed Myotis	LIKELY	LIKELY	✔	✔	YES	YES	Northwest Forest Plan	YES	NO	SEE SPECIES DISCUSSION
Pacific Pallid Bat					NO	NO	Northwest Forest Plan	N/A	NO	The project area does not contain suitable habitat for this species. Pallid bats are usually associated with desert areas. In Oregon west of the Cascades, the species is restricted to the drier interior valleys of the southern portion of the state (Verts and Carraway 1998). The closest sighting is 50 miles southwest of the project area. No impacts anticipated.
Pacific Shrew	LIKELY	✔	✔	✔	YES	YES	Northwest Forest Plan	YES	NO	SEE SPECIES DISCUSSION

Northern Spotted Owl

Large contiguous blocks of nesting, roosting, and foraging habitat NRF[147] habitat are necessary for nesting success and survival of this species. Within the southern Cascades, a 1.2-mile radius circle around an owl nest/activity center represents its home range. Forty percent NRF within 1.2 miles (1,182 acres) is considered the minimum acceptable amount of home range habitat for long-term owl survival. The United States Fish and Wildlife Service (USFWS) utilizes this bench mark to determine if a proposed project will result in an "incidental take" of the species under the Endangered Species Act (ESA). Dispersal habitat[148] for spotted owls satisfies needs for foraging, roosting, and protection from predators. Maintenance of dispersal habitat on a minimum of 50% of federal lands within a given area (e.g., planning area, sub-watershed, quarter-township) is a conventional threshold utilized to evaluate dispersal habitat conditions.

Habitat loss is the primary factor impacting northern spotted owl survivability (Forsman et al. 1984). Non-habitat disturbing activities (e.g., hiking, recreation, etc.) are thought to be relatively insignificant threats (USDI 1995).

AFFECTED ENVIRONMENT

The project area is not located in a CHU or LSR[149]. There are no known spotted owl pairs within 1.0 miles of Diamond Lake proper. The closest known spotted owl to the project area is located approximately 2.1 miles north of Diamond Lake and 0.3 miles west of the Lake Creek project area boundary.

Spotted owl NRF habitat in the vicinity of Diamond Lake was field verified by Forest Service and USFWS biologists. There are 544 acres of NRF habitat within the 7,856 acre project area boundary. There have been no recent surveys for spotted owls within the project area. However, occupancy of these NRF stands by nesting birds is considered unlikely due to elevation and high levels of year-round human use in and closely adjacent to the habitat.

At the landscape scale, a July 2003 USFWS Biological Opinion concluded that the "condition of the Forest's (Umpqua National Forest) LSR's has not changed very much since they were established and habitat exists that should facilitate the movement of spotted owls across the landscape; the landscape should support the conservation and recovery of spotted owls by

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[147] At high elevations ($\geq$ 4,500 feet), nesting, roosting, and foraging habitat for the spotted owl usually occurs in late successional coniferous forests containing the following habitat features: large snags or large conifer trees (>26 inches d.b.h.) with broken tops, large branches or cavities for nesting; a multi-layered closed canopy that facilitates thermal regulation and protection from predation during roosting; and adequate amounts of dead wood on the forest floor to support populations of prey species (small mammals) for foraging.
[148] Dispersal habitat in high elevation forests is characterized by forests that have a minimum average tree diameter of 9 inches and $\geq$ 40% canopy cover.
[149] Critical habitats for the spotted owl are mapped areas of land designated by the UF Fish and Wildlife Service to provide protection of spotted owl habitat under the ESA. Any modification of habitat in Critical Habitat Units (CHUs) that may affect either NRF or dispersal habitat must be addressed through consultation. Late Successional Reserves (LSRS) are land allocations under the Northwest Forest Plan that are also designed to provide functional connected habitat for spotted owls at the species range scale.

providing for clusters of reproducing spotted owls and the connnectivity between those clusters" (USDI 2003 pg. 31).

ENVIRONMENTAL EFFECTS

Direct Effects:

The project area is not located in a CHU; there would be "no effect" to critical habitat under any alternative. None of the alternatives would destroy, degrade or downgrade habitat for spotted owls. Thus, under Alternatives 1-4 there would be "no effect" to habitat.

Alternative 1 would have no direct effects to spotted owls or their habitat.

If spotted owls were nesting in NRF habitat within the project area, there would be potential direct effects to the species associated with some of the proposed activities. Because habitat loss rather than disturbance impacts are believed to be the limiting factor for this species, all potential disturbance impacts are considered to be minor.

Alternatives 2 and 3 would reconstruct the existing canal within the lake and adjacent to Lake Creek. Reconstruction activities would entail staging and utilization of heavy equipment within 0.25 miles of unsurveyed suitable spotted owl habitat during the early (March 1-July 15) and late (July 16-September 30) nesting season for this species. Duration of activities would be four to eight weeks. Additionally, it is possible that equipment associated with boat ramp extensions, connected actions by the Resort, and fish rendering operations could create above ambient noise levels within 0.25 miles of unsurveyed suitable habitat during the breeding season. For purposes of consultation, the United States Fish and Wildlife Service (USFWS) assumes that all unsurveyed suitable spotted owl habitat is occupied and that operation of heavy power equipment in proximity to spotted owls could disrupt their normal reproductive activites (USFWS 2003 Biological Opinion Log # 1-15-03-F-0454). Based on these assumptions, proposed activities described above "may affect and are likely to adversely affect the northern spotted owl".

Under Alternatives 2 and 3 Diamond Lake would be treated with rotenone. Based on information documented under "Toxicity of Rotenone to Wildlife", spotted owls would not be harmed if they ingested rotenone treated water.

Under Alternative 4, it is possible that equipment staging for commercial fish harvesting activities and fish rendering operations could occur within 0.25 miles of unsurveyed suitable habitat at the north end of Diamond Lake during the spotted owl breeding season. Based on the aforementioned USFWS assumptions, these activities could result in a disturbance effect to spotted owls. Thus, this alternative "may affect and is likely to adversely affect the northern spotted owl".

Seasonal restrictions to protect spotted owls during the breeding season are not proposed as mitigation because they would make implementation of action alternatives infeasible.

Indirect Effects:

Alternative 1 perptetuates the existing condition of Diamond Lake; however, due to the this species habits and lack of confirmed presence in the project area, it is not reasonable to assume any risk to spotted owls from ingestion of algal toxins. None of the alternatives impact existing or future spotted owl habitat in the project area. There are no anticipated existing or future impacts to the owl's prey base associated with any of the alternatives. Thus, there are no expected indirect effects for any alternative.

Cumulative Effects:
Cumulative effects tables (Tables 9-11) document a broad range of past, present, and reasonably foreseeable actions that may contribute to the cumulative effects of land management activities on the spotted owl within the analysis area. None of the action alternatives contribute to the cumulative effect of habitat loss, the primary threat to the species.

Alternative 1 makes no contribution to a cumulative disturbance effect to this species because monitoring that is perpetuated under this alternative would not exceed ambient noise and thus would not be expected to impact spotted owls. Alternatives 2, 3, and 4 represent a potential contribution to a cumulative disturbance effect for the species. However, because spotted owl habitat is limited in the project area, the scale of this potential effect is minor and considered insignificant to the species. Cumulative effects of disturbance activities on spotted owls were recently analyzed at the Forest-wide scale. The USFWS evaluated proposed activities (FY2003-2007) that did not modify habitat, but had a potential disturbance effect on owls; they determined that these activities were not likely to result in jeopardy to the spotted owl (USDI 2003 Biological Opinion Log # 1-15-03-F-0454). Therefore, at the landscape scale no substantive cumulative effects are anticipated.

Conclusions:
Following consideration of the direct, indirect and cumulative effects of the proposed activities, it is determined that:

Alternative 1 would have "no effect" on spotted owls.

Alternatives 2, 3, and 4 would have "no effect" on spotted owl habitat or CHU's, but "may affect and are likely to adversely affect" individual spotted owls through disturbance during the breeding season. There are no meaningful or measureable differences between the action alternatives with respect to potential effects on spotted owls.

<u>Northern Bald Eagle</u>

The bald eagle tends to nest in close proximity to large bodies of water such as lakes, rivers, and large streams. Eagles prey primarily upon fish, but they are also opportunistic feeders that utilize waterfowl, shorebirds, and carrion. Primary habitat components include clean water with abundant populations of fish and large perch trees and roost sites located nearby. Nest and roost trees are often the biggest trees available with stout limbs capable of supporting large nesting structures. Nest trees must also have suitable flight paths into the nest and offer good visibility of the surrounding terrain. The breeding season for the species in Oregon is generally January 1 through August 31.

Bald eagles were placed on the federal Endangered Species list in 1978 due to reduction of numbers caused by DDT and other pesticides in their food supply. The Pacific Bald Eagle Recovery Plan (Recovery Plan) provides guidelines and population goals for muliple management zones (Recovery Zones) within the seven state Pacific Recovery Region (Recovery Region) - Oregon, Washington, California, Idaho, Nevada, Montana, and Wyoming (USDI 1986).

AFFECTED ENVIRONMENT

There are two eagle nest sites at Diamond Lake – the Rocky Point and Silent Creek sites. Over 20 years of annual reproductive survey data exists for each of these sites. Reproductive history by decade is summarized in Table 35 below.

Table 35. Reproductive History of Bald Eagle Nest Sites at Diamond Lake.

Site Name	Time Period	Young Fledged
ROCKY POINT	1982-1989	**1 Total** (1 in 1987)
	1990-1999	**4 Total** (1 in 1992) (2 in 1994) (1 in 1995)
	2000-2003	**5 Total** (1 in 2001) (2 in 2002) (2* in 2003)
SILENT CREEK	1981-1989	**4 Total** (1 in 1981) (1 in 1982) (1 in 1985) (1 in 1986)
	1990-1999	**6 Total** (1 in 1990) (? in 1991) (1 in 1994) (2 in 1995) (1 in 1998) (1 in 1999)
	2000-2003	**5 Total** (2 in 2000) (1* in 2001) (2 in 2002)

* = young assumed fledged, but not actually observed flying.

The Rocky Point bald eagle nest was first discovered in 1982. Reproductive success appears to have increased steadily over time at this site. The nest was active in 2003 and the birds successfully fledged two young. The Silent Creek nest was first discovered in 1981. Reproductive success also apears to be on a postive trend at this site. However, although the nest was active in 2003, the eagles failed to fledge any young.

Historic midwinter bald eagle surveys provide sporadic documentation of winter-time eagle presence at Diamond Lake over the past decade. However, it is likely that eagles use the lake year round. According to eagle expert Frank Isaacs, the nesting eagles are generally on territory at Diamond Lake by January. Diamond Lake freezes in most winters by early December so foraging opportunities at the lake are limited to areas of open water around the Short and Silent Creek inlet and Lake Creek outlet. Diamond Lake eagles probably go downstream to forage until ice-off which usually occurs from late March to early May. Nesting activities proceed from winter through spring and summer. Young eagles likely remain at Diamond Lake until late fall (Pers. comm. Frank Isaacs).

There are two additional eagle nests in the broader analysis area for this project. There is one eagle nest at Lemolo Lake and one at Toketee Lake. Eagles are known to use these lakes year-round. At the landscape scale, available information indicates that bald eagle populations are increasing range-wide. In the Pacific Recovery Region, the number of occupied territories has consistently increased since 1986. Eagle productivity goals for the Recovery Region have been met since 1990, but distribution and nesting goals for some Recovery Zones within the Recovery Region have not been met (USDI 2003).

In Oregon, for the 1998 - 2002 time period, the state-wide population, distribution, and productivity goals were met. Eight out of ten Recovery Zones met or exceeded their population goals and thus attained the 80% distribution level identified in the Recovery Plan. The state-wide average for productivity exceeded the goal of 1.0 young fledged per pair (Pers. comm. Frank Isaacs).

The project area is located within the California/Oregon Coast Recovery Zone (#13). During the 1998-2002 time period, all Recovery Plan goals for this zone were met. The population goal for Recovery Zone #13 is 45 occupied territories; in 2002 there were 83 occupied territories. The productivity goal is 1.0 young fledged per pair; from 1998-2002, the five year average productivity rate was 1.07 (Pers. comm. Frank Isaacs).

ENVIRONMENTAL EFFECTS

Direct Effects:
Alternative 1 would have no direct effects to bald eagles because no habitat or disturbance impacts are expected to occur.

Alternatives 2 and 3 propose multiple activities that would potentially directly affect bald eagles at Diamond Lake throughout the lifetime of the project. Canal reconstruction activities would occur within line of sight of the Rocky Point eagle nest and in-lake activities would occur in areas utilized as foraging habitat by the pair. These activities would likely occur in late spring or summer during the bald eagle breeding season and thus represent a potential disturbance impact. However, this is considered to be a discountable effect to the species because bald eagles at Diamond Lake have adapted to high levels of year-round human use and continue to reproduce successfully; based on this information, it is considered unlikely that this potential disturbance effect would actually occur.

The proposed draw down respresents a short-term beneficial effect to bald eagles at Diamond Lake because fish would be concentrated into a smaller area and readily accessible to the birds. However, subsequent mechanical fish removal activities would reduce the availability of prey and potentially disrupt normal foraging activites for both nesting eagle pairs. Mechanical harvest activities would likely occur late in the breeding season when young eagles are about to fledge. These activities are not expected to hinder reproductive success because an adequate prey base would likely remain in Diamond Lake (or downstream) and eagles would not be expected to abandon their young at this stage in the breeding season.

Rotenone treatment would occur after the bald eagle breeding season, but eagles would still be present at the lake. Eagles would be expected to ingest rotenone treated water and consume rotenone killed fish. However, as described in the "Toxicity of Rotenone to Wildlife" section of this chapter, eagles are not expected to be harmed. Because the rotenone treatment is designed to kill all of the fish, this activity would effectively eliminate the primary prey base for bald eagles at Diamond Lake for an extended period of time. Because it would occur after young eagles have fledged (and likely dispersed), loss of prey base in late fall would not compromise eagle reproductive success in the year of chemical treatment. Eagles normally utilizing Diamond Lake in the late fall to early winter season could be displaced to adjacent water bodies downstream or east of the Cascades.

The Rocky Point and Silent Creek eagle pairs would be expected to be on territory by the January following chemical treatment and would likely attempt to nest as usual (Pers. comm., Frank Isaacs). Under normal circumstances, nesting bald eagles probably routinely forage in adjacent/downstream habitat until ice-off at Diamond Lake in the spring. Lack of available fish prey base at Diamond Lake in the late spring and summer when fish are normally abundant at the lake, and eagles are feeding themselves and their young, represents the greatest potential adverse affect associated with these alternatives. Although eagles would not be expected to abandon their nests, lack of a fish prey base could compromise nesting success (Pers. comm., Frank Isaacs).

Because timing of proposed restocking of Diamond Lake with fish would be based on ecological indices of lake health (i.e. when the biota in the lake has recovered adequately to support fish without compromising water quality), it is not possible to state unequivocably when the eagle prey base would be restored. However, for this analysis, it is assumed that Diamond Lake would not be stocked with many fish in the first spring/summer following the chemical treatment, but would be stocked to a greater exten in the following spring/summer. Based on this assumption, bald eagle nesting success would be compromised for one to two breeding seasons.

For Alternatives 2 and 3, the mitigation of a supplemental feeding program (described in Chapter 2) would reduce potential effects to nesting bald eagles associated with the short-term loss of their fish prey base:

Fish restocking under Alternatives 2 & 3 would restore the eagle prey base at Diamond Lake and thus beneficially affect eagles. Alternative 3 would be expected to provide a higher number or larger prey items more quickly than Alternative 2 because Alternative 3 proposes stocking with legal-sized fish while Alternative 2 is primarily a fingerling-based stocking strategy. None of the other activities proposed under these alternatives nor the connected actions associated with them have consequential effects to the bald eagle or its habitat.

Alternative 4 would utilize commercial fish operations for approximately two months in June and July and one month in September on an annual basis to harvest tui chub from Diamond Lake. Commercial fishing activities represent a potential disturbance affect to eagles during the breeding season. However, as discussed earlier, it is considered unlikely that these additional activities would actually disturb eagles given the existing high levels of human activity at the lake. This represents a discountable effect to the species. Commercial fishing would also reduce the available prey base for eagles. These activities are not expected to hinder reproductive success because an adequate prey base would likely remain in Diamond Lake throughout the lifetime of the project[150]. This is considered to be an insignificant effect to the species.

Indirect Effects:
Alternative 1 perpetuates the existing condition, forgoes the opportunity to address declining water quality and thus leaves eagles vulnerable to exposure to toxic algae blooms in the future. Under this alternative, it is possible that eagles would become ill or die from ingestion of water containing algal toxins during or following a summer bloom.

Alternatives 2 and 3 could result in increased use of Lemolo and Toketee Lakes by the Diamond Lake eagles during the time when the fish prey base is absent or limited at Diamond Lake. As a result, the Lemolo and Toketee eagles and winter migrant eagles could experience a temporary increased competition for prey. This potential effect is considered insignificant because the downstream prey base is likely adequate to support the additional foraging pressure and the supplemental feeding mitigation would reduce the dependence of the Diamond Lake eagles on downstream forage.

Under Alternative 4, it is expected that annual commercial fishing operations would be needed beyond the lifetime of this project to control the tui chub population. Thus, potential disturbance effects and prey base reduction effects described above would be expected to continue in the future. As documented above, these potential effects are considered discountable and insignificant, respectively.

Cumulative Effects:
Past, present, and future management activities that entail fish stocking and development near Diamond and Lemolo Lakes and the North Umpqua River are the primary management activities of relevance to bald eagles in the analysis area (Tables 9-11).

Alternatives 2, 3, and 4 represent a potential contribution to cumulative disturbance and prey base effects to bald eagles. However, the consequences of these potential cumulative effects are considered to be insignificant to the species because it is expected that under a worse case scenario, the bald eagles at Diamond Lake would fail to successfully reproduce for one to two breeding seasons; given the positive status of the bald eagle population within Recovery Zone #13 and State-wide, this temporary lack of recruitment would not be considered a

[150] For Alternative 4, the "lifetime of the project" is a six year time period.

threat to the continued recovery of the bald eagle. Alternative 1 contributes to the cumulative effects in that it maintains the existing condition and leaves eagles vulnerable to exposure to algal toxins.

Conclusions:
Alternative 1 represents the greatest sustained risk to bald eagles at Diamond Lake over time. Alternatives 2 and 3 have greater potential short-term adverse effects than Alternative 4 and higher potential for long-term habitat improvement through improved water quality than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3.

Following consideration of the direct, indirect and cumulative effects of the proposed activities, it is determined that:

> Alternative 1 "may affect and is likely to adversely affect" bald eagles through perpetuation of eagle exposure to toxic algae blooms.
>
> Alternatives 2 and 3, as mitigated, "may affect and are likely to adversely affect" bald eagles through temporary substantial reductions in available prey base and potential effects on reproductive success.
>
> Alternative 4, "may affect but is not likely to adversely affect" bald eagles by insignificant reductions in prey base and discountable potential disturbance effects.

<u>Harlequin Duck</u>

Harlequins are sea ducks which migrate inland to breed in the mountains. They prefer large, rocky, swift streams or rivers, generally with many down trees, out-washed root wads, and similar debris about the edges of the stream course. Nest locations are adjacent to rapids or other turbulent water. The species feeds mainly on animal matter including mollusks, crustaceans, insects and fish. Typical first observations of this duck in mountain streams occur between March to April while nesting occurs from May to early June. The males return to the coast after the egg clutch is completed, but the female and brood will remain in the stream/river system until late September. In North America, their numbers appear to be declining as a result of habitat loss, oil spills and disturbance to nesting ducks by humans (Turbak 1999). However, at a state-wide scale it is difficult to determine population trends because historic population numbers are unknown.

AFFECTED ENVIRONMENT

There are no known sitings of harlequin ducks within the project area. The closest observation of this species is approximately 8.9 miles west of the project area boundary on the North Umpqua River. Lake Creek represents low quality potential habitat for this species within the project area. Surveys for harlequins were conducted according to protocol on Lake Creek on May 27 and August 6, 2003. No harlequin ducks were detected.

Portions of the North Umpqua River that occur within the larger project analysis area are also known habitat for the harlequin duck. There are eleven recent (1985 to present) observations of harlequins along the North Umpqua River (and its tributaries) during the breeding season.

At the landscape scale, a 1993 comprehensive survey effort for harlequin ducks in Northwest Oregon identified 47 breeding pairs (Thompson et al. 1993); however, due to survey techniques, this is probably an underestimate of the breeding population in the area (Dowlan 1996).

ENVIRONMENTAL EFFECTS

Direct Impacts:
Based on lack of detections during recent surveys, lack of historical observations and low quality of potential habitat for harlequin ducks within the project area, it is considered unlikely that harlequins would be utilizing Lake Creek during the lifetime of this project. However, because the species is known to occur on the Forest, it is reasonable to assume species presence for purposes of full disclosure.

Alternative 1 would have no anticipated direct impacts to harlequin ducks because it does not propose activities on Lake Creek.

Alternatives 2 and 3 propose multiple activities that could potentially impact harlequins and their habitat. Canal reconstruction activities adjacent to Lake Creek have the potential to disturb individual ducks or broods, if ducks were utilizing the area during implementation. Draw down of the lake would temporarily change potential habitat conditions in Lake Creek by increasing the flow. This would have minor habitat impacts because high flows would temporarily degrade macroinvertebrate prey habitat (see Fish and Streams sections for details). This impact is probably best characterized as a neutral impact to the species because harlequins would be utilizing their coastal winter habitat during the majority of the draw down period (late September to late March).

The temporary dewatering of Lake Creek during the rotenone treatment and subsequent low flows during the lake refill period(described in detail in the Streams section), would eliminate potential habitat for harlequins on portions of the stream in the short-term. Potential Lake Creek habitat would likely be unuseable by harlequin ducks for one breeding season due to lack of flow and macroinvertebrate prey base. This potential impact is considered to be minor because of the availability of other higher quality habitat in the watershed and the low liklihood that harlequins actually breed on Lake Creek.

No rotenone treatment is planned for Lake Creek and as described above, the creek would be dewatered during lake treatment. Thus, harlequin ducks would not be expected to ingest rotenone treated water or prey items; if they did, no adverse impacts would be expected (see "Toxicity of Rotenone to Wildlife" section). Proposed monitoring represents a minor, potential disturbance impact, if harlequin ducks were utilizing Lake Creek during monitoring activities; this is considered to be an insignificant and discountable impact. None of the other activities proposed under these alternative nor the connected actions associated with them have consequential impacts to harlequins or their habitat.

Alternative 4 would only potentially impact harlequin ducks through proposed monitoring activities. Monitoring is an occasional activity, and represents a temporary and minor disturbance impact to the species. This is considered to be an insignificant and discountable impact.

Indirect Impacts:
Alternative 1 perpetuates ongoing monitoring activities and thus, represents a minor, potential disturbance impact to the species. Because harlequins are not expected to use Diamond Lake, risk of exposure to algal toxins is considered to be neglible.

None of the alternatives are expected to impact harlequin ducks or their habitat downstream of the project area (beyond Lake Creek) based on the following rationale. Aternative 1 would maintain the existing condition. Under Alternatives 2 and 3, rotenone treated water would be confined to Diamond Lake and thus, no downstream impacts to the harlequin prey base are anticipated. The water flow contribution of Lake Creek is a small percentage of the total North Umpqua River system flow, thus manipulations of this flow under Alternatives 2 and 3 would not be expected to change habitat conditions for harlequins on the North Umpqua River. Under Alternative 4, all proposed activities are confined to Diamond Lake and would essentially maintain the existing condition downstream.

Alternatives 1 and 4 would perpetuate the existing condition and would not be expected to change the quality of potential harlequin habitat in Lake Creek in the future. Based on conclusions drawn by the Project Hydrologist, changes in Lake Creek associated with Alternatives 2 and 3 would be short-term and not expected to substantially change the future habitat conditions. It is expected that sustained high flows would create additional habitat complexity in Lake Creek over time (deep pools) that would benefit macroinvertebrate prey for harlequins. Subsequently, pools would fill in and a return to baseline levels of macroinvertebrates would occur. This represents a minor benefit or neutral impact to future harlequin habitat on Lake Creek.

Cumulative Impacts:
Cumulative effects Tables 9-11 document a broad range of past, present, and reasonably foreseeable actions that contribute to the cumulative effect of land management activities on the harlequin duck within the analysis area. Activities that manipulate historic stream flow regimes and result in increased human activity in proximity to stream habitat are contributors to a cumulative habitat loss and disturbance effect. Of note are past activities such as the construction of Highway 138 and the installation of PacifiCorp operations that affected harlequin duck habitat on the North Umpqua corridor; past, present, and future water quality

monitoring efforts on Lake Creek and implementation of water rights at Diamond Lake within the project area; and presumed increases in recreational use on the North Umpqua River in the future.

Alternatives 2 and 3 represent a minor potential contribution to the cumulative disturbance and habitat impacts on the species. Alternatives 1 and 4 only contribute to the cumulative effects in that they maintain the existing condition.

The majority of known and suspected breeding habitat for harlequin ducks within the analysis area and on the Forest is contained in the Wild and Scenic North Umpqua River corridor that spans from Soda Springs Dam down to Rock Creek. According to the North Umpqua River Watershed Analysis (USDA April 2001, V.2) only an estimated 12% of the riparian habitat within this 33.8 mile stretch of the river has been converted from forest into paved roads, gravel roads, residential areas and other facilities. No future timber harvest and little future development is expected in this area. Additionally, tributaries to the North Umpqua River corridor that also contain harlequin habitat are protected under the NWFP through standard and guidelines for Riparian Reserves. Thus, availability of suitable habitat for harlequin ducks is not considered to be a limiting factor for the species and cumulative impacts are considered to be minor.

Conclusions:
Alternatives 2 and 3 have a greater potential to impact harlequin ducks than Alternatives 1 and 4. However, impacts to the species are considered to be minor under all alternatives.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, 3, and 4 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species".

<u>Bufflehead</u>

Buffleheads are small "diving ducks" that can be found on small ponds to large lakes, and larger streams and rivers. They breed and nest in tree cavities in coniferous-deciduous woodland near lakes and ponds. In freshwater, these ducks feed on aquatic insects, snails, amphipods(small crustaceans), small fish and some aquatic vegetation (American Ornithologists' Union 1983).

AFFECTED ENVIRONMENT

Buffleheads are known to occur at Diamond Lake. They are considered to be an uncommon to fairly common spring migrant and an abundant fall migrant. They have been documented in small numbers during the summer at the sewage ponds and South Shore meadow area during Audubon Society surveys in 1996-2002. Buffleheads nested at the sewage ponds adjacent to Diamond Lake in 1989 and 1990 (Fix 1990).

According to Fix (1990) this species begins to arrive in numbers during October, peaking in early - to mid November. They tend to concentrate at the south end of the lake, but individuals and small groups may be seen anywhere on the lake in the fall months. They winter on Toketee Lake, and likely on other area lakes that do not completely freeze. Fix (1990) estimated that a maximum of approximately 1,000 buffleheads utilized Diamond Lake during early November of 1988 and 1989.

At the landscape scale, buffleheads are considered to be a common spring and fall migrant in Oregon. Marshall et al. (2003) describes the species as possibly the most ubiquitous diving duck in western Oregon during the late fall through early spring. However, the breeding population is considered sensitive by ODFW because of small size and limited nesting habitat.

ENVIRONMENTAL EFFECTS

Direct Impacts:
Alternative 1 would have no anticipated direct impacts on buffleheads.

Alternatives 2 and 3 have potential impacts on both individuals and habitat of this species. Survey data during the 1996-2002 breeding seasons document only one observation of a single bufflehead on Diamond Lake proper near the South Shore meadows on 6/26/99 (Umpqua Valley Audubon database). Based on this information, spring and summer activities on Diamond Lake and Lake Creek (i.e., canal reconstruction, mechanical fish harvests, etc.) would not be expected to impact buffleheads.

Buffleheads would likely be present on Diamond Lake in small numbers during the September rotenone treatment proposed under Alternatives 2 and 3. As described in the "Toxicity of Rotenone to Wildlife" section of this document, buffleheads are not expected to be harmed as a result of ingesting water or consuming dead prey. However, in the months of October and November when buffleheads are present in large numbers, rotenone treatment would substantially reduce available prey items in Diamond Lake for fall migrants of this species. The majority of migrating buffleheads would likely be displaced to the Klamath Basin, further along on their southern migration route (Pers. comm. Ron Maertz). This represents a potential adverse impact to both individuals and habitat. Because the duration of the impacts are short-term (one to two fall seasons), other suitable habitat is available to displaced birds and no deaths are expected to occur, consequences of this displacement effect to the species would not be expected to result in a loss of species viability or a trend toward Federal listing. None of the other activities proposed under these alternatives nor the connected actions associated with them have consequential impacts to buffleheads or their habitat.

Alternative 4 would have minor potential impacts to buffleheads. Proposed commercial fish harvesting operations occuring annually in the month of September have the potential to disturb a small number of buffleheads that might be using Diamond Lake proper at this time. It is also possible that individuals could be harmed by becoming entangled in a gill net. Other proposed activities would occur in the spring and summer and would not be expected to impact the species.

Indirect Impacts:
Alternative 1 perpetuates the existing condition, forgoes the opportunity to address declining water quality and thus leaves buffleheads vulnerable to exposure to toxic algae blooms in the future. Under this alternative, it is possible that buffleheads would become ill or die from ingestion of water containing algal toxins during or following a summer bloom (see Effects of Algal Toxins on Wildlife section). Alternative 1 would also indirectly impact this species by perpetuating lake conditions that support a limited and declining future population of aquatic macroinvertebrates (see Fisheries report for details).

Alternatives 2 and 3 would be expected to result in a beneficial impact to the species by facilitating the return of a more abundant and diverse aquatic macroinvertebrate prey base for the species in the near future (beginning one or two years following rotenone treatment) when the lake recovers (see Fisheries section for details).

Impacts to the abundance and diversity of the future prey base for buffleheads at Diamond Lake are uncertain under Alternative 4 due to the fact that only a portion of the tui chub population would be removed and tui chub are very effective predators on macroinvertebrates. However, it is assumed that some positive impacts would be realized (see Fisheries section for details).

Cumulative Impacts:
As documented above, concern for this species in Oregon is focused on the breeding population. Lack of suitable nesting cavities and high levels of human disturbance during the breeding season are considered to be the primary limiting factors for buffleheads in the state (Marshall et al. 2003). Sewage ponds where the species has nested (one pair) would not be impacted by the project. There is no documented breeding by buffleheads on Diamond Lake proper. Thus, none of the alternatives are expected to impact breeding buffleheads or nesting habitat. Based on this information, in combination with the knowledge that buffleheads are one of the most common fall migrants in western Oregon, potential cumulative effects associated with the proposed activities from this project considered in the context of all activities documented in the cumulative effects Tables 9-11 would not be expected to result in a loss of species viability or a trend toward Federal listing.

Conclusions:
Alternative 1 represents the greatest sustained risk to buffleheads at Diamond Lake over time through exposure to algal toxins. Alternatives 2 and 3 have greater potential short-term adverse impacts than Alternative 4 and higher potential for long-term habitat improvement through improved water quality and prey base than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, 3, and 4 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species".

Yellow Rail

Yellow rails are secretive birds that inhabit shallowly flooded sedge meadows at 4,100- 5,000 feet in elevation. The yellow rail mainly breeds east of the Rocky Mountains in the northern United States and southern Canada. However, there is an isolated population in the Klamath Basin in south-central Oregon (Popper and Stern 1996). The majority of yellow rails in Oregon and the more optimal habitats occur at the Klamath National Wildlife Refuge and on BLM and Forest Service Lands (Winema National Forest) in the Fourmile Creek and Jack Spring areas. Lundsten and Popper (2002) estimate that there are 235-285 breeding pairs in Oregon.

AFFECTED ENVIRONMENT

There are no historic or recent sitings of yellow rails within the project area or on the Umpqua National Forest. The closest observation of this species is approximately 12 miles northeast of the project area at Big Marsh on the Deschutes National Forest.

Limited, low quality potential habitat for the species exists within the project area in the Silent Creek marshes at the southern end of Diamond Lake. Surveys for yellow rails were conducted according to protocol on June 26 and July 7, 2003. No yellow rails were detected. At a landscape scale, the Oregon yellow rail population is generally considered stable because the majority of the population is located on federally-owned lands and birds are protected during the breeding season. However, because of the small size and limited distribution of the yellow rail state-wide, the birds are still considered at risk (Pers. comm. Ken Popper 2003).

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:
Based on lack of historic occurrence anywhere on the Forest, lack of detections during recent surveys in the project area, and limited quantity and quality of potential habitat within the project area, it is not reasonable to assume that yellow rails would be present within the project area during the lifetime of this project. Thus, no direct, indirect, or cumulative impacts to individual yellow rails are expected under any of the proposed alternatives.

Alternatives 1 and 4 would have no direct, indirect or cumulative impacts to yellow rail habitat because both alternatives would effectively maintain and perpetuate the existing condition of habitat for the species.

Alternatives 2 and 3 propose a draw down that would temporarily dewater the Silent Creek marshes adjacent to Diamond Lake. Drying of the marshes would degrade the quality of potential yellow rail habitat in the short-term. Because existing potential habitat is considered to be of no meaningful benefit to the species, and because the majority of the southwest Oregon population is protected during the breeding season, potential direct, indirect, and cumulative impacts associated with these alternatives are considered insignificant to the species. None of the other activities proposed under these alternative nor the connected actions associated with them have consequential impacts to yellow rails or their habitat.

Conclusions:
Potential impacts to yellow rails are considered to be minor under all alternatives. Alternatives 2 and 3 have temporary habitat impacts and there is no meaningful or measureable differences between the two.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1 and 4 would have "no impact" on the yellow rail.
>
> Alternatives 2 and 3 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."

Oregon Spotted Frog

The spotted frog is nearly always found in or near a perennial water body such as a spring, pond, lake or sluggish stream. The species is most often associated with nonwoody wetland plant communities (species such as sedges, rushes, and grasses) (Leonard, et al. 1993). The introduction of exotic species (i.e. bullfrogs and non-native fish species) and urban development are believed to be the primary causes of their population decline (there are no bull frogs in Diamond Lake). Although high elevation lakes in the Cascades are potential habitat for this species, spotted frogs have never been recorded in Douglas County.

AFFECTED ENVIRONMENT

Diamond Lake contains very low quality potential habitat for the Oregon spotted frog; this species is not known or expected to occur in the project area. The species was not detected in Diamond Lake, Horse or Teal Lakes or Lake Creek during formal surveys by Hayes in 1996 and 1997. No documented historical records occur in or near the project area. According to Hayes (Pers. comm. 2003) all valid records of Oregon spotted frogs occurring south of Willamette Pass in Oregon are located in the Klamath Basin. Oregon spotted frogs only cross the Cascade Mountain crest north of Williamette Pass where the crest is lower, reflecting a biogeographic pattern repeated by several species. The liklihood of occupancy of Diamond Lake by spotted frogs is considered to be very low to none (Pers. comm. Marc Hayes). The closest observation of this species is a large population approximately 12 miles northeast of the project area at Big Marsh on the Deschutes National Forest.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:

Based on lack of historic occurrence anywhere on the Forest or in Douglas County, lack of detections during recent surveys in the project area, and the opinion of Herpetologist Marc Hayes, it is not reasonable to assume that spotted frogs would be present within the project area during the lifetime of this project. Thus, no direct, indirect, or cumulative impacts to individual spotted frogs are expected under any of the proposed alternatives.

Alternative 1 perpetuates degraded water quality and prey conditions in Diamond Lake, but as described for Alternatives 2 and 3 below, because the habitat is not expected to be occupied by spotted frogs now or in the future, this is considered to be a discountable and insignificant impact.

Activities associated with Alternatives 2 and 3 that modify conditions in and around Diamond Lake (including fish stocking) would degrade potential habitat in the short-term. Although these alternatives are expected to improve the future prey base, overall quality of habitat would not be expected to improve due to the continued presence of predatory fish. Because existing potential habitat is considered to be of no meaningful benefit to the species, and because it is considered unlikely that potential habitat would ever be naturally occupied by the species due the topographic barriers described above, the potential direct, indirect, and cumulative impacts associated with these alternatives are considered to be both insignificant and discountable. The connected actions associated with these alternatives have no consequential impacts to spotted frogs or their habitat.

Alternative 4 would have no direct, indirect or cumulative impacts to potential habitat because it would essentially maintain and perpetuate the existing condition of habitat for the species.

Conclusions:
Potential impacts to spotted frogs are considered to be minor under all alternatives. Alternatives 1, 2 and 3 have potential habitat impacts. There is no meaningful difference between the three alternatives.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2 and 3 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."
>
> Alternatives 4 would have "no impact" on the spotted frog.

California Wolverine

Wolverines are the largest member of the mustelid (weasel) family and are considered to be one of the rarest mammals in North America (Ruggiero et al. 1994). In the western United States, its distribution extends as far south as California, where it is listed as "threatened". and Colorado (listed as "endangered"). It is generally associated with remote, sparsely inhabited, high elevation subalpine and alpine forests at elevations ranging from 6,000 feet to above timberline. They have large home ranges (39 to 351 square miles) and travel long distances (commonly 18-25 miles) in daily hunting. Wolverines tend to avoid human developments and extensive human settlements and major access routes may function as dispersal barriers for this species (Ruggiero et al. 1994). A carnivore, the wolverine will eat almost anything it can catch, but is thought to primarily be a scavenger and feeds on large mammal carrion, especially in the winter months. Highest densities of this species occur in areas with low human activity and adequate year-round food supplies. Females den in caves, rock crevices, or hollow logs and are susceptible to disturbance while denning.

AFFECTED ENVIRONMENT

There are two historic sightings of wolverine within the project area boundary, one in 1956 and one in 1971. Potential denning habitat for the species is located 2.7 miles east of the project area in the Mount Thielsen Wilderness. There is a 1995 wolverine sighting adjacent to this potential denning habitat.

Helicopter surveys conducted in 1997 by ODFW and the USFS located tracks and a potential wolverine den within the Wilderness, 4.8 miles northeast of the project area. However, as surveyors gained additional on-the-ground experience at track and den identification, they began to question the validity of this sighting; they now have a low level of confidence in the sighting and believe the tracks seen were likely American marten (Pers. comm., Raymond J. Davis).

Helicopter surveys for wolverine have occurred for three consecutive winters (2001-2003) in the Mt. Theilsen and Sky Lakes Wilderness areas (south of Crater Lake). No confirmed wolverine tracks or dens were located during these surveys. Additional surveys are planned for the next two years.

Although it is possible that the project area could lie within the home range of one or more wolverines, habitat effectiveness for this species is greatly reduced by the year-round, high levels of human use at and adjacent to Diamond Lake. In general, wolverine would be expected to avoid the project area rather than utilize it as habitat.

Ruggiero et al. (1994) documents 23 records of wolverine in Oregon from 1981-1992 compared with 57 records from 1913-1980 and describes the current status in the state as unknown. The USFWS was recently petitioned to list the wolverine as threatened or endangered in the lower 48 states of the United States. The October 21, 2003 USFWS finding (68 FR 60112) concludes that the petition and other available information did not present substantial scientific or commercial information indicating that listing the wolverine in the contiguous United States may be warranted.

ENVIRONMENTAL EFFECTS

Direct Impacts:
Alternative 1 would have no anticipated direct impacts on wolverines or their habitat because no activity would occur. None of the action alternatives would impact denning habitat or be expected to disturb denning wolverines. Increased levels of human use represent the only potential impact that warrants discussion.

High levels of human use reduce habitat effectiveness for wolverine. Existing high levels of year-round human use adjacent to Diamond Lake reduce the liklihood that wolverine would utilize this area even if it was contained in a wolverine home range. However, because the species has been documented in the project area, potential impacts are described for purposes of full disclosure.

Under Alternatives 2, 3, 4 implementation of the majority of the proposed activities (including the connected actions) would result in increased levels of human use in and around Diamond Lake. If a wolverine attempted to approach Diamond Lake during the lifetime of the project, these activities in combination with existing ambient noises levels, would be expected to compel the animal to avoid the area. This potential habitat effectiveness and disturbance impact is considered to be insignificant (immeasureable) and discountable (unlikely to occur).

Indirect Impacts:
Alternatives 1 would only be expected to impact wolverine by perpetuating water qualitiy monitoring on Lake Creek. Increased human activity associated with monitoring would have the potential to temporarily displace any individuals that might be using the area. As described above, this potential disturbance impact is considered to be iinsignificant and discountable. Risk of exposure to algal toxins is considered to be neglible.

Alternatives 2, 3, 4, are all designed to improve water quality and the recreational fishery at Diamond Lake. If successful, it is reasonable to assume that human use in the spring/summer/fall would increase in the future as a result of implementation. As such, all of the action alternatives would further reduce the effectiveness of the forest surrounding Diamond Lake as suitable habitat for wolverines.

Cumulative Impacts:
Past activities that resulted in the development of Diamond Lake as a high use, year-round recreation area led to habitat conditions that limit use of the project area by wolverines. Increased human use resulting from Alternatives 1, 2, 3, and 4, and ongoing and future management activities in the area represent a minor contribution to the cumulative effect of reduced habitat effectiveness for this species.

Due to the existing levels of human development and recreational use, the lack of denning habitat in the project area, and the lack of documented den sites during the recent surveys of the adjacent Mt. Thielsen Wilderness, the potential cumulative effect of reduced habitat effectiveness is considered to be insignificant to the species.

Conclusions:
Potential impacts to wolverine are considered to be minor under all alternatives. Alternatives 1, 2, 3 and 4 have the potential to reduce habitat effectiveness through increased human use. There are no meaningful differences between the potential impacts of these alternatives on this species.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, 3, and 4 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."

Pacific Fisher

A medium-sized member of the weasel family, the fisher is associated with low to mid-elevation (<4,000 ft.) late-successional/old growth forests in western Oregon; they are also closely associated with forested riparian areas, which they use for foraging, resting and as travel corridors (Heinemeyer and Jones 1994). Within late-successional forests, large snags and trees (≥20 inches d.b.h.) with hollows or cavities are important structures for maternal den sites (Thomas et al. 1993). The fisher is primarily a carnivore and its diet consists mostly of small mammals (e.g., rodents, shrews, squirrels, hares, porcupine and beaver), birds and carrion. Forest stands with high levels of coarse woody debris are thought to be good habitat for prey.

Human activities (such as trapping and poisoning) have resulted in the apparent extirpation of fishers throughout much of their historical range in the Pacific states. Populations of fishers in Oregon are restricted to two disjunct and genetically isolated populations in the southwestern portion of the state: one in the southern Cascade Range and one in the northern Siskiyou Mountains. The population in the southern Cascade Range was reintroduced and is descended from fishers that were translocated to Oregon from British Columbia and Minnesota between 1961-1981 (Aubrey and Lewis, 2003). Because of the isolation and long distances between populations, Aubrey and Lewis (2003) conclude that the historical continuity in fisher distribution that once provided for genetic interchange among fisher populations in the Pacific states no longer exists.

AFFECTED ENVIRONMENT

There are no known fisher den sites within or adjacent to the project area. There is a documented 1993 sighting of a fisher near the southern project area boundary adjacent to Silent Creek. There is also a reliable 1996 fisher sighting approximately 2.7 miles west of Lake Creek. Although the majority of the project area is higher elevation than is normally utilized by this species, it is considered to be potential habitat. Based on the elevation and habitat preferences it is expected the project area would be used by dispersing fishers.

At the landscape scale, the southern Cascade Range population of fishers is located approximately 18 miles southwest of the project area boundary. A July 3, 2003 finding by the

USFWS published in the Federal Register documents that the West Coast population of the fisher may be a distinct population segment for which listing under the ESA may be warranted. A status review to determine if listing is warranted is currently underway (68 FR 41169).

ENVIRONMENTAL EFFECTS

Direct Impacts:
None of the alternatives would reduce available den sites for fisher and none of the alternatives would be expected to disturb denning individuals.

Alternatives 1 and 4 would only impact fisher through ongoing and proposed water quality monitoring on Lake Creek. Increased human activity associated with monitoring would have the potential to temporarily displace any individuals that might be using the area. Due to the rarity of the species, it is considered unlikely that this potential impact would actually occur. If it did occur, it would be inconsequential to the species.

Alternatives 2 and 3 have the potential to impact fisher habitat through the temporary dewatering of portions of Lake Creek and the temporary drying of wetlands adjacent to Silent Creek. Because of their use of forested riparian areas the temporary dewatering of portions of Lake Creek and drying of wetlands around Silent Creek could reduce the suitability of this habitat for some fisher prey species. Consequences of this potential impact are considered to be minor, due to the limited scale of this impact relative to the availability of suitable habitat and prey in proximity to the project area. Potential monitoring impacts would be the same as described above for Alternatives 1 and 4. None of the other activities proposed under these alternatives, nor the connected actions associated with them have consequential impacts to fisher or their habitat.

Indirect Impacts:
Alternative 1 would only be expected to impact fisher by perpetuating water quality monitoring on Lake Creek. Increased human activity associated with monitoring would have the potential to temporarily displace any individuals that might be using the area. As described above, this potential disturbance impact is considered to be insignificant and discountable. Risk of exposure to algal toxins is considered to be neglible for this species.

None of the alternatives would impact future fisher habitat in the project area. There are no anticipated impacts to the fisher's future prey base associated with any of the alternatives.

Cumulative Impacts:
Direct mortality from trapping and predator control efforts and habitat loss from timber harvest and human development led to the extirpation of fisher throughout much of its historical range in the Pacific States (Aubrey and Lewis, 2003). Past, present, and future activities that fragment late-successional habitat (timber harvest and road building), remove coarse woody debris (fuels reduction projects), and develop riparian areas (campgrounds etc.) are considered to be the primary activities that contribute to the potential cumulative impacts of land management on fishers in the analysis area (Tables 9-11)

Alternatives 2 and 3 represent a short-term, minor contribution to the cumulative habitat impact and Alternatives 1, 2, 3, 4 represent an inconsequential contribution to a disturbance impact for this species. The high elevation and existing levels of human development in the analysis area limit its potential importance to fisher. There are no documented fisher den sites anywhere on the Forest. The ongoing and future management activities in the analysis area would occur primarily in existing developed areas. Based on this information, the potential cumulative impacts to fisher are considered insignificant to the species.

Conclusions:
Potential impacts to fisher are considered to be minor under all alternatives. Alternatives 2 and 3 have a higher potential to impact the species than Alternatives 1 and 4. Alternatives 1 and 4 would only impact the species through increased human use in potential habitat.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, 3, and 4 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."

Pacific Fringed Myotis

This bat is usually described as a cave-dwelling bat (Verts and Carraway 1998, Cristy and West 1993), but are also known to roost in rock crevices, bridges, buildings, large trees and snags (Cross et al. 1996, Weller and Zabel 2001). They mate from September to February and females form maternity colonies of up to several hundred individuals, which are usually in caves, but may occur in large hollow trees (Pat Ormsbee, pers. com.).

Weller and Zabel (2001) documented that habitat use by this species is influenced by the availability of large (>12 inch d.b.h.), tall snags for roosting. Roosts tend to be near stream channels (Weller and Zabel 2001), which are used for travel and foraging corridors, and also occur in portions of stands that have lower canopy closures. This species of bat uses multiple trees or snags as roost sites (Weller and Zabel 2001) and have been documented to use up to five different sites during an 18 day period (Cross et al. 1996).

Fringed myotis commonly feed on insects along forest edges and stream corridors; beetles, moths, and spiders make up a large portion (approximately 94%) of their diet (Verts and Carraway 1998). The species is believed to migrate in the fall, but little is known about the magnitude of movements or the migratory destination (O'Farrell and Studier 1980).

The following ecological information about the fringed myotis bat is relevant: (1) young bats are generally fledged and indistinguishable from adults by August; (2) female bats are adding fat during the late summer and early fall to prepare for hibernation; (3) females and young would likely have permanently left the maternal colony by September; (4) fringed myotis bats probably migrate to lower elevations in the fall and are likely hibernating by November; and (5) the majority of their prey items are terrestrial rather than aquatic insects (Verts and Carraway 1998, O'Farrell and Studier 1980).

AFFECTED ENVIRONMENT

There are ten documented occurrences of Pacific fringed myotis on or near the Umpqua National Forest. There are no documented observations of the species within the project area. However, the area contains suitable habitat; it is likely that they do occur, and species presence is assumed. The closest sighting of this species is a 1983 observation of a single bat roosting under a bridge, 14.3 miles to the west of the project area.

At a landscape scale, there is a strong concern that loss of snags and large decadent trees from the widespread conversion of old-growth forests to young, even-aged plantations in this region has significantly reduced the availability of potential roosts for this and other bats in the Pacific Northwest (USDA/USDI 1994 – Appendix J2-49).

ENVIRONMENTAL EFFECTS

Direct Impacts:
Alternatives 1 and 4 would have no direct impacts on this bat because neither alternative would impact individuals or habitat.

Alternatives 2 and 3 have potential impacts on both individuals and habitat of this species. These alternatives would dewater portions of Lake Creek for approximately 2 months in the late fall (mid September – mid November). These alternatives also propose a rotenone treatment that would eliminate most aquatic insects from Diamond Lake in about mid September. There is too little data on the migration habits of this species to determine whether the bats would have migrated to lower elevations by mid September; however, for purposes of full disclosure, it is assumed that some fringed bats would still be utilizing the project area for foraging during the fall season. Based on these assumptions, dewatering of Lake Creek would temporarily degrade habitat for the species through the removal of drinking water and aquatic prey items along portions of the stream. Consequences of this potential impact are considered to be minor, due to the limited scale of this impact relative to the availability of suitable habitat downstream on Lake Creek and availability of terrestrial prey in and adjacent to the project area.

Bats utilizing Diamond Lake during and after the mid September rotenone treatment would be exposed to rotenone treated water. As described in the "Toxicity of Rotenone to Wildlife" section of this document, bats (mammals) are not expected to be harmed as a result of ingesting water or consuming dead prey. Removal of aquatic insects represents the greatest potential impact to fringed bats associated with these alternatives. Consequences of this impact are considered insignificant to the species because fringed bats tend to prey heavily on terrestrial insects, young of the year would already be fledged, and there is available foraging habitat adjacent to the project area, if bats were temporarily displaced as a result of the lack of aquatic prey. Fringed bats would not be present at the lake during the late fall, winter, or early spring. The aquatic prey base would begin recovery in the spring/summer following rotenone treatment, but the population would still be expected to be lower than the existing population. Thus, bats would likely still be reliant on terrestrial prey and adjacent habitat to supplement the limited aquatic prey base during the summer to fall season following treatment. These impacts to the aquatic prey base are expected to have insignificant consequences to the population of fringed myotis bats (Pers. comm., Dr. John Hayes, Pat Ormsbee). None of the other activities proposed under these alternative nor the connected actions associated with them have consequential impacts to fringed myotis bats or their habitat.

Indirect Impacts:
Because aquatic insects are not the primary prey for this species, all of the potential impacts to prey are considered to be minor.

Alternative 1 would indirectly impact this species by perpetuating lake conditions that support a limited and declining future population of aquatic insects (see Fish section). It is also possible that bats would be harmed or killed by ingesting algal toxins during or following a bloom.

Alternatives 2 and 3 would be expected to result in an indirect beneficial impact to the species by facilitating the return of a more abundant and diverse aquatic prey base for the species in the future when the lake recovers (see Fisheries section for details).

Impacts to the abundance and diversity of the future aquatic prey base for fringed myotis bats at Diamond Lake are uncertain under Alternative 4 due to the fact that only a portion of the tui chub population would be removed and tui chub are very effective predators on aquatic macroinvertebrates. However, it is assumed that some positive impacts to aquatic prey would be realized for an unknown period of time (see Fish section).

Cumulative Impacts:
Loss of available large snag habitat across the landscape is considered to be the primary limiting factor for this species. Potential past, present, and future activities that remove large snags and late-successional habitat (i.e. timber harvest, hazard tree removal, human developments) are considered to be the primary activities that contribute to the potential cumulative impacts of land management on fringed bats in the analysis area (Tables 9-11)

None of the alternatives would remove large snags or trees from the project area; thus none contribute significantly to the cumulative impacts to this species. With the exception of hazard tree removal in developed areas around Diamond Lake, little loss of snag habitat within the project area is expected in the future. The project area is bounded by Mt. Bailey Roadless Area to the west, Mt. Thielsen Wilderness to the east, and Crater Lake National Park to the south; due to the management objectives of these areas, little loss of large snag or late-successional habitat is expected on the majority of lands adjacent to project area. Protection of Riparian Reserves would also limit future habitat impacts to the north. Based on this information, the potential cumulative impacts to fringed bats are considered insignificant to the species under all alternatives.

Conclusions:
Alternative 1 represents the greatest sustained risk to the fringed myotis bat over time through perpetuation of toxic algae blooms. Alternatives 2 and 3 have greater potential short-term adverse effects than Alternative 4, but higher potential for long-term habitat

improvement through improved water quality and prey base than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, 3, and 4 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."

Pacific Shrew

One of the largest shrews the Pacific shrew is found in humid forests, marshes, and thickets and is considered a riparian species (Gomez and Anthony 1998); however, it has been found as far as 20 meters away from stream banks (Anthony et al. 1987). It is more commonly found in early-successional forests and less often in late-successional stands. It requires down logs, brushy thickets, or ground debris for cover and feeding. Prey items include snails, slugs, centipedes, insect larvae, earthworms and some vegetable matter. Nests are made of dry grass or leaves and are placed in a stump or down log.

AFFECTED ENVIRONMENT

There are no known observations of the Pacific shrew in the project area. However, the project area is considered to be suitable habitat and species presence is assumed (surveys were not conducted nor recommended for this species because of the high incidence of shrew mortality associated with known survey methods). The closest observation of the species is approximately 3.6 miles southwest of the project area in a DEMO Unit at Watson Falls.

Recent surveys indicate that the Pacific shrew is well-distributed on the Umpqua National Forest. There are 31 documented observations of the shrew on the Forest and they occur on all four Ranger Districts.

ENVIRONMENTAL EFFECTS

Direct Impacts:
Alternatives 1 and 4 would have no direct impacts to the species because no habitat alteration or other activities that would potentially harm individuals would occur.

Alternatives 2 and 3 have the potential to impact shrews and their habitat through the temporary dewatering of portions of Lake Creek and the temporary drying of wetlands adjacent to Silent Creek. These activites could reduce the suitability of this habitat for some shrew prey species in the short-term. As a result, it is possible that individual shrews could be temporarily displaced or compelled to forage over wider areas during this time. A number of factors would likely mitigate the consequences and extent of this potential impact: moisture-retaining microrefugia (down logs and clumps of senescent vegetation at the base of shrubs and trees) adjacent to the creek and within the wetlands would be expected to support a number of prey species; fall and winter precipitation would serve to add and retain moisture in the impacted area for much of the time; and adjacent suitable habitat and prey would be available to support the species. Thus, potential impacts are believed insignificant to the species. None of the other activities proposed under these alternatives nor the connected actions associated with them have consequential impacts to shrews or their habitat.

Indirect Impacts:
Alternative 1 perpetuates the existing condition of water quality at Diamond Lake and thus perpetuates toxic algae blooms. It is possible that shrews could be harmed or killed by ingesting algal toxins in Diamond Lake. The liklihood of shrews frequently watering in Diamond Lake proper is considered to be very low.

There are no anticipated indirect impacts associated with any of the other alternatives because none of the alternatives are expected to modify the condition of future habitat for the species.

Cumulative Impacts:
Past, present, and future activities (i.e. fuels reduction and human developments in riparian habitat) that remove vegetation and down woody debris from suitable undeveloped riparian habitats are considered to be the primary activities that contribute to the potential cumulative impacts of land management on Pacific shrews in the analysis area (Tables 9-11)

Alternatives 2 and 3 represent a short-term, limited-scale contribution to the cumulative habitat impact for this species because of the potential impacts to prey species. Death of individuals would not be expected as a result of proposed activities. Alternative 1 represents a minor risk to individuals of this species because of potential ingestion of algal toxins. Recent surveys on the Umpqua National Forest indicate that the species may actually be locally common. Little manipulation within undeveloped ripararian habitat is expected in the future within the analysis area. Based on all of the above, the potential cumulative impact is not considered significant to the species under any alternative.

Conclusions:
Alternatives 2 and 3 have temporary habitat impacts to Pacific shrews and there is no meaningful or measureable differences between these two alternatives. Alternative 1 represents a perceived low risk to the species through exposure to algal toxins.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1, 2, and 3 "may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of the species."
>
> Alternative 4 would have "no impact" on the Pacific shrew.

SURVEY & MANAGE SPECIES

The Forest Plan requires protection of certain wildlife species, which may not be fully protected by other standard and guidelines of the plan, especially when projects occur outside of Late Successional Reserves (LSR's) or Riparian Reserves. Recent amendments to the

Northwest Forest Plan redefined Survey and Manage categories based on new information and species characteristics (USDA/USDI 2001). On this District five survey and manage wildlife species are currently considered: red tree vole, great gray owl, Oregon Megomphix (snail), Crater Lake tight coil (snail), and the Chace Sideband (snail). There are no known sites of the Oregon Megomphix in the project area and surveys are no longer required for this species (USDA/USDI 2001). Surveys are not required or recommended for the red tree vole because proposed activities are not habitat disturbing activities that have the potential to cause a significant negative effect on the species habitat or the persistence of the species at the site (Survey Protocol for the Red Tree Vole, V. 2.1, 2002). The remaining species are discussed in detail below.

Great Gray Owl

This owl is one of the largest owls in North America. It nests in late-successional forests (>60% canopy closure), but forages in early-successional habitat (e.g., meadows, clearcuts). Within the range of the northern spotted owl, it is most common in lodgepole pine forests adjacent to meadows, but is also found in other coniferous forest types. Great gray owls in Oregon prey most often on voles and pocket gophers (Marshall et al. 2003). Although little is known about the existing population numbers or changes in numbers over time, it is believed that populations of great gray owls in this state may have declined in recent years due to habitat loss resulting from harvest of old-growth forests as well as urban sprawl in Deschutes County (Marshall et al. 2003).

AFFECTED ENVIRONMENT

There are no confirmed great gray owl nests in or adjacent to the project area. The closest documented nest site for the species is approximately 6.5 miles to the west. Silent Creek and Kelsay Valley wetlands, as well as scattered riparian meadows along Lake Creek are potential foraging habitat for great gray owls within or closely adjacent to the project area.

Protocol surveys are not required for this project because there are no ground disturbing activities proposed in great gray owl nesting habitat (USDA/USDI Survey Protocol 1995 revised 1997). However, multiple surveys have been conducted for great gray owls in and adjacent to the Diamond Lake area in recent years. Multi-visit surveys were conducted in the Lemolo Lake/Lake Creek area in 1994, 1996, 1997, 1998, and 2003. Several detections of great gray owls were made within and closely adjacent to the project area, near the mouth of Lake Creek, during August of 1994. Nighttime auditory responses were received from an adult female (1996), an adult male (1998), and a juvenile (2003) during these separate survey efforts in the vicinity of Lemolo Lake and lower Lake Creek. Anecdotal sightings of great gray owls in the same general area are also documented from 1979 and 1983. Based on the above information, it is assumed that great gray owls utilize meadows within and adjacent to the project area for foraging and possibly nest in surrounding forests.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:

None of the alternatives would remove or degrade potential nesting habitat for great gray owls. Therefore, no direct, indirect, or cumulative effects to nesting habitat would occur. Alternatives 1 and 4 would have no anticipated impact on great gray owls or their habitat; the risk of great gray owls consuming algal toxins is neglible.

Alternatives 2 and 3 have the potential to temporarily modify foraging habitat in a neutral or beneficial manner. Primary prey items for great gray owls (pocket gophers and voles) occupy meadow habitats adjacent to forests. Most of these animals utilize ground burrows and would not use areas that were so wet that burrows would collapse or become filled with water. The temporary dewatering of Lake Creek would not be expected to result in a noticeable drying affect on meadows adjacent to Lake Creek that are downstream from its confluence with Theilsen Creek. Thus, in areas where great gray owls are known to forage, these alternatives would be expected to have a neutral impact on prey habitat. The draw down of Diamond Lake is expected to result in the temporary drying of the wet meadows at the south end of the lake. Drying of areas that are normally inundated with water would improve habitat for voles and pocket gophers and thus could indirectly benefit great gray owls in the short-term. When considered in the context of past, present, and reasonable foreseeable activities in the area (Tables 9-11), because these alternatives do not modify nesting habitat and the scale and duration of the neutral or beneficial impact is limited, potential cumulative impacts are considered to be inconsequencial to the species. None of the other activities proposed under theres alternatives nor the connected actions associated with them have consequential impacts to great gray owls or their habitat.

Conclusions:
Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that:

> Alternatives 1 and 4 would have no impact on great gray owls.
>
> Alternatives 2 and 3 would have neutral or beneficial impacts on individuals or habitat in the short-term. There is no difference between the alternatives’ potential impacts to the species.

Crater Lake Tightcoil Snail

This tiny snail may be found in perennially wet situations in mature conifer forests, among rushes, mosses, and other surface vegetation or under rocks and woody debris within 33 feet of open water in wetlands, springs, seeps, and riparian areas, generally in areas which remain under snow for long periods in the winter. Riparian habitats in the Eastern Oregon Cascades may be limited to the extent of permanent surface moisture, which is often much less than 33 feet from open water (USDA/USDIa 2003).

AFFECTED ENVIRONMENT

Wetland habitat in the Diamond Lake project area is potential habitat for this species. Two survey visits for the Crater Lake tightcoil were conducted within suitable habitat in the project area in 2003. This species was documented at five locations within the planning area adjacent to Lake Creek. Additional potential habitat for this species exists within the same 6th field watershed.

Distribution of the Crater Lake tightcoil sites along Lake Creek is as follows: three sites are located below the confluence with Thielsen Creek (sites 7, 8, 26); one site is located near two small tributaries that would not be influenced by the draw down (site 18); and one site is located before the Thielsen Creek confluence with no tributary influence (site 16).

The Crater Lake tightcoil has been located at several locations on the Diamond Lake Ranger District in springs and wetland habitat types. Numerous individuals (greater than 20) were located at the Crystal Springs site approximately 1.8 miles from the project area.

According to the 2003 Annual Species Review for Survey and Manage Species, the Crater Lake tightcoil is categorized as a Category A^2 species (USDA/USDI 2003b). Species in this category, are considered rare, require pre-disturbance surveys, and require management of known sites.

The Management Recommendation for the Crater Lake tightcoil that is relevant to this project is:

> Avoid activities that would lower the water table at the site, thus reducing soil moisture below that required by the species, or possibly altering vegetative communities (USDA/USDI 1999).

The January 2001 ROD for Amendments to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standards and Guidelines(USDA/USDI 2001) allows occasional exemptions to the manage all known sites requirement as documented below:

> Professional judgement, coupled with locally specific information and advice from taxa specialists about the species, may be used to identify occasional sites not needed for persistence. These exceptions will be reviewed by the REO (S&G’s pg. 8).

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:
Alternatives 1 and 4 would have no impact on the Crater Lake tightcoil because they do not propose activities that would alter habitat or potentially harm individuals.

Alternatives 2 and 3 have potential impacts on individuals and habitat of this species. Under these alternatives, portions of Lake Creek between Diamond Lake and the confluence of Lake Creek and Thielsen Creek would be effectively dewatered for the time period beginning around the middle of September and ending in approximately early November. Subsequently, this same section of Lake Creek would be maintained at low flows until late spring or early summer (see Stream section for details). For the portions of Lake Creek extending from the Thielsen Creek confluence to Lemolo Lake, Lake Creek's flow would be approximately 15-20% of normal seasonal flow during the period of no outflow from Diamond Lake, and would then increase for the winter to spring/summer period when a minimum of 10 cfs of water would be allowed to exit Diamond Lake.

According to the project Hydrologist and Groundwater specialist, it is expected that sites 7, 8,18, and 26 would experience minor changes in the ground water and limited changes in the soil moisture. The microclimate ranges tolerated by these snails is not known, so it is not possible to confidently conclude that the draw down would have no impact on the species at this site. However, other mitigating factors include rain and snow which would be contributing moisture to these sites during much of the draw down period, and moisture-holding microsites such as down logs and riparian vegetation which would remain intact and available for snails and/or eggs.

It is expected that site 16 would experience major changes in the groundwater and corresponding changes in the soil moisture. Thus, it is possible that snails or eggs could become dessicated at this site. Natural mitigating factors (precipitation and microhabitats) would also be available at this site.

In summary, Alternatives 2 and 3 would result in an unquantified level of temporary habitat degradation; minor in four areas and more substantial in one area. It is possible that snail or egg survival could be negatively impacted by the dewatering of Lake Creek, particularly at site 16. Because so little is known about the microclimate tolerances of this species, pre- and post- draw down monitoring of soil moisture and species presence would occur. To reduce the consequences of potential loss of individual snails or eggs translocation of some individuals from the Crystal Springs sites would occur if post-project surveys result in absence of the species at any of the sites listed above.

Additional spot surveys of suitable habitat in proximity to the project area are also planned to assess prevalence and distribution of the species in the watershed.

Conclusions:
Alternatives 1 and 4 would have no impact on the Crater Lake tightcoil.

Alternatives 2 and 3 may impact individuals and habitat of this species. Consultation with Nancy Duncan, Regional Mollusk Taxa Lead has occurred; Duncan reviewed the project and concluded that these alternatives, as mitigated, would not affect persistence of the species (Duncan 2004). On 02-17-04, the Interagency Survey and Manage Group[151] responsible for approving exemptions on survey and manage issues, reviewed the project, concurred with Duncan's determination, and exempted the Forest from the manage known site requirements for this project (Huff 2004).

Chace Sideband

Habitat for this snail is usually found within 98 feet of rocky areas, talus deposits and in associated riparian areas in the Klamath physiograph province and adjacent portions of the southwestern Oregon Cascades. Areas of herbaceous vegetation in these rocky landscapes adjacent to forested habitats are preferred habitat. Moist, shaded rock surfaces are preferred for daily refuges. In more mesic, forested habitats, especially in the Oregon Cascades, the species is associated with large woody debris and the typical rocky habitat is not required. Forest habitats without either rock features or large woody debris are not currently considered to be suitable habitat for this species (USDA/USDIa 2003).

AFFECTED ENVIRONMENT

This snail is not known to occur within the project area or anywhere on the Diamond Lake Ranger District. The species does occur and appears to be fairly common in suitable habitat on the adjacent Tiller Ranger District. The closest sighting of this species is 17 miles southwest of the project area boundary. The Diamond Lake project area contains a very limited amount of low quality habitat for the species. Two survey visits for the Chace sideband were conducted within suitable habitat in the project area in 2003. This species was not detected during surveys.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:
The project area does not occur within the known range of the species and surveys did not detect the species within the project area. There are no anticipated impacts associated with this project.

Conclusions:
Alternatives 1, 2, 3, and 4 would have no impact on the Chace sideband snail.

[151] The Interagency Survey and Manage Group is the entity that has the authority to approve exemptions to survey and manage management guidelines. They are the current Regional Ecosystem Office (REO) representatives.

MANAGEMENT INDICATOR SPECIES

The Umpqua National Forest Land and Resource Management Plan (1990) identifies the following species/groups as Management Indicator Species (MIS) for the Forest: northern spotted owl, pileated woodpecker, marten, bald eagle, peregrine falcon, Roosevelt Elk, blacktail deer, and cavity nesters. The bald eagle, peregrine falcon, and northern spotted owl were addressed in the PETS section of this chapter . Marten are addressed under "Other Mammals" below.

None of these alternatives would modify habitat (snags) for pileated woodpeckers and cavity nesters. There are no anticipated negative impacts to these species or habitat associated with this project and thus they will not be discussed further.

Deer and elk are known to utilize the project area. None of the alternatives would degrade habitat for these species. However, deer and elk likely utilize Diamond Lake as drinking water and thus, there are potential impacts to individuals.

Alternative 1 forgoes the opportunity to address declining water quality and leaves deer and elk vulnerable to exposure to toxic algae blooms. As documented in the "Effects of Toxic Algae Blooms on Wildlife" section of this document, algal toxins are known to cause mortality in mammals. Because deer and elk are expected to consume relatively large quantities of water during the summer months, it is anticipated that some individuals may become ill or die from ingestion of water containing algal toxins during or following a summer bloom at some point in the future. Because area deer and elk populations are large, impacts would not be expected to lead to a trend toward Federal listing or cause a loss of viability of these species.

Under Alternatives 2 and 3, deer and elk utilizing Diamond Lake during and after the mid September rotenone treatment would be exposed to rotenone treated water. As described in the "Toxicity of Rotenone to Wildlife" section of this document, deer and elk are not expected to be harmed as a result of ingesting water.

LANDBIRD CONSERVATION PLAN CONSISTENCY

Continental and local declines in numerous bird populations have lead to concerns for the future of migratory and resident landbirds. The Forest Service (USDA 2000) and the Partners in Flight Conservation Program have developed a conservation plan to maintain and restore forest habitats necessary to sustain long-term, healthy bird populations. This plan focuses on 28 bird species (see Attachment 2 of the Wildlife Report) representing a range of habitats from stand initiation to old forest and provides recommendations for forest management at both the stand and landscape-scale.

The Landbird Conservation Plan is a habitat-based conservation effort and as such the types of activities proposed under this project are not addressed in the Plan. Alternative 4 would have no impact on landbirds or habitat because none of the proposed activities would alter habitat or potentially harm individuals.

Alternative 1 forgoes the opportunity to address declining water quality and leaves landbirds vulnerable to exposure to toxic algae blooms. As documented in the "Effects of Toxic Algae Blooms on Wildlife" section of this document, algal toxins are known to cause mortality in songbirds. Therefore, under this alternative, it is possible that some landbirds would become ill or die from ingestion of water containing algal toxins during or following a summer bloom at some point in the future. The extent of this potential impact to landbirds over time is unknown.

Alternatives 2 and 3 have the potential to temporarily modify habitat for the Lincoln's Sparrow through the drying of wetlands within the project area. Lincoln's sparrows have been detected at the sewage ponds and occasionally during spring/summer surveys near the Silent Creek wetlands. This short-term impact is considered inconsequential to the species, due to its limited scale and duration, as well as the anticipated low numbers of individuals potentially impacted. There are no management recommendations for this species in the Landbird Conservation Plan other than conducting monitoring and research to determine status, distribution, and habitat relationships for the species. Pre and post project monitoring of the Silent Creek wetlands would occur for these alternatives.

Alternatives 2 and 3 would also result in a temporary loss of aquatic insects in Diamond Lake during the fall of the proposed rotenone treatment. Aquatic insect populations would begin recovery in the spring and summer following treatment and would subsequently be expected to exceed present numbers and species diversity in the years that follow (see Benthic Organism section). Landbirds that prey heavily on aquatic insects could be temporarily displaced to adjacent areas during the fall when aquatic insects are limited within the project area. Young of the year would already be fledged by this time, limiting the consequences of this impact to landbirds. In the long-term, Alternatives 2 and 3 would be expected to beneficially impact those species that utilize aquatic insects as prey. For a complete species list of landbirds, annual bird survey data from the Umpqua Valley Audubon Society (1996-2003) is on file at the Diamond Lake Ranger District. Following consideration of potential impacts, it is determined that these alternatives may temporarily impact landbird habitat, but would not have consequential impacts to the species. These alternatives are considered to be consistent with the Landbird Conservation Plan.

AQUATIC CONSERVATION STRATEGY CONSISTENCY

The Aquatic Conservation Strategy (ACS) is aimed at restoring and maintaining the ecological health of watersheds. Its goal is to retain, restore, and protect ecological processes and landforms that contribute habitat elements to streams and promote good habitat conditions for fish and other aquatic and riparian dependent organisms. ACS objectives are discussed in detail in other sections of this document. The ACS objective most relevant to wildlife is #9 – maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species. For wildlife, ACS consistency is addressed primarily in the context of riparian-dependent mollusks and vertebrate species. Species specific impacts for riparian associated wildlife are discussed in detail throughout this section. Thus, the following represents a broad, general summary that addresses multiple scales. The landscape or watershed scale is considered to be the most appropriate scale for meeting ACS objectives.

Alternative 1 would maintain existing habitat for riparian associated wildlife species. However, because toxic algal blooms place several species at risk, no action is considered inconsistent with ACS objective #9. This alternative fails to address declining water quality and loss of aquatic invertebrate diversity and abundance in Diamond Lake and as such has potential long-term negative impacts to some riparian dependent species. Thus, this alternative may retard attainment of this ACS objective at both the project scale and at the landscape scale by perpetuating downstream impacts on water quality.

Alternatives 2 and 3 would have temporary impacts to riparian habitat on Lake Creek and in Diamond Lake at the project scale. In the longer term, these alternatives would be expected to have a neutral affect on Lake Creek and its associated wildlife, and would be expected to improve the water quality and species diversity and abundance of the aquatic prey base in Diamond Lake. In this context, at both the project and the landscape scale, these alternatives are consistent with habitat restoration objective #9.

Alternative 4 would generally maintain existing habitat conditions for riparian associated wildlife species in Diamond Lake and Lake Creek. In the short-term, this alternative would have a primarily neutral influence on attainment of ACS objective #9. In the longer term, at both the project and the landscape scale, this alternative is designed to improve habitat conditions in Diamond Lake and as such, is consistent with this ACS objective.

OTHER NON-TARGET SPECIES

Analysis of all the following species or species groups is not necessarily required under the Forest Service Biological Evaluation process. However, potential impacts to these species/groups are described for purposes of full disclosure.

Osprey

Ospreys are large birds of prey that breed statewide except in dry treeless southeastern regions and Columbia Basin grasslands. In Oregon, the species generally nests on top of large live trees, snags, or utility poles located within 2 miles of water with an accessible fish population. Ospreys feed almost exclusively on live fish, but dead fish and other non-fish food items are occasionally utilized. The species experienced a nationwide decline in the 1950’s and 60’s associated with the widespread use of DDT. DDT was banned in the United States in 1972 and osprey populations have now recovered to historic levels in Oregon and throughout most of their range (Marshall et al. 2003).

AFFECTED ENVIRONMENT

Ospreys utilize Diamond Lake and Lake Creek primarily during the nesting season. The birds generally arrive in the area in early April, breed and nest through the summer, and then begin fall migration in mid September (Pers comm., Ron Maertz, 2003).

The Diamond Lake Restoration project area has likely supported some number of nesting osprey since shortly after 1910 when the lake was first stocked with fish. There are no available data documenting how many osprey nests historically occurred in the vicinity of the lake, nor how osprey responded to the temporarily fishless condition of Diamond Lake following the 1954 rotenone treatment. Fix (1990) summarized his birding observations on the Diamond Lake Ranger District over the seven year time period from 1984-1990. Fix characterized osprey at Diamond Lake as a fairly common summer resident with high nesting success. Anecdotal observations by long-time residents of Diamond Lake indicate that osprey use at the lake appeared to be declining by 1996 (McAuliffe, Correspondence to ODFW, 1996). Surveys completed by the Umpqua Valley Audubon Society from 1996-2002 appear to indicate that the osprey population at Diamond Lake has been relatively stable over the past eight years (Pers. comm., Alice Parker, 2003).

ODFW completed an aerial survey on June 30, 2003 to document osprey nests in and adjacent to the project area. Thirteen osprey nests were observed. Ten nests were located adjacent to Diamond Lake and the other three were along Lake Creek. Six of the osprey nests were active. Reproductive success of these nests is unknown.

Ospreys at Diamond Lake have adapted to a high level of year-round human use. Thus, potential disturbance impacts that don't result in habitat or prey modification are considered very unlikely to occur under any alternatives and will not be discussed.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:
Alternative 1 perpetuates the existing condition, forgoes the opportunity to address declining water quality and leaves osprey vulnerable to exposure to toxic algae blooms in the future. Under this alternative, it is possible that osprey would become ill or die from ingestion of water containing algal toxins during or following a summer bloom. The extent of this potential impact to osprey over time is unknown.

Alternatives 2 and 3 would have potential impacts to osprey and their habitat. Osprey begin fall migration around mid September in this area. Both historic and recent survey efforts indicate low use of Diamond Lake during the fall season (Fix 1990; Audubon Surveys 1996-2002). However, it is assumed that a small number of indivduals would be present at Diamond Lake during a mid-September rotenone treatment. Osprey would be expected to ingest rotenone treated water and consume rotenone killed fish. However, as described in the "Toxicity of Rotenone to Wildlife" section of this document, they are not expected to be harmed.

Rotenone treatment would temporarily eliminate the fish prey base for this species at Diamond Lake. However, immediately following treatment, birds still present at the lake would likley feed on fish carcasses for a short-time and then would begin or continue migration as the prey base declined and the season progressed. Loss of prey base would likely have the greatest potential impacts on osprey during the following spring and summer when birds returned to the lake to nest. During this breeding season, lack of a fish prey base could compromise nesting success for the species. This potential impact would be mitigated by the supplemental feeding program described for bald eagles. However, it is still expected that reproductive success could be reduced for some of the six pairs of osprey currently nesting at

Diamond Lake for one to two breeding seasons. Monitoring of reproductive success would occur during the supplemental feeding program and for two years following restoration of the fish prey base.

As described in detail in the bald eagle section, Alternatives 2 and 3 would be expected to improve future habitat in the planning area by restocking with trout. Increases in the availability of a larger prey item (trout) could result in a return to higher numbers of nesting osprey at Diamond Lake in the future. Alternative 3 would be expected to provide a higher number or larger prey items more quickly than Alternative 2 because Alternative 3 proposes stocking with legal-sized fish while Alternative 2 is primarily a fingerling based stocking strategy.

For Alternatives 2 and 3, when considered in the context of past, present, and reasonable foreseeable activities in the project area (Tables 9-11), it is expected that potential impacts would have insignificant consequences to the species because: potential negative impacts are limited to one or two breeding seasons followed by a long-term improvement in habitat; the supplemental feeding program would reduce the intensity of the impact, populations of osprey on the Forest and state-wide are stable; and ongoing and reasonably foreseeable actions that would modify osprey habitat are limited.

Alternative 4 would utilize commercial fish operations for approximately two months in June and July and one month in September on an annual basis to harvest tui chub from Diamond Lake. It is possible that osprey could be harmed by becoming entangled in gill nets during commercial fishing operations (Pers. com. Dave Loomis). It is considered unlikely that this potential impact would occur frequently enough to represent a significant impact to the species. Commercial fishing would also reduce the available prey base for osprey during the breeding season. These activities would disrupt foraging during the breeding season, but are not expected to hinder reproductive success because commercial fishing areas would be staggered, allowing undisturbed access to the majority of the lake at a given point in time and adequate prey base would likely remain in Diamond Lake throughout the lifetime of the project. This is considered to be an insignificant effect to the species. When considered in the context of past, present, and reasonable foreseeable activities in the project area, potential impacts associated with this alternative are expected to have insignificant consequences to the species because: impacts are limited in scale and intensity; populations of osprey on the Forest and state-wide are stable; and ongoing and reasonably foreseeable actions that would modify osprey habitat are limited.

Conclusions:
Alternative 1 represents the greatest sustained risk to osprey at Diamond Lake because of the continued presence of toxic algae blooms over time. Alternatives 2 and 3 have greater potential short-term adverse effects than Alternative 4 and higher potential for long-term habitat improvement through improved water quality than Alternatives 1 or 4. There are no measureable differences between Alternatives 2 and 3 with regard to effects to this species.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that Alternatives 1, 2, 3, and 4 may temporarily impact osprey, but would not have consequential impacts to the species.

Waterbirds

AFFECTED ENVIRONMENT

Diamond Lake proper provides nesting habitat for a number of waterfowl, shorebirds, and other water-associated bird species, but is probably most important as a fall migration stop for waterfowl. Additionally, the sewage ponds just northeast of Diamond Lake are considered to be important nesting and migration stopover habitat for this species group in the summer and fall. Based on extensive birding experience, Fix (1990) characterized waterbird utilization of Diamond Lake from 1984-1990 as remarkable for supporting heavy use by both humans and waterfowl[152]

In 2000-2002, from 10-25 bird species that rely solely or primarily on fish or aquatic insect prey were detected during point-count surveys by the Umpqua Valley Audubon Society at the south end of Diamond Lake. All of the species documented in Table 36 were present during the 2000, 2001, or 2002 survey seasons in numbers greater than 10. Fall surveys did not occur after mid to late September.

[152] "Diamond Lake is remarkable for supporting heavy use by both humans and waterfowl. From October into December, a fine concentration of dabbling and diving ducks, grebes, coots, and gulls may be found assembled on the south portion of the lake. Submergent vegetation offers a strong attraction for these birds, and they feed heavily in preparation for the flight to wintering grounds elsewhere. Thousands of American Coots, hundreds of American Wigeon and Lesser Scaup, and dozens of Common and Hooded Mergansers dot the lake at this time. Loons, Red-necked Grebe, Clark's Grebe, Surf and White-winged Scoters, Red-breasted Merganser, Eurasian Wigeon, and Herring and Bonaparte's Gulls have been seen among this flock.

The sheltered northwest corner of the lake supports a small flock of waterfowl concurrently, chiefly Barrow's Goldeneyes, Buffleheads, Eared Grebes, and the occassional loon.

The lake is slow birding during much of the rest of the year. Small numbers of migrant waterfowl appear on the lake during mid- and late spring. Common loons and Horned Grebes are probably regular at this time. Barrow's Goldeneye is by far the most common nesting duck, and family groups may be encountered anywhere along the lakeshore from June into September (Fix 1990).

Table 36. Waterbirds detected in numbers greater than 10 during the 2000-2002 surveys at the South Shore Picnic Area and South Shore Meadows Survey Points on Diamond Lake.

Species	Spring/ Summer Survey Date	Highest Number of Individuals Documented in Spring/Summer	Fall Survey Date	Highest Number of Individuals Documented in Fall	Survey Location
Pied-billed grebe	8/23/00	11	9/11/00	51	SS Meadow
Western grebe	8/22/00	55	9/11/00	179	SS Meadow
California gull	8/23/00	29	9/11/00	24	SS Meadow
No species were detected in numbers greater than 10 in the 2001 surveys					SS Meadow
Common merganser	7/25/02	128	-----	-----	SS Meadow
Pied-billed grebe	8/30/00	16	9/13/00	22	SS Picnic Area
Western grebe	7/19/00	120	9/13/00	174	SS Picnic Area
American wigeon	-----	-----	9/28/00	30	SS Picnic Area
Common merganser	-----	-----	9/13/00	87	SS Picnic Area
American Coot	-----	-----	9/28/00	360	SS Picnic Area
California gull	8/10/00	17	9/28/00	31	SS Picnic Area
Western grebe	8/10/01	195	-----	-----	SS Picnic Area
Clark's grebe	6/18/01	110	-----	-----	SS Picnic Area
Common merganser	6/2/01	10	-----	-----	SS Picnic Area
California gull	8/10/01	35	9/15/01	17	SS Picnic Area
Western grebe	8/8/02	428	No September survey data was available for the South Shore Picnic Area.		
Clark's grebe	7/11/02	21			
Common merganser	7/31/02	161			
California gull	6/20/02	44			
Double-crested cormorant	8/8/02	12			
Tree swallow*	8/8/02	29			
Violet green swallow*	7/31/02	17			
Barn swallow*	7/31/02	57			

***** These species are not dependent on aquatic insects, but would utilize them heavily at Diamond Lake.

Other waterbirds known to use Diamond Lake, which are closely tied to a fish prey base but do not occur in high numbers are: the great blue heron and belted-kingfisher. For a complete species list of waterbirds, annual bird survey data from the Umpqua Valley Audubon Society (1996-2003) is on file at the Diamond Lake Ranger District.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:

Alternative 1 forgoes the opportunity to address declining water quality and leaves waterbirds vulnerable to exposure to toxic algae blooms. As documented in the "Effects of Toxic Algae Blooms on Wildlife" section of this document, algal toxins are known to cause mortality in waterbirds. Thus, under this alternative, it is expected that some waterbirds would become ill or die from ingestion of water containing algal toxins during or following a summer bloom at some point in the future. The extent of this potential impact to water birds over time is unknown; however, large populations make loss of viability of these species improbable. Alternative 1 would also indirectly impact these species by perpetuating lake conditions that support a limited and declining future population of aquatic macroinvertebrates (see Fish section).

Alternatives 2 and 3 would have potential impacts to waterbirds and their habitat. Waterbirds would be expected to ingest rotenone treated water and consume rotenone killed prey species. However, as described in the "Toxicity of Rotenone to Wildlife" section of this document, they are not expected to be harmed. Waterfowl, shorebirds, and others that forage primarily on fish or aquatic insects and traditionally utilize Diamond Lake as a fall migration stop over would likely not have an adequate prey base in the late fall and early winter following a rotenone treatment. These birds would probably be displaced to habitat further south on their migration routes (Pers comm. Alice Parker). It is possible that some weaker individuals might not survive the extended migration. Similarly, in the spring/summer following treatment, the lake ecosystem would not have recovered sufficiently to support the water species that it traditionally supports. Again, some displacement to adjacent habitats would be expected. These habitat and displacement impacts are short-term impacts and would be expected to occur for two fall seasons and one to two spring/summer seasons.

When the lake recovers, Alternatives 2 and 3 would be expected to result in a beneficial indirect impact to waterbirds by facilitating the return of a more abundant and diverse aquatic macroinvertebrate prey base for insectivorous species, as well as a fish prey base for piscivorous birds (see Fish section).

For Alternatives 2 and 3, when considered in the context of past, present, and reasonable foreseeable activities in the project area, it is expected that potential impacts would have insignificant consequences to waterbird species because: potential negative impacts are limited to one or two breeding and migration seasons followed by a long-term improvement in habitat; availability of alternative habitat further along on the bird's migration routes would reduce the intensity of the impact; the majority of these species occur in very large numbers; and ongoing and reasonably foreseeable actions that would modify habitat within the project area are limited.

Alternative 4 would utilize commercial fish operations for approximately two months in June and July and one month in September on an annual basis to harvest tui chub from Diamond Lake. It is expected that some waterbirds could be harmed or killed by becoming entangled in gill nets during commercial fishing operations (Pers. comm. Dave Loomis). Because these species generally occur in very large numbers across their range it is considered unlikely that this potential impact would occur frequently enough to represent a significant impact to the species. Commercial fishing would also reduce the available prey base for piscivorous species during the breeding season. These activities would disrupt foraging during the breeding season, but are not expected to hinder reproductive success because commercial fishing areas would be staggered, allowing undisturbed access to the majority of the lake at a given point in time and adequate prey base would likely remain in Diamond Lake throughout the lifetime of the project. This is considered to be an insignificant effect to these species. When considered in the context of past, present, and reasonable foreseeable activities in the project area, potential impacts associated with this alternative are expected to have insignificant consequences to the species because: impacts are limited in scale and intensity; these species generally occur in very large numbers across their range, and ongoing and reasonably foreseeable actions that would modify habitat within the project area are limited.

Conclusions:
Alternative 1 represents the greatest sustained risk to waterbirds at Diamond Lake over time through exposure to algal toxins. Alternatives 2 and 3 have greater potential short-term adverse impacts than Alternative 4 and higher potential for long-term habitat improvement through improved water quality and prey base than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that Alternatives 1, 2, 3, and 4 may temporarily impact waterbirds, but would not have consequential impacts to any species.

Reptiles and Amphibians (Herps)

AFFECTED ENVIRONMENT

No surveys are required for amphibians or reptiles that are not included on the Regional Forester Sensitive Species list or Survey and Manage list. However, systematic surveys of habitat in Diamond Lake and Lake Creek were completed in 1996 and 1997.

Professional herpetologist, Marc Hayes assembled historical data and conducted surveys of the aquatic amphibian and reptile fauna of Diamond Lake in 1996 (Hayes 1997). The following seven species were documented: western toad; pacific chorus frog; Cascades frog; northwestern salamader; long-toed salamander; rough-skinned newt and common garter snake. Surveys of Lake Creek conducted by Hayes in 1997 documented the same species with the following exceptions: long-toed salamaders were not detected and an additional species the northwestern garter snakes was documented (Hayes 1998).

The majority of these species are common on this Forest and in Oregon and are not included on ODFW or Oregon Natural Heritage Program (ONHP) species of concern lists. The Cascade frog is coded as "Sensitive-Vulnerable" by ODFW; and "not rare, apparently secure throughout range" and "rare, threatened or uncommon in Oregon" by ONHP. The western toad is coded "Sensitive-Vulnerable" by ODFW and "not rare, apparently secure throughout range and in Oregon" by ONHP.

Hayes (1997, 1998) notes that both Diamond Lake and Lake Creek are currently poor quality habitat for amphibians for a variety of reasons including: predatory fish, high pH, low prey availability, lack of protected still water habitats, etc. The author notes that most amphibian recruitment occurs off Diamond Lake proper and concludes that collectively, the data indicate that Diamond Lake is a sink[153] for amphibians.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:
Alternative 1 perpetuates the existing condition, forgoes the opportunity to address declining water quality and leaves herps vulnerable to exposure to toxic algae blooms in the future. Under this alternative, it is possible that some herps would become ill or die through ingestion, absorption, or respiration of algal toxins during or following a summer bloom. The extent of this potential impact to herps over time is not known.

Alternatives 2 and 3 would have potential impacts to aquatic herps and their habitat. Both increased flows and dewatering of portions of Lake Creek associated with the draw down of Diamond Lake would impact herps on Lake Creek. Hayes (1998) documented that the overall numbers of herps recorded along the channel of Lake Creek were extremely low. He noted that a number of factors likely contribute to these low numbers including presence of predacious fish, lack of stillwater habitat, and low water quality. Hayes described that well over 99% of the amphibian and reptile observations made during surveys of Lake Creek were recorded at off-channel sites lacking a direct surface connection to Lake Creek, and that nearly all of the observations were made at two off-channel sites below Highway 138 - Long Marsh and Pit Lakes. Changes in flow on Lake Creek would have no measureable impact on Long Marsh and Pit Lakes (Pers. comm. Steve Hofford). Additionally, both the increased and decreased flows on Lake Creek would occur primarily in the late fall through winter season when effects to most amphibians would be reduced. Based on the above information, it is believed that a limited number of individuals would be impacted by these activities.

Hayes (1998) notes the possibility of negative impacts to amphibian habitat associated with the draw down, but does not reach definitive conclusions. Due to the low quality of existing habitat and low potential for the habitat to serve as other than "sink" habitat in the future, these habitat impacts are considered to be insignificant to the herptofauna of Lake Creek.

The draw down could also affect amphibians through potential impacts to Horse and Teal Lakes just south of Diamond Lake. Several factors such as snow melt and precipitation make those impacts difficult to predict with accuracy; however, it is considered likely that by the late spring or early summer, there may not be available open water to support amphibian reproduction in these lakes (see Groundwater sections for details). This potential impact may be the most serious impact to amphibians because these areas support the most amphibian reproduction in the near vicinity of Diamond Lake (Hayes 1997).

The proposed September rotenone treatment has the potential to result in direct mortality to some individual herps that utilize Diamond Lake (particularly gill-breathing life forms). Hayes (1997) notes that for the seven species documented during the 1996 surveys amphibian use of Diamond Lake appears to be limited for all species except the rough-skinned newt. In

[153] Habitat where death and individuals leaving the population is greater than birth and individuals moving into the population.

particular, the western toad, Cascades frog, and long-toed salamanders showed no evidence of reproduction in Diamond Lake in 1996 (Hayes 1997).

Hayes (1997) documents that "Mortality from rotenone treatment would probably be restricted to individuals that remain in the draw down application pool from the already low late-summer numbers likely to be present around the lake. Based on life histories of amphibians present, except for the northwestern salamander and rough-skinned newt, numbers of individuals subject to mortality are likely to be few to nil (pg. 1)." No direct mortality from rotenone treatment would be expected in Lake Creek because treated water would be confined to Diamond Lake. Rotenone treatment would also temporarily eliminate the aquatic insect prey base in the lake. Although little or no mortality would be expected for garter snakes (reptiles), they would be indirectly impacted through a loss of amphibian prey base.

Because rotenone treatment would result in the loss of some amphibians in Diamond Lake and because Horse and Teal Lakes, the areas considered most likely to support recolonization of the lake following treatment (Hayes 1997) would be impacted under these alternatives, post project monitoring for amphibians would occur for Diamond, Horse, and Teal Lakes. If amphibian populations and species diversity do not recover naturally active transplanting of amphibians back into these lakes would occur (see mitigation in Chapter 2).

When considered in the context of past, present, and reasonable foreseeable activities in the project area, it is determined that Alternatives 2 and 3 may impact individuals or habitat, but are not likely to contribute to a trend toward federal listing or loss of viability of any species. This conclusion is based on the following rationale: although numbers are likely lower the Diamond Lake vicinity still retains the entire aquatic amphibian and reptile fauna it had historically and that would be anticipated at this elevation (Hayes 1997); low levels of direct mortality are expected for most species; most species are either common on the landscape or potential impacts to the species are minimal (i.e. western toad and Cascade frog); negative impacts to aquatic prey base are short-term and potential improvement of prey base in the long-term is expected; and sources of individuals for passive and active recolonization exist in the immediate vicinity (Pitt Lakes and Long Marsh).

Alternative 4 would have minor potential impacts to aquatic herps. Individuals could be harmed or killed during commercial fishing operations in the lake. Dragging nets or seines through aquatic vegetation could damage egg masses and further limit reproduction in the lake. When considered in the context of past, present, and reasonable foreseeable activities in the project area it is determined that Alternative 4 may impact individuals or habitat, but is not likely to contribute to a trend toward federal listing or loss of viability of any species. This conclusion is based on the following rationale: although numbers are likely lower, the Diamond Lake vicinity still retains the entire aquatic amphibian and reptile fauna it had historically and would be anticipated at this elevation (Hayes 1997); low levels of direct mortality are expected for most species; and most species are either common on the landscape or potential impacts to the species are insignificant.

Conclusions:
Alternatives 1, 2 and 3 have a higher potential to adversely affect herps than Alterantive 4. Alternative 1 represents a sustained risk to the species and predicted losses of some number of individuals through exposure to algal toxins. Alternatives 2 and 3 represent a short-term impact to the species and known losses of some number of individuals through rotenone treatment mortality.

Alternatives 2 and 3 have higher potential for long-term habitat improvement through improved water quality and prey base than Alternatives 1 or 4. However, these differences may not be meaningful to this species groups because proposed fish stocking under all alternatives lowers the habitat effectiveness of Diamond Lake for amphibians.

Following consideration of the direct, indirect and cumulative effects of the proposed activities, it is determined that:

> Alternatives 2 and 3, as mitigated, may temporarily impact amphibians, but would not have long-term consequential impacts to any species.
>
> Alternatives 1 and 4 may temporarily impact amphibians, but would not have long-term consequential impacts to any species.

Bats

AFFECTED ENVIRONMENT

Diamond Lake and the surrounding terrestrial environments are potential habitat for a variety of bats. ODFW biologist Terry Farrell compiled a list of ten bat species that are known or suspected to occur in the Diamond Lake area (Pers. comm., Terry Farrell). This species list was validated by two other bat biologists (Pers. comms., Dr. John Hayes, Pat Ormsbee). All of these bats are insectivorous and opportunistic, although some species seem to be more selective of moths, beetles, or flies. These species all tend to capture their prey while in flight and most are thought to be associated with forest openings and/or water (Verts and Carraway 1998).

A list of the ten species, along with abundance and a brief habitat and prey description, follows are described in Table 37 below (the fringed myotis bat was addressed earlier in this document).

Table 37. Potential bat species at Diamond Lake and their habits and habitats.

Species	Habitat and Prey Description
Little Brown Bat	Common and widespread. Inhabits forests generally near water. Diet consists mostly of true flies, especially chironomids, with termites and caddisflies also being consumed.
Yuma Myotis	Uncommon to rare. This species is strongly associated with habitats near water. Typical forage consists mostly of true flies with lower numbers of termites and moths consumed as well.
Long-eared Myotis	Uncommon in western Oregon. Conifer forest associated. This species forages by picking their prey from the surfaces of various types of substrate (bark, leaves, rocks, the ground, etc.). Prey for this "hovering gleaner" includes mostly moths and beetles, with lower numbers of spiders, true flies, and other insects.
Fringed Myotis	Probably uncommon in Oregon. Associated with caves/mines in forests. Their diet consists mostly of moths and spiders, with some beetles and true flies also preyed upon.
Long-legged Myotis	Common in Oregon. Strongly associated with mature conifer forests. Feeds almost exclusively on moths, although is known to consume spiders, termites, and other insects.
California Myotis	Common in western Oregon. Old growth associated, often near water, they use bark for roosting. Prey includes mostly true flies (Diptera), with lower percentages of moths, caddisflies, spiders, and termites.
Silver-haired Bat	Abundance poorly known, likely uncommon. Strongly associated with mature forests. This species' diet consists mostly of moths, termites, and true flies, however they utilize a number arthropod taxa in smaller percentages.
Big Brown Bat	Common and widespread. Associated with coniferous and deciduous forests. This species consumes mostly beetles and moths, although also will opportunistically forage on true flies, termites, and a variety of other insects.
Hoary Bat	Uncommon in western Oregon. Strongly associated with coniferous or mixed stands. Prey consists almost exclusively of moths although they are known to eat true flies and other insects.
Townsend's Bat	Uncommon. Associated with caves and mines in forested areas. This bat feeds selectively on moths with very little variation in prey type.

Little is known about the migratory habits of most of these bats species. Silver-haired and hoary bats in Oregon are known to migrate in the fall to southern California and Mexico. The remaining species likely migrate in the fall at least to lower elevations (Pers. comm. Dr. John Hayes) and all generally hibernate in winter. However, individuals of some species may awaken and feed periodically during periods of warm winter weather at low elevations.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:

Alternative 1 would indirectly impact these species by perpetuating lake conditions that support a limited and declining future population of aquatic insects (see Fisheries section for details). It is also possible that bats would be harmed or killed by ingesting algal toxins during or following a bloom.

Alternatives 2 and 3 have potential impacts on both individuals and habitat of these species. These alternatives would dewater portions of Lake Creek for approximately 2 months in the late fall (mid September – mid November) and low water conditions would persist for several months, reducing available aquatic prey in the dewatered/low water areas. These alternatives also propose a rotenone treatment that would eliminate most aquatic insects from Diamond Lake in about mid September. Although all of these bats are probably starting to move to lower elevations by mid September, species presence is assumed. Additionally, although many bat species prey heavily on terrestrial insects (moths, beetles, etc.), all will forage on aquatic insects to some extent and thus would be potentially impacted to a greater or lesser degree by a loss of aquatic prey base.

Potential direct, indirect and cumulative impacts to the other nine bat species described above would be essentially the same as those described for the fringed myotis bat earlier in this section. Species such as the Yuma myotis and the little brown bat that are more reliant on aquatic insects as a primary forage item are likely to incur greater impacts than species such as the long-legged myotis or the Townsend's bat that feed almost exclusively on moths. However, for all of the above species, impacts to the aquatic prey base are expected to have insignificant consequences to their populations because: bats are opportunistic, generalist feeders and are not likely dependent on a single source or location for food; there is available foraging habitat adjacent to the project area if bats were temporarily displaced as a result of the lack of aquatic prey; and many bats have likely already moved down to lower elevations during this time of year (Pers. comm., Dr. John Hayes, Pat Ormsbee).

Indirect impacts to the abundance and diversity of the future aquatic prey base for these bats at Diamond Lake are uncertain under Alternative 4 due to the fact that only a portion of the tui chub population would be removed and tui chub are very effective predators on aquatic macroinvertebrates. However, it is assumed that some positive impacts to aquatic insects would be realized for an unknown period of time (see Fishsection).

Conclusions:

Alternative 1 represents the greatest sustained risk to these bats over time. Alternatives 2 and 3 have greater potential short-term adverse effects than Alternative 4 and higher potential for long-term habitat improvement through improved water quality and prey base than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3 with regard to impacts to these species.

Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that Alternatives 1, 2, 3, and 4 may temporarily impact bats, but would not have long-term consequential impacts to any species.

Other Mammals

AFFECTED ENVIRONMENT

The Diamond Lake area has a number of mammal species that are known to occur in the area, but do not receive special consideration for their management. Some of these species may be affected by the Diamond Lake Restoration Project and include the American beaver, common raccoon, American marten, ermine, long-tailed weasel, mink, and river otter. Most of these species are aquatic, semi-aquatic, or riparian associated. Table 38 compiled from wildlife sighting information and Verts and Carraway (1998) identifies some of their habitat and forage characteristics.

Table 38. Other mammals at Diamond Lake and their habits and habitats.

Species	Habits and Habitats
American beaver	Common and widespread. Associated with aquatic and riparian habitats. Forages on herbaceous and woody vegetation that grows near water.
Common raccoon	Common and widespread. Strongly associated with water and/or forested habitats. May also be associated closely with areas of human activity. A dietary generalist, raccoons eat almost anything organic.
American marten	Uncommon and restricted to higher elevations in Oregon. Martens are associated with contiguous forests that have high canopy closure. Forage consists mostly of mammals, although birds, insects, and fruit are known to be consumed seasonally.
Ermine	Uncommon and widespread. Ermine are associated with early successional habitats as well as forests. Preys upon small mammals that are typically no larger than mouse-sized and occasionally on birds and earthworms.
Long-tailed weasel	Uncommon and widespread. Long-tailed weasels occupy a wide variety of habitats ranging from mature forests to alpine tundra. Diet consists mostly of small mammals up to rabbit sized, although they are considered opportunists that will eat most vertebrate species encountered.
Mink	Uncommon and widespread. Mink are strongly associated with water and wetlands. Prey consists mostly of fish, mammals, and crayfish, although birds and reptiles are eaten as well.
River otter	Uncommon and widespread. River otters are aquatic obligates and are strongly associated with water habitats. Their prey consists mostly of fish, although they are known to consume crustaceans, amphibians, birds, and mollusks as well.

ENVIRONMENTAL EFFECTS

Direct, Indirect, and Cumulative Impacts:

Alternative 1 perpetuates the existing condition and forgoes the opportunity to address declining water quality in Diamond Lake. For species such as beaver, raccoon, mink and river otter that spend a significant portion of their lives in water or prey primarily on aquatic species, it is possible that some individuals would become ill or die from exposure to algal toxins during or following a summer bloom. It is also possible that any of the mammals could drink from the lake and be exposed to toxins. The extent of these potential impacts over time is unknown. There are no anticipated impacts to other mammals that are not aquatic associates.

Alternatives 2 and 3 have potential impacts to individuals and habitats of some of these species. Beaver, raccoon, mink, and river otter spend a significant portion of their lives in water or prey primarily on aquatic species. These species have the greatest potential to be affected by proposed activities. All of the above species would be expected to ingest rotenone treated water and consume rotenone killed prey species. However, as described in the "Toxicity of Rotenone to Wildlife" section of this document, they are not expected to be harmed. Rotenone treatment would eliminate aquatic prey species for river otter, raccoons, and mink in Diamond Lake proper for one to two summers. It is expected that individuals of these species would be temporarily displaced to adjacent habitats within the project area (i.e. Silent and Lake Creeks and tributaries). Alternatives 2 and 3 would be expected to result in a future beneficial indirect impact to these species by facilitating the return of a more abundant and diverse aquatic macroinvertebrate prey base as well as a fish prey base.

Minor impacts to beavers would be expected as a result of the draw down. During the winter of the draw down, receding water levels would create an increased distance between the lodges, the beaver's winter food stash, and the lake water. It is doubtful that these habitat modifications would harm the beavers, but it likely represents an additional energetic expense for individuals.

The dewatering and low flow periods on Lake Creek associated with the proposed draw down represent a temporary modification of habitat and prey base for all of the seven species identified above. Although individuals could be affected, consequences to these species are considered to be minor due to the limited scale of the action and the availability of adjacent habitat within the project area.

For Alternatives 2 and 3, when considered in the context of past, present, and reasonable foreseeable activities in the project area (Tables 9-11), it is expected that potential impacts would have insignificant consequences to these mammal species because: potential negative impacts are short-term followed by a long-term improvement in habitat; availability of alternative habitat within and adjacent to the project area would reduce the intensity of the impact; and the number of individuals potentially impacted is expected to be limited.

Alternative 4 would utilize commercial fish operations for approximately two months in June and July and one month in September on an annual basis to harvest tui chub from Diamond Lake. It is expected that occassionally beaver, river otter, and possibly mink could be harmed or killed by becoming entangled in gill nets during commercial fishing operations (Pers. comm., Dave Loomis). It is considered unlikely that this potential impact would occur frequently enough to represent a significant impact to these species. Commercial fishing would also reduce the available prey base for piscivorous[154] species. Because commercial fishing areas would be staggered allowing undisturbed access to the majority of the lake at a given point in time and adequate prey base would likely remain in Diamond Lake throughout

[154] Piscivorous means "fish-eating".

the lifetime of the project. This is considered to be an insignificant effect to these species. When considered in the context of past, present, and reasonable foreseeable activities in the project area, potential impacts associated with this alternative are expected to have insignificant consequences to these species because impacts are limited in scale and intensity and the number of individuals potentially impacted is expected to be limited.

Conclusions:
Alternative 1 represents the greatest sustained risk to some of these mammal species over time through exposure to toxic algae blooms. Alternatives 2 and 3 have greater potential short-term adverse effects than Alternative 4 and higher potential for long-term habitat improvement for some species through improved water quality and prey base than Alternatives 1 or 4. There are no meaningful or measureable differences between Alternatives 2 and 3. Following consideration of the direct, indirect and cumulative impacts of the proposed activities, it is determined that Alternatives 1, 2, 3, and 4 may temporarily impact some of these mammals, but would not have long-term consequential impacts to any species.

SUMMARY TABLE

Effects/Impacts determinations are documented in Table 39 for Threatened, Endangered and Sensitive Wildlife Species.

Table 39. Determination of effects to Threatened, Endangered, and Sensitive Wildlife Species.

	SPECIES	DETERMINATION OF EFFECT BY ALTERNATIVE*			
		1	2	3	4
BIRDS	Northern Spotted Owl	NE	LAA	LAA	LAA
	Bald Eagle	LAA	LAA	LAA	NLAA
	Peregrine Falcon	NI	NI	NI	NI
	Harlequin Duck	MIIH	MIIH	MIIH	MIIH
	Bufflehead	MIIH	MIIH	MIIH	MIIH
	Yellow Rail	NI	MIIH	MIIH	NI
AMPHIBIANS	Oregon Spotted Frog	MIIH	MIIH	MIIH	NI
	Foothill Yellow-legged Frog	NI	NI	NI	NI
	Southern Torrent Salamander	NI	NI	NI	NI
REPTILES	Western Pond Turtle	NI	NI	NI	NI
	Common Kingsnake	NI	NI	NI	NI

	SPECIES	DETERMINATION OF EFFECT BY ALTERNATIVE*			
		1	2	3	4
MAMMALS	Canada Lynx	NE	NE	NE	NE
	California Wolverine	MIIH	MIIH	MIIH	MIIH
	Pacific Fisher	MIIH	MIIH	MIIH	MIIH
	Pacific Fringed Bat	MIIH	MIIH	MIIH	MIIH
	Pacific Pallid Bat	NI	NI	NI	NI
	Pacific Shrew	NI	MIIH	MIIH	NI

***** *Threatened and endangered species determination calls follow nomenclature established by the US Fish and Wildlife Service (**NE**= No Effect, **NLAA**= Not Likely to Adversely Affect, **LAA**= Likely to Adversely Affect). Sensitive species determinations follow nomenclature established in the Forest Service Handbook (**NI**= no Impact, **MIIH**= May Impact Individuals or Habitat but will not Likely Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species, **WIFV** = Will Impact Individuals or Habitat with a Consequence that the Action May Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species).*

SOCIAL ENVIRONMENT

HUMAN HEALTH RISK

Scoping identified a concern that the proposed rotenone treatment would present risks to human health and safety through exposure to rotenone. The potential effects to human health associated with the use of rotenone are tracked in this section. Additionally, because Alternative 1 proposes no active management at Diamond Lake, it is assumed that toxic algae blooms would continue to present human health risks. Therefore, the effects of toxic algae blooms on human health are also documented in this section.

TOXICITY OF ALGAE BLOOMS TO HUMANS

The blue-green algal blooms in Diamond Lake during the summers of 2001, 2002, and 2003 have presented risks to human health. Blue-green algae, also known as cyanobacteria, are single-celled aquatic plants found in surface waters worldwide that produce toxins. Such toxins have been implicated in human health problems ranging from skin irritation and gastrointestinal upset, to death from liver or respiratory failure (Chorus and Bartram 1999; Chorus 2001)

The two main species of toxin-producing blue-green algae associated with the blooms in Diamond Lake are *Anabaena flos-aquae* and *Microcystis aeruginosa*, with *Anabaena* more prominent (Eilers and Kann 2002). *Anabaena* is most frequently associated with the powerful neurotoxin, anatoxin-a; however, it can also produce the liver toxin, microcystins. *Microcystis aeruginosa* also produces microcystins, the liver toxin. (Yoo et al. 1995). These species, like all blue-green algae, have compounds in their cell walls that are responsible for the adverse skin, eye, mucosal, and digestive reactions reported by people who have come in contact with them (Chorus 2001).

Anatoxin-a[155]

Anatoxin-a affects the nervous system, often leading to convulsions and death by suffocation (Carmichael 1994). Animals exposed to anatoxin-a through drinking *Anabaena*-contaminated water, grooming scum from their coats or feathers, or in laboratory tests, die of the poison within minutes or hours. Cattle, pet dogs, waterfowl and others have met their deaths in this way (Backer 2002).

In 2002 the first human presumed to die from *Anabaena* toxin in the United States occurred near Madison, Wisconsin, when a teenage boy died 48 hours after diving and swimming in a scum-coated pond. Several others who went into the pond at the same time also developed gastrointestinal symptoms, but only one, who had also gone completely underwater, became acutely ill with diarrhea. However, because of the length of time between exposure and death, some uncertainty remains as the whether algal toxins were the direct cause of death (Milwaukee Journal Sentinel, 2002).

Insufficient data exists to establish reliable safety thresholds for human exposure to anatoxin-a. Human studies are lacking and although there is experimental laboratory data generated from mice, it is considered inadequate for the formulation of human Tolerable Daily Intake Standards, whether for toddlers or adults (Chorus and Bartram 1999). However, Dr. Wayne Carmichael of Wright State University suggested that 100 micrograms per liter of water would present a lethal risk to pets (Table 40) drinking from shoreline areas where blooms tend to be concentrated. In 2001, anatoxin-a concentrations were detected as high as 300 ug/L (micrograms per liter of water) in Diamond Lake.

Uncertainty exists as to accumulation of anatoxin-a in fish tissue; fishermen may be at risk in eating their catches (Falconer 1993). Finally, although it does not appear to be the case that recurrent low exposure to anatoxin-a leads to health problems later on, this is not established, and there is concern that people repeatedly exposed may become sensitized and develop increasingly more severe reactions with each new exposure (Backer 2002).

Microcystins[156]

Microcystins were first isolated from *Microcystis aeruginosa*, but are also produced by other species, including *Anabaena*. These powerful liver toxins disrupt the structure of liver cells, causing cell destruction, liver hemorrhage, liver necrosis, and death (Carmichael 1994).

Microcystins in the water supply of a renal (kidney) dialysis clinic in Brazil resulted in the illness of 110 of 113 patients, including the deaths of 55 patients from liver hemorrhage and

[155] Anatoxin-a is an alkaloid that acts as a post-synaptic depolarizing neuromuscular blocking agent, causing nerve impulses to over-stimulate muscle cells, particularly those involved in breathing.

[156] Microcystins were first isolated from *Microcystis aeruginosa* but are also produced by other species, including Anabaena. These hepatotoxins (liver toxins) are powerful cyclical peptides which disrupt the structure of liver cells.

liver failure (Backer 2002). Microcystin delivered by the nasal route to experimental rodents also resulted in erosion of the nasal mucosa to the point of hemorrhage. In addition to liver toxicity, long-term laboratory animal studies indicate that microcystins promote tumors and birth defects (Falconer et al. 1988). Anecdotal evidence for such chronic effects on humans is based in large part on the high rates of liver cancer in the rural regions of China where drinking water was obtained from ditches and ponds with large blue-green algae loads. Where drinking water supplies have been changed to deep wells, cancer rates have begun to drop.

Microcystin poisoning has been implicated in the largest number of blue-green algae-associated animal deaths worldwide, and enough work has been done, both with rodents and pigs on microcystin effects at various levels of exposure, that the World Health Organization (WHO) has issued a provisional guideline of 1 microgram per liter of water (ug/L) for microcystin concentration in drinking water. Microcystin concentrations found during three summers sampling and testing the waters of Diamond Lake have been less than 1 ug/L except one sample in 2003, which was 2.54 ug/L, exceeding the preliminary WHO guideline.

The exposure risks associated with microcystin toxins are exacerbated over that of Anatoxin-a, because the toxins continue to release into the water, remaining even after the *Microcystis* bloom has visually dissipated (Lam et al. 1995). Thus, microcystin has the potential of exerting continued risk to human health when it may not be obvious.

Table 40. Summary of the toxicity information available on algae toxins.

	Anatoxin-a	Microcystin
Proposed Safe Concentrations	Not established—100 ug/l would likely kill a dog drinking from the lake (Carmichael),	1 ug/kg/day (Proposed by World Health Organization)
Levels observed in D. Lake	Up to 300 ug/L	Up to 2.54 ug/L
Non-acute effects	unknown	Probably carcinogenic

TOXICITY OF ROTENONE TO HUMANS

Rotenone products have been classified by the US Environmental Protection Agency (USEPA) as Category 1 materials which are in the "extremely toxic" range for acute (short-term) toxicity. Laboratory mammals are used to assess the levels of toxicity. The Extension Toxicology Network[157] affiliated with several prominent Universities across the United States summarized the following information from the scientific literature on rotenone toxicity in mammals (ExToxNet, 1996). In acute oral exposure studies, where large doses are fed to test animals over a short time, rotenone was found to be slightly to moderately toxic to mammals.

[157] ExToxNet is a pesticide Information project of cooperative Offices of Cornell University, Oregon State University, the University of Idaho, University of California at Davis, and the Institute for Environmental Toxicology at Michigan State University.

Reported oral LD50 values range from 132 to 1500 mg/kg of body weight in rats. The LD50 is the amount of ingested material that would be lethal to the average laboratory mammal. When 50 percent of the animals in the experiment die, the average lethal dose (LD) is established. Ingested rotenone is believed to be moderately toxic to humans with an oral lethal dose estimated to be between 300 to 500 mg/kg of body weight. Human fatalities are rare perhaps because rotenone is not widely used and because its irritating action causes prompt vomiting (ExToxNet, 1996). Both the liquid and powered formulations of rotenone in their undiluted states are reported to be potentially fatal to humans if inhaled or ingested. Ingestion or inhalation can cause numbness, nausea, vomiting, and tremors.

The rotenone formulations are moderately to highly toxic when inhaled and are therefore considered more toxic when inhaled than when ingested. In rats and dogs exposed to rotenone dust, the inhalation fatal dose was uniformly smaller than the oral fatal dose. Fifty percent of female rats died when exposed to a concentration of 0.045 mg/liter of air over a 4 hour period (Prentiss Incorporated, 2000b). A spray of 5% rotenone in water was fatal to a 100-pound pig when exposed to 250 mL of the airborne mixture (ExToxNet, 1996).

In chronic toxicity studies, where non-lethal doses are fed to laboratory animals over extended periods of time, rotenone has been found to have low levels of toxicity when ingested. Dogs fed rotenone for 6 months at doses up to 10 mg/kg/day showed reduced food consumption and therefore weight loss. At the highest doses, blood chemistry was adversely affected possibly due to gastrointestinal lesions and chronic bleeding (ExToxNet, 1996).

Rotenone formulations proposed for use in Alternatives 2 and 3 are reported to be slightly toxic to non-irritating to the skin from dermal exposure. Dermal exposure to rotenone can cause skin and eye irritation. The lethal dose to rabbits from skin absorption of the powdered formulation was greater than 2,020 mg/kg (Prentiss Incorporated, 2000a).

Other toxic effects of rotenone have also been characterized by studies with lab animals and summarized by ExToxNet (1996) and USEPA Integrated Risk Information System (IRIS) (2003). Reproductive toxicity was established in a two generation rat reproduction study conducted by the USEPA in 1983 (IRIS, 2003). Rats fed at 1.88 mg/kg/day (equal to 37.5 ppm) exhibited the lowest effect level for reproductive toxicity while rats fed 0.38 mg/kg/day (equal to 7.5 ppm) exhibited the no-observed effects level. Whether rotenone is teratogenic (causes birth defects) is not known since a feeding study of pregnant rats showed skeletal deformations in rat pups at low doses, but no deformities at higher doses. Rotenone was found not to be mutagenic (cause changes in the genetic material of cells) in treated mice and rats based on several studies at the cellular level. Most rodent studies have revealed no evidence of carcinogenic activity and the prevailing scientific opinion is that rotenone is not carcinogenic (USEPA, 1981 and 1989). USEPA last conducted a comprehensive review of rotenone in 1988 and re-registration is tentatively scheduled for 2006.

A recent study (Betarbet et al, 2000) reported that rats injected with rotenone at 2 to 3 mg/kg body weight each day in the jugular vein for 5 weeks showed symptoms similar to that of Parkinson's disease. Other chemicals were administered with the rotenone to enhance tissue penetration. None of the other studies that used realistic exposure pathways (oral, inhalation or dermal) of rotenone have reported such findings. Betarbet et al (2000) demonstrated that rotenone is an inhibitor of one of the five enzyme complexes in cells of test mammals. Neurological research continues to explore the link between Parkinson's disease and pesticide exposures (such as rotenone and others). Although the exact cause of Parkinson's disease is unknown, recent epidemiological studies suggest an association with single gene mutations, toxic exposures, or some combination of the two factors (Greenamyre et al, 2003). The USEPA has reviewed this study and is determining the appropriate course of action. The results of this review will help determine what next steps the USEPA will take towards the completion of the next rotenone review (USEPA 2003).

Inert Ingredients, Metabolites, and other Chemicals used with Rotenone

Chemical manufacturers often add other ingredients to their formulations, called inert ingredients, to enhance effectiveness. The powered formulation, Pro Noxfish® that would be applied to Diamond Lake has no added inert ingredients; it is composed simply of the ground up plant material. The liquid Noxfish® that would be applied to Short and Silent Creeks, contains inert emulsifiers, solvents, and carriers that are important in ensuring the solubility and dispersion of this liquid formulation. Water treated with Noxfish® was found to contain rotenolone (the metabolite of rotenone), and volatile organic compounds (trichloroethylene, xylene, toluene, and trimethylbenzene) and semi-volatile organic compounds (naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene). These volatile and semi-volatile organic compounds naturally breakdown and dissipate in treated water before rotenone and rotenolone (Finlayson et al. 2000).

Five California rotenone projects were monitored for the fate of the compounds of powdered and liquid formulations including inerts in sediments (Finlayson et al, 2001). Only the naphthalene and methyl naphthalene (associated with Noxfish®) temporarily accumulated in sediments, but this was for a period of less than 8 weeks. The other inert compounds in Noxfish® did not persist in sediments.

Nine California rotenone projects were monitored for the inert ingredients in Noxfish® in surface water (Finlayson et al, 2001). All ingredients were well below the minimum concentrations allowed under maximum contaminant levels (MCLs) for these ingredients in drinking water standards set by the EPA (Finlayson, 2001). Of the seven organic compounds found in Noxfish, trichloroethylene (TCE) is the only carcinogen; the rest are considered noncarcinogens. However, there are inconsistencies in the scientific literature regarding whether naphthalene is carcinogenic. Naphthalene was reported in one source as causing carcinogenic activity in rat nose tissue in an inhalation study (US National Toxicology Program, 2001). The bulk of the toxicology literature however, supports that naphthalene is not carcinogenic.

Following application of Noxfish® at 1 mg/L, samples collected during application into flowing water did not detect TCE (<0.5 ug/L) or xylene (<0.5 ug/L) except for one sample collected immediately below a drip station at 0.76 ug/L TCE and 0.56 ug/L xylene. Naphthalene and 2-methylnapthalene were detected at concentrations ranges of <0.5 to 57 ug/L and <2 to 50 ug/L.

The USEPA has established drinking water standards for levels of rotenone and associated chemicals (Table 41).

Table 41. Human Health Standards, Risk-based Safe Levels, and Detection Limits for Rotenone and Other Associated Ingredients in Drinking Water.

Fish Toxicant Ingredients	Maximum Contaminant Level[1] (ug/L)	Maximum Contaminant Level Goal[1] (ug/L)	Preliminary Remediation Goal[2] (ug/L)	Analytical Detection Limit (ug/L)	Analytical Method
Rotenone	Not Available	Not Available	150	50	SDWA EPA Method 553 (HPLC)
Naphthalene	Not Available	Not Available	6.2	0.5	SWDA EPA Method 524.5
Toluene	1,000	1,000	720	0.5	SWDA EPA Method 524.5
Trichloroethy-lene	5	Zero	0.028	0.006[3]	USEPA 8260 Mod SIM
Trimethylben-zene	Not Available	Not Available	Not Available	0.5	SWDA EPA Method 524.5
Xylene	10,000	10,000	210	0.1	USEPA 8260 Mod SIM

NOTES:
1. USEPA 2002b Based on safe drinking water standards.
2. USEPA 2002a Based on safe risk-based levels for residential tap water use
3. Value provided is the MDL instead of the reporting limit. The reporting limit for TCE is 0.05 ug/L using EPA Method 8260 Mod GCMS-SIM.

MCL – maximum contaminate level. The highest level of a chemical allowed in drinking water. It is an enforceable level under the Safe Drinking Water Act.
PRG - preliminary remedial goal. The level of a chemical in drinking water that is not expected to cause any adverse effects for a lifetime of exposure. Lifetime exposure is based on 30 years of exposure for a child and adult drinking 1 and 2 liters, respectively.
Analytical Detection Limit. The level at which a chemical can be accurately and precisely quantified by a certain method.
SWDA – Safe Drinking Water Act. Gives EPA the authority to set drinking water standards. Used in the context of analytical methods developed under the SWDA program for monitoring water quality.
RCRA - Resource Conservation and Recovery Act. Used in the context of analytical methods developed under the RCRA program for monitoring water quality.

The possible metabolites of rotenone are carbon dioxide and a more water soluble compound (rotenolone) that is excreted in the urine. Studies indicate that approximately 20 percent of applied oral doses are eliminated from the animals system within 24 hours.

Potassium permanganate is an oxidizer that would be used with this project to neutralize the rotenone formulations in the event of a spill. It has no deleterious effects at the concentrations normally associated with the neutralizing process (Finlayson et al, 2000). However, in its concentrated form, it is caustic to mucous membranes in the nose and throat. The required protective clothing and breathing apparatus when handling the concentrated powder would lessen human health risks.

AFFECTED ENVIRONMENT

TOXIC ALGAL BLOOMS

Extensive amounts of blue-green algae in Diamond Lake over the last few years produced toxins to the point of risking human health. The large population of tui chub in Diamond Lake has the potential to contribute to the hazardous algal blooms in two ways. First, tui chub can eat the larger-sized zooplankton reducing their populations to the point that they no longer effectively graze on the algal cells and thus no longer keep the algal population in check. Secondly, the tui chub population can increase the nutrient concentration in the lake through excretion of nitrogen and phosphorus in forms available for algal growth, essentially adding fertilizer for the plant population to expand. These ecological changes in conjunction with optimal climatic conditions of warm, sunny weather and calm, fertile water may have enhanced the blooms in Diamond Lake.

Alert level guidelines based on cell counts have been established for blue-green algae blooms in drinking and recreational waters (Yoo et al. 1995; Chorus and Bartram 1999). Alert Level 1 is 500 cells/ml and requires increased frequency of monitoring; Alert Level 2 is 2000 cells/ml and requires alerting the public and posting water bodies; Alert Level 3 is 15,000 cells/ml and warrants a recreational closure for water contact recreation. Alert Level 3 was shown in a study to result in skin and mucosal irritation and gastrointestinal symptoms. Diamond Lake has reached Alert Level 3 during the summer months of 2001-2003. Consequently, Diamond Lake was closed to swimming and all water contact from August 10 to August 30, 2001; July 23 to August 7, 2002; and from July 1 to August 12, 2003—a total of 46 days over three summers. Due to diligent monitoring and lake closures, no people are known to have suffered illness from exposure to blue-green algae toxins thus far at Diamond Lake.

The amount of toxin produced by the blue-green algae in Diamond Lake is highly variable, but it is generally related to their density or sheer amount in the water column (Chorus and Bartram 1999). Moreover, because these blue-green algae cells are buoyant and frequently concentrate at the surface, wind may concentrate cells along the shoreline or in bays, causing toxins to be at sufficiently high levels, and sufficiently accessible, to be dangerous to humans who come in contact with them (Chorus and Bartram 1999).

The blooms make the affected water disagreeable such that people tend to voluntarily limit their exposure. Although few people would be likely to actively drink from such a source, the possibility of recreational exposure through accidental immersion and ingestion or aspiration exists, especially if boating activities are going on. Even a scummy lake can look irresistible on a blazing afternoon, and if mats of bloom wash up onto the shoreline, there may be considerable risk to young children (Chorus 2001).

It is also difficult to know how much toxin is actually out there in Diamond Lake at any given time. Tests to determine toxin levels take time; the bloom may be in a period of exponential growth, with toxin levels changing fast, or be dying off, in which case breakdown of the cells may be releasing large amounts of toxin into water that looks free of problems. Wind and wave motion may concentrate the bloom and its toxins in one part of the lake, leaving other areas apparently free of problems.

Under current conditions of extremely high numbers of tui chub, toxic blue-green algae blooms (and subsequent lake closures) will likely continue annually, with the severity determined by the variability in climate during the summer. Under current high nutrient excretion rates by tui chub, the main determinant of yearly toxic bloom variability will depend on the occurrence of the calm, sunny, warm conditions that tend to favor blooms of blue-green algae (Kann 2003). However, under a given set of climatic conditions the likelihood of large algae blooms are predicted to be diminished (although periodic blooms can still be expected) as available nutrients decrease in the water column if tui chub were removed (Kann 2003).

Though surface waters are at continued risk of contamination, groundwater is not susceptible to contamination from toxic algae blooms. Chorus and Bartram (1999) assessed groundwater for the presence of algal cells and algal toxin. They found extreme low levels of both algae cells and algae toxins in ground water. These authors reported that from 93.7 to 99.7 percent of the algae cells and 97.5 to 99.5 percent of the toxins were filtered out of the surface water as it traveled through the sediments and rock substrate of the ground water environment.

ENVIRONMENTAL EFFECTS

TOXIC ALGAL BLOOMS

Direct Effects:

Direct effects to human health would be those that occur in the short-term, over a period of several years, and at the immediate site of Diamond Lake itself.

Under Alternative 1, the general visiting public would continue to be at risk of exposure to lake waters contaminated with blue-green algae toxins. Elevated concentrations of either anatoxin-a or microcystins, or both, can be expected to continue during warm, sunny weather as long as tui chub remain abundant in Diamond Lake. The likelihood of exposure would be lessened by annual water monitoring for the algae toxins that would be used to alert lake users and to trigger necessary lake closures.

However, as time goes on, the chances of public exposure by accident or by ignoring the warnings and closures would increase simply due to the long-term presence of the risk coupled with the popularity of Diamond Lake to the recreating public. Since the concentrations of toxins can be variable in the lake depending on location, depth, shoreline configurations, wind effects and rapid algal population shifts, the toxicity monitoring may not catch hot spots of concentrated toxins and timely lake closures may not always occur. In this event, swimmers or boaters could potentially receive a dose of the toxin(s) and become seriously ill. If such a dermally exposed person were to accidentally swallow concentrated toxins at the same time, there may be a potential of death, such as may have occurred in Wisconsin in 2002. However, the probability of mortality is still extremely low.

Agency employees or private contractors involved in the toxicity monitoring would also be at continued risk under Alternative 1. Since these administrative workers would be seeking out areas of concentrated toxins, the consequences of accidental submersion would be relatively high. Such an accident could result in the direct effect of serious illness or even death if some of the toxin is swallowed during the accident. These potential direct effects to the health of administrative personnel would be lessened by safety training and the implementation of pre-planned mitigation such as washing with clean water immediately following an incident.

Under Alternative 1, the domestic water from both the shallow and deep aquifer wells would not be at risk of contamination from algal toxins. This is because the toxins are expected to be filtered out of the water by the sediments and rock that exists in the ground water environment (Chorus and Bartram, 1999).

Under either Alternative 2 or 3, prior to the rotenone application when the lake would be drawn down by about 8 feet in elevation, toxic algae blooms could be significant if weather conditions were conducive to blooms. Moreover, wave action on exposed sediments along the dewatered shoreline coupled with boat-generated turbulence could release more phosphorous than would normally occur if the lake was full of water. Under the right weather conditions, the disturbed sediments associated with implementation of Alternatives 2 or 3 could lead to more algae growth and potentially more risk to the workers involved in implementing either of these alternatives. The potential of exacerbated algae growth, over and above that predicted under Alternative 1, is expected to be limited however because the phosphorus available for plant growth (i.e. dissolved in the water column) has a strong tendency to bind to sediment particles. Its residence time as dissolved phosphorus in the water column would depend on the amount of oxygen available in the lake water at the time. However, rapid uptake by sediment particles is expected (Johnson 2003) with only a limited possibility of enhanced algae population growth under Alternative 2 and 3.

Because scores of people would be involved in the implementation of either Alternatives 2 or 3, the potential of administrative or application worker exposure to algae toxins is higher than the risk to administrative personnel only charged with water monitoring under Alternative 1. This is simply because more people would be at risk of accidental exposure to algae toxins under Alternatives 2 and 3 compared to Alternative 1 over the short-term.

Alternative 4 is expected to result in direct short-term public health hazards associated with exposure to toxic algae similar to that disclosed under Alternative 1. This is because Alternative 4 is expected to take about six years to affect tui chub populations, the primary driver of the toxic algae blooms. During this time frame, the people who visit and live at Diamond Lake would be susceptible to all the exposure pathways to anatoxin-a and microcystins described under Alternative 1. Alternative 4 presents the most risk to the health of administrative personnel from blue-green algae toxins because of the intense labor involved in fish removal and the sheer number of workers that would have to venture out on the lake every September (when a risk exists of exposure to algae toxins) to run gill nets and conduct other mechanical fish removal activities.

Indirect Effects:

Indirect effects to human health are those that would occur downstream of Diamond Lake and effects that would occur in the future, over the long-term.

The consumption of water or dermal exposure of water downstream of Diamond Lake in Lake Creek could potentially put members of the public at risk of illness under all alternatives. This downstream, indirect effect is only possible during the same risk periods of high algal toxin concentrations experienced in Diamond Lake itself. The blue-green algae toxins in Lake Creek would only be those delivered from Diamond Lake. Since Lake Creek has turbulent flow that is not conducive to algae proliferation, no additional growth of algae or associated toxic releases are expected to originate in Lake Creek itself. The likelihood of anyone receiving a dose of blue-green algae toxins out of Lake Creek would be lessened by the heightened public awareness and lake closures that would be put into effect as necessary, under all alternatives. These potential downstream indirect effects would be sustained over long periods of time under Alternatives 1 and 4, but would be short-lived under Alternatives 2 and 3 since Alternatives 2 and 3 both rapidly reduce the tui chub population. However, an exact time period of the response of algal blooms to tui chub removal can not be determined.

The risk of any indirect effect from toxic algae to the health of Lake Creek users would progressively lessen in a downstream direction as tributary streams, with no connection to Diamond Lake, enter Lake Creek and dilute toxin concentrations. Likewise, the risks to human health from exposure to algae toxins in Lemolo Lake, located 12 miles downstream of Diamond Lake, is much less than that of Lake Creek. No indirect downstream effects to human health at Lemolo Lake are expected to occur under any of the alternatives. This large reservoir is fed by many tributary streams, including the North Umpqua River, that function to mix and dilute blue-green algae toxins below levels of concern (Hofford 2003). No testing for blue-green algae toxin has occurred in Lemolo Lake.

Under Alternative 1, the indirect effects to human health over long periods of time are expected to be similar to the direct effects to human health disclosed above; the potential of serious illness or even death from toxic algae would be present through the same exposure pathways. However, the chances of actually experiencing impacts to human heath associated with Alternative 1 increase with time simply due to the additive effects of summer after summer of potential public and administrative worker exposure. As time passes, assuming a fairly static population of tui chub, weather conditions could align to create toxic concentrations above those experienced to date. On the other hand, cooler more overcast summers would result is fewer blooms and lower toxic concentrations. The threat of realizing indirect effects to human health over the long-term, under Alternative 1, can be expected to gradually increase over the years if the regional weather warming patterns continue on the same trajectory as the last few decades.

No long-term impacts to human health from exposure to toxic algae booms are expected under either Alternative 2 or 3. Instead, Alternatives 2 and 3 are expected to result in indirect beneficial effects to human health hazard levels in the long-run relative to the existing condition. Predicting the effect of tui chub removal on the magnitude and annual trends of toxic algal blooms in Diamond Lake is difficult due to uncertainty in such factors as inter-annual climatic variability, restocking of the lake with rainbow trout, internal nutrient recycling from the sediments, and response of the zooplankton and benthic communities. Nonetheless, it is clear that based upon paleolimnological data that the lake began changing shortly after being stocked with trout, and that the greatest increases in *Anabaena* were associated with increased populations of tui chub (Eilers et al, 2001). Both Alternative 2 and 3 are therefore expected to result in a long-term lessening of risks to human health relative to Alternative 1.

Under Alternative 4, the indirect effects to human health over long periods of time are expected to be similar to the indirect effects to human health disclosed above for Alternative 1; the potential of serious illness or even death from toxic algae would be present through the same exposure pathways. However, under Alternative 4, the gradual long-term decline of tui chub can be expected to result in fewer toxic algae blooms, lessening public health risks proportionately. Table 42 summarizes the risks to the various groups of people if exposed to toxic algae in Diamond Lake.

Table 42. Summary of Exposure Risks to the Algal Toxins Associated with the Diamond Lake Restoration Project.

Alternative	Administrative or Application Workers	General visiting public and other residents
1	4 workers every summer at high risk of accidental exposure to algae toxins (during water sampling) over multiple summers for the foreseeable future.	Hundreds of water recreationists (swimmers, boaters, water skiers, sailboarders) could be exposed to algae toxins every summer if monitoring does not adequately detect toxin levels and lake closures are not timely.
2 & 3	25 workers at high risk of accidental exposure to algae toxins (during applications of rotenone from boats) and fish toxicants (while handling the concentrated formulations) during 1 summer.	No exposure anticipated.
4	15 workers/summer at high risk of accidental exposure to algae toxins during both water monitoring and fish removal work over multiple summers for the foreseeable future.	Hundreds of water recreationists (swimmers, boaters, water skiers, sailboarders) could be exposed to algae toxins every summer if monitoring does not adequately detect toxin levels and lake closures are not timely.

AFFECTED ENVIRONMENT

ROTENONE

There are only two possible pathways of public exposure to the rotenone formulations proposed under Alternatives 2 and 3 of this project--either eating contaminated fish or drinking contaminated water. The other possible exposure pathways, dermal exposure and inhalation exposure, would not be possible for members of the public. No dermal exposure associated with the public swimming or wading in the treated waters is expected because the rotenone would not be concentrated enough once it has been mixed in the lake to lead to any concerns regarding dermal exposure (Finlayson et al. 2000). Rotenone product labels state that swimming would be allowed once the product has been mixed into the water according to label instructions (Prentiss 2000). Moreover, no member of the public would have access to the concentrated formulations to receive a meaningful dermal dose. Similarly, no public exposure via inhalation of either rotenone formulation is expected since the work areas where such dose pathways are possible would be under tight security with no public entry allowed. Airborne drift into adjacent area was found to be 1000 times less toxic than the no observed effect level of the chemical (Finlayson et al. 2000).

It would be extremely unlikely that members of the public would have access to dead or dying fish in order to unwittingly consume any contaminated fish and receive a dose of the fish toxicant. This is because Diamond Lake would be closed to public entry during the treatment period; public awareness of the closure would be heightened well in advance of the treatment; and because warning signs would be posted throughout the area. Since the fish in Diamond Lake are expected to be rapidly killed by the treatment within a 2 to 3 week period, there would be no lingering danger of anglers ignoring the warnings and potentially angling and consuming fish. The large number of carcasses would be further disincentive for human consumption. No fish would be restocked into Diamond Lake until well after all residues are gone.

The primary pathway for members of the public to be exposed to rotenone is by drinking well water. This pathway presents more risk than the consumption of tainted fish because the water would essentially look and smell normal a few days following the application. The water in the lake itself presents the greatest risk to potential water drinkers, while waters downstream of the lake present little to no risk of public exposure. The risk of consuming contaminated water would be prevented by supplying drinking water to well users if rotenone or other added ingredients are detected in any of the monitoring wells. Based on the groundwater transport and modeling assessment, the Forest Service monitoring wells are adequate to intercept any rotenone or other added ingredients far in advance of transfer to a domestic well.

The consumption of contaminated surface water out of Diamond Lake by visiting members of the public is unlikely given the closure to public entry, the heightened public awareness, and the warning signs that would be in place throughout the area. These mitigation measures would remain in force until all risk of exposure is eliminated.

The potential for contamination of the groundwater is lessened somewhat however, due to the strong tendency of rotenone to attach to soil particles and organic sediment such as that found in the lake bottom. The lake sediments are expected to rapidly capture and hold the chemical, essentially "filtering" it out of the water column as the water from the lake enters the groundwater environment.

The primary concern for public consumption of tainted drinking water is associated with the domestic water users of the Diamond Lake area—primarily the users of shallow wells that service the summer homes on the west shore of the lake (Figure 4). A study conducted by the Forest Service of the potential for groundwater contamination was done for this project (Breeden, 2003). A total of 16 monitoring wells were installed to investigate groundwater movements around the lake. The study showed that the shallow aquifer on the north and northwest shores of Diamond Lake, which supplies most of the domestic wells in that area, can be expected to receive groundwater originating from the Lake during the fall and winter months. If treated water from the lake does in fact enter the shallow aquifer that supplies the west shore domestic users, then health risk could potentially exist for as long as 8 weeks or until the toxicant fully breaks down.

There are 102 summer homes located on west shore of Diamond Lake and all but about 20 are serviced by wells tapped into the shallow aquifer that is susceptible to contamination from treated lake water. Those summer home wells not at risk are the deeper wells, typically greater than 60 to 100 feet deep that tap into the deep aquifer. The Forest Service Thielsen View campground, also located on the west shore of Diamond Lake (with 60 camp sites), is also serviced by a well located in the shallow aquifer where contamination from the lake is possible. The Oregon Department of Fish and Wildlife maintains a small work facility at the Lake Creek outlet. The drinking water for this facility comes from Lake Creek which will be dry during the period of concern, so no exposure from the drinking water at this location is possible.

The draw down of the lake would result in no surface water flowing out of the lake at its only natural outflow, Lake Creek, or at the constructed drainage canal plumbed into Lake Creek. The draw down would occur during the winter months prior to the proposed September treatment. By September of the year of treatment, during the lowest flows of the year, the lake level is expected to be about 8 feet in elevation below the Lake Creek outlet. The chance of a fall rainstorm large enough to rewater the lake causing contaminated water to flow out of the Lake is extremely low. More than 20-inches of rain would need to fall to rewater the lake to the point of spilling over into Lake Creek during the two month period between around September 15 to November 15. Based on historic weather data, the average rain fall for this time period was 7.5-inches and the probability of receiving as much as 20 inches is extremely low. However, a mitigation measure is incorporated into both Alternatives 2 and 3 (Chapter 2) that would reconstruct the outflow structure of Diamond Lake in Lake Creek to an elevation that would contain any unexpectedly large amount of rainfall during this two month period.

Both Alternatives 2 and 3 include a mitigation measure requiring the closure of these two outlets with headgate structures until tests indicated that rotenone, rotenolone[158], and all semi-volatile and volatile organic compounds[159] associated with the chemical treatment had dissipated to non-detectable or trace levels in both the water column and lake bottom sediments (approximately one to two months). The rotenone and its byproducts including the inert ingredients found in the liquid formulation, would be fully broken down prior to any downstream delivery of surface waters and associated sediments. Therefore, no downstream public exposure associated with surface water consumption is expected in Lake Creek or Lemolo reservoir, 12 miles downstream of Diamond Lake.

The Forest Service also investigated the potential of contaminated groundwater to discharge into Lake Creek. In September 2003, the Forest Service conducted a groundwater seepage study along a six mile length of Lake Creek. The results of this study showed that Lake Creek received no appreciable increase in flow due to groundwater discharge into the creek. No contamination of Lake Creek and its downstream areas, including Lemolo reservoir from the groundwater aquifer is expected. Groundwater discharge at a location further downstream of the six mile study area was not examined. However, the longer travel time to any potential discharge locations further downstream, the tendency for rotenone to bind with soil particles at the bottom of the lake, and the tendency for the rotenone to breakdown over time, all make the potential of groundwater contamination of downstream water bodies such as lower Lake Creek and Lemolo reservoir very remote.

The required mitigation measure under both Alternatives 2 and 3, of monitoring the waters of Diamond Lake and Lake Creek following the rotenone treatment will confirm whether or not any downstream waters contain any trace of the toxicant. If any residues are detected, the

[158] Rotenolone is the metabolite (by product) of rotenone (Finlayson et al. 2000).
[159] The liquid rotenone formulation Noxfish® contains inert emulsifiers, solvents, and carriers that are important in ensuring the solubility and dispersion of rotenone in water. Waters treated with Noxfish® may contain rotenone, rotenolone, and volatile (xylene, trichloroethylene, toluene, and trimethylbenzene) and semi-volatile (naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene) organic compounds. These volatile and semi-volatile organic compounds dissipate in treated water before rotenone and rotenolone (Finlayson et al. 2000).

exposure to members of the public through drinking water from wells around the reservoir would be minimized by public notification, warning signs, supplied bottled water, and/or potential closures that would be put into effect. In the very remote case that the water supplies from Lake Creek and/or Lemolo are threatened, actions to minimize exposure would be taken.

The most likely individuals to be exposed to rotenone formulations proposed for this project are the application workers who will be involved in removing the concentrated formulations from their original containers, diluting, and mixing the formulations, filling application containers, and applying the rotenone out of boats in the lake and at drip stations in Silent and Short Creeks. At each step, the risk of accidental exposure is present. The primary exposure pathway would be via inhalation of the powdered formulation, Pro-Noxfish®, when rotenone become airborne once removed from its container and handled. The primary exposure pathway for the liquid Noxfish® would be inhalation or dermal exposure during handling. The same exposure pathways would be possible during any unanticipated spills. Mitigation measures in place under Alternatives 2 and 3 to substantially limit the risk to application workers include:

- A 24 hours/day security effort where the rotenone is stored.
- Enough potassium permanganate (rotenone neutralizer) would be on-hand to neutralize the largest container of rotenone stored on site.
- Certified pesticide applicators would be responsible for all phases of rotenone application.
- The protective equipment listed on the labels of both rotenone formulations will be used by all personnel who handle these products. This includes disposable coveralls, gloves, eye protection, nitrile gloves, and air purifying respirators. Air purifying respirators provide a 10 to 50 fold protection factor. Extra replacements will be available at all times during the implementation phase.
- All of the following detailed plans would be completed according to recommendations and examples provided in the "Rotenone Use in Fisheries Management: Administrative and Technical Guidelines Manual" (Finlayson et al. 2000) prior to project implementation: rotenone application plan, site safety plan, site security plan, and a spill contingency plan.

ENVIRONMENTAL EFFECTS

Direct Effects:

Direct effects to human health are those that occur in the short-term, over a period of several years, and at the immediate site of Diamond Lake itself.

For the general visiting public, no exposure to the fish toxicant is expected, therefore no direct effect to the health of the visiting public is expected under either Alternatives 2 or 3. For members of the public who live at Diamond Lake there is a risk of exposure with the possible consumption of contaminated water from the wells on the west side of the lake. Concentrations of rotenone in drinking water are not predicted to be measurable or significant. This is because of the very dilute levels of rotenone that would exist in the lake (up to 0.10 ppm or mg/L). The worst-case concentration of rotenone to occur in the lake immediately after application is 0.10 mg/L which is below the USEPA PRG[160] safe level of 0.15 mg/L Table 41). The safe level is protective of children and adults drinking 1 and 2 liters of water per day, respectively, for 350 days per year for 30 years. Risks from inert ingredients are difficult to predict, but are likely very low given the large dilution.

Dermal contact of contaminants potentially in the groundwater while bathing or showering is not predicted to be a significant exposure pathway. Concentrations of rotenone in the lake are projected to be around 0.1 milligram of rotenone per liter of treated lake water (mg/L) which is below the safe level for tap water use established by the EPA (0.15 mg/L) (Table 41). For the chemicals of concern, dermal contact risk would be considered insignificant until well water concentrations exceeded tap water PRGs.

Moreover, since rotenone breaks down rapidly in sunlight, and since it is strongly bound to lake sediments, the concentrations that may actually show up in well water is expected to be substantially lower than the concentration in the lake itself. If summer home owners were to drink the dilute concentration over the course of several days, illness is possible but not likely.

To further lessen any risks to human health, bottled drinking water would be supplied to the users of all potentially impacted wells if rotenone or any of the associated added ingredients are detected in the monitoring wells on the lake's west shore. Supplied drinking water will only be ceased once it is determined that no detectable levels of rotenone or Noxfish® additives are below detectable levels. If monitoring wells or domestic wells sampling detects any of these chemicals above the USEPA Tap Water PRG, users will be advised of their risks and discontinuance of well use may be enforced. Through temporary closure of Diamond Lake to the visiting public and temporary discontinuance of well use where appropriate, oral exposures would be significantly minimized or eliminated.

Application workers are most at risk of receiving a dose and becoming sick from this project. If spills on the skin or splashes into eyes, or accidental inhalation occurs and such exposures are not washed off as required or if the victim is not moved to an area of fresh air as required, then application workers could become temporarily ill. In an extreme case of high exposure, death could occur. These potential direct effects to human health are expected to be minimized and/or avoided all together by following the prudent industrial handling practices required by law and as mitigation measures of this project. Risk to application workers is minimized through ensuring adequate safety measures are taken to minimize exposure. By completing the rotenone application plan, site safety plan, site security plan, and a spill contingency plan, risk to site personnel including ODFW Staff and certified application workers would be substantially reduced to safe levels or eliminated.

[160] PRG - preliminary remedial goal. The level of a chemical in drinking water that is not expected to cause any adverse effects for a lifetime of exposure. Lifetime exposure is based on 30 years of exposure for a child and adult drinking 1 and 2 liters, respectively.

Neither Alternatives 1 nor 4 would result in any direct effects to the public or administrative personnel from rotenone or its additives because the fish toxicant would not be applied under either of these alternatives.

Indirect Effects:

The indirect effects associated with Alternatives 2 and 3 involve effects to human health downstream of Diamond Lake and effects to human health over long periods of time.

The water in Diamond Lake is rich in nutrients (nitrogen and phosphorus) largely due to an overabundance of fish. Nutrient rich waters can lead to downstream public health concerns when such waters are consumed. Both Alternatives 2 and 3 would send nutrient rich waters to downstream areas during the winter draw down period. However, these draw down waters would be delivered during the cooler, wetter winter months of the year when proliferation of plant growth (typically associated with a nutrient flux) is less likely and when the dilution of the lake water would be maximized. Due to the timing of the draw down, no indirect effects to human health associated with downstream water consumption are expected.

Following the draw down and rotenone treatment, the lake is expected to have increased nutrient loads from the decomposition of dead fish and nutrient rich suspended sediments generated by wave action and the other connected activities that would occur when the lake level is 8 feet in elevation lower than normal. Moreover, because zooplankton populations would be killed by rotenone, a short-term increase in phytoplankton abundance is expected along with the water quality problems associated with algae proliferation. Once the lake begins to finally spill into Lake Creek, these short-term interactions may function together to decrease water quality downstream in Lake Creek and Lemolo reservoir. Alternatives 2 and 3 could result in a short-term indirect effect to the health of potential downstream users of Lake Creek with an increased risk of water borne pathogens and associated illness. This short-term potential indirect effect is not expected to be a risk within or downstream of Lemolo reservoir because by the time the nutrient-rich waters reach the reservoir, there would be substantial dilution from small tributaries and from the North Umpqua River that mixes with Lake Creek in Lemolo Lake.

With eliminated or substantially reduced populations of tui chub, Diamond Lake would have lower levels of nutrients, thus lower downstream eutrophication in Lake Creek and Lemolo Reservoir. Alternatives 2 and 3 have the greatest potential to result in indirect long-term beneficial effects to downstream water quality and the health of the people who may potentially drink from these downstream waters.

Neither Alternatives 1 nor 4 would result in any indirect effects to the public or administrative personnel from rotenone or its additives, because the fish toxicant would not be applied under either of these alternatives.

Cumulative Effects from Both Forms of Toxins:

Under Alternative 1, the potential exists for cumulative effects to human health over years of chronic exposure to algal toxins. Uncertainty exists as to accumulation of anatoxin-a in fish tissue, so that fishermen may be at risk in eating their catches (Falconer 1993). Although it does not appear to be the case that recurrent low exposure to anatoxin-a leads to health problems later on, this is not established, and there is concern that people so exposed may become sensitized and develop increasingly more severe reactions with each new exposure (Backer 2002).

Anecdotal evidence for chronic effects of microcystins on humans is based in large part on the high rates of primary liver cancer in the rural regions of China where drinking water was obtained from ditches and ponds with large cyanobacteria loads. Where drinking water supplies have been changed from surface sources to deep wells, cancer rates have begun to drop (although other contributing factors are also being addressed). Other studies have shown microcystins to promote liver tumor development in lab animals. Yet, there is much uncertainty regarding the potential cumulative effects to human health under Alternative 1.

Under Alternatives 2 and 3, the possibility exists that workers exposed to both rotenone and algae toxins, while implementing either of these alternatives, could become ill or more sensitized to the toxic effects of either of these toxins as a result of exposure to both. This potential cumulative effect would apply to the workers who would be implementing these alternatives and the risk would be over the course of about a month. No studies have been done to confirm this possibility. Over the longer-term, within a few years of implementation, both Alternatives 2 and 3 are predicted to result in a beneficial effect to human health, lessening the possibility of chronic cumulative effects of toxic algae blooms compared to Alternative 1.

The potential cumulative effects to human health under Alternative 4 are similar to that of Alternative 1. Given the uncertainty of the long-term effectiveness of Alternative 4 at reducing the chub population and the fact that this alternative puts more workers at risk of exposure to algae toxins, the chances of cumulative effects to human health may actually be higher than Alternative 1. This is especially true if the same workers were repeatedly exposed year after year to the algal toxins.

Cumulative effects are also assessed by evaluating the potential effects of past, present, and reasonably foreseeable actions added to the effects of the various alternatives. In the vicinity of Diamond Lake, other pesticides have been used in the project area in the past. Table 9 shows that the herbicides Cimizine, 2,4-D and Trichlopyr were sprayed along the road shoulders of Highway 138 to clear vegetation between 1980 and 1983. The herbicide picloram was used in the project area when it was spot applied to individual plants or groups of spotted knapweed at several locations using a backpack sprayer along Highway 138 near Diamond Lake and near the south entrance to Diamond Lake. From the mid 1960's to 1982 the pesticide Malathion was applied multiple times each summer to kill mosquitoes at the south shore marsh and various other areas around the lakeshore. Of the above pesticides, only the use of picloram to spray scattered groups of spotted knapweed is reasonably foreseeable in the future in the immediate vicinity of Diamond Lake. The small amount of picloram used in 2003 and expected to be used over the next few years in the vicinity of the project has little chance of entering surface or ground water given the extremely small amounts needed to spray the scattered plant populations and the time of year that spray has been and would continue to be applied (dry summer months, Umpqua National Forest Noxious Weed

Environmental Assessment). Moreover, the other pesticides used in previous decades (1960-1980's) have essentially no chance of resulting in any additive cumulative effect to human health over and above any exposure to either rotenone or algae toxins because the previously used pesticides would have disappeared by now.

A multitude of past, present, and reasonably foreseeable projects and activities use various forms of petroleum products that can be harmful to human health. These past and on-going activities and projects include activities such as timber sales, forest fuels reduction projects, forest thinning, hazard tree removal, campground maintenance and improvement, highway construction and reconstructions, paving projects, facility construction and reconstruction, and marina operations and boating (Tables 9, 10 and 11). Any of these that have taken place or are on-going, or that will occur during the implementation of either alternatives 2 or 3, within the watershed of Diamond Lake, could potentially deliver petroleum-type toxicants to surface water and groundwater of the lake. This possibility is heightened if substantial spills were to occur in association with any of the projects. However, mitigation measures built into each of these projects reduces the risk of petroleum spills occurring.

Some of the inert ingredients of the liquid rotenone formulation (trichloroethylene, naphthalene, and xylene) are also present in the fuel of motor boats, and as a result are commonly found in lakes where motorized activities occur. Prior to breakdown of these inert ingredients in Noxfish®, there is a potential of an additive effect from these compounds from both the Noxfish® and the boat use (during the application and mixing of the powered rotenone that does not contain any inert ingredients). Added together, from both sources, these inert ingredients could potentially reach higher concentrations than if no boats were used in the Lake. However, Finlayson (2000) reported that concentrations of these compounds in water immediately following treatments using Noxfish were low and presented no health risks. Since the Noxfish® would only be applied to two fish bearing streams that feed into Diamond Lake and since most of the rotenone used under Alternative 2 and 3 would be the powdered formulation lacking any other ingredients, the likelihood of additive effects is very low. If it did occur it would last a short time over a few weeks, because trichloroethylene, naphthalene, and xylene all break down within about three weeks time (Table 15, in the Lake Ecology Section of this DEIS). Those most at risk of an additive effect would be the application workers involved in implementing either Alternative 2 or 3.

Given long-term exposure to various forms of toxicants in the environment, it is conceivable that human health could be incrementally compromised by long-term exposure to these products in the waters of Diamond Lake. This could potentially result in cumulative effects to human health when added to the effects from toxins potentially received as a result of any of the alternatives associated with this project. However, there is no scientific literature to support this hypothesis.

OVERVIEW AND COMPARISON OF TOXICITY RISKS

The blue-green algae toxins presently found in Diamond Lake and the formulations of rotenone proposed for use in Diamond Lake are both potentially very dangerous to people in terms of acute toxicity. The Environmental Protection Agency has established preliminary remedial goals (PRGs) for rotenone and most of the inert ingredients found in the liquid formulation of rotenone (Table 41) where consumption is not expected to cause any adverse effects for a lifetime of exposure. The USEPA has not established safe levels in water for either of the blue-green algae toxins. There have been fewer investigations into the human health risks of the blue-green algae toxins compared to that for rotenone. In terms of acute toxicity where large doses are received, both rotenone and the blue-green algae toxins can cause serious illness or be deadly to people (Table 43). In terms of chronic, long-term exposure to low levels of these toxins, rotenone has been found to be relatively benign, while not enough data exists for any good conclusions on the long-term effects of exposure to low levels of either anatoxin-a or microcystin.

Table 43. Comparison of Alternatives for Potential Worst-Case Human Health Impacts

Alternatives Toxin type	Alternative 1 algae toxins		Alternatives 2 and 3 algae toxins and rotenone		Alternative 4 algae toxins	
Group	**Adminis-trative workers**	**General public**	**Administrative workers & summer home residents**	**General public**	**Administrative workers**	**General public**
Level and duration of possible exposure	Workers — Exposure to high concentra tions of algae toxins for many years.	Exposure to low concen-trations of algae toxins, every summer for many years.	Workers — exposure to high concentrations of algae toxin and rotenone for 1 month. Residents — exposure to low concentrations rotenone for 1 month if wells are contaminated and bottled water not used.	No exposure to either toxin due to draw down and strict controls	Workers — exposure to high concentrations of algae toxins for at least 6 years.	Exposure to low concen-trations of algae toxins, every summer for at least 6 years
Potential con-sequences if exposed	Workers — serious illness or death	Mild to serious illness; latent long-term effects unknown.	Workers — serious illness or death Residents — potential illness	None	Workers — serious illness or death Residents — potential illness; latent long-term effects unknown	Mild to serious illness, latent long-term effects unknown

RECREATION

Scoping brought out several concerns related to recreation including: potential impacts to visual quality, swimming, fishing, boating, and camping and access to the lake and surrounding recreation sites during project implementation. This issue is tracked in this section.

For the purpose of the recreation analysis and disclosure, it was necessary to assume a timeframe for implementation. Therefore, several tables in this section display information based on the years 2004 through 2009. However, implementation of any of the alternatives, except no action, is dependant on timely completion of the NEPA and appeals process as well as funding to pay for the implementation. Thus, 2004 would be the earliest possible year to begin implementation, if an action alternative is selected.

AFFECTED ENVIRONMENT

Diamond Lake is a high use destination recreation area and has traditionally been recognized as a regionally renowned trout fishery with an average of over 100,000 angler trips annually, during its peak (Figure 44). Diamond Lake is located at an elevation of 5,191 feet, is over 3,000 acres in size, and is approximately 3.5 miles long by 1.5 miles wide. Forest Service Road 4795 surrounds the lake and is the main access route to the recreation facilities. The area is easily accessible via Oregon State Highways 138, 230 and 97. Diamond Lake is 82 to 92 miles from the equidistant population centers of Bend, Klamath Falls, Medford and Roseburg.

Figure 44. Fishing boats at Diamond Lake.

Diamond Lake is identified in the Umpqua National Forest Land and Resource Management Plan (1990) as a special management area (MA 2). This management area is to be administered for concentrated developed recreation under Prescription A4-1[161]. In order to meet the recreational demand, the Diamond Lake Recreation Area contains extensive Forest Service and private developments under special-use permits. The classification of the

[161] Prescription A4-1 refers to Concentrated Developed Recreation. "It applies to groups or clusters of developed recreation sites, (public and private at …Diamond Lake) and the undeveloped land areas between them. Good access is provided to the areas via paved roads. The area is associated with high recreational-use water bodies. Recreational management will favor activities such as resort use, camping, picnicking, visitor information services, boating, fishing, interpretation, and developed and dispersed winter sports. Concentrated Developed Recreation emphasizes management of developed recreation sites as a complementary group" (UNF-LRMP, page 152, 1990).

Diamond Lake Recreation Area is generally "rural" by the Recreation Opportunity Spectrum[162] (ROS) and the associated visual quality objective for the area is "retention" with the exception that facilities can be modified to meet ROS goals. Visual retention means that management activities are not evident to the casual forest visitor. The Diamond Lake area provides a wide variety of year-round recreational opportunities including: fishing, swimming, boating, camping, hiking, scenery viewing, birding, mountain biking, horseback riding, hunting, cross-country skiing, snowmobiling and other snow play.

The earliest recreation use at Diamond Lake coincided with the stocking of the lake with fish in 1910. There were some US Forest Service camps in the area before 1920 and in 1922, a US Forest Service special use permit was issued to the Diamond Lake Improvement Company to construct a resort at the north end of the lake. This involved a few tents, a store and a lodge. Around the same time, special use permits were issued for Recreation Cabins along the west shore. Primary access to the Lake was via the south from Medford and Klamath Falls. The US Forest Service estimated 1,500 people visited Diamond Lake in 1921. Over the next thirty years, improvements were made to public campground facilities, the Diamond Lake Resort, and additional cabins were built in the summer home tract on the west shore. By the 1960's, development was at a level similar to what exists today. In 1964, paving of State Highway 138 significantly improved access from the Roseburg and Bend population areas. The historic use patterns continue today and in spite of recent water quality and fishery declines, the length of stay at Diamond Lake (average of eight days) is considerably longer than the national average for a recreation trip (4.9 days) and longer than an average Oregon recreation trip (6.1 days). This is because Diamond Lake is typically used as a destination camping location.

In addition to the summer homes, the Diamond Lake Resort, and the private RV Park, there are currently Forest Service facilities that provide a capacity of 3,274 persons at one time. The Forest Service facilities include three developed campgrounds, group reservation areas and day use sites. There are 36 flush-type restroom buildings, three shower buildings, two dump stations, 417 campsites, three fish cleaning stations, five boat ramps, one pavilion, one amphitheater, 9.5 miles of sewer line, 100 waste water sumps, 12 miles of water line, 140 water hydrants, four oxidation lagoons (20 acres), and two deep-water wells.

2001 RECREATION SURVEY DATA

In 2001, a survey of recreation user characteristics covering behaviors and attitudes was conducted on the Umpqua National Forest (Burns et al. 2002). Questions addressed reasons for visiting Diamond Lake, primary activities, satisfaction levels and future intentions to revisit. Another survey was also conducted in the Diamond Lake area using face-to-face interviews with visitors at recreation areas with a total of 649 interviews.

The following are highlights of the survey results (Burns et al. 2002):

[162] Recreation Opportunity Spectrum: A framework in which to categorize the range of recreation experiences that can be provided on Forest land. The classes range from primitive, or Wilderness, recreation to urban park settings. Recreation opportunities are determined on national forest land by "(a) physical criteria such as remoteness and existing disturbances to the natural character of the land, (b) the kind and number of recreation users, and (c) current and planned management, law and policy" (Spjut and Marsh, page 1, 1981)

- Regarding trip characteristics, there was a tendency to have repeat visitors; 74% of Diamond Lake visitors came 1 to 10 times in a typical year and over half of the respondents stayed at the lake 3-5 days. Two-thirds of the visitors said the lake was their primary destination and of the remaining third, 43% of those reported that Crater Lake was their primary destination. The vast majority of visitors (93%) were in groups of family and friends.

- Generally, there was participation at Diamond Lake in many different activities. Most likely participation was in relaxing/hanging out (46%), viewing natural features (40%), camping (37%) and hiking/walking (36%). About one-fifth used resorts, cabins or other accommodations on National Forest lands and one-third (33%) reported participating in fishing. Other popular activities included picnicking (29%) and bicycling (26%) (Burns et al. 2002).

- When asked about primary activity undertaken, while at Diamond Lake, the top three were: (1) camping in developed sites (23%), general relaxing/hanging out (21%) and fishing (18%).

- Most survey questions solicited a visitor response on a scale of 1 (awful) to 5 (excellent). Customer satisfaction of the recreation setting at Diamond Lake rated a 4.6 followed by responsiveness of staff at 4.2. Health and cleanliness rated lower at 3.8 and it was noted "This may be related to the lake health issues encountered in the summer 2001 recreation season" (Burns et al. 2002). The customer satisfaction indicator at Diamond Lake on fishing received a particularly low score (2.6) although health and safety related indicators (drinking water, clean toilets, etc) rated higher from 3.7 to 4.1. The rating value for "the lake/river and its surrounding area in good condition" was lower at 3.7 and there was general agreement of 4.2 that "fishing at Diamond Lake is not what it used to be."

- The most important reasons for visiting Diamond Lake were to be outdoors for relaxation and to get away from the regular routine (4.6). Respondents indicated that "This place means a lot to me" (4.2); they were very likely to recommend the area to others (4.3); and showed a strong intention to revisit (4.5). Overall, there was a high level of satisfaction among Diamond Lake visitors about their trip with 86% of visitors rating their experience 8 or higher on a 10-point satisfaction scale.

2003 RECREATION SURVEY DATA

In 2003, Burns et al. conducted additional visitor-surveys at Diamond Lake during ongoing water quality fluctuations over the course of the summer recreation season. A total of 475 surveys were completed covering the time periods (a) prior to the lake closure, (b) during the closure (due to toxic algae blooms), and (c) after the lake reopened to swimming and boating. The results of this survey showed some differences from the 2001 survey and clarified preferences that people identified related to the issues driving this DEIS (i.e. water quality and the recreational fishery). The following are preliminary results of the surveys:

Diamond Lake visitors are loyal, often repeat visitors whose primary destination is Diamond Lake. Primary recreation activities of general recreating/hanging out and viewing natural features doubled from 2001 to 2003 (from 28% to 46% and 40% to 82% respectively). A decline in the number of visitors pursuing fishing as a primary activity went from 18% in 2001 to just 8% in 2003.

Some of the primary findings in this preliminary analysis are: among visitors who were polled, there is a greater concern for water quality than for the quality of recreational fisheries at Diamond Lake; current visitors are not likely to stop visiting Diamond Lake due to water quality or recreational fisheries issues; however, if water quality improves, many are likely to visit more often in the future; and Diamond Lake visitors indicated that they visit the lake to pursue a relaxing experience rather than to achieve a physical gain. It is also worth noting that many of the recreationists who historically fished Diamond Lake have stopped visiting, and thus, may not have been represented in the survey. Also, over one-quarter of responses were neutral for the water quality and fishing improvement questions.

First-time visitors increased at Diamond Lake from 9% in 2001 to 33% in 2003. There was a decline in repeat visitors in the same period from 91% to 67%. An average of eight days was spent at Diamond Lake by visitors in 2003 and the majority of respondents (87%) stayed overnight.

SENSE OF PLACE

A "Sense of Place" (SOP) analysis was completed for the Diamond Lake Restoration project. This analysis is based on the concept that there is connectedness between recreation activities, settings, experiences, and benefits. When one or more of these elements change, it can have a direct effect on a person's perception of sense of place and their enjoyment of the area. The SOP analysis provides recreation managers with a broader landscape context that enhances understanding of current recreation use and future visitor needs. The detailed SOP analysis for this project is included in the Recreation report and is incorporated by reference into this document.

Six of the ten areas (SOP units, Figure 45) that may be affected by implementation of project alternatives are: water sports, family camp, Diamond Lake resort, summer home, undeveloped riparian, and Lake Creek units (Table 44). Each unit is also classified within the Recreation Opportunity Spectrum according to the type of setting it provides and the Visual Quality Objectives (VQO's) for the viewshed of each SOP unit.

Table 44. Summary information for six SOP units in the Diamond Lake Restoration Project Area.

SOP Unit	Summary Description	ROS Classification	Visual Quality Objectives

SOP Unit	Summary Description	ROS Classification	Visual Quality Objectives
Water Sports	A 3,031 acre water magnet, in an intact mountain setting that supports outdoor recreation use for passive and active water-based pursuits in a remote, but social environment which contributes substantially to the local economy.	Rural Rural (existing developed recreation)	Foreground Retention
Family Camp	High-capacity, highly developed day-use, camping and boating facilities on a mountain lake in a High Cascade forest, anchored by volcanic peaks, that supports multi-generational families and groups during summer and fall seasons.	Rural Rural (existing developed recreation) Rural (potential developed site)	Foreground Retention Foreground Partial Retention
Diamond Lake Resort	A year-round, high mountain destination with a full service, lakeside resort serving "Joe and Jane" citizen and multi-generational families. Located close to many outdoor recreation opportunities. Diamond Lake Resort also has options for extensive social experiences, including major events and festivals.	Rural	Foreground Retention
Summer Homes	Multi-generational, single-family recreation residences, under special-use permit for seasonal use along the shoreline of Diamond Lake. Area includes 102 summer residences.	Rural Rural (existing developed recreation)	Foreground Retention
Undeveloped Riparian	A lush, vegetated area with standing or sub-grade water levels that support wildlife habitat areas attractive to dispersed recreationists such as birdwatchers and photographers.	Rural Rural (existing developed recreation) Rural (potential developed site)	Foreground Retention Foreground Partial Retention
Lake Creek	This meandering, linear, riparian feature contains the Lake Creek waterway and provides dispersed recreation opportunities, fish and wildlife habitat, as well as downstream water supplies.	Roaded natural (sensitivity level 1) Roaded natural (sensitivity level 2) Rural Rural (potential developed site)	Foreground Retention Foreground Partial Retention Modification

Visual Quality Objectives[163]

Retention - Management activities are not visually evident.

Partial Retention - Management activities remain visually subordinate to the characteristic landscape.

Modification - Management activities may visually dominate the original characteristic landscape.

Maximum Modification - Management activates of vegetative and landform alterations may dominate the characteristic landscape.

Distance Zones

Foreground - The limit of the zone is based upon the distances at which details can be perceived. Normally, in foreground views the individual boughs of trees form texture. It will usually be limited to areas within ¼ to ½ mile of the observer, but is determined on a case-by-case basis.

Middleground - This zone extends from the foreground zone to 3 to 5 miles from the observer. Texture normally is characterized by the masses of trees in the stands of uniform tree cover. Individual tree forms are usually only discernable in very open or sparse stands.

Background - This zone extends from the middle ground to infinity. Texture in stands of uniform tree cover is generally very weak or non-existent. In very open or sparse timber stands, texture is seen as groups or patterns of trees.

Sensitivity Levels

Highest sensitivity - sensitivity level 1 includes all seen areas from primary travel routes, use areas and water bodies where, as a minimum, at least one-fourth of the Forest visitors have a major concern for scenic qualities.

Average sensitivity - sensitivity level 2 includes all seen areas from primary travel routes, use areas, and water bodies where less than one-fourth of the Forest visitors have a major concern for scenic qualities.

Lowest sensitivity - sensitivity level 3 includes all seen areas from secondary travel routes, use areas, and water bodies where less than one-fourth of the Forest visitors have a major concern for scenic qualities.

Recreation Opportunity Spectrum (ROS)[164]

Roaded Natural – Area characterized by predominantly natural-appearing environments with moderate evidence of the sights and sounds of people. Such evidences usually harmonize with the natural environment.

Rural – Area characterized by substantially modified natural environment, with sights and sounds of humans readily evident and interaction between users often moderate to high.

[163] Umpqua National Forest Land and Resource Management Plan (1990).

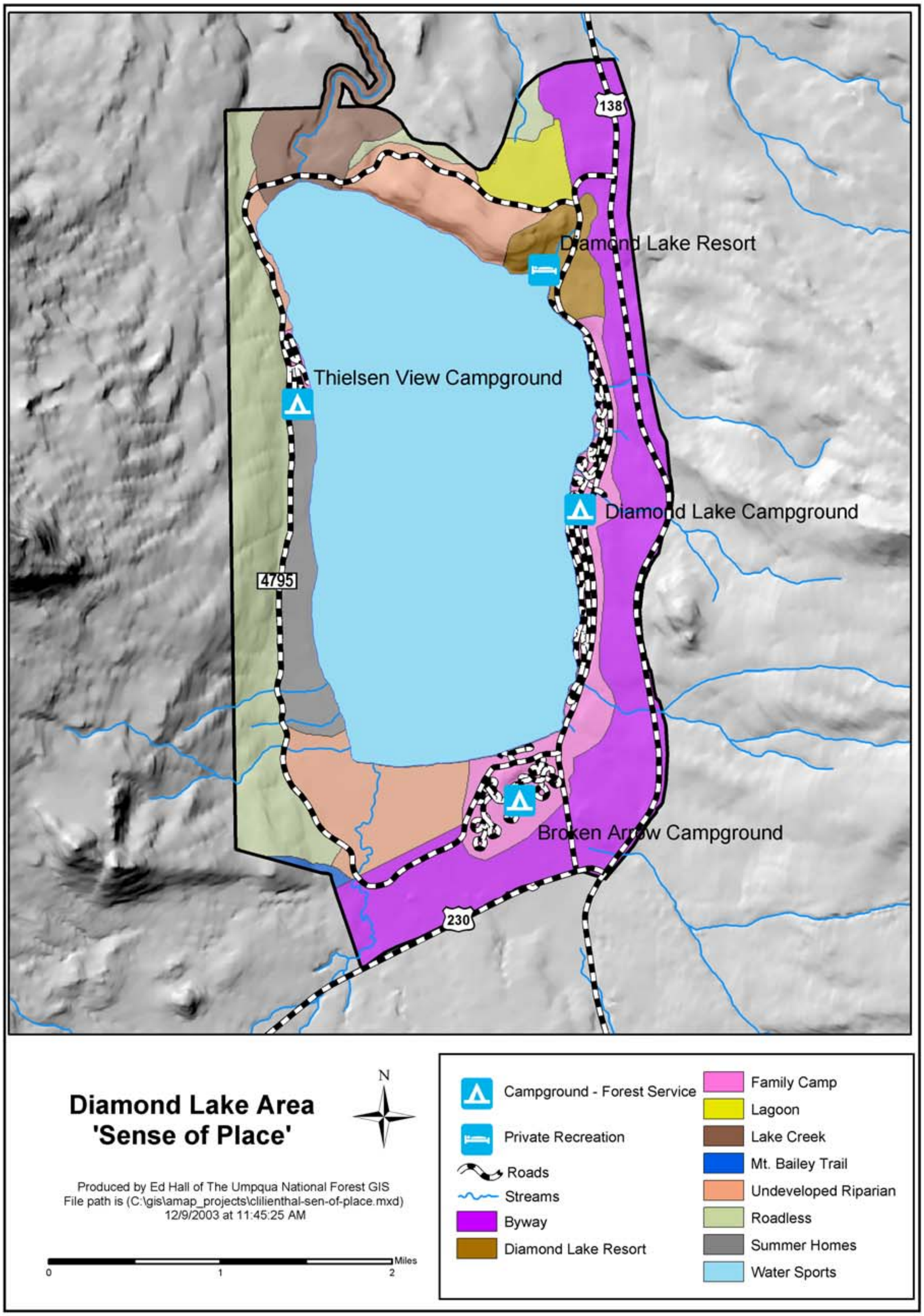

Figure 45. Sense of Place Units within the Diamond Lake Restoration Project Area.

There are three Sense of Place units where developed recreation facilities are located and the maximum capacity for use is determined. These are in the Diamond Lake Resort, family camp, and summer home units (Figure 45). Capacity data for boats, the Diamond Lake Resort, and the public camping facilities are included in the Recreation Report in the appendix of this DEIS.

RECREATION VISITATION

Documented use figures over the years are available for the three campgrounds at Diamond Lake located in the family camp SOP unit (Table 45). All three campgrounds had a downward trend in use after 1992. Depending on the site, there was a 37% to 60% decline in visitor use from the high visitation year of 1992. The main factors influencing the decline in visitation appear to be the reduced fishing opportunities and the declining water quality in Diamond Lake. According to a Forest Service visitor use survey conducted in 1996, "camping and fishing are the two primary reasons people visited Diamond Lake, with bicycling, hiking and sightseeing being other popular reasons" (Diamond Lake Ranger District Files, 1998). Recent visitor surveys are showing a shift in the primary reasons people visit Diamond Lake.

Table 45. Annual Occupancy at Diamond Lake Campgrounds from 1989-2003.

Year	Diamond Lake	Thielsen View	Broken Arrow
1989	64,600	16,100	10,800
1990	65,800	18,700	12,700
1991	70,100	22,500	13,800
1992	70,600	24,200	16,800
1993	62,400	23,400	15,800
1994	65,400	17,400	15,100
1995	62,800	14,700	15,900
1996	57,900	9,300	11,400
1997	49,500	9,000	9,000
1998	45,045	7,583	12,986
1999	No data	No data	7,946
2000	No data	No data	8,593
2001	50,113	8,164	8,411
2002	47,754	7,709	7,537
2003	44,855	5,511	6,732

One of the most dramatic changes in recreational use of Diamond Lake in recent years has been the decline in angler use associated with the declining rainbow trout fishery (Diamond Lake Ranger District 1998). The Oregon Department of Fish and Wildlife has records for annual angler trips to Diamond Lake that span a fifty year time period (Table 46, ODFW, 2003). Although information on angler trips was not collected for most of the 1980's and early 1990's, the declining trend in the recreational fishery over time is still evident (Table 46).

Table 46. Annual Angler Trips at Diamond Lake

Year	Angler Trips

Year	Angler Trips
1952	5,100
1953	5,900
1954	1,000
1955	0 (Fish were not stocked in the year following rotenone treatment)
1956	34,700
1957	52,600
1958	43,000
1959	27,800
1960	37,400
1961	39,300
1962	70,600
1963	93,300
1964	115,500
1965	139,500
1966	133,700
1967	131,900
1968	105,900
1969	122,900
1970	117,000
1971	96,200
1972	86,600
1973	112,300
1974	102,800
1975	106,600
1976	90,900
1977	102,000
1978	138,700
1979-1988	(Data was not collected)
1989	82,400
1990-1993	(Data was not collected)
1994	54,300
1995	(Data was not collected)
1996	35,500
1997	28,000
1998	10,000
1999	6,000
2000	14,100 (Experimental stocking)
2001	20,000 (Experimental stocking)
2002	19,800 (Experimental stocking)

The recreational fishery was re-established at Diamond Lake in the late 1950's following a rotenone treatment to remove the first infestation of tui chub. Use in the area rose following the paving of State Highway 138 in 1964. From 1963-1978, Diamond Lake supported an average of 112,238 annual angler trips with high use years in 1965 (139,500 angler trips) and 1978 (138,700 angler trips). Although angler trip data is not available for most of the 1980's, according to the Diamond Lake Watershed Analysis (1998), angler use decreased during this decade, in part due to increased fuel prices and the state of the economy in general. In

1989, annual angler trips had declined by nearly 30,000 from the average during the 1960's and 1970's.

In 1992, tui chub were found again in Diamond Lake. As the tui chub population increased over the next decade the trout fishery decreased. Angler trips started to severely decline from 82,400 angler trips in 1989, to 35,000 in 1996, down to a low of 6,000 angler trips in 1999. In 2000, ODFW began an experimental fish stocking program to support a minimal recreational fishery and determine if any hatchery strains could effectively compete with or prey on the tui chub. Figure 46 illustrates the decline in angler trips associated with overpopulation of the lake by tui chub.

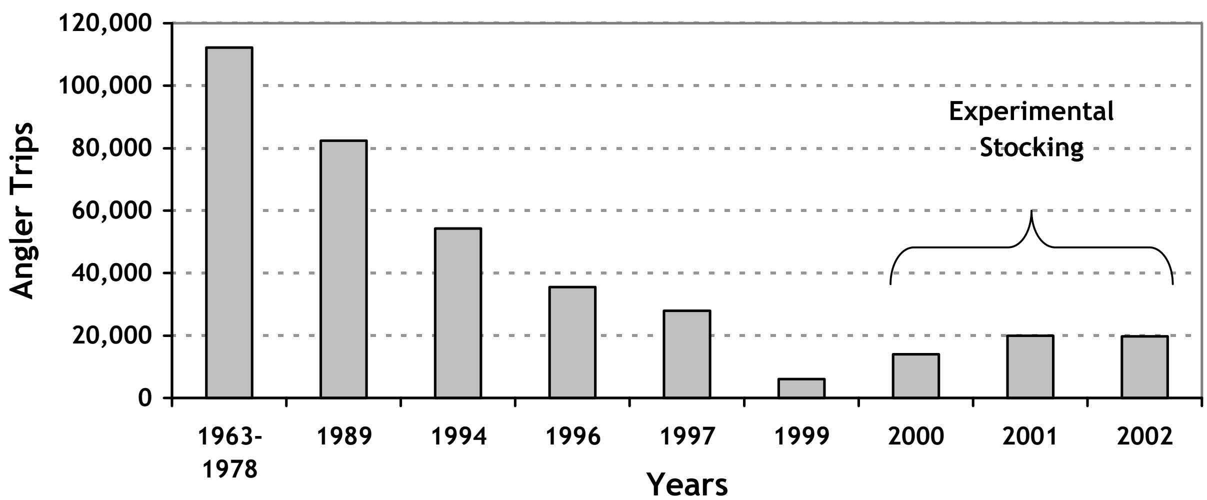

Figure 46. Declining Angler Trips at Diamond Lake

As previously mentioned, campground occupancy declined dramatically during the 1990's primarily in response to the diminished recreational fishery. This conclusion is supported by the fact that campground use declined during the spring and fall shoulder seasons when fishing was traditionally the best and summer use remained steady even with the declining fishery (Diamond Lake Ranger District, 1998). The authors of the Recreation Assessment and Analysis for Diamond Lake and Lemolo Lake Watersheds (1998) concluded that "the demand for camping at the Forest Service Campgrounds at Diamond Lake has been on a steady decline since 1992, when the decline in the demand for fishing was first observed. It is obvious that most of the decline in demand for overnight use is a direct result of the decline in the fishery, but other forces have changed the demand for camping and other activities in the area…including an economic turn-down."

Displacement of Visitors

As described throughout this DEIS, during portions of the past three summers the water quality in Diamond Lake became so degraded due to algae blooms, that a closure was placed on swimming and all water contact. These closures occurred during August 10-30, 2001, July 23-August 7, 2002 and July 1-August 12, 2003. This occurred for 21 days in 2001, 16 days in 2002 and 43 days in 2003, for a total of 80 days of closure to swimming and all water contact.

The closures were disruptive to the recreation season and resulted in displacement of visitors and cancellation of events[165].

The 1996 Oregon Marine Board Recreational Boating Survey reported that Diamond Lake dropped from its 1992 ranking as the 12th most popular boating water body in Oregon to the rank of 24th, representing a 50% drop in boater use in just four years following the tui chub infestation (Evans and Associates, 1989). Tahkenitch Lake (located in western Douglas County) showed a 38% increase in boater use over the same period (Shuyler, 1996). Tahkenitch Lake's rise in ranking could be partially due to former Diamond Lake anglers switching to a new water body.

ENVIRONMENTAL EFFECTS

Direct Effects:

Alternative 1

Alternative 1 would have no effect on any of the sense of place (SOP) locations since there would be no canal reconstruction, no draw down of the lake, no mechanical fish harvest or fish carcass removal. There would be no chemical treatment and no need to drain and refill the lake. The water quality would remain poor and there would be continued closure potential to water contact activities due to toxic algae blooms. Visitors would continue to have unmet expectations for water quality and the fishery (Burns, et. al. 2002). Under Alternative 1, there would be traditional user displacement because of the uncertainty of water quality. People may postpone or schedule vacations elsewhere. Customer expectation of water-based activities would be compromised, indefinitely. The scenic resources and the recreation opportunity spectrum setting would continue as they presently exist which includes a substantial change in the visual nature of the lake when it turns from blue to green during summer algae blooms.

Table 47 summarizes the expected changes in the recreational fishery over a six-year timeframe estimated for this project (ODFW, 2003). Alternative 1 would result in continued depressed fishing opportunities as fish quantities would be significantly lower than past levels. In 2004 and 2005, 100,000 legal-sized fish would be stocked resulting in a projected 20,000 angler trips the first year and 10,000 each year thereafter through 2009. From 2006 to 2010, 24,000 legal-sized fish would be introduced annually. This put and take fishery would yield a higher success rate than the recent past, but less than historic levels.

Table 47. Alternative 1: Expected Changes in the Diamond Lake Recreational Fishery from 2004-2009 (ODFW, 2003).

Year	Angler Trips	Catch
2004	20,000	20,000

[165] One example: a triathlon was canceled due to one of the closures. (Rick Rockholt, Personal Communication, 2003).

2005	10,000	10,000
2006	10,000	10,000
2007	10,000	10,000
2008	10,000	10,000
2009	10,000	10,000

A continued reduction in recreation is expected during the spring and fall. Continued displacement of traditional visitors to other recreation locations, such as Lemolo Lake and other fishing lakes within a 2-hour drive of population centers, is also expected. There would be no direct, indirect, or cumulative impacts to the scenic quality within the project area other than the change in water color during algae blooms.

Indirect Effects:

Alternative 1
More recreation use may continue to occur at nearby (within 20 miles) recreation sites and water-based destinations such as Poole Creek Campground and Lemolo Lake. Other Douglas County waters may attract boaters and fishermen from the Roseburg and Eugene area. Adjacent Counties may receive additional local recreation use from people who have historically preferred to camp and fish at Diamond Lake. Little to no effect is expected on visitors hunting in the surrounding areas, on people using off-road vehicles, or on forest management activities beyond the immediate vicinity of Diamond Lake.

Cumulative Effects:

Alternative 1

Management activities that led to the development of recreational facilities and opportunities in the past and present (i.e. campground, resort, boat ramp and trail construction; fish stocking; etc.,) are the primary contributors to a cumulative effect of management on the recreation resource in the project area (Tables 9-11). For many visitors, these improvements over time represent a beneficial contribution. Similarly, reasonably foreseeable activities such as boat ramp and campground improvements are also considered to be a positive contribution to the cumulative effect of management on recreation opportunities. However, improvements to these facilities are not expected to compensate for negative affects on recreation perpetuated under Alternative 1.

According to the 2003 visitor survey (Burns et al. 2003), up to 25% of the respondents indicated they may not return to Diamond Lake if the water quality does not improve. There may also be a continued shift in the type of activities visitors engage in at Diamond Lake in the future (i.e. less fishing and water contact activities).

Because of uncertainty of water quality conditions, there may be a reluctance on the part of groups to plan events at Diamond Lake during the high recreation use period of July and August which would continue to depress visitor use figures and could potentially affect the ability of the Forest Service over time to acquire funds to maintain present facilities. This would affect the Diamond Lake Resort and family camp sense of place units to a greater extent than some of the other units in the project area because the attraction for water-based activities and safe, family camping would continue to be uncertain over the long-term.

Direct Effects:

Alternative 2

Direct effects under Alternative 2 on recreation would be on the following SOP units: Diamond Lake resort, family camp, Lake Creek, undeveloped riparian, summer homes, and water sports (Figure 45).

Scenic Quality

Scenic quality would be impacted by the draw down of the lake of up to eight feet below the normal lake level for a period of about 18 months. This would affect the Diamond Lake Resort, family camp, Lake Creek, undeveloped riparian and summer homes units. Diamond Lake would look more like a reservoir than a natural mountain lake. The visual quality level of retention would be impacted in the short term such that management activities would be evident, but the surrounding landscape would continue to visually dominate unless the point of view is directly on the shore. There would be odor expected with the draw down from the smell of rotting vegetation and creatures not normally exposed to air and sun. Dead fish, as a result of the rotenone treatment, would wash up on the shores and add to the odor until they could be collected for disposal. This would be expected to attract more carrion-eating birds such as gulls, ravens, and bald eagles. Wetland and riparian areas near Silent Creek and the northwest portion of the lake would be dewatered with resulting die-off of vegetation and browning of formerly green vegetation. Mud flats would be exposed and may support weed growth from the changed conditions as well as crack from drying. The use area of the lakeshore along the Diamond Lake Resort, family camp and summer homes areas, where the shore use is heaviest, would be limited. Dock extensions would be necessary to access the water sports SOP unit and would result in additional visual distraction in the area.

The visual quality during the canal reconstruction period would be heavily impacted, as management activities would dominate during this time. During the reconstruction of the canal on the north end of the lake, about 300 feet of area extending between Road 4795 and the lake would be under construction for four to six weeks while the canal is reconstructed to its original dimensions. A floating dredge would also deepen the existing canal in the lake to its original dimensions (about 700 feet long, 18 feet wide and 8 feet deep). Dredge material would be stockpiled inside a silt fence (permeable plastic barrier and T-posts) on the northwest corner of the lake to expand the existing wetland. Dredge material is expected to be about one foot to eighteen inches deep, consisting of about 900 cubic yards of material. The silt fence would remain in place for about two months before removal.

Mitigations measures incorporated into the project (Chapter 2) that include use of natural appearing building materials, consistent but unobtrusive signage, and designs that blend into the surroundings would help lessen the impacts to scenic quality. Visual quality would slowly improve as vegetation recovers the first year. By the second year, there would be only slight evidence of these management activities in the water sports, undeveloped riparian and Lake Creek SOP units.

General Recreation

Alternative 2 would have a direct affect on recreation activity in the project area. There would be an 18-month limited use period during the lake drawn down, chemical application, mechanical fish removal, and lake refill that would directly affect boating, fishing, water sports in general, and normal access to summer homes, Theilsen View Campground, the bike trail, and dispersed recreation use in the vicinity of Lake Creek. People who access the north end of the lake to fish from the shore, at the beach area and rock promontory, would not be able to use the area during the draw down, canal reconstruction, and wetland expansion. During the reconstruction of the canal, one-lane of traffic would be permitted, with controls on Road 4795. While the bike trail would be temporarily removed, bicycle traffic would be rerouted onto the one-lane road.

During the draw down period, there may a temporary increase in fishing use if catch limits are lifted to encourage use of existing trout in the lake before the fish kill with rotenone. There would be some camping at Diamond Lake expected and some of the proposed activities might even attract viewers due to the novelty of the action. But the initial interest is likely to pass quickly until the conditions improved so that people could safely and comfortably access the water and participate in their favorite activities again. There is a risk of permanent loss of some traditional visitors as they find different locations to recreate that meet their expectations.

Recreational Fishery

Substantial changes in the recreational fishery would occur under Alternative 2, which would result in improved angler opportunities at Diamond Lake (Table 48, ODFW 2003). These are estimates based on existing knowledge; ecological indices and water quality responses would determine actual fish stocking levels and associated angler trips under all action alternatives.

Table 48. Alternative 2: Expected Changes in the Diamond Lake Recreational Fishery from 2004-2009 (ODFW 2003).

Year	Angler Trips	Catch
2004	20,000	20,000
2005	5,000	5,000
2006	25,000	30,000
2007	60,000	100,000
2008	80,000	200,000
2009	100,000	200,000

As illustrated in the above table, in 2004 (or year one), 20,000 angler trips are predicted during the spring and summer up until the lake closure and the rotenone application. In year two, if the ecological indices are favorable to allow for stocking, a small number of fish would be stocked in the spring resulting in potentially about 5,000 angler trips. The angler trips would steadily increase in subsequent years under Alternative 2 as the put-grow and take fishery expands with stocking in the absence of tui chub.

Connected Actions

There are several connected actions proposed by the Diamond Lake Resort that would result in direct affects on the recreation resource. During the lake draw down, the Resort would take advantage of access to the lake bed to conduct a dock clean-up near the South Shore Store. The Resort would also conduct a clean-up around the Diamond Lake Marina including relocation of sediment accumulation. These activities would be expected to visually dominate during the expected two-week period of the clean-up. When the sediments are shaped and blended naturally with the terrain and converted to areas of landscaping, in the long-term, it would enhance the present condition and return the visual quality level to retention which is the visual quality objective around the structures at the Resort (within the Diamond Lake Resort SOP unit). Clean up would also potentially result in a safer environment for boaters by eliminating underwater hazards.

Indirect Effects:

<u>Alternative 2</u>

Implementation of Alternative 2 is expected to result in improvement in the water quality which would indirectly effect recreation. Within 2 years of implementation, there may be some improvements in water quality as evidenced by clearer water during the summer, even though there may still be natural algae blooms in spring and fall. Water quality is expected to continue to improve every year and thus, would potentially attract visitors back who have been deterred by recent algae blooms and lake closures.

There would also be indirect effects on recreation because of the information needed to direct people and manage use during the implementation period of the alternative, as well as into the future. There would be an increased need for safety and security patrols of recreation users and operational equipment during alternative implementation. There would be an increased need for signs, brochures, and interpretive material to inform the public about the operations. Active dialogue with visitors may be necessary to assist visitors in adaptation and compliance with boat inspection and angler stamp rules that may be needed to manage the fish population and reduce the probability of tui chub reintroduction.

Some of the activities proposed under Alternative 2 would affect recreation outside the immediate vicinity of Diamond Lake. ODFW would not be able to store water in Diamond Lake under their water right during the year of a rotenone treatment. If precipitation was low during that year and there was not adequate water available to satisfy water rights for downstream users, the Rock Creek Fish Hatchery could be negatively affected. Water stored in Diamond Lake was released to supply the hatchery with water three times in the past thirteen years due to drought conditions. Under these conditions, if the hatchery was unable to obtain water, they would have to turn their fish stock loose early, which would reduce the attraction at the hatchery for visitors and result in less visitation.

Cumulative Effects:

<u>Alternative 2</u>

Past, present and reasonably foreseeable management activities that contribute to a cumulative effect on recreation are the same as described for Alternative 1. In general, these management activities have resulted, or will result in, a positive influence on recreational opportunities in the project area. As described above, Alternative 2 would result in a reduction in recreation visitor use at Diamond Lake over the first 18-month period of implementation. However, during the remaining lifetime of the project and in the future, this alternative is expected to result in enhanced recreational opportunities due to improvements in the water quality and recreation fishery in the lake.

The greatly improved fishery under this alternative would likely increase camping and overnight stays at Diamond Lake Resort and other camping facilities in the area. The increase in water quality beginning within 2 years of treatment would be expected to restore people's desire to use the lake for water-based activities and likely increase visitor use. Thus, when added to past, present, and future management activities, this alternative represents a beneficial cumulative effect on the recreation resource.

The scenic quality is expected to be restored within one to two years following activities, with mitigation measures (described in Chapter 2). Moreover, enhancements to scenic quality are expected as a result of the connected actions under this alternative which include improvements to the marina and the dock clean-up completed during the draw-down. Thus, no long-term negative cumulative effects on scenic quality are anticipated.

Direct and Indirect Effects:

Alternative 3

The direct and indirect effects on recreation from Alternative 3 would be the same as Alternative 2 except for the fish stocking strategy. Fish stocking under Alternative 3 would be a "put and take fishery", meaning that 12-inch legal-sized fish would be stocked and harvested in the same year. This fish stocking strategy was designed to minimize impacts to the food chain and ultimately water quality by stocking domestic trout that tend not to eat any of the natural food items in the lake (zooplankton and benthic invertebrates).

Alternative 3 would result in an improved recreational fishery over Alternative 1 for the lifetime of the project (Table 49, ODFW 2003).

Table 49. Alternative 3: Expected Changes in the Diamond Lake Recreational Fishery from 2004-2009 (ODFW 2003).

Year	Angler Trips	Catch
2004	20,000	20,000
2005	5,000	5,000
2006	30,000	40,000
2007	60,000	80,000
2008	70,000	120,000
2009	80,000	160,000

Lower angler trips and catch numbers are predicted in the out-years under Alternative 3 (Table 49) compared to Alternative 2 (Table 48) due to the put and take strategy used in Alternative 3. Under Alternative 3, 12-inch domestic rainbows would be stocked rather than fingerlings, but these domestic fish are not expected to survive the winter to become part of the fishery in subsequent years. The fingerlings used in the put-grow and take fishery under Alternative 2, would survive the winter to be available in the fishery as progressively larger fish each year they escape being caught.

Differences in water quality improvement between Alternatives 2 and 3 are not expected to be substantial enough to result in meaningful differences in their affects on the recreation resource.

Cumulative Effects:

Alternative 3

Cumulative effects under this alternative would be the same as described for Alternative 2 except for the changes in the recreational fishery. Generally the long-term effect of this alternative would be a marked improvement in the fishery from the present. Under Alternative 3, angler trips would be expected to approach historic levels in about 2008. However, the fish caught by anglers would likely be substantially smaller than the historic 3 or 4-pounders. Over time, the put and take fish stocking strategy would provide a good family attraction. However, traditional anglers looking for a trophy fish would likely go elsewhere to satisfy their desire to catch bigger fish.

Direct Effects:

Alternative 4

Alternative 4 would directly affect scenic and recreation resources at Diamond Lake through high levels of mechanical tui chub removal that would occur for about 3 months out of every year for the lifetime of the project. This alternative would primarily affect the water sports SOP unit (Figure 45).

Commercial nets, seines and traps would be used annually in June and July and again in September to harvest tui chub from Diamond Lake. About 1/3 of the lake would be closed at one time to allow this activity to occur and water sports and fishing would be prohibited in those areas at that time. There would be considerable signing to alert people to avoid those areas. These warning signs would be an intrusion on the aesthetics of the lake. There would be use of electro-shocking boats in limited areas and removal of dead fish. Thus, the available and useable surface space of the lake would go down annually in the spring and fall.

This alternative would utilize a featured species or trophy fishery and would provide a different type of recreational fishery than existed historically. The planted fish stock would be larger, piscivorous (fish eating) fish and a shift in regulations would cause a shift in user type. There would be greater regulation to support the trophy fishery, and the historic type of family fishing would go down. This type of fishery would attract visitors, but there could also be more conflict among users for the best fishing locations. There may be a bounty instituted on tui chub that could draw a different user type to the lake.

Alternative 4 would result in an improved recreational fishery compared to Alternative 1 (Table 50, ODFW 2003). However, Alternative 4 is projected to yield substantially fewer angler trips in the out years compared to either Alternatives 2 or 3. These estimates assume a disrupted fishery associated with spring and fall tui chub netting, which would affect the angler trips and result in a leveling off at about 50,000 angler trips per year.

Table 50. Alternative 4: Expected Changes in the Diamond Lake Recreational Fishery from 2004-2009 (ODFW 2003).

Year	Angler Trips	Catch
2004	20,000	20,000
2005	30,000	30,000
2006	50,000	50,000
2007	50,000	50,000
2008	50,000	60,000
2009	50,000	70,000

Indirect Effects:

Alternative 4

Because of the intensity of management activity to mechanically reduce the tui chub, and the change in the type of fishery, the need for information sharing and education would be heightened under Alternative 4. There may be short-term negative effects to visitors from dead fish that were shocked, but missed during collection. Traditional users may shift to Lemolo Lake or some other location for a family fishing experience that allows more harvest as opposed to a trophy fishery where more fish would need to be released.

Little to no change in water quality is expected during the first 3-4 years, which would result in some visitors choosing alternative recreation locations. By year six, some improvement in water quality would be expected, but not as noticeable as in Alternatives 2 and 3. More visitors may continue to be displaced under this alternative due to continued disappointments related to water quality.

Cumulative Effects:

Alternative 4

Past, present and reasonably foreseeable management activities that contribute to a cumulative effect on recreation are primarily the same as described in Alternative 1. In general, these management activities have resulted, or will result in, a positive influence on recreational opportunities in the project area. However, because it is anticipated that annual commercial fishing operations would be needed to effectively limit tui chub recruitment in Diamond Lake beyond the lifetime of this project; some negative cumulative effects are expected under Alternative 4.

Alternative 4 would be more successful in providing angler trips on Diamond Lake than Alternative 1, but at a lower level than Alternative 2 and 3. There would be temporary negative effects on scenic quality every year for about 3 months during chub removal activity in the form of equipment operation and warning signs posted around the lake. However, there are no additional effects on the undeveloped riparian, Lake Creek, Diamond Lake Resort, or family camp SOP units as there would be under Alternatives 2 and 3.

The long-term result of this alternative would be that tui chub would remain in the lake at some level necessitating continued activity into the future. Thus, a long-term negative cumulative effect on scenic quality and angling opportunities is expected under Alternative 4. It is important to note that two of the three primary activities that attract visitors to Diamond Lake, according to the 2001 and 2003 visitor surveys, will continue to be provided: camping in developed sites (23%) and general relaxing and hanging out (21%). Fishing is the third primary activity, at 18%. Displaced anglers are expected to return, to some degree, as some anglers would be willing to adapt to the different fish retention levels associated with a trophy fishery.

Summary of Alternatives Effects on Recreation Use:
Overall, effects on recreation use are expected to differ by alternatives with some variation among the SOP units (Table 51).

Table 51. Summary of Alternative Effects on Recreation Use

SOP Unit	Alt. 1 – No Action	Alt. 2 & 3 -- Rotenone	Alt. 4 – Mechanical & Biological
Watersports	Expected short-term and long-term reduction in use due to algae blooms/closures; especially during the shoulder recreation seasons.	Expected short-term reduction in use during 18-month treatment period; long-term increase in use expected due to enhanced water quality and fisheries.	Fluctuating use is expected indefinitely with reduced use periods during tui chub harvesting with 1/3 of the lake unavailable.
Family Camp	Expected short-term and long-term reduction in use due to algae blooms/closures associated with fishing and swimming activities.	Expected downturn in use during 18-month treatment period; long-term increase in use due to improved fisheries and water quality.	Reduction of recreation use expected indefinitely due to intrusion of operations and reduced capacity at recreation facilities in spring and fall.
Diamond Lake Resort	Similar to Family Camp	Visitor use is expected to increase from commercial activities associated with treatments; recreation use is expected to decrease during the 18-month treatment period and increase in the long-term.	Fluctuating commercial and recreation use expected with reduction of recreation use expected in spring and fall.
Summer Homes	Continued reduction in use due to algae blooms/closures and reduced fishery.	Increase in visitation following the 18-month treatment period due to improved fisheries and water quality.	Some increase in use expected on a fluctuating basis – downturn expected during tui chub harvest.
Undeveloped	Negligible effect.	Reduction in recreation use during the 18-month treatment	Negligible Effect.

SOP Unit	Alt. 1 – No Action	Alt. 2 & 3 -- Rotenone	Alt. 4 – Mechanical & Biological
Riparian		period; long-term increase in use.	

Alternative 1 would result in continued decreases in recreation use due to lake closures associated with toxic algae blooms that limit water access and affect the fishable trout populations. Alternatives 2 and 3 would have the most positive long-term effect on recreation use. Alternative 4 would result in fluctuating recreation use levels, with an infusion of commercial use, due to continued, intermittent treatments for tui chub.

ECONOMICS

There were several concerns related to economics identified during scoping: potential impacts to tourism, private businesses at the lake, and outlying area businesses; potential impacts to campground and fishing license revenues; and project implementation costs. This issue is tracked in this section.

For the purpose of the economic analysis and disclosure, it was necessary to assume a timeframe for implementation. Therefore several tables in this section display information based on the years 2004 through 2009. However, implementation of any of the alternatives, except no action, is dependant on timely completion of the NEPA and appeals process as well as funding to pay for the implementation. Thus, 2004 would be the earliest possible year to begin implementation if an action alternative is selected.

AFFECTED ENVIRONMENT

Defining the regional economic area to which Diamond Lake belongs is complicated because it lies in the southeast corner of Douglas County and near portions of nine other counties (Coos, Curry, Josephine, Jackson, Klamath, Lake, Deschutes, Lane and Linn) located within a 90-mile radius. Historically, 60-70 percent of the visitors to Diamond Lake came from within this 90-mile radius region (Stone 2003). If the above counties were considered the area that would be affected by changes in visitation to Diamond Lake due to changes in the trout fishery and water quality, the associated changes in income and employment would be small within the context of the total regional economy. On the other hand, if the affected region is defined as the area within a 10-mile radius of Diamond Lake the effects would be much more pronounced, but such a small area cannot be considered a functional economy since it does not include the bulk of economic transactions or flow of trade.

After a review of existing studies and discussion with regional experts, including the former Umpqua National Forest economist, it was determined that the majority of the economic impacts associated with potential water quality and fishing improvements at Diamond Lake are likely to occur within the three county region of Douglas, Jackson and Klamath counties. Therefore, this area is considered the affected environment for modeling the economic effects of the alternatives and is termed the Diamond Lake Economic Area.

REGIONAL POPULATION AND ECONOMIC INDICATORS

Table 52 displays population levels and economic indicators for the three individual counties in comparison to the state as a whole (Center for Population Research and Census 2002; U.S. Census Bureau 2002; U.S. Bureau of Economic Analysis 2003b). All data presented are for the most recent year available. The population of the three county area in 2002 was estimated at 353,450. In 2001 the unemployment rate in Jackson County was equal to the state unemployment rate, while Douglas and Klamath counties had higher unemployment rates. Each of the counties had a higher percentage of people not in the labor force in 2000 compared to the state percentage. Both median household income in 2000 and per capita income in 2001 were highest for the state as a whole, followed by Jackson, Douglas and Klamath counties. Similarly, the percentage of individuals in poverty in 2000 was lowest for the state as a whole, followed by Jackson, Douglas and Klamath counties.

Table 52. Population and economic indicators for Oregon and the three Counties in the Diamond Lake Economic Area.

	Oregon	Douglas County	Jackson County	Klamath County
Population, 2002	3,504,700	101,300	187,600	64,550
Unemployment rate, 2001	6.3%	9%	6.3%	9.5%
% Not in the Labor Force, 2000	34.8%	43.1%	38.7%	40.3%
Median Household Income, 2000	$40,916	$33,231	$36,461	$31,537
Per capita Income, 2001	$28,222	$23,039	$25,505	$21,913
% of Individuals in poverty, 2000	11.6%	13.1%	12.5%	16.8%

ECONOMIC STRUCTURE

Table 53 displays some basic employment statistics for 2001 for Oregon, the local region and the three individual counties[166] (U.S. Bureau of Economic Analysis, 2003b).
Employment in this table is measured in annual equivalents, or the yearly average of all full- and part-time jobs. For example, a person who works 12 months at a full-time job is counted as one job. A person who works three seasonal or part-time jobs during the year would be counted as three jobs. This measure is not the same as a full-time equivalent (FTE)[167]. In considering the employment data presented, the annual equivalent count may overstate or understate some sectors depending on its level of seasonal or part-time hiring.

Table 53. 2001 Employment by Industry for Oregon and the three Counties in the Diamond Lake Economic Area.

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[166] Government data made available to the public are subject to nondisclosure rules. This applies when the data reported may disclose the operations of a single firm. Due to nondisclosure rules for several sectors in Klamath County, these sectors were lumped into the “Other” category.

[167] An FTE is equal to one person working full time for 12 months; three people each working full time for 4 months would be counted as a single FTE.

Nonfarm[168] employment by sector	Oregon	Diamond Lake E. Area	Douglas County	Jackson County	Klamath County
	Jobs **(Percent)**				
Construction	120,622 **(6%)**	11,225 **(6%)**	2,490 **(5%)**	6,766 **(7%)**	1,969 **(6%)**
Manufacturing	228,753 **(11%)**	16,995 **(9%)**	6,365 **(13%)**	7,851 **(8%)**	2,779 **(9%)**
Transportation & Warehousing	61,499 **(3%)**	5,813 **(3%)**	2,100 **(4%)**	2,764 **(3%)**	949 **(3%)**
Information	46,031 **(2%)**	3,141 **(2%)**	549 **(1%)**	2,223 **(2%)**	369 **(1%)**
Finance and Insurance	85,478 **(4%)**	5,572 **(3%)**	1,250 **(3%)**	3,341 **(3%)**	981 **(3%)**
Real Estate, Rental & Leasing	82,693 **(4%)**	7,277 **(4%)**	1,679 **(3%)**	4,369 **(4%)**	1,229 **(4%)**
Wholesale trade	82,337 **(4%)**	4,281 **(2%)**	923 **(2%)**	2,582 **(3%)**	776 **(2%)**
Retail trade	241,721 **(12%)**	26,741 **(15%)**	6,144 **(13%)**	16,614 **(16%)**	4,006 **(13%)**
Government	278,692 **(14%)**	25,614 **(14%)**	8,523 **(17%)**	11,529 **(11%)**	5,562 **(18%)**
Accommodation & Food Services	143,274 **(7%)**	14,051 **(8%)**	3,369 **(7%)**	8,137 **(8%)**	2,545 **(8%)**
Arts, Entertainment & Recreation	42,832 **(2%)**	4,200 **(2%)**	798 **(2%)**	2,894 **(3%)**	508 **(2%)**
Other[169]	621,660 **(30%)**	56,231 **(31%)**	14,575 **(30%)**	32,303 **(32%)**	9,353 **(30%)**
Total	2,041,321	181,739	48,972	101,647	31,120

The 2000 distribution of employment by industry sector in the Diamond Lake Economic Area differs in some respects from the state of Oregon as a whole. The area had 2% less of its employment in manufacturing, 2% less in wholesale trade, and 1% less in finance and insurance. The industrial sectors associated with serving tourists are not easily identified, but have been defined to include the following (Bureau of Economic Analysis, 2003a): hotels and lodging places, eating and drinking places, railroads and related services, local and bus passenger transit, taxicabs, air transportation, water transportation, automotive rental and leasing, travel agency services, amusement and recreation services, membership sports and recreation clubs, motion pictures and other entertainment, professional sports clubs and promoters, gasoline service stations, and retail excluding restaurants and gas stations. With the exception of the transportation related businesses, most of these businesses fall within the broader sectors of retail trade and services. Table 3 shows the Diamond Lake Economic Area had 3% more employment in the retail trade sector, and 1% more in the combined accommodations & food services and arts, entertainment & recreation sectors compared to the state of Oregon as a whole. This means that tourism-related industries are an important part of the Diamond Lake Economic Area economy.

[168] Nonfarm employment is defined as all employment, both full and part time not associated with farming.
[169] Includes Agricultural Services, Forestry, Fishing & Other; Mining; Utilities; and Services other than Accommodation & Food Services and Arts, Entertainment & Recreation.

TRAVEL RELATED ECONOMIC ACTIVITY

Estimates of economic activity generated from travel related spending for Oregon and the three individual counties is provided in Table 54, which shows that the Diamond Lake Economic Area had a higher percentage of its total employment generated from travel spending compared to the state. Douglas County had the highest percentage of travel related employment in the state (Dean Runyan Associates, 2002).

Table 54. Travel Impacts for Oregon and the three Counties in the Diamond Lake Economic Area, 2001

	Oregon	Diamond Lake E. Area	Douglas County	Jackson County	Klamath County
Destination Spending[170] ($ Million)	5,624	728.0	203.8	256	109.5
Earnings ($ Million)	1,556	232.4	48.4	62.6	26.6
Employment [171] (jobs)	95,600	13,540	3,530	4,380	1,980
Employment (% of total jobs)	4.7%	5.4%	7.2%	4.3%	6.4%
Local Tax Receipts[172] ($ Million)	73	14.3	.7	3.0	.9
State Tax Receipts ($ Million)	160	29.3	5.3	11	2.9

DIAMOND LAKE DEVELOPED RECREATION FACILITIES

There are three Forest Service campgrounds located on or near Diamond Lake—Diamond Lake, Thielsen View and Broken Arrow. Table 55 displays revenues collected at these campgrounds (U.S. Forest Service, Umpqua National Forest, Diamond Lake Ranger District).

Table 55. Diamond Lake Forest Service Campground Revenues

	1988	1992	1996[173]	1997[174]	1998	1999	2000	2001
Campground	Revenues in $							
Diamond Lake	121,375	202,943	123,095	164,096	157,988	155,217	170,773	154,148
Thielsen	22,337	30,496	20,719	21,336	18,038	11,523	20,925	20,542
Broken Arrow	14,667	25,047	25,031	26,645	21,602	28,019	29,791	30,208
Total	$158,379	$258,486	$168,845	$212,077	$197,628	$194,759	$221,489	$204,898

Campground receipts were 21% lower in 2001 than 1992, despite an increase in camping fees. Much of the decrease in camping use has been attributed to the decline in the quality of the

170 Destination Spending does not include air transportation or travel arrangement.
171 Employment includes all full- and part-time payroll employees and working proprietors.
172 Property taxes are not included.
173 The Spring Fire in 1996 had an effect on camping at Diamond Lake.
174 There was a campsite fee increase in 1997.

fishery at Diamond Lake (David Evans and Associates 1998). Between 1989 and 2002, the correlation coefficient[175] between estimated angler trips and estimated campground usage was .80, which indicates a strong correlation between the two.[176]

In addition to these campgrounds, Diamond Lake Improvement Company operates Diamond Lake Resort under a Forest Service special use permit[177]. The lodge currently has 92 overnight units including 42 rental cabins (6 person occupancy), 40 motel units (2 person occupancy) and 10 studio units (2 person occupancy). Diamond Lake Resort reported 75,000 overnight occasions in 1992 and 51,100 overnight occasions in 1997 (David Evans and Associates 1998). Current use from April through September based on occupancy rates is estimated to be around 35,900 overnight occasions (Rockholt 2003). This decrease is again believed to be attributable to the decrease in the quality of the fishery, as occupancy rates remain between 95-100% in July and August, but have decreased dramatically in the spring and fall periods that have traditionally attracted anglers to the area.

Figure 47 displays total sales revenues at the resort during the fishing season (April through October) for the years from 1986 to 2002. The line in the figure represent sales for all months combined (total sales), while the columns represent sales during the shoulder season (defined here to include the months of April, May, June, September and October) and the peak season (defined here as the months of July and August). This figure clearly reveals the downward trends for both total fishing sales and total shoulder season (spring and fall) sales. Peak season sales have remained fairly constant, while total and shoulder season sales decreased by 28 percent and 49 percent, respectively, between 1992 and 1999. The resort's accounting firm reports that the experimental fish stocking program, which stocked larger, catchable fish over the last few years helped increase fishing season revenues during that time. Sales to fire fighting crews also increased revenues in 2002 (Koneckny 2003).

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[175] A correlation coefficient is a common statistic for indicating the strength of a linear relationship between two variables. It is a number ranging between –1 and 1. A positive correlation means as the value of one variable increases, the value of the other variable also tends to increase. A small or zero correlation coefficient tells us that the two variables are unrelated, while a value close to 1 indicates a strong positive linear relationship and a value close to –1 indicates a strong negative relationship. (Cody and Smith 1997)

[176] Estimated angler trips and campground usage were not available for every year, thus the correlation coefficient is for the years 1989, 1994, 1996-1999, and 2001-2002.

[177] Special use permits are issued by the Forest Service to the private sector when a business is established on, or revenues are generated from, public Forest Service managed lands. A percentage of the revenue generated from the business is paid to the federal government.

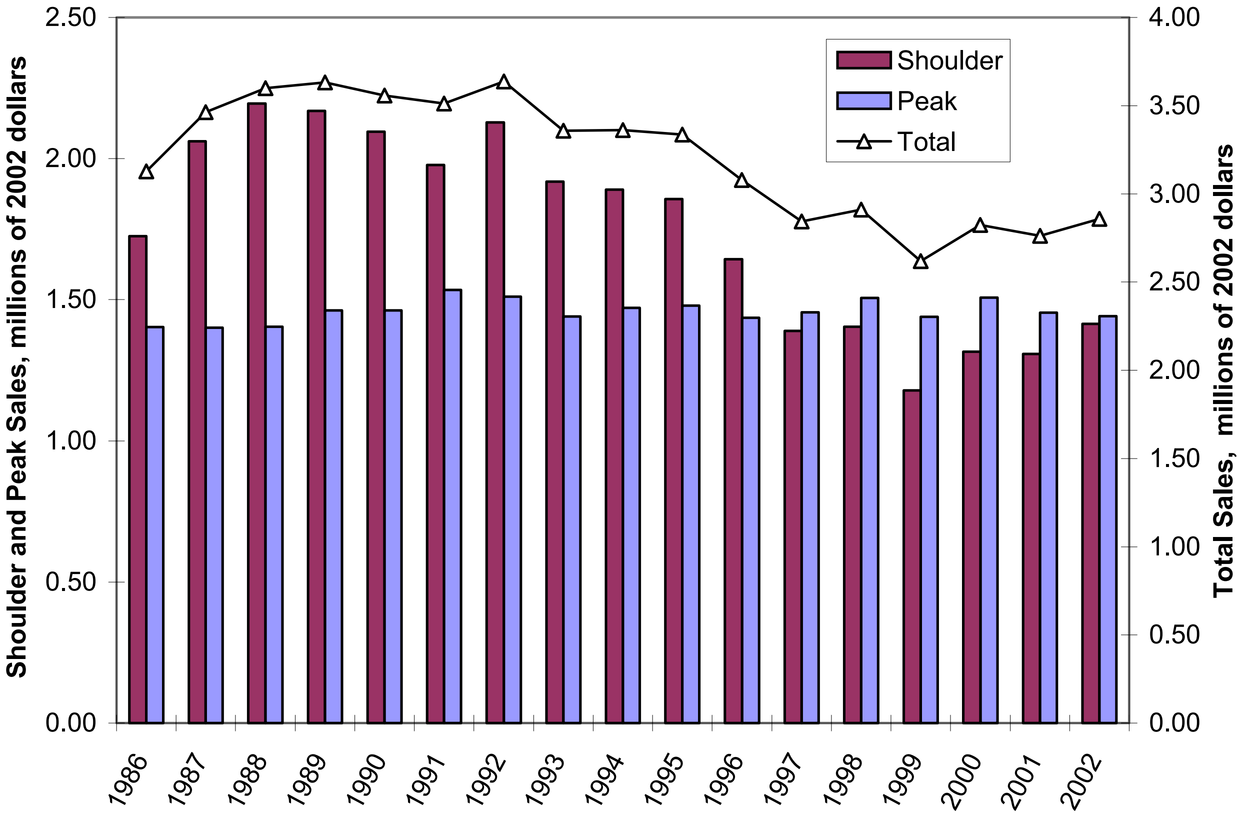

Figure 47. Diamond Lake Resort total sales for the shoulder (April-June, Sept. & Oct), peak (July & August) and total fishing season (April-October), 1986-2002 (Crone with data from Konecny 2003).

Figure 48 displays the same type of information, but only includes sales by the resort's marina department. Boat rentals and sales of fishing related items are reflected here. Again, while peak season marina sales are more variable than total peak season sales (displayed in Fig.1), they do not display the strongly decreasing trend of the total and shoulder season marina sales. Between 1992 and 1999, total fishing season marina sales decreased by 49 percent while shoulder season marina sales decreased by 74 percent. These results strongly indicate that the decrease in the quality of the fishery is the primary cause of decreased revenues for the resort. The strong correlation coefficient, .96, between estimated angler trips at the lake and total resort sales between 1989 and 2002 also supports this premise.[178]

[178] Estimated angler trip data was not available for every year, thus the correlation coefficient is for the years 1989, 1994 and 1996-2002.

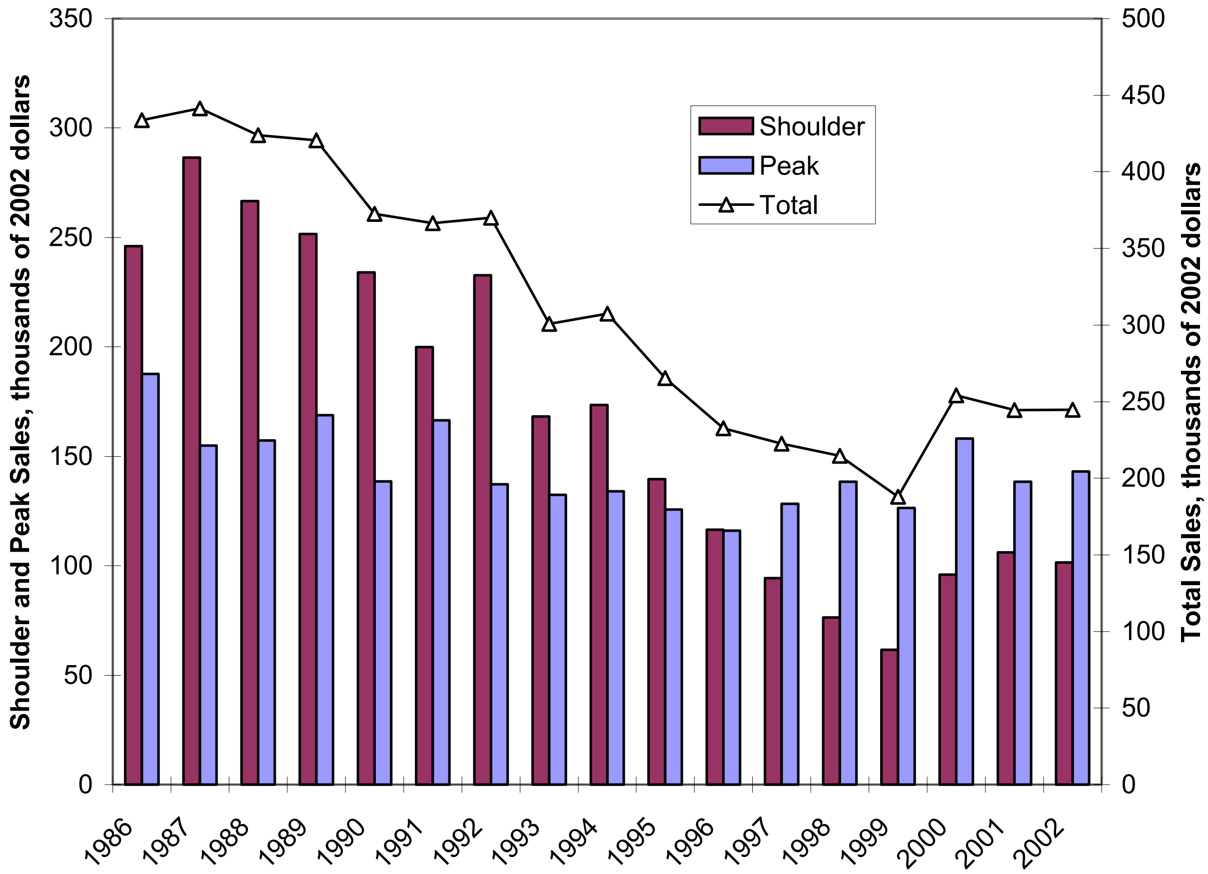

Figure 48. Diamond Lake Resort marina sales for the shoulder (April-June, Sept. & Oct), peak (July & August) and total fishing season (April-October), 1986-2002 (Crone with data from Konecny 2003).

In a letter to the Umpqua National Forest Supervisor, the president of the Diamond Lake Improvement Company states (Koch 2003):

> Recreation at Diamond Lake is driven by successful trout fishing and other lake related activities. With a second infestation of Tui Chubs discovered in 1992 and the temporary mid-summer closure of the lake to water activities due to harmful Algae blooms the past two years, our annual revenue has crashed a crippling $700,000! . . . We have been forced to curtail over 30 summer jobs. . . . We have also cancelled plans for major renovations on our lodging units . . . Always in the past we have been able to save money from the higher summer income to help carry us through the slower season and make the necessary repairs and capital improvements. That opportunity is now gone.

Konecny (2003) provided data documenting that upkeep expenditures at the resort have trended downward, especially over the past five years. She states, "Because of uncertainties surrounding the timing of the lake restoration project and the nature thereof, Diamond Lake Resort is conserving cash to cover fixed costs (such as debt service payments) while the lake restoration project is in progress. The Resort is in the awkward position of needing to upgrade its facilities, but also must conserve cash to weather the lake restoration process."

The number of fishing licenses sold at Diamond Lake Resort between 1996 and 2002 is also highly correlated (.96) with the number of angler trips occurring at the lake. The number of fishing licenses sold at the resort fell by 47 percent between 1996 and 1999 and in 2002 was only 64 percent of the 1996 level.

There is also a permitted recreational vehicle (RV) park on the lake, Diamond Lake RV Park, with 140 RV/trailer sites. The RV Park reported a decrease from 37,800 overnight occasions in 1992 to 21,100 occasions in 1997 (David Evans and Associates 1998).

EFFECTS OF THE FISHERY DECLINE ON LOCAL ECONOMIC ACTIVITY

Table 56 shows the estimated number of angler trips at Diamond Lake from 1975 to 2002 (Unpublished creel survey data, Oregon Department of Fish and Wildlife). Additional discussion on the declining recreational fishery is included in the Recreation Report.

Table 56. Angler trips at Diamond Lake.

	1975	1976	1977	1978	1989	1994	1996	1997	1998	1999	2000	2001	2002
	Angler trips in thousands												
Trips	106.6	90.9	102	138.7	82.4	54.3	35.3	28	10	6	14.1	20	19.8

Using expenditure profiles for local and non-local anglers from a survey and reports prepared for ODFW in 1991 (The Research Group 1991a,b), but modified to reflect Douglas, Jackson and Klamath as the local economic area[179], a reduction in angler trips from the high of 138,700 in 1978 to the low of 6,000 in 1999 resulted in the following roughly estimated economic effects (sales and labor income are reported in 2000 dollars) in the area:

Decline in annual sales: $4.9 million
Decline in annual labor income: $1.4 million
Decline in annual employment: 70 jobs

If anglers from the local region (Douglas, Jackson and Klamath counties) are excluded in the calculation as is usually done in economic impact analysis, the rough estimates are:

Decline in annual sales: $3.2 million
Decline in annual labor income: $1 million
Decline in annual employment: 51 jobs

These are rough estimates because they assume that angler expenditure profiles (inflated to 2000 dollars) in 1978 and 1999 were similar to what they were in 1989, the year the

[179] The industrial structure of the three county region--Douglas, Jackson and Klamath--that existed in 2000 was used in the development of the IMPLAN model used to estimate effects here (Minnesota Implan Group 1999, 2003).

expenditure survey was conducted.[180] Additionally, the local angler expenditure profiles used here are based on estimated angler expenditures by residents of ODFW's southwest zone on trips to fish for trout at lakes or reservoirs within the southwest zone. The ODFW southwest zone includes Douglas, Jackson, Coos, Curry and Josephine counties. Table 57 displays the expenditure profiles from the 1989 survey with expenditures inflated to 2000 dollars (Crone with data from The Research Group, 1991b). The expenditure profile for the local area anglers includes all trip related expenditures whether they occur at home, enroute or at the fishing destination. The expenditure profile for non-local area anglers does not include any at home expenditures, but includes one-half of the enroute expenditures and all of their fishing destination expenditures.

The assumption was also made that thirty percent of the angler trips at Diamond Lake were by residents from the three county local area (local area anglers) while seventy percent of the angler trips were by people from outside this three county region (non-local area anglers). This assumption was based on an analysis of zip code data from the National Visitor Use Monitoring data set for the Umpqua National Forest (U.S. Forest Service 2002) for the subset of visitors surveyed in the Diamond Lake area.

Table 57. Trip related per day angler expenditure profiles for expenditures within the local area.

	Local area angler	Non-local area angler
Expenditure Category	Expenditures in 2000 dollars	
Transportation, gas, etc.	$12.80	$2.87
Lodging	2.08	6.63
Food/drink at stores	11.86	3.33
Food/drink at restaurants	2.28	3.67
Guide and charter fees	.17	0
Boat gas	2.83	1.72
Rental equipment	.40	1.94
Supplies and miscellaneous	5.36	1.44
Other expenses	1.84	1.63
Total	$39.62	$22.94

ENVIRONMENTAL EFFECTS

EFFECTS ON LOCAL ECONOMIC ACTIVITY

The direct effects are those that would affect economic measures (sales, labor, income, and employment) over a six-year period within the Diamond Lake Economic Area. Table 58 displays estimates of the potential direct and indirect effects on local economic activity associated with the predicted amount of angler trips for each alternative for the years 2004 to 2009. The three county region consisting of Douglas, Jackson and Klamath counties is

[180] A recent national survey reports an average of $29 (in 2000$) for trip expenditures per day by U.S. residents fishing in Oregon. (U.S. Dept. of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Dept. of Commerce, U.S. Census Bureau, 2003). This average includes anglers fishing for all types of fish species (cold and warm fresh water species as well as saltwater species) and on all types of waters (rivers, streams, ponds, lakes, reservoirs and oceans).

considered to be the local area and employment is measured as the number of full and part-time jobs[181].

Because all alternatives have the same amount of angler trips predicted for 2004, the local economic activity associated with angler use of the lake is the same across alternatives. In 2005 angler effects on local economic activity are greatest under Alternative 4, followed by Alternative 1, and the least angler related economic activity is generated under Alternatives 2 and 3. In 2006, Alternative 4 again ranks highest followed by Alternatives 3, 2 and 1 in that order. In 2007, Alternatives 2 and 3 generate the same amount of economic activity and rank highest followed by Alternatives 4 and 1, respectively. In 2008, Alternative 2 has the highest predicted amount of angling and associated local economic activity, followed by Alternatives 3, 4 and 1 in that order. By 2009, the predicted number of angler trips under Alternative 2 is 100,000 which correspond to the annual average goal set for Diamond Lake by the Oregon Fish and Wildlife commission in its 1990 management plan. In 2009 the local economic activity generated by anglers under Alternative 2 is 25 percent higher than that generated under Alternative 3, 100 percent higher than that generated under Alternative 4 and 900 percent higher than that generated under Alternative 1.

Table 58. Estimated local economic activity associated with the predicted number of total angler trips by alternative.

		2004	2005	2006	2007	2008	2009	Total
Alt 1	Angler trips	20,000	10,000	10,000	10,000	10,000	10,000	70,000
	Sales	$752,503	$376,251	$376,251	$376,251	$376,251	$376,251	$2,633,759
	Labor Income	$211,563	$105,781	$105,781	$105,781	$105,781	$105,781	$740,469
	Employment	11	5	5	5	5	5	37
Alt. 2	Angler trips	20,000	5,000	25,000	60,000	80,000	100,000	290,000
	Sales	$752,503	$188,126	$940,628	$2,257,508	$3,010,010	$3,762,513	10,911,287
	Labor Income	$211,563	$52,891	$264,453	$634,688	$846,251	$1,057,813	$3,067,659
	Employment	11	3	13	32	42	53	153
Alt. 3	Angler trips	20,000	5,000	30,000	60,000	70,000	80,000	265,000
	Sales	$752,503	$188,126	$1,128,754	$2,257,508	$2,633,759	$3,010,010	$9,970,659
	Labor Income	$211,563	$52,891	$317,344	$634,688	$740,469	$846,251	$2,803,205
	Employment	11	3	16	32	37	42	140
Alt. 4	Angler trips	20,000	30,000	50,000	50,000	50,000	50,000	250,000
	Sales	$752,503	$1,128,754	$1,881,258	$1,881,258	$1,881,258	$1,881,258	$9,406,282

[181] Major assumptions underlying these estimates are: 1) the 1989 expenditure profiles (inflated to 2000 dollars) are representative of expenditure profiles for local area and non-local area anglers for the years 2004 to 2009, under all alternatives; 2) the proportion of local area (30%) and non-local area (70%) angling days at Diamond Lake remains constant for the years 2004 to 2009, under all alternatives; 3) the economic structure of the three county local area does not change significantly between 2000 and 2009; and 4) the predicted amount of angler trips for the years 2004 to 2009 by alternative actually occur.

		2004	2005	2006	2007	2008	2009	Total
	Labor Income	$211,563	$317,344	$528,907	$528,907	$528,907	$528,907	$2,644,533
	Employment	11	16	26	26	26	26	132

Table 58 presents what has been referred to as both a "contribution analysis" and a "significance analysis." In such an analysis the intent is to look at the contribution of expenditures by recreational visitors (in this case anglers) to the economic activity in an area, regardless of whether the expenditures represent an inflow of new money to the area or a recirculation of money already there. If the objective is to capture the impact of only the new money coming into the area, only the expenditures by recreational visitors (in this case anglers) coming from outside the local area should be considered. The results of such an analysis by excluding local area angler expenditures, although the impacts are smaller, the ranking of the alternatives by year is the same as discussed above for Table 58 (See Table 8 in the Economics Report). Additionally, the magnitude of the differences in effects on local economic activity across alternatives in the year 2009 are also exactly the same as discussed above.

In the Recreation section of this DEIS it is suggested that the mix of types of anglers fishing at Diamond Lake may vary by alternative. For example, when comparing Alternatives 3 and Alternative 4, although more fish are likely to be caught, the fish are likely to be smaller under Alternative 3 than under Alternative 4. Additionally, regulations designed to keep predacious fish in the lake to eat the tui chub, may result in more of a "catch and release" fishery in Alternative 4 compared to a harvest fishery in Alternative 3. Thus, Alternative 3 may attract more "family oriented" anglers, while Alternative 4 may attract more "trophy fish oriented" anglers. Because the mix of angler types by alternative was not quantitatively predicted and separate expenditure profiles for different types of anglers do not exist in any case, it is not possible to accurately quantify differences in effects on local economic activity due to different mixes of angler types.

EFFECTS ON DIAMOND LAKE DEVELOPED RECREATION FACILITIES

Under Alternative 1, the predicted number of anglers at Diamond Lake would remain at historically low levels. It is reasonably foreseeable that the angler trips, campground use and revenues, fishing licenses sales, and marina sales by Diamond Lake Resort would continue at depressed levels in the future under Alternative 1. Diamond Lake developed recreation facilities (both public and private) would continue to suffer from reduced use and revenues. Because water quality is not predicted to improve under this alternative, recreational visits may decrease even below current levels for the reasons noted in the Recreation section of this DEIS. This would further dampen revenues at the developed recreation facilities. Considering the past several years of reduced revenues and the predicted continued reduction of revenues, Alternative 1 would have the cumulative effect of a possible permanent reduction in revenues which may lead to the eventual closure of some of the developed recreation facilities at the lake.

Under Alternatives 2 and 3, recreation use is predicted to decrease during the 18-month period when the lake is drawn down, chemicals are applied, reconstruction activities take place, fish are mechanically removed, and water management activities take place during the lake refill period. As recreation use is reduced during this period, direct and indirect revenues at the developed recreation facilities would also be reduced. Direct revenues from workers carrying out the above-mentioned lake restoration activities as well as those from workers engaged in the Diamond Lake Resort marina cleanup and improvement and South Shore Store/Pizza Parlor dock area cleanup projects may offset part of these reduced recreation revenues. Once the predicted number of anglers at the lake starts to increase there is likely to be a corresponding increase in both visitors and revenues at the developed recreation facilities. Water quality is predicted to eventually improve under both Alternative 2 and 3. This improvement is likely to attract returning and new non-angling water based recreation visitors, which may further increase revenues at the developed recreation facilities. When combined with the past reduction in revenues and the predicted increase in revenues as a result of these alternatives, there would likely be a beneficial cumulative effect to the economy of the Diamond Lake Economic Area as improvements in the water quality and recreational fishery result in increased recreation visits over time.

Under Alternative 4 some water based recreational activities are likely to be reduced while the yearly mechanical harvest of tui chub occurs. This would likely result in reduced revenues at the developed recreational facilities during these periods. This reduction may be partially offset by revenues generated from workers engaged in the mechanical harvest activities. As the amount of angling activity increases to 50,000 angler trips in 2006, revenues at the developed facilities are likely to increase. However, since angler trips are predicted to remain at 50,000 each year thereafter, which is substantially below the pre-tui chub amount of angling, it is unlikely that revenues at the developed facilities would increase to their previous levels. Water quality is not predicted to improve until 2009 or 2010 and even that improvement may be minimal. In the meantime, water quality issues may continue to raise concerns by recreational visitors who may choose to go to other areas to recreate, reducing revenues at the Diamond Lake developed facilities. When combined with the past reduction in revenues and the predicted increase in revenues as a result of this alternative, there would likely be a beneficial cumulative effect to the economy of the Diamond Lake Area as improvements in the recreational fishery result in increased recreation visits over time. However, the beneficial effect is likely to be lower than under Alternatives 2 and 3, because angler trips are predicted to increase less and changes in water quality are less certain.

PROJECT IMPLEMENTATION COSTS

Table 59 displays estimates of the costs associated with implementing each of the alternatives for the years from 2004 to 2009. These figures represent best estimates of costs given currently available information. Details on the derivation of individual cost estimates are available from the Umpqua National Forest and are included in the project record. Monitoring activities under Alternative 1 include only water quality monitoring, while the action alternatives include water quality, fish and biological indices monitoring. Alternative 2 would cost substantially less than the others two action alternatives to implement. The different fish stocking strategies explains the difference between Alternative 2 and 3, with the higher expense of raising 12-inch hatchery catchable fish, at over 3 million dollars over the 6 year period, compared to raising fingerlings at only about $177,000 in Alternative 2.

The high costs of Alternative 4 are explained both by expensive fish stocking and labor of tui chub removal.

Table 59. Estimated project implementation costs by alternative.

Alternative	Activity	Cost Estimate
Alt. 1	Monitoring	$404,400
	Lake closure coordination	134,400
	Fish Stocking	171,000
	Total	**$709,800**
Alt. 2	Canal reconstruction	$393,000
	Lake draw down	15,100 – 21,100
	Mechanical fish removal & utilization (commercial operation)	150,000 – 225,000
	ODFW fish removal	50,000
	Rotenone product & application cost	974,300 – 1,024,300
	Fish carcass removal and utilization	60,000 – 100,000
	Lake refill	6,000 – 10,000
	Monitoring	822,200
	Fish stocking	177,000
	Education	50,000 – 100,000
	Total	**$2,697,600 – 2,922,600**
Alt. 3	Canal reconstruction	$393,000
	Lake draw down	15,100 – 21,100
	Mechanical fish removal & utilization (commercial operation)	150,000 – 225,000
	ODFW fish removal	50,000
	Rotenone product & application cost	974,300 – 1,024,300
	Fish carcass removal and utilization	60,000 – 100,000
	Lake refill	6,000 – 10,000
	Monitoring	822,200
	Fish stocking	3,176,000

Alternative	Activity	Cost Estimate
	Education	50,000 – 100,000
	Total	**$5,696,600 – 5,921,600**
Alt. 4	Annual mechanical fish harvest and utilization (commercial operation)	$1,857,000
	ODFW fish removal	270,000
	Monitoring	922,200
	Fish stocking	3,000,000
	Education	50,000 – 100,000
	Total	**$6,099,200 - $6,149,200**

UNAVOIDABLE ADVERSE IMPACTS

Implementation of various alternatives may result in potential adverse environmental effects that may not be mitigated or avoided. The specific effects associated with project activities are discussed throughout this chapter. Interdisciplinary project design helped eliminate or mitigate many potential impacts. All Forest Plan Standards and Guidelines, Best Management Practices (BMPs), and other mitigation measures (found in Chapter 2) also lessen potential effects.

However, the potential still exists for adverse impact. Under Alternatives 2 and 3, any species that breaths through gills (fish or the larval-form of amphibians) or gill-like structures (the larvae of mosquitoes, midges, dragonflies, mayflies, and caddisflies etc., and other bottom dwelling invertebrates like crayfish, leeches, worms, etc.) would unavoidably be killed by the rotenone. However, these life forms are expected to rebound to pre-tui chub conditions within about a year of the treatment. Mitigation (reintroductions) is designed to shorten this period of time for species that are slower to recover. In this context, the species of wildlife that eat either fish from Diamond Lake (osprey, bald eagles, cormorants, fish eating ducks, river otters, etc.) or that eat insects from Diamond Lake (bats, ducks, and other birds, etc.) would experience unavoidable adverse impacts when rotenone kills a major prey base for these species. This, in general, translates to unavoidable impacts such as lower birth rates, stress on individuals, and possible mortality of some individuals unable to seek or transfer to other food sources.

The lake draw down under Alternatives 2 and 3 would also result in a number of unavoidable adverse impacts. As a result of the draw down, Lake Creek would experience a sustained level of bankfull flow for several months, which would not occur otherwise under natural conditions. Following that, a portion of upper Lake Creek would experience no or very little stream flow for several months, while the lower reaches of Lake Creek would experience lower than normal flows for several months. These unnatural flow fluctuations would result in unavoidable adverse impacts to the plants and animals that inhabit the riparian and aquatic ecosystems of this creek, as described in this chapter.

The draw down under Alternative 2 and 3 would also result in unavoidable adverse impact to the shallow aquifer causing changes to the groundwater system. These unavoidable impacts to the ground water system would result in the temporary, partial drying of two wetland habitats associated with Diamond Lake. In this context, the species of plants and animals dependant on wetland habitats would experience some level of unavoidable adverse impacts. A species of mollusk recognized as a survey and manage species in the Northwest Forest Plan would likely experience the loss of some individuals in the population at the Lake Creek wetland, while a species of survey and manage moss would likely experience the same type of impact at the Silent Creek wetland. In both of these cases mitigation (supplemental recolonization of the mollusk population and the addition of water to some of the moss locations) would lessen the level of unavoidable adverse impacts. In all cases, these unavoidable impacts to wetland habitats are not long-term and no species would be extirpated from the project area as a result of either Alternative 2 or 3.

Changes to the ground water system are also expected to result in the temporary drying of some domestic wells located on the west shore of Diamond Lake under Alternatives 2 and 3. The unavoidable adverse impacts to summer home residents on the west shore of Diamond Lake would be partially mitigated (supplying bottled water to west shore residents) to lessen the degree of unavoidable impacts to the domestic water users that tap into the shallow aquifer.

Also under Alternatives 2 and 3, recreationists would experience a temporary, unavoidable loss of access to recreational waters during the rotenone treatment and following it for several weeks. Likewise under Alternative 4, water recreationists would lose access to about 1/3 of the lake for 3 months each summer and fall as fish removal activities occur during June, July and September. These activities would displace and or disrupt recreationists. Under Alternative 1, the reasonably foreseeable periodic lake closures due to toxic algae blooms would exert unavoidable adverse impact to water-oriented recreationists eliminating this type of recreation during closures.

Under Alternative 1, an unavoidable adverse impact could be realized in the form of potential human health impacts from either chronic or acute exposure of water recreationists to algae toxins. This is a long-term unavoidable impact. Alternative 4 would exert a similar degree of unavoidable adverse impacts to human health as Alternative 1, but the length of time of such health risks is expected to be shortened as chub populations slowly decline over a several year period.

Under the Action Alternatives, no Forest Plan Standards and Guidelines would be violated[182], and monitoring is prescribed to ensure that effects are within the limits disclosed and that mitigation measures and BMP's are functioning as planned. All of these unavoidable impacts are disclosed in detail earlier in this chapter.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

[182] Alternatives 2 and 3 require a non-significant amendment to a standard and guideline for the application of rotenone to Diamond Lake and Silent and Short Creeks. This is not a violation of a standard and guideline and is described in detail in this DEIS.

Irreversible and irretrievable both apply to the use of nonrenewable resources such as minerals or cultural resources. Irreversible also includes loss of future options.
For example, some or all of the timber production from a roadway is irretrievably lost during the time the area is used as a road. If the road is decommissioned, timber production can be resumed. The timber production lost is irretrievable, but the action is not irreversible.

Implementation of any of the Diamond Lake Restoration Project alternatives would result in varying levels of irretrievable economic losses such as loss of income associated with sale of recreation goods and services, campground revenues, and associated jobs. The irretrievable economic losses vary by alternative with losses being longer-term and greater under Alternatives 1 and 4 due to the continued depressed fishery compared to a much shorter-term depressed fishery under Alternatives 2 and 3. No irreversible economic losses are anticipated however, under any action alternative since the tui chub problem would be alleviated wholly, or in part, leading to recovered economic parameters. Even under Alternative 1, no irreversible economic losses are anticipated since future options would still exist to address the tui chub problem.

Similarly, recreational experiences associated with water sports on Diamond Lake would be irretrievably lost under all project alternatives. The irretrievable losses of water-oriented recreational experiences such as fishing, boating, swimming, and sailboarding vary by alternative. The periodic lake closures due to toxic algae blooms under Alternative 1 would last into the foreseeable future resulting in long-term irretrievable losses of recreational experiences. The relatively short-term loss of water-related recreation opportunities of Diamond Lake due to the draw down and rotenone treatments under Alternatives 2 and 3 would be irretrievable as would the loss of use of portions of the lake under Alternative 4 every June, July and September. Yet, no irreversible recreation losses are anticipated under any action alternative since the tui chub problem would be alleviated wholly, or in part, leading to enhanced water sports in the long-term. Even under Alternative 1, no irreversible recreational opportunity losses are anticipated since future options would still exist to address the tui chub problem. The Economics and Recreation sections in this chapter describe these conditions in more detail.

SHORT TERM AND LONG TERM PRODUCTIVITY

NEPA requires consideration of the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity (40 CFR 1502.16). It is the intent of this project to continue to manage lake resources so that they are available for future generations. The recreational fishery at Diamond Lake, if recovered, is a renewable resource used by people. Sustaining a renewable recreational fishery depends largely on tui chub control and achieving a balance between the number and type of fish stocked and the effect of that stocking on the native fauna. A rigorous aquatic food chain monitoring strategy is incorporated into all action alternatives to manage the health of the Lake's food chain in concert with fish stocking. As populations of phytoplankton, zooplankton and benthic organisms fluctuate with levels of fish stocking, modifications to fish stocking will be made in order to maintain the long-term productivity and health of the lake. The Lake Ecology, Water Quality, and Aquatic Biology sections of this chapter describe conditions related to short and long-term lake health and productivity. No impacts to soil productivity would occur with this project.

Specifically Required Disclosures

PUBLIC AND WORKER SAFETY

Potential effects to public and worker safety are addressed above under the title Human Health.

CULTURAL RESOURCES

The project area has been surveyed for cultural resources. Mitigation measures for Alternatives 2 and 3 as stated in Chapter 2 would document any findings and impacts during canal reconstruction; with the required mitigation, there would be no adverse effects to cultural resources with these alternatives. Alternatives 1 and 4 would have no adverse effects to cultural resources. No other direct, indirect, or cumulative effects would occur.

UNIQUE HABITATS, WETLANDS AND FLOODPLAINS

Unique habitats within the project area are the wetlands. Potential affects to wetlands are described above under the titles groundwater and terrestrial vegetation. Potential affects to floodplains (Riparian Reserves) are described under the title stream ecology.

PRIME FARMLANDS, RANGELANDS, FORESTLANDS OR PARKLANDS

No prime farmlands, rangelands, forestlands or parklands exist within the area; therefore; no direct, indirect or cumulative effects would occur.

POTENTIAL OR UNUSUAL EXPENDITURES OF ENERGY

The action alternatives would require expenditures of fuel for workers to access the project, use of fuel for barges to transport rotenone, and/or use of fuel for fishing boats during commercial fishing operations. The no action alternative would require minimal expenditure of fuel (only fuel used during monitoring operations). No other direct, indirect, or cumulative effects or other potential uses of energy are expected to occur with any of the alternatives.

CONFLICTS WITH PLANS OR POLICIES OF OTHER JURISDICTIONS

Implementation of any of the alternatives would not conflict with the plans or policies of other jurisdictions, including the Tribes. This project would not conflict with any other policies, regulations, or laws, including the Clean Water Act, Endangered Species Act, and the National Historic Preservation Act. There would be no effects to air quality from exhaust from boat engines (beyond what normally occurs) and compliance with the Clean Air Act would be achieved.

CONSUMERS, CIVIL RIGHTS, MINORITY GROUPS, AND WOMEN

Contracting procedures would ensure that projects made available to contractors through this project would be advertised and awarded in a manner that gives proper consideration to minority and women-owned business groups. Because of this consideration, there would be no direct, indirect, or cumulative effects to consumers, civil rights, minority groups with implementation of any of the alternatives.

ENVIRONMENTAL JUSTICE

On February 11, 1994, President Clinton signed Executive Order 12898. This order directs Federal agencies to address environmental justice by identifying and disclosing the effects of the proposed activities on minority and low-income populations. The effects of the proposed alternatives on the economic conditions of the area are disclosed in the Economics section of this document. The decline in fishing and water recreation activities associated with the large tui chub population has had the greatest affect on communities that rely on Diamond Lake for income. The action alternatives would increase fishing and summer recreation opportunities within 6 years, thereby increasing income to communities that depend on these resources (see Economics section).

According to statistical data for Douglas County, 6.1% of the population is made up of minorities. For Klamath County, 12.6% of the population consists of minority groups, while in Jackson County minorities make up 8.4% of the population (US Census Bureau, Census 2000). As displayed in the Economics section of this document, unemployment and poverty in the tri-county area are higher than the State averages. However, where the economic effects would be greatest (such as in the Diamond Lake area), few minority groups or low-income groups are found. Because of this, very few individuals of minority populations would likely be affected by this project. Individual minority workers or fishing guides may be affected during the draw down and rotenone operations under Alternatives 2 and 3. Low-income populations who may spend time camping at Diamond Lake may also be impacted by during implementation when short-term closures occur. These groups may choose to recreate elsewhere, and would likely not be negatively impacted. However, these effects would end when the lake is refilled and fishing and other recreational activities resume. Overall, none of the alternatives imposes any other additional hardships on minority or low-income communities; therefore, there would be no direct, indirect, or cumulative effects to environmental justice with any alternative.