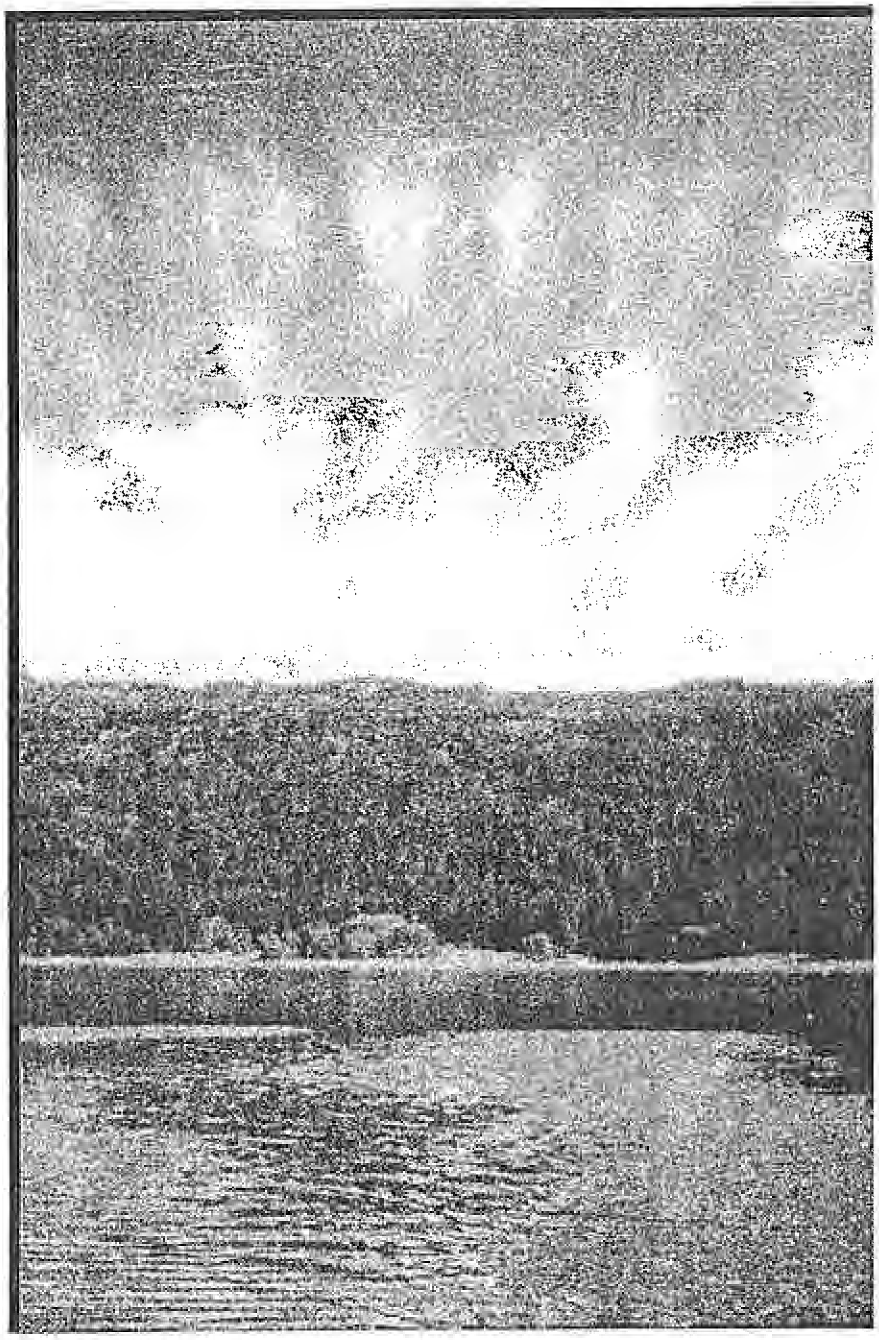
Cascade Reservoir
Phase 1
Watershed Management Plan



Idaho Division of Environmental Quality
Southwest Idaho Regional Office
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CASCADE RESERVOIR
Phase I
Watershed Management Plan

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Foreword

This Watershed Management Plan is a Total Maximum Daily Load and provides a phased solution to water quality degradation in Cascade Reservoir and its tributaries. This plan was developed by the Southwest Idaho Regional Office of the Division of Environmental Quality (DEQ) and is consistent with Idaho Code 39-3611 which concerns the "Development and Implementation of Total Maximum Daily Loads or Equivalent Processes." The objective of the plan is to restore water quality in Cascade Reservoir and its tributaries to a level that protects beneficial uses. The plan identifies who will implement the plan, ongoing assessment of the success of the plan and how implementation will achieve the objectives of the plan.

It is important to note that correction of the water quality problems in Cascade Reservoir will not happen overnight. Successful implementation of this plan requires a coordinated effort of planning and best management practice implementation involving the concerned governmental agencies and land owners in the watershed over the next several years.

Acknowledgements

A very large portion of the land in the watershed is forest land and is managed as national forest or is privately owned by Boise Cascade Corporation. The efforts of the Boise and Payette National Forests and Boise Cascade Corporation in the project are critical to its success. Their continuing support is very much appreciated.

We would like to acknowledge the Idaho Soil Conservation Commission, the Idaho Department of Fish & Game, the Natural Resource Conservation Service, the Bureau of Reclamation, the Valley Soil and Water Conservation District, Valley County, the City of Cascade and the Cascade Reservoir Association for their participation in meetings, contributions of important background information and their assistance with management and implementation of the project.

On behalf of the Southwest Idaho Regional Office of DEQ, we wish to expressly acknowledge the Cascade Reservoir Coordinating Council, the Technical Advisory Committee and all the subwatershed work groups for their support in this effort.

Finally, we thank the citizens of the State of Idaho and surrounding states for putting Cascade Reservoir on the map by continually supporting it for its existing recreational attributes and for being strong advocates for its restoration. This continued support has helped maintain the reservoir as an essential fishery in the state.

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1.0 Introduction

The purpose of this plan is to establish an approach to improve water quality in Cascade Reservoir. Cascade Reservoir has been identified as water quality limited because it is not in compliance with Idaho water quality standards. Specifically, designated beneficial uses for the reservoir, including fishing, swimming, boating and agricultural water supply, are impaired because of excessive algal growth. The cause of these existing conditions has been identified as excessive phosphorus loading to the reservoir from the surrounding watershed. The water quality of Cascade Reservoir has been identified as impaired as specified under Section 303(d) of the Clean Water Act (CWA). Section 303(d) requires each state to submit a biennial list to the Environmental Protection Agency (EPA) which identifies those waters throughout the state that are not achieving state water quality standards in spite of the application of technology-based controls in National Pollutant Discharge Elimination System (NPDES) permits and Best Management Practices (BMPs) for nonpoint source. Such water bodies are known as "water quality-limited." After identification of a water quality limited segment, the state must then develop a total maximum daily load (TMDL) for each pollutant that is impairing protected uses. TMDLs are first developed on water quality limited segments identified by the state as high priority waters. Once the state has identified the actual pollutant load discharged from both point and nonpoint source activities, controls can be implemented to reduce the daily load of pollutants until the water body is brought back into compliance with water quality standards. Once developed, TMDLs are submitted to the EPA for approval. Congress mandated that the EPA identify water quality limited segments and develop TMDLs if the state does not fulfill its responsibilities under Section 303(d) of the CWA. The Idaho Department of Health and Welfare (IDHW), Division of Environmental Quality (DEQ) is directed by state statute (*see* Idaho Code Section 39-3601 *et seq.*) to develop TMDLs.

1.1 History

The water quality of Cascade Reservoir has been monitored periodically over the past twenty years (Clark & Wroten, 1975; Klahr, 1988; Klahr, 1989; Entranco, 1991; Ingham, 1992; Worth 1993 and 1994). Past monitoring has indicated that water quality within Cascade Reservoir is clearly impaired from an abundance of nutrients entering the reservoir through the many streams and from overland runoff. Phosphorus is the pollutant of concern that stimulates the growth of noxious aquatic weeds and algae blooms. In 1975, Clark & Wroten reported that water quality within the reservoir was good yet slightly eutrophic, noting that orthophosphate was conducive to algal growth. Later reports demonstrated that phosphorus was entering the reservoir from nonpoint sources, primarily from spring runoff and irrigation returns, and from point sources. Continued input of phosphorus and fluctuations in water level within the reservoir have led to eutrophic conditions in the reservoir.

1.2 Major Water Quality Concerns and Priority Issues

1.2.1 Issues of Concern

Dense mats of blue-green algae on Cascade Reservoir in the summers of 1993 and 1994 signaled a further decline in water quality. In September 1993, twenty-three cattle died by ingesting toxins produced by blue-green algae from the reservoir, and public health advisories were issued by IDHW, Division of Health suggesting that contact with the reservoir should be avoided. These events and the surrounding media attention have fostered renewed efforts by public interest groups and resource management agencies to correct long standing water quality problems in Cascade Reservoir.

The reservoir experienced poor water quality in 1993, a normal runoff year, due to increased input of phosphorus which encouraged the growth of excess algae as measured by chlorophyll a concentrations. Even though phosphorus loads decreased in 1994, the reservoir continued to experience poor water quality due to low flows, decreased dissolved oxygen (DO), warm water temperatures and internal recycling of nutrients. These conditions placed tremendous stress on the reservoir's fish population. A substantial fish kill occurred and a fish salvage effort was initiated. For these two water years, all beneficial uses were impacted.

Several other factors are major concerns for Cascade Reservoir. The reservoir is a shallow man-made water body with a mean depth of 25 feet at full pool. As such, it is highly susceptible to eutrophication due to nutrient loading and elevated summer water temperatures within the watershed.

Internal recycling of existing phosphorus in the reservoir is a concern. This source is estimated to contribute about 19% of the annual phosphorus load to the reservoir. Reduction of this source is accomplished in smaller systems by dredging. Dredging the shallower portions of a reservoir the size of Cascade would be very costly and may cause significant water quality problems through disturbance of the sediments.

Drawdown of the reservoir is another concern. A minimum conservation pool of 300,000 acre-feet is currently in place for the reservoir. The pool was administratively established by the U. S. Bureau of Reclamation (BOR) to provide a sufficient zone of oxygenated water for winter fish survival. There is evidence that this volume is not sufficient to protect fish populations during the summer months. In addition, summer water quality concerns were not adequately considered in establishing the pool. BOR, DEQ and the Idaho Department of Fish and Game (IDFG) will study pool elevations in relation to DO and nutrient concentrations in the future to determine a suitable conservation pool to protect the fishery and other beneficial uses throughout the year.

Cascade Reservoir has been identified as water quality limited due to violations of water quality standards for DO, temperature and pH. Adequate DO is a fundamental measure of the waterbody's ability to support aquatic life. Ambient water quality monitoring indicates that

Cascade Reservoir experiences periodic low DO levels during the summer months. Elevated temperatures and algal productivity influence DO levels.

Water quality data collected by DEQ in 1993 and 1994 reveal a significant phosphorus load during spring runoff. The condition of the some parts of the watershed, especially riparian areas, may be contributing to this situation. As spring flows increase, degraded riparian areas contribute to increased phosphorus loads with accelerated runoff due to inadequate holding capacities.

Phosphorus is often the most important nutrient which limits growth of algae in lakes and reservoirs. However, nitrogen is also an important nutrient which affects the growth of algae. The balance of these two nutrients can influence the type of algae species that grow and dominate a lake or reservoir. Although water quality data from Cascade Reservoir suggest that phosphorus supply is largely responsible for the prevalence of algae, the quantity and concentrations of nitrogen entering the reservoir contribute to the growth of algae blooms.

1.2.2 Tributaries to the Reservoir

Two tributaries of Cascade Reservoir are listed as Special Resource Waters under the IDHW Rules, IDAPA 16.01.02, Water Quality Standards and Wastewater Treatment Requirements, Lake Fork Creek and Gold Fork River. The criteria for special resource waters are discussed in Section 2.2.3. Both of these streams contribute elevated phosphorus loads during the water year. Diversion of a significant portion of these streams during the irrigation season reduces potential fish habitat, increases water temperatures, and decreases DO as flows reach the reservoir. The condition of the riparian areas of these tributaries varies from poor to excellent.

In Water Year (WY) 1994, Boulder Creek contributed about 3% of the water volume of the reservoir, but it also had the highest average concentration of phosphorus in the watershed. Boulder Creek is almost totally diverted for irrigation during the summer months. Degraded riparian areas contribute to increased sediment loading from this watershed.

1.2.3 Geographic Areas of Special Concern

Water quality conditions in Cascade Reservoir and the surrounding watershed are of great concern to the residents of Valley County because the watershed contains many popular hiking, bicycling, camping, boating, water skiing, fishing, hunting, snowmobiling, cross country skiing and other outdoor opportunities. The reservoir was once the state's most popular fishery, but today ranks ninth in the state in angler hours. It also provides storage for downstream irrigation needs.

The community's commerce, tourism, jobs, and the beauty of the area around Cascade Reservoir as a vacation retreat depend upon the quality of the water in the reservoir and its watershed. Valley County is one of the fastest growing areas in Idaho. The national compounded growth rate in the last three years has been 1.0%, Idaho's growth rate has been 2.7%, and Valley

County's growth rate has been 3.7%. At this rate, Valley County will have 4,030 more residents by the year 2000, and that doesn't include the transient population related to tourism. The University of Idaho estimates that in 1993 one million people in the category "travel & tourism" (which includes everyone not a resident of the area) passed through or stopped in Valley County. This far exceeds that of a decade ago and will surely increase as more people discover Cascade Reservoir and its watershed.

Habitat of the Bald Eagle, a threatened species, is another important consideration. There are several pairs which nest around the reservoir and rely upon the surrounding ecosystem, including fish in the Reservoir, for their source of food. Bald Eagles cycle through two stages of habitat use. During the spring and summer, they are widely dispersed and often associate with family groups. The distribution of Bald Eagles changes in the winter as they migrate and concentrate at specific sites within the winter range (United States Fish and Wildlife Service, 1986).

Bald Eagle nests are usually located in uneven aged, multi-storied stands with old growth components. Bald Eagles usually nest in the same areas each year and often use the same nests repeatedly. Large cottonwoods, Ponderosa pines and Douglas firs are used. Snags, trees with exposed lateral limbs, or with dead tops are often present in nesting territories and are used for perching or as access points to and from the nest. Forests with suitable nest and perch trees are critical to Bald Eagle populations. Bald Eagles are particularly intolerant of human disturbance during the breeding season (late February to May). They are generally more sensitive to disturbance during courtship, egg laying, and incubation. Their sensitivity decreases as young develop.

Nest sites are distributed around the periphery of the reservoir, usually within 2.4 miles of shore. The eagles use shallow areas, gently sloping shorelines and wetlands. Important prey for eagles include fish, birds and mammals.

1.2.4 Plan Goals and Objectives

To improve the quality of water in Cascade Reservoir and its tributaries, the current contribution of phosphorus from external sources must be reduced by 37% and this reduction must be maintained for a period of five years (see Section 4). This target reduction will be used as the preliminary goal for Cascade Reservoir. The goal includes a 7% margin of safety. The reduction level was established through the use of a model designed specifically for Cascade Reservoir (Chapra, 1990). A 37% reduction in loading was selected because it is anticipated to result in water quality improvements that reach the desired criteria of 10 μg/l chlorophyll a and 0.025 mg/l total phosphorus in the reservoir. The model suggests that these concentrations are needed to reduce excessive algae growth in the reservoir. Additional data analysis and modeling planned for Phase II may indicate a need to change the reduction goal.

The goal of this plan is to achieve state water quality standards in Cascade Reservoir and its tributaries. This goal will be accomplished by focusing efforts on reducing the source and transport of nutrients throughout the watershed. Reduction in the quantity of nutrients entering the reservoir will, in time, modify chemical and biological processes and result in improved water quality. Key components of this plan are:

- establishment of measurable objectives (load reductions) for improvement of water quality;
- timely implementation of specific management actions to achieve load reductions;
- monitoring assessment of the success of load reduction goals;
- ensuring meaningful public involvement in implementation of the plan through the local coordinating council and subwatershed work groups;
- identification of a comprehensive watershed management plan that effectively expresses to the public and policy makers the rationale, approach and long-term strategies for water quality problem solving, and pollution prevention;
- consolidation of various state and federal assessment and reporting requirements into a single plan to improve efficiency in resource use; and
- identification of innovative management approaches that both protect Idaho's surface and ground water and allow for sound economic planning and growth.

1.2.5 Watershed Approach

This plan utilizes a watershed approach to address water quality concerns because pollutant sources throughout the geographic area drain into the reservoir (watershed) and contribute to water quality problems. Each subwatershed affecting the reservoir is being managed to address its own individual characteristics and the needs of those who live, recreate and work there. The watershed approach is holistic and encourages community-based problem solving. This Watershed Management Plan (plan) constitutes the equivalent of a TMDL and is consistent with Idaho Code 39-3601.

The plan will have three phases:

Phase I — Establish initial nutrient reduction goal and implementation strategy.

Phase II — Further evaluation of phosphorus reduction goals and possible alternatives and development of a more detailed implementation plan.

Phase III — Plan evaluation and modification.

Total Maximum Daily Load

The TMDL process is described in Section 303(d) of the CWA (40 CFR 130.7. TMDLs are plans designed to direct management actions so that polluted water bodies are restored to a level that achieves state water quality standards. A TMDL is a mechanism for determining how much pollutant a waterbody can safely assimilate (the loading capacity) without violating state water quality standards. An essential component of a TMDL is identifying the current volume and sources of pollutants discharged to the waterbody. Thereafter, a determination can be made identifying the amount of pollutants each source may discharge (the allocations). Point sources of pollution, those discharges from discrete pipes or conveyances, will receive a wasteload allocation (WLA) which specifies how much of the pollutant each point source can release to the waterbody. Nonpoint sources of pollution, all other activities causing pollution in the reservoir, will receive a load allocation (LA), which specifies how much pollutant can be released to a waterbody.

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{margin of safety}$$

Loading capacity is established taking into account seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between pollution control mechanisms and water quality. Calculating the exact pollutant load for pollutants running off the land (nonpoint sources) is difficult and often dependent on weather conditions. Therefore, a phased TMDL is necessary which identifies interim load allocations, with further monitoring to gauge the success of management actions in achieving load reduction goals and the affect of actual load reductions on the water quality in the reservoir.

2.0 General Watershed Description

2.1 Physical/Geographic/Features

Cascade Reservoir is located in the Payette River Basin in Valley County, Idaho (See Figure 2.1). Upper Payette Lake forms the headwaters of the basin, followed by Big Payette Lake, the North Fork Payette River and Cascade Reservoir. The North Fork Payette River eventually discharges into the main Payette River near Banks, Idaho, 35 miles downstream. The watershed is approximately 357,000 acres. Major tributaries to the reservoir include the North Fork Payette River, Mud Creek, Lake Fork, Boulder Creek, Gold Fork River, and Willow Creek.

The reservoir is located in the lower end of a moderately high elevation (4,800 feet) valley between West Mountain to the west and the Salmon River Mountains to the east. The watershed is transitional ecologically with the western half of the valley found within the Blue Mountains ecoregion (Omernik & Gallant, 1986), which is characterized by mountain ranges separated by fault valleys and synclinal basins. The eastern and northern sections of the watershed are found within the Northern Rockies ecoregion with geology and soils typical of the northern portion of the Rocky Mountains. The geology and coarse-textured soils of the region are influenced primarily by the crystalline igneous rock of volcanic origin known as the Idaho Batholith. Natural vegetation in the watershed includes spruce/fir forests, mountain grass/forb meadows and various riparian/wetland complexes.

2.1.1 Project Area

The project area is represented in Figure 2.2. There are twelve subwatersheds in the Cascade Reservoir watershed. Nine of these subwatersheds are addressed in this plan. They are the North Fork Payette River, Mud Creek, Lake Fork Creek, Boulder Creek, Willow Creek, Gold Fork River, Kennally Creek, Cascade (east side of the reservoir) and West Mountain. For the purposes of this plan, Kennally Creek is included in the Gold Fork River subwatershed because it does not drain directly into Cascade Reservoir. Lake Fork Creek above Little Payette Lake is combined with the lower portion of that subwatershed. Big Payette Lake contains two subwatersheds and is being addressed in a separate project coordinated by the Big Payette Lake Water Quality Council. Therefore, this plan will reference eight subwatersheds.

2.2 Land Use/Demography

2.2.1 Population

There are several towns and villages located along State Highway 55 which parallels the North Fork Payette River through most of the watershed. These towns include McCall, Lake Fork, Donnelly, Roseberry and Cascade. A thriving tourist and recreational industry exists within the watershed. This accounts for a significant transient (non-county resident) population. The most popular destinations include Ponderosa State Park near McCall, Big Payette Lake, Cascade Reservoir and Brundage Ski Area. There is extensive vacation home development around both the lake and the reservoir.

Figure 2.1.

Cascade Reservoir Watershed

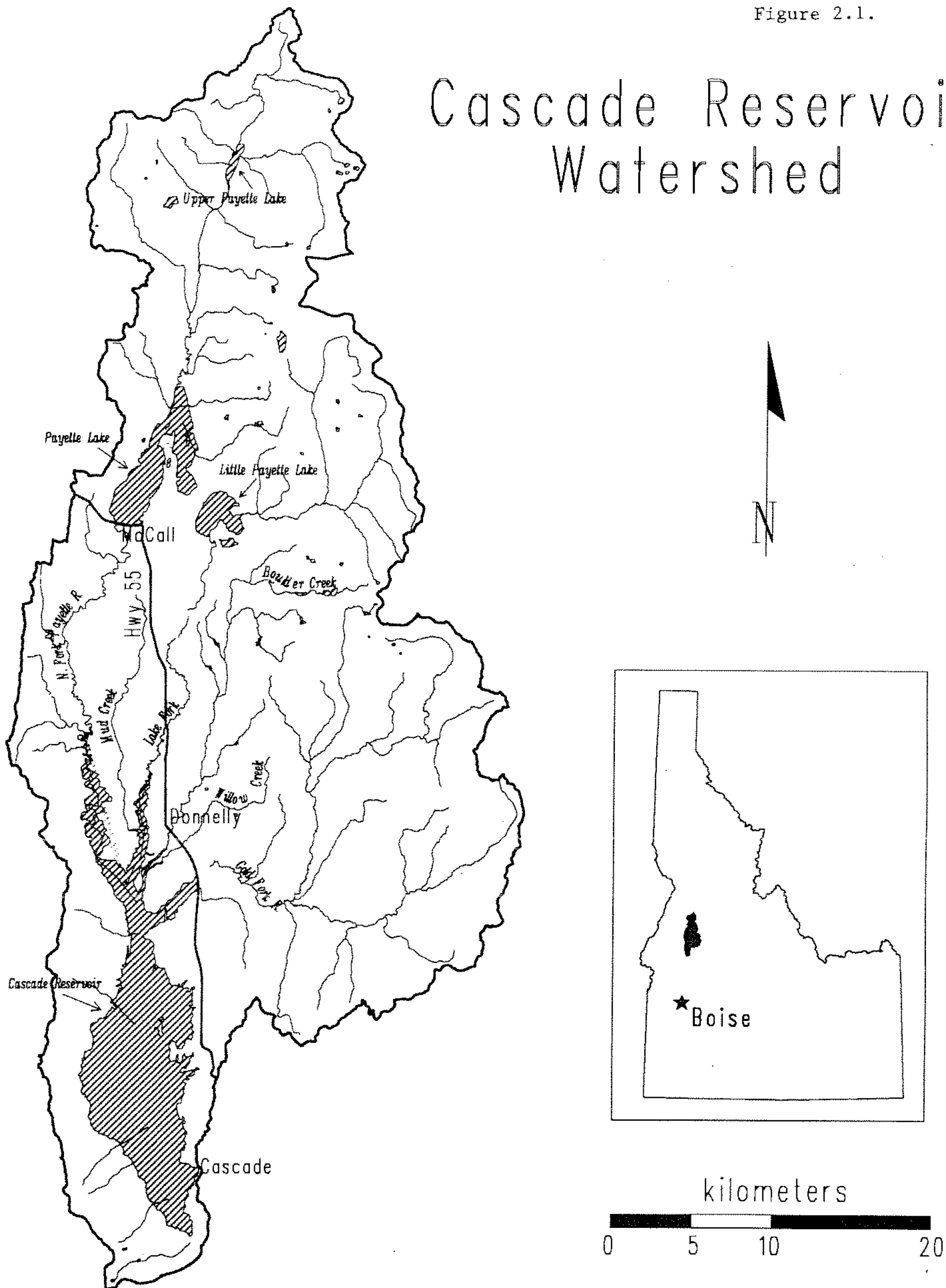

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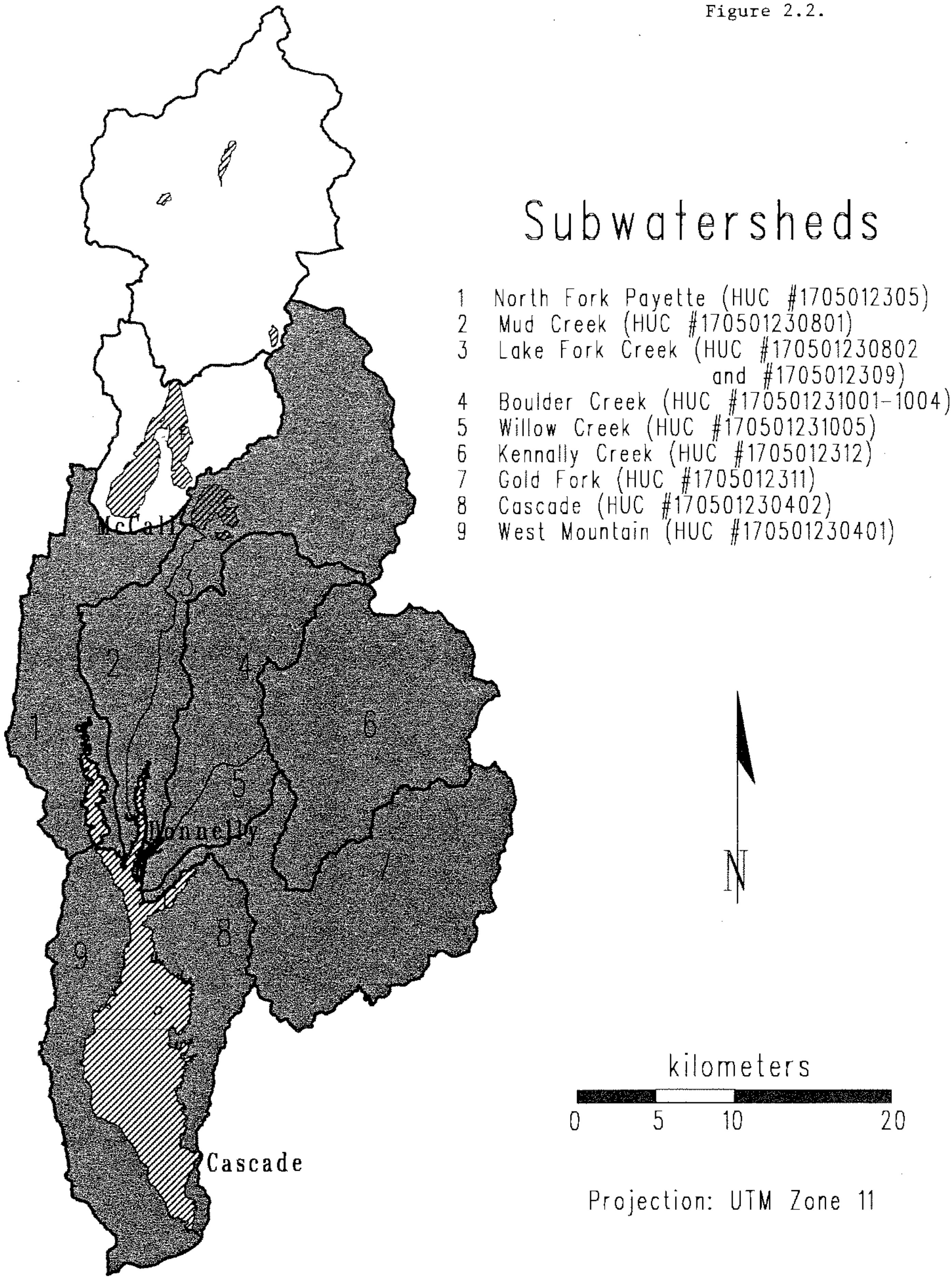
Figure 2.2.



Subwatersheds
1 North Fork Payette (HUC #1705012305)
2 Mud Creek (HUC #170501230801)
3 Lake Fork Creek (HUC #170501230802 and #1705012309)
4 Boulder Creek (HUC #170501231001-1004)
5 Willow Creek (HUC #170501231005)
6 Kennally Creek (HUC #1705012312)
7 Gold Fork (HUC #1705012311)
8 Cascade (HUC #170501230402)
9 West Mountain (HUC #170501230401)
McCall
Donnelly
Cascade
1
2
3
4
5
6
7
8
9
N
kilometers
0
5
10
20
Projection: UTM Zone 11

The following population statistics for Valley County are from the Valley County Comprehensive Plan (1995).

	Population
Total Unincorporated Areas in Valley County	4,023
City of McCall	2,604
City of Cascade	1,120
City of Donnelly	173
Total Valley County Population	7,920

2.2.2 Land Use Characteristics

The watershed is predominantly forested (approximately 71%), both public and private (Entranco, 1991). The three largest land owners are the Boise National Forest (BNF), Payette National Forest (PNF), and Boise Cascade Corporation (BCC). The state also owns a large piece of land north and east of Payette and Little Payette Lakes and smaller portions throughout the eastern side of the watershed. Most of the valley between Payette Lake and Cascade Reservoir is privately owned and used for agricultural purposes including irrigated and non-irrigated cropland (approximately 2%), and irrigated and non-irrigated pasture and rangeland (approximately 21%). The remaining 6% of the watershed consists of water bodies and urban/residential areas. The rate of construction of recreational homes in the watershed has increased in the last four years.

2.2.3 Special Designations and Listings

Numerical Water Quality Standards

The Idaho Water Quality Standards and Wastewater Treatment requirements establish numerical criteria for water quality parameters based on designated beneficial uses. DO is a critical parameter for the protection of aquatic life. The State of Idaho water quality standards establish the following criteria for minimum concentrations of DO in lakes and reservoirs:

> "DO concentrations exceeding 6 mg/l at all times. In lakes and reservoirs this standard does not apply to:
>
> (1) The bottom 20% of water depth in lakes and reservoirs where depths are thirty-five (35) meters or less.
>
> (2) Those waters of the hypolimnion in stratified lakes and reservoirs."

Water Quality Standards

The CWA requires each state to protect their surface waters from pollution. State waters are protected through adoption and enforcement of the Idaho water quality standards. A water quality standard defines the water quality goals of a particular water body by designating the use or uses to be made of the water and establishing numerical and narrative criteria (ambient conditions) necessary to protect the designated and "existing" uses. Existing uses are those surface water uses actually attained on or after November 28, 1975, whether or not they are designated uses. States are to take into account such uses as public, agricultural and industrial water supplies, protection and propagation of fish, shellfish and wildlife, and recreation in and on the water when establishing designated uses for water bodies. Idaho has adopted water quality standards, which are found under the IDHW Rules, IDAPA 16.01.02, Water Quality Standards and Wastewater Treatment Requirements.

Idaho has established the following uses and criteria for its water bodies:

All Waters: Are protected through general surface water quality criteria. Narrative criteria prohibit ambient concentrations of certain pollutants which impair designated uses. Narrative criteria established in Idaho water quality standards include: hazardous materials, toxic substances, deleterious materials, radioactive materials, floating, suspended or submerged matter, excess nutrients, oxygen demanding materials and sediment (IDAPA 16.01.02.200).

Agricultural Water Supply: Waters which are suitable or intended to be made suitable for the irrigation of crops or as drinking water for livestock (IDAPA 16.01.02.100.01.a). Criteria: Numeric criteria as needed derived from the EPA's Blue Book (IDAPA 16.01.02.250.03.b).

Domestic Water Supply: Waters which are suitable or intended to be made suitable for drinking water supplies (IDAPA 16.01.02.100.01.b). Criteria: Numeric criteria for specific constituents and turbidity (IDAPA 16.01.02.250.03.a).

Industrial Water Supply: Waters which are suitable or intended to be made suitable for industrial water supplies. This use applies to all waters of the state (IDAPA 16.01.02.100.01.c). Criteria: General surface water quality criteria (IDAPA 16.01.02.200).

Cold Water Biota: Waters which are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species which have optimal growing temperatures below 18°C. (IDAPA 16.01.02.100.02.a). Criteria: Numeric criteria for pH, DO, gas saturation, residual chlorine, water temperature, ammonia, turbidity, and toxics (IDAPA 16.01.02.250.02.a and c).

Warm Water Biota: Waters which are suitable or are intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species which have optimal growing temperatures above 18°C

(IDAPA 16.01.02.100.02.b). Criteria: Numeric criteria for pH, DO, gas saturation, residual chlorine, water temperature, ammonia, and toxics (IDAPA 16.01.02.250.02.a and b).

Salmonid Spawning: Waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes (IDAPA 16.01.02.100.02.c). Criteria: Numeric criteria for pH, gas saturation, residual chlorine, DO, intergravel DO, water temperature, ammonia, and toxics (IDAPA 16.01.02.250.02.a and d).

Primary Contact Recreation: Surface waters which are suitable or are intended to be made suitable for prolonged and intimate contact by humans or for recreational activities when the ingestion of small quantities of water is likely to occur. Such waters include, but are not restricted to, those used for swimming, water skiing or skin diving (IDAPA 16.01.02.100.03.a). Criteria: Numeric criteria for fecal coliform bacteria applied between May 1st and September 30th (recreation season) (IDAPA 16.01.02.250.01.a).

Secondary Contact Recreation: Surface waters which are suitable or are intended to be made suitable for recreational uses on or about the water which are not included in the primary contact category. These waters may be used for fishing, boating, wading, and other activities where ingestion of raw water is not probable (IDAPA 16.01.02.100.03.b). Criteria: Numeric criteria for fecal coliform bacteria (IDAPA 16.01.02.250.01.b).

Wildlife Habitats: Waters which are suitable or are intended to be made suitable for wildlife habitats. This use applies to all surface waters of the state (IDAPA 16.01.02.100.04). Criteria: General surface water quality criteria (IDAPA 16.01.02.200).

Aesthetics: This use applies to all surface waters of the state (IDAPA 16.01.02.100.05). Criteria: General surface water quality criteria (IDAPA 16.01.02.200).

Special Resource Water: Those specific segments or bodies of water which are recognized as needing intensive protection to preserve outstanding or unique characteristics. Designation as a special resource water recognizes at least one of the following characteristics: a) the water is of outstanding high quality, exceeding both criteria for primary contact recreation and cold water biota; b) the water is of unique ecological significance; c) the water possesses outstanding recreational or aesthetic qualities; d) intensive protection of the quality of the water is in paramount interest of the people of Idaho; e) the water is a part of the National Wild and Scenic River System, is within a State or National Park or wildlife refuge and is of prime or major importance to that park or refuge; f) intensive protection of the quality of the water is necessary to maintain an existing but jeopardized beneficial use (IDAPA 16.01.02.054). Special resource waters receive additional point source discharge restrictions (IDAPA 16.01.02.054.03 and 400.01.b).

Designated uses are established for water bodies when it is determined that such use is attainable (except for Industrial Water Supply, Aesthetic and Wildlife uses which are applied to all water bodies in the state). For example, a particular water body may be designated for Domestic Water Supply, Cold Water Biota, and Primary Contact Recreation based on an assessment of the stream's physical, chemical, and biological (including habitat) characteristics although such uses may not be presently existing for that water body. If the water body is capable of supporting these uses based on the assessment, then the water body should be designated for those uses in the state's water quality standards. Once designated, the use is protected from impacts that may impair the use through application of numerical and narrative water quality criteria.

Currently, Idaho has classified all the major rivers and reservoirs in the state with specific designated uses. However, most tributaries to these water bodies are not classified. Unclassified waters are automatically designated for primary contact recreation unless the physical characteristics of the water body prevent primary contact recreation. In those cases, the water body is designated for secondary contact recreation.

Existing uses of waters that are not designated are also protected. Both federal and state rules protect existing uses through the antidegradation policy (*See* Idaho Code Section 39-3603 and IDAPA 16.01.02,051). Impacts to existing uses are best prevented through provisions in the water quality standards intended to protect designated uses.

Idaho has designated uses for water bodies within the Cascade Reservoir watershed as follows:

NORTH FORK PAYETTE RIVER - source to McCall.

Domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary and secondary contact recreation, and special resource water.

NORTH FORK PAYETTE RIVER - McCall to Cascade Dam (includes the reservoir).

Domestic water supply, agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation.

LAKE FORK OF THE NORTH FORK PAYETTE RIVER - source to mouth.

Domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary and secondary contact recreation, and special resource water.

GOLD FORK OF THE NORTH FORK PAYETTE RIVER - source to mouth.

Domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary and secondary contact recreation, and special resource water.

NORTH FORK PAYETTE RIVER - Cascade Dam to mouth (Banks).

Domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary and secondary contact recreation, and special resource water.

All other water bodies within the watershed are unclassified, thus, they are automatically designated for primary contact recreation only.

Idaho had included the Cascade Reservoir on its water quality limited list due to impairment from excess nutrients. The reservoir was listed as a high priority for TMDL development. A number of additional water bodies in the watershed were added to the water quality limited list. Table 2.1 lists water quality limited water bodies and pollutants within the watershed affecting the reservoir.

Table 2.1. Water quality limited water bodies.

Water Body	Boundaries	Pollutants	Potential Criteria
Mud Creek	source to reservoir	nutrients, sediment, pathogens, ammonia	General - nutrients, sediment. Numerical - DO, ammonia, turbidity, intergravel DO
Boulder Creek	source to reservoir	nutrients, sediment, thermal modification, flow alteration	General - nutrients, sediment. Numerical - DO, temperature, turbidity, intergravel DO
Gold Fork River	Flat Creek to reservoir	nutrients and sediment	General - nutrients, sediment. Numeric - turbidity, intergravel DO
Brown's Pond	on Lake Fork	habitat alteration	unknown
Campbell Creek	Boise National Forest	sediment	General - sediment. Numeric - turbidity, intergravel DO
French Creek	Boise National Forest	sediment	General - sediment. Numeric - turbidity, intergravel DO
Hazard Creek	Boise National Forest	sediment	General - sediment. Numeric - turbidity, intergravel DO

The watershed management plan will be implemented to improve water quality in all of the water quality limited tributaries of Cascade Reservoir.

3.0 Inventory of Pollutant Sources and Loads

3.1 Major Categories and Types of Pollutants

3.1.1 Point Source Pollution

Only two point sources of pollution presently contribute nutrients and other constituents to Cascade Reservoir. Both facilities discharge wastewater directly to the North Fork Payette River upstream of Cascade Reservoir under NPDES permits. The City of McCall operates a wastewater treatment plant designed to treat 1.8 million gallons per day (MGD.) Average daily flow is approximately 0.7 MGD but peak flows have been reported at 2.3 MGD due to infiltration of ground water and snow melt. Ground water and snow melt sources contribute as much as 1.6 MGD on a seasonal basis to the base flow from domestic sources (J.U.B., 1995). A second facility is operated by the IDFG Fish Hatchery at McCall, Idaho. The hatchery utilizes approximately 20 cubic feet per second (cfs) (12.9 MGD) of water for maintenance and growth of Chinook Salmon stocks.

3.1.2 Nonpoint Source Pollution

Nonpoint sources of pollution affecting Cascade Reservoir include forest management practices, agricultural management (crop and grazing management), recreational impacts (campgrounds, parks, boat ramps), urban runoff, nutrient enriched ground water from septic tanks in close proximity to the reservoir shoreline or tributary streams, shoreline erosion, and internal recycling of nutrients. Studies performed by Clarke, 1995, indicate that stream channel erosion accounts for more than 40% of the total sediment yield to the reservoir.

Forest Management Sources

Major pollutants associated with forest management activities include sediment and nutrients. Related impacts are alteration of stream temperature and flow. Erosion associated with construction of roads (cut and fill), land slides on unstable slopes, erosion of road surfaces, and erosion of harvest areas are the primary sources of sediment. Material deposited in streams can be quickly transported to the reservoir during high stream flows. Sediment materials deposited in streams during low flow conditions may be re-suspended during the next high flow event. Additional sediment is produced by channel enlargement (bed and bank erosion)(Clarke, 1995). Virtually all of the forested lands within the Cascade Reservoir watershed have an extensive network of logging roads.

Geology of the forest lands may be conducive to erosion and production of sediments. Much of the Cascade Reservoir watershed is contained within the Idaho batholith (Schmidt and Mackin, 1970) which includes all forest lands east of the reservoir. Geology of forest lands west of the reservoir is about 6% basalt and related volcanics; 60% granitic rocks, gneiss and schist; 30% glacial moraine; and 4% glacial outwash (Clarke, 1995). Most of the forest lands in the Gold Fork River subwatershed (the largest forested subwatershed) are comprised of decomposing granitics. This material is highly erodible and surface soils often contain fine particulate materials that are easily transported. Natural sediment yields for Upper Kennally Creek have been estimated at 4 to 45 tons/mi^2/yr (average 400 tons/yr; PNF, 1994). Cumulative sediment yields for the Gold Fork River subwatershed have been estimated at 1,281 tons/yr (BNF,1993).

Grazing impacts (cattle and sheep) on forest lands are an additional source of nutrients and sediment due to stream bank disturbance and removal of riparian vegetation with associated increases in stream temperatures. Extensive portions of forest land within the Cascade Reservoir watershed are utilized for grazing, particularly lands on the west shore of the reservoir where steep mountain slopes grade to the valley floor. Many of the streams within forest lands have been impacted by grazing.

Agricultural Sources

Primary sources of pollutants associated with agriculture are sediment and nutrients. Related impacts are alteration of stream flows and temperatures. The predominant agricultural practice is cattle grazing. Each spring, large numbers of cattle are brought into the valley and remain until fall. Croplands (approximately 5,000 acres) comprise about 8% of the total agricultural land (63,150 acres).

Impacts from grazing include direct and indirect nutrient enrichment of streams, bacterial contamination, unstable stream banks due to trampling and increased sedimentation. One of the sources of sediment delivery to streams is sheet and rill erosion of pasture land. Improper grazing management can result in over utilization of pastures causing soil compaction and a reduction of ground cover. These conditions can reduce water infiltration and result in increased runoff and export of nutrients. The Valley Soil and Water Conservation District (VSWCD) reports that many grazing pastures have highly compacted soils. Local streams are the major source of water for livestock and a secondary source of forage. Access to these streams is generally unrestricted. As a result, banks have become unstable in many stream reaches. Bank erosion is accelerated and riparian vegetation has been removed or heavily grazed. Increased sedimentation of the streams and removal of vegetation can promote increased stream temperatures and export of nutrients associated with sediments.

Fertilizers are reportedly not used on pastures, although addition of fertilizer is practiced as a means to enhance establishment and growth of newly seeded pastures. Commercial fertilizers are applied in the production of oats and other grains.

Flood irrigation is the most common practice used to irrigate pasture land. Water is diverted from local streams through a series of extensive canals and ditches cut into the landscape along natural contours. Water is usually applied in excess, creating surface runoff which is diverted to local streams or returns as shallow ground water. These waters generally contain high concentrations of phosphorus and nitrogen compared to ambient concentrations of local streams (Klahr, 1988). These same irrigation systems funnel and accelerate delivery of runoff from snow melt during spring thaw.

Recreational Sources

The U.S. Forest Service (USFS), the BOR and the City of Cascade operate and maintain public access to the lake for a variety of uses (boating and fishing are the most popular). Facilities include 17 boat ramps, 105 picnic areas, and 406 camping sites. Cascade Reservoir now ranks ninth in the state as measured by angler hours and fish landed by anglers. Economic value as a sport fishery has been estimated at over one million dollars annually by the IDFG. Due to its proximity to populated urban areas of the state, the reservoir is a major destination site.

Pollution effects from recreation include hydrocarbons from outboard motors, organic material from fish cleaning, potential bacterial contamination from human waste (improper sanitary disposal) and addition of nutrients, grease and oils from parking lot runoff at camp grounds and boat ramps. Sediments are also contributed by erosion of banks around popular beach areas and camping sites.

Physical carrying capacity of the reservoir for recreational boating has been established at 1,300 boats/day (BOR, 1992). Peak use during a weekend has been estimated at 150 to 200 boats.

Urban Runoff Sources

There are only three major urban centers in the Cascade Reservoir watershed; the incorporated cities and associated impact areas of Cascade (population 1,120), Donnelly (population 173), and McCall (population 2,604). The transient (nonresident) tourist/recreation population will increase potential impacts from urban runoff. A significant increase in seasonal usage occurs during the summer (summer cottage use). A majority of the City of Cascade resides outside the hydrologic drainage area of Cascade Reservoir. Runoff from Donnelly enters Boulder Creek and Lake Fork Creek through a network of road swales and drainage ditches. Approximately half of the City of McCall runoff enters the North Fork Payette River through storm sewers, road swales and ditches. The McCall Airport serves a small commercial fleet and private planes. Runoff from this facility drains to the North Fork Payette River. Numerous residential developments of varying densities have been constructed around the reservoir.

Pollutant sources of concern associated with urban runoff include nutrients, sediment from erosion of conveyance systems, oils, pesticides and bacteria. Rural ranchettes, in addition to contributing the common urban pollutants, are a potential source of high nutrient loading and bacteria from hobby livestock such as horses, sheep and other domestic livestock. Animal densities are often greater than the available land can support, causing over utilization and problems with waste management. Poor drainage and runoff from snow melt can wash these materials into local streams.

Ground Water Enrichment Sources

Phosphorus contributions from septic tank effluent have been estimated. Estimates are derived based on the number of installed systems, usage, and application of a phosphorus soil retention factor (Reckhow and Simpson, 1980). The soil retention coefficient is an estimate of how well the soil matrix functions in binding and reducing the transport of phosphorus through shallow ground water. The most important mechanisms responsible for immobilizing phosphorus are the formation of insoluble iron and aluminum phosphate compounds and the adsorption of phosphate ions onto clay particles (Tilstra, 1972).

Although binding capacity for soils in the Cascade Reservoir watershed is good for surface soils, phosphorus sorption declines rapidly with depth (McGeehan, 1995). Seasonally high ground water tables may increase mobilization of phosphorus and eventually transport all phosphorus from septic tank effluent to the reservoir.

Reservoir Water Levels and Internal Recycling

Availability of sediment-bound phosphorus and potential leaching into surface water can be affected by operational conditions controlling the water depth over the reservoir sediments. Fluctuating water levels that periodically expose lake sediments or alter the aerobic/anaerobic conditions at the sediment/water interface affect the sink/source characteristics of these sediments.

Under annual drawdown conditions, availability of phosphorus in sediment may be increased, further contributing to the enrichment of the water column and increased algal productivity. Improved understanding of the sediment interactions would facilitate development of operational guidelines to reduce recycling of nutrients and improve water quality.

3.2 Data Sources and Assessment Methods

3.2.1 Evaluation of Watershed Mass Balance Budget of Nutrients and Water Entering the Reservoir

Based on a review of previous studies and available data, estimates of the amount and sources of nutrients can be derived for watershed point and nonpoint sources from information collected during WYs 1981 (Zimmer, 1983), and 1989 (Entranco, 1991), and monitoring conducted by DEQ during WYs 1993 and 1994. Each of these studies has collected data from the same general points of inflow to the reservoir (see Figure A.2). Bulk nutrient contributions of each subwatershed have been monitored at the lower ends of each major tributary. Stream flow and water quality has been measured at least monthly (EPA, 1977) or biweekly during spring snow melt (Zimmer, 1983, Entranco, 1991; DEQ, 1993;1994). A gross annual estimate of cumulative inflows to Cascade Reservoir is calculated by the BOR using the change in storage method. The above studies have used these BOR estimates to extrapolate missing flow data when direct stream measurements were not available.

Annual estimates of the point and nonpoint sources of phosphorus entering Cascade Reservoir through runoff are presented in Table 3.1. Annual estimates of phosphorus loading vary greatly from year to year. These differences may be related to differences in runoff conditions (Table 3.2) and errors in estimates of individual stream flow, concentration of nutrients, and frequency of measurement. Sample locations and frequency and methods of measurement are most consistent among surveys conducted in WY 1989, 1993, and 1994. Highest rates of phosphorus loading were observed in 1993 following several consecutive years of below normal precipitation (Figure 3.1). Precipitation in 1993 was 25.91 inches, slightly above the 50 year average of 21.8 inches. Phosphorus loading to the reservoir declined by more than 50% and runoff declined by 49% in the following water year in response to a decline in total precipitation (20.91 inches).

Table 3.1 Total annual phosphorus loading in kilograms (kg) to Cascade Reservoir.

	Years			
NONPOINT SOURCES	1981[a]	1989[b]	1993[c]	1994[c]
Tributary Inflows				
N.F.Payette River	3,150	12,713	18,699	4,464
Gold Fork River	1,990	6,827	12,208	5,518
Boulder Creek	2,990	5,578	5,554	1,195
Lake Fork Creek	1,110	1,057	6,759	1,919
Misc. Tributaries	12,500			
Mud Creek		466	1,104	637
Willow Creek		969	1,257	962
West Mountain	2,440	1,056	3,023	1,149
Septic Tanks	no data	133	1,917	1,917
Total	24,180	28,799	50,523	17,672
POINT SOURCES				
McCall Wastewater Treatment Plant	1,780[d]	5,160	3,815	3,947
Fish Hatchery		726	218	218
Total	1,780	5,886	4,033	4,165
PRECIPITATION	1,875[d]	3,158	3,530	2,849
Total Inflows	27,835	37,843	58,086	24,776
Outflows N.F. Payette River	27,450			
Retention				
Net Retention	385			
Percent Inflows	1.4			

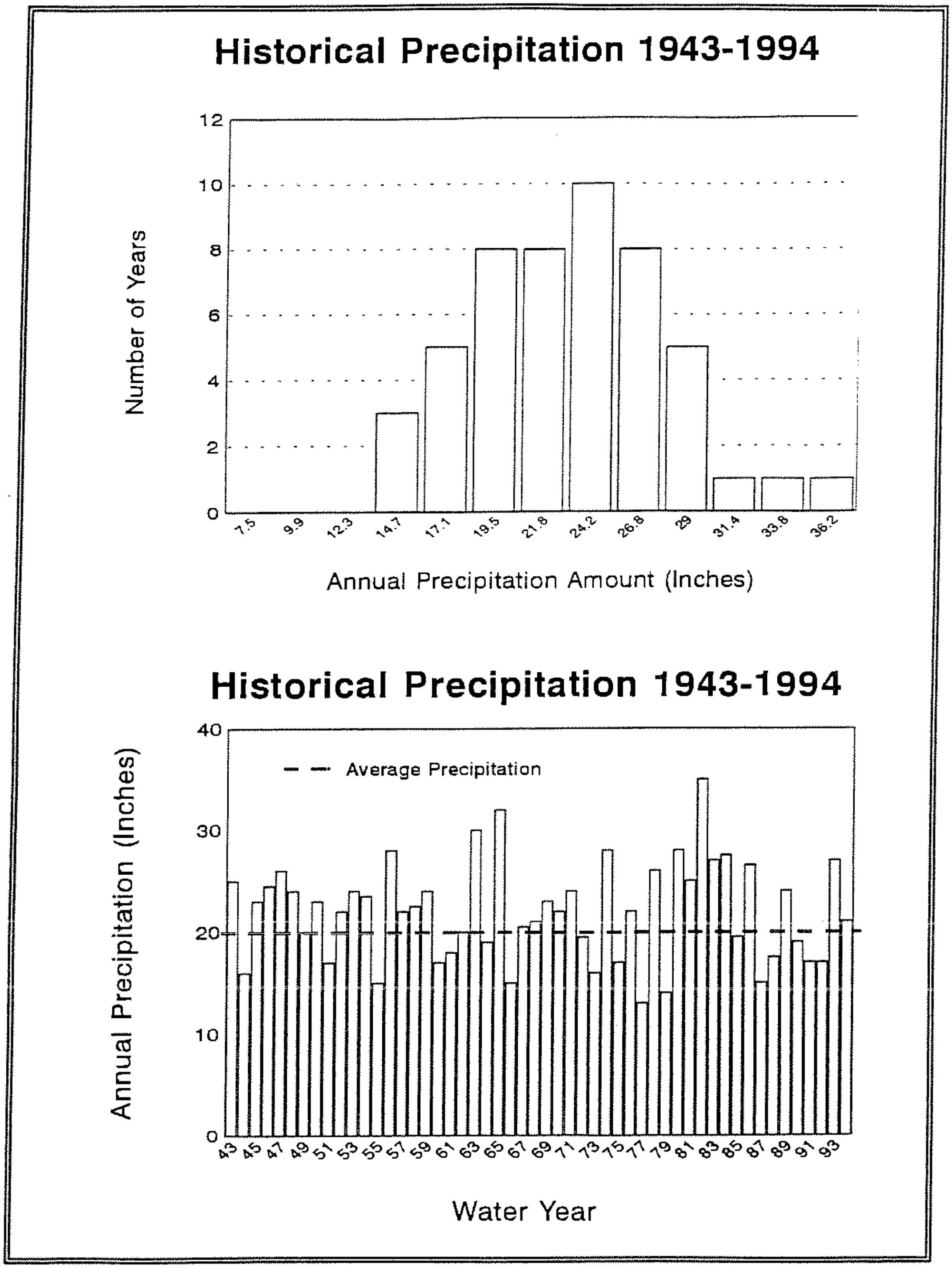
[a]=Source data Zimmer (1983); [b]=Source data Entranco (1991); [c]=Source data Worth (1993, 1994); [d]=Source estimates EPA (1977)

Table 3.2 Total annual inflows and outflows for Cascade Reservoir.

MORPHOMETRIC MEASURES[d]				
Volume (Total Capacity)	703,200 acre-ft (867.4 x 10^6 m^3)			
Mean Depth	26.5 ft (8.1 m)			
Surface Area	26,500 acres (107.24 km^2)			
SOURCE	ANNUAL INFLOWS AND OUTFLOWS (acre-ft)			
	1981[a]	1989[b]	1993[c]	1994[c]
N.F. Payette River	239,967	274,878	316,810	138,144
Gold Fork River	94,690	148,556	173,052	66,095
Boulder Creek	52,614	55,498	26,119	8,806
Lake Fork Creek	100,770	78,318	108,074	29,678
Misc. Tributaries				
West Mountain	87,312	25,283	36,684	12,570
Other	164,572	2,457		
Willow Creek		4,890	7,105	2,696
Mud Creek		8,272	11,495	4,738
Total Runoff	739,925	598,152	538,738	262,727
(BOR Estimate)			(752,260)	(298,100)
Precipitation	61,628	51,189	57,218	46,176
(Inches)	(27.9)	(23.18)	(25.91)	(20.91)
% Normal (22.14)	126	104	117	94
Outflows - N. F. Payette River	846,200	531,178	662,922	407,182
Residence Time - yr (Volume/Outflow)	0.83	1.34	1.06	1.7

[a]=Source data Zimmer (1983); [b]=Source data Entranco (1991); [c]=Source data Worth (1993, 1994); [d]=Source data BOR

Figure 3.1. Annual precipitation records and distribution of precipitation frequency for Cascade Reservoir (Records from BOR)



Nonpoint source runoff accounts for an average of 81% (ranging from a high of 88% in 1993, to a low of 72% in 1994) of the total input of phosphorus. The North Fork Payette River contributes the largest percentage of nutrients due to the corresponding large contribution of water from this source, averaging 46%, 47%, and 53%, respectively for WYs 1989, 1993 and 1994 (Figure 3.2).

Point source contributions of phosphorus from the treatment plant in WY 1975 are based on measured concentrations in the effluent and estimates of discharge volume. Estimates for WY 1981 were based on measured differences in water quality upstream and downstream of the effluent discharge (Zimmer, 1983). The remaining estimates are obtained from NPDES reporting of monthly average concentrations and discharge volume.

Contributions of phosphorus from direct precipitation were based on a constant of 0.175 kg/ha (0.4324 kg/ac) phosphorus of lake surface for WY 1981 (EPA, 1977). Estimates for the remaining water years were obtained by applying a phosphorus content of precipitation (assumed equal to 0.05 mg/l) and multiplying by the volume of direct rainfall/snowfall in the water budget. Actual measurements of phosphorus content in precipitation have not been obtained and could be underestimated in the loading budget.

Estimates of phosphorus contributions from septic tank effluent were evaluated using four different accounting techniques. The method used is presented in Table 3.3.

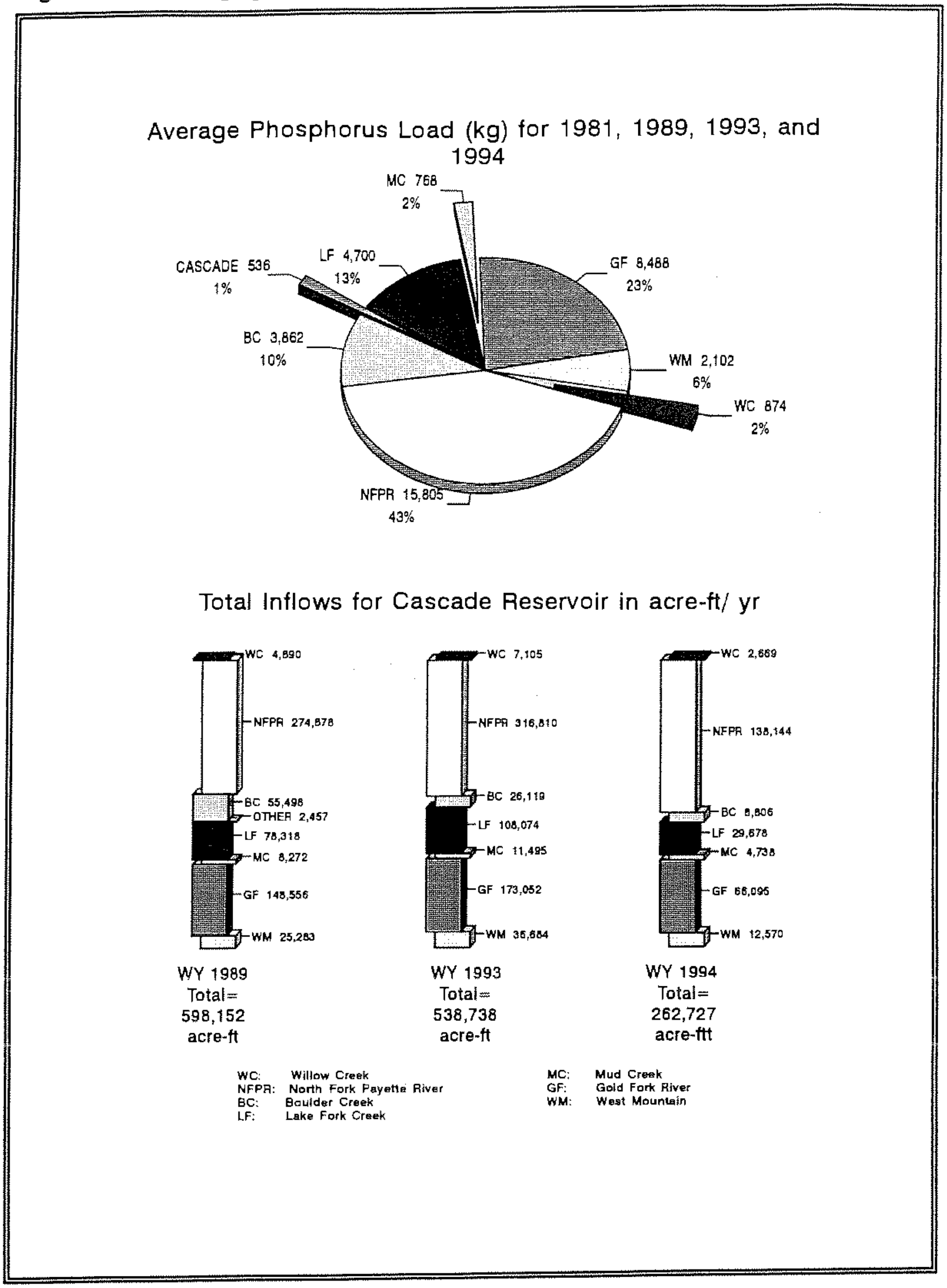
Although binding capacity for soils in the Cascade Watershed is good for surface soils, phosphorus sorption declines rapidly with depth (McGeehan, 1995). Seasonally high ground water tables may increase mobilization of phosphorus and eventually transport all sources of phosphorus from septic tank effluent to the reservoir. Estimates for WY 1993 and 1994, were based on a soil retention factor of 0.1 (poor binding capacity), number dwelling units with septic tanks around the reservoir, use days by season, number persons per household, and a effluent phosphorus loading of 0.9 kg/person/yr phosphorus (moderate rate for no restrictions on phosphate detergent; Uttormark et al.,1974).

Other potentially important contributions of phosphorus are associated with erosion of shorelines within the reservoir. The amount of the annual phosphorus loading attributed to this source is unknown. DEQ initiated analysis of watershed soils for phosphorus content in 1994. Results of this work will provide an estimate of the quantity of phosphorus associated with a variety of soil types that can be extrapolated to estimate contributions from shoreline erosion.

3.3 Subwatershed Summaries

Land ownership and land uses in each of the subwatersheds are shown in Figure 3.3 and Table 3.4. Information is based on inventories conducted by the Idaho Soil Conservation Commission (SCC) prior to 1989. The total watershed occupies approximately 357,000 acres. Forest lands comprise more than 71% of the acreage with agriculture accounting for 23%. The information is somewhat dated due to accelerated conversion of agricultural lands and other open spaces to rural ranchettes. The City of Boise, Idaho's largest metropolitan center 70 miles south of Cascade, Idaho, is undergoing rapid growth and in turn stimulating growth of Valley County. Land prices are comparatively lower and recreational opportunities are abundant, making Valley

Figure 3.2. Average phosphorus load and total inflows by subwatershed



County a popular recreation area and an attractive market for second homes. A revised land use delineation currently being prepared using county tax records and converted to GIS for mapping will be presented in Phase II.

Table 3.3 Septic Tank Loading Calculations

Calculation of septic tank TP contribution using Export Coefficient and Soil Retention Factors.

Method assumes that soils retain SOME of the Phosphorus.

Area	Name	Soil Type	# Septic Tanks	System Avg. Age Yrs.	Summer Use Days	Person Use	Occupied # Units	Avg. Use Days Seasonal Capita/yr	Winter Use Days	Person Use	Occupied # Units	Permanent Capita/yr	Soil Retention Factor	Estimated Load Based on Total P Output @ Coef. Value 1.8kg/yr High (kg/yr)	0.9kg/yr Med(kg/yr)	0.3kg/yr Low(kg/yr)
1	Tamarack Falls		277	8	150	4	166	273	215	3	83	147	0.1	680	340	113
2	Duck Creek		79	7	150	4	47	78	215	3	24	42	0.1	194	97	32
3	Deer Creek		82	9	150	4	49	81	215	3	25	43	0.1	201	101	34
4	West Mountain		364	10	150	4	218	359	215	3	109	193	0.1	894	447	149
5	Ponderosa		105	8	150	4	63	104	215	3	32	56	0.1	258	129	43
6	Crown Point		176	8	150	4	106	174	215	3	53	93	0.1	432	216	72
7	Day Star		75	9	150	4	45	74	215	3	23	40	0.1	184	92	31
8	Wagon Wheel		240	9	150	4	144	237	215	3	72	127	0.1	590	295	98
9	Morning Dawn		163	11	150	4	98	161	215	3	49	86	0.1	400	200	67
			1561				937	1540			468	828	0.10			

	High (kg/yr)	Med(kg/yr)	Low(kg/yr)
Total	3835	1917	639
Winter	1341	670	223
Summer	2494	1247	416
#1994 TP	14.5	7.8	2.8
#1989 TP	9.3	4.9	1.7
#1993 TP	6.0	3.1	1.1

* Soil retention factor estimates the adsorption capacity of soils to trap phosphorus. Ground water tables, age of septic systems and soil type effect the retention capacity. Retention values range from 0 – 1.0; 0 = no retention and 1.0 = 100% retention of P.

** Typical literature values for phosphorus inputs from septic tanks with no phosphate detergent restrictions (Uttormark et. al. 1974).

kg/yr TP/single dwelling unit/person @ Effluent Concentrations			
Effluent concentrations	20mg/l	15mg/l	20mg/l
Septic Output coefficients	1.0441	0.7831	1.0441

Figure 3.3.

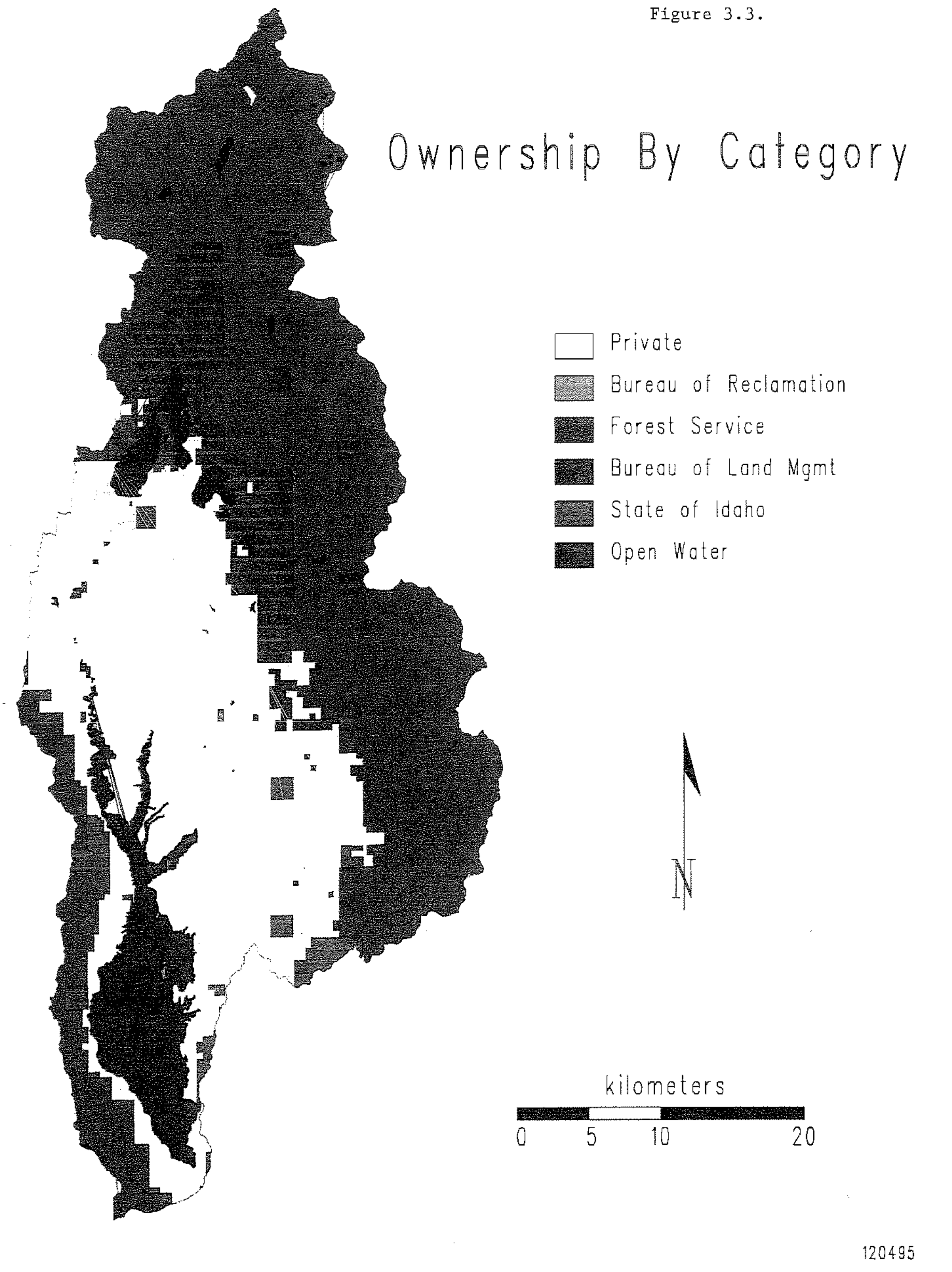

Ownership By Category
Private
Bureau of Reclamation
Forest Service
Bureau of Land Mgmt
State of Idaho
Open Water
N
kilometers
0
5
10
20
120495

Table 3.4 Drainage area and land use associated with subwatershed monitoring sites.

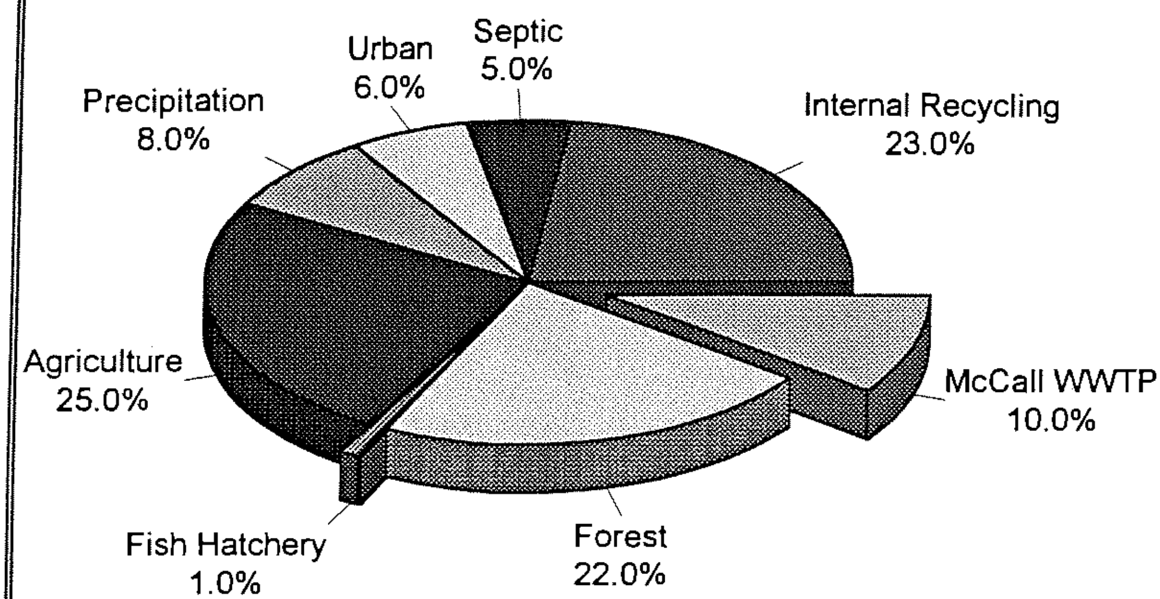
Subwatershed	Drainage Area (acres)	Irr. Pasture (acres)	Non-Irr. Pasture (acres)	Irr. Crop (acres)	Non-Irr. Crop (acres)	Range Land (acres)	Forest Land (acres)	Rec. Land (acres)	Urban Land (acres)	Water + Wild Life (acres)
Boulder Creek	27,788	**7,724**	947	267	346	144	**17,292**		886	183
Cascade	18,390	**5,690**	2,060	1,226		196	**6,318**	129	2,173	599
Gold Fork River	97,153	717	1,607	231	156		**93,874**		398	171
Lake Fork Creek	49,878	7,689	1331				**39,653**		974	231
Mud Creek	14,702	**11,056**	35	1572			646		1,301	93
NF Payette River	30,490	**6,426**	1,393	183		**5,641**	12,756		**3,405**	685
West Mountain	27,581	538					22,909	565	**2,997**	599
Willow Creek	8149	**3,110**	835	581	127	365	**2,439**		655	37
Total	274,131	42,950	8,208	4,060	629	6,346	195,887	740	12,789	2598

[Bold] = Indicates dominate land use.

3.4 Pollutant Loading Analysis

Combined point and nonpoint source contributions of phosphorus are summarized in Figure 3.4. The loads in Figure 3.4 were determined by averaging 1) the yearly loads for septic, internal recycling, precipitation and fish hatchery, and 2) the years 1981, 1989, 1993 and 1994 for the McCall wastewater treatment plant (WWTP). The loads for forestry, agriculture and urban were proportioned by relative area and applied to the remainder of the total load after subtracting the sources mentioned above.

Figure 3.4. Cascade Reservoir phosphorus loading



Average Measured Load 37,135 kg/yr Phosphorus

Agriculture	9358 kg/yr P	Septic	1917 kg/yr P
Internal Recycling	8719 kg/yr P	Precipitation	2853 kg/yr P
Forest	7877 kg/yr P	Urban	2349 kg/yr P
McCall WWTP	3675 kg/yr P	Fish Hatchery	387 kg/yr P

Forest and agricultural activities contribute similar proportions of the total phosphorus load under the range of conditions monitored. Urban and recreational nonpoint sources comprised a relatively small percentage of the total phosphorus load (6% and 8%). Monitoring data indicates that the City of McCall wastewater treatment plant accounts for 10% of the total phosphorus load to the reservoir during drought conditions due to a corresponding reduction in nonpoint source loading. Under average conditions, with a corresponding increase in nonpoint source loading, this source accounts for only 9% of the total load.

Internal recycling is a potentially large and significant contributor of phosphorus. Approximately 8,719 kg phosphorus was estimated as the load from this component using the 1989 version of the Cascade model. Although this same value was used to calculate a budget for subsequent years, it is highly likely that annual contributions vary considerably under differing limnological conditions. Revised models will be used to provide more accurate estimates of load due to internal recycling and to compare estimates of the change in reservoir content of phosphorus before and after fall turnover of the reservoir.

4.0 Watershed Management Strategy

The overall goal of the watershed management strategy is to improve water quality in Cascade Reservoir so the reservoir can support beneficial uses. In watersheds where a significant part of the pollutants come from nonpoint sources, it is often difficult to fully determine the contributions from each source and to identify the management actions that will result in specific water quality improvements. In part, the difficulties result from the inability to measure pollutants released from nonpoint sources and from a lack of data on the phosphorus reduction that can be expected from specific BMPs. DEQ proposes to address these problems by seeking water quality improvements using a phased approach.

The phased approach consists of setting a goal and strategy for reducing phosphorus load to the reservoir based on the best information available at this time. The strategy will be implemented and monitoring will be conducted to evaluate progress. If the phosphorus reduction goal is not met, the strategy will be revised. If the phosphorus reduction goal is met and the reservoir still is not able to support beneficial uses, the goal and strategy will be revised based on improved information (Figure 4.1).

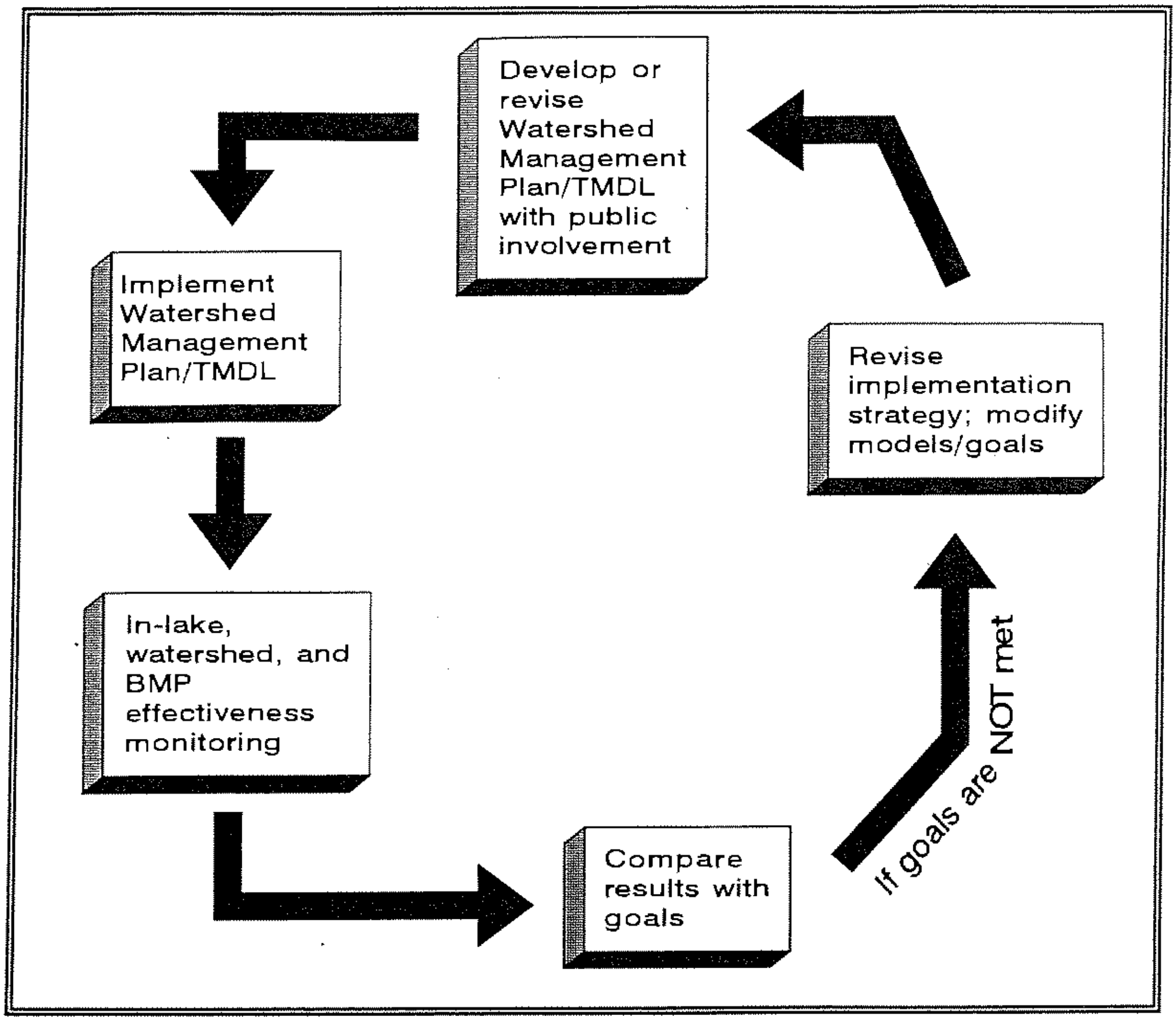
In recent years water quality problems in Cascade Reservoir have resulted in public health concerns. In 1993 the IDHW, Division of Health issued a public health advisory recommending that the public avoid contact with reservoir water. Because of the public health concerns DEQ, in cooperation with the community and other agencies, promptly initiated efforts to improve water quality.

Phase I of the Cascade Reservoir plan formalizes an initial phosphorus reduction goal, outlines an implementation strategy for improving water quality and describes ongoing water quality improvement efforts. DEQ plans to continue data collection and evaluation to further refine the phosphorus reduction goal, while Phase I of the plan is being implemented.

During Phase I implementation, DEQ will:

- work with the community to implement water quality improvement projects to achieve the phosphorus reduction goal;
- monitor implementation of water quality improvement projects;
- continue to collect and evaluate data to improve our ability to predict the water quality effects of management actions;
- continue water quality monitoring to measure the effects of phosphorus reduction efforts; and
- continue to work with the community to develop a more detailed implementation strategy.

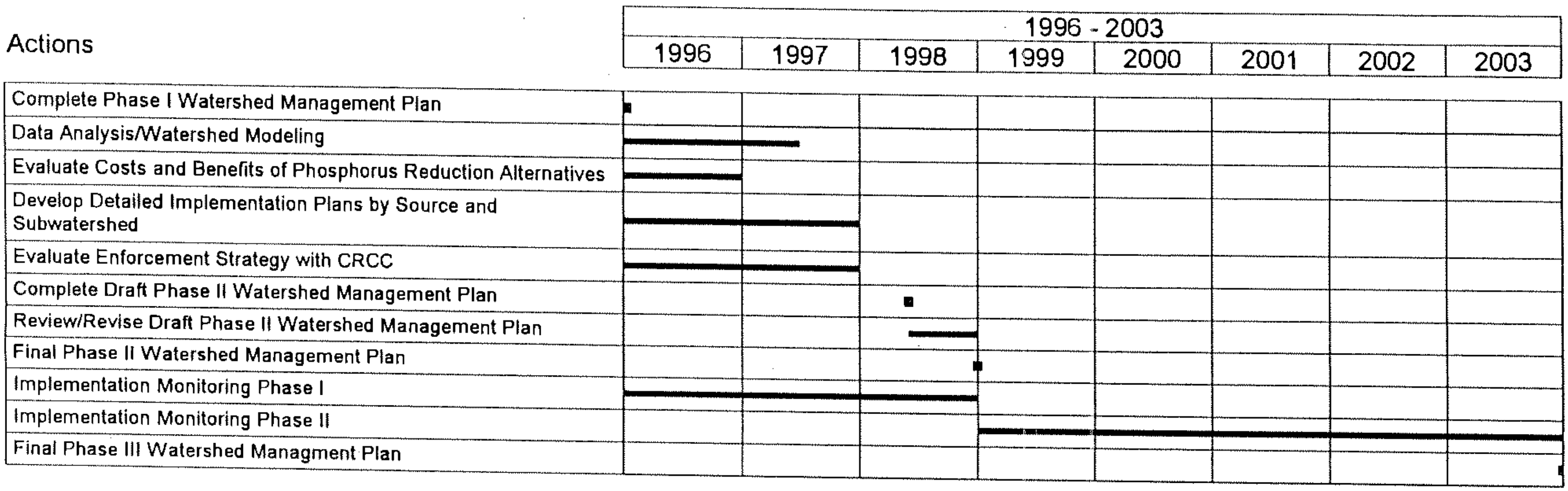
Figure 4.1 A phased approach to implementation of the phosphorus reduction goal.



Phase II of the plan will include further evaluation of phosphorus reduction goals and alternatives and a more detailed implementation plan. The implementation plan will identify specific phosphorus reduction actions needed to allow the Reservoir to support beneficial uses, including an evaluation of costs and benefits for the proposed treatment actions. DEQ plans to complete Phase II of the plan in 1998 and to implement Phase II for five years or until 2003. During Phase II implementation, DEQ will continue monitoring to determine if phosphorus reduction efforts are successful and the reservoir meets water quality standards. If the phosphorus reduction efforts are not successful, DEQ will determine if there is a need to change the load allocation or implementation strategy in Phase III. Figure 4.2 shows a tentative schedule for completion and implementation of Phases I, II and III of the Watershed Management Plan.

The watershed management strategy focuses on the control and reduction of nutrients contributed by the eight major subwatersheds flowing into Cascade Reservoir. Management actions to achieve load reductions will focus on point sources and cost effective voluntary reductions from

Figure 4.2 Tentative schedule for Phases I, II and III of the Watershed Management Plan.



nonpoint sources that can be effectively reduced or eliminated on a long term basis. The Technical Advisory Committee (TAC) and the Cascade Reservoir Coordinating Council (CRCC) are developing criteria for evaluating individual projects.

Within this overall framework, DEQ will place priority on addressing the most significant sources of phosphorus in each subwatershed first. However, a voluntary program depends on willing participation. Sources that are not necessarily the most significant will be treated to reduce phosphorus where demonstration projects may help encourage broader acceptance of BMPs.

4.1 Load Allocation

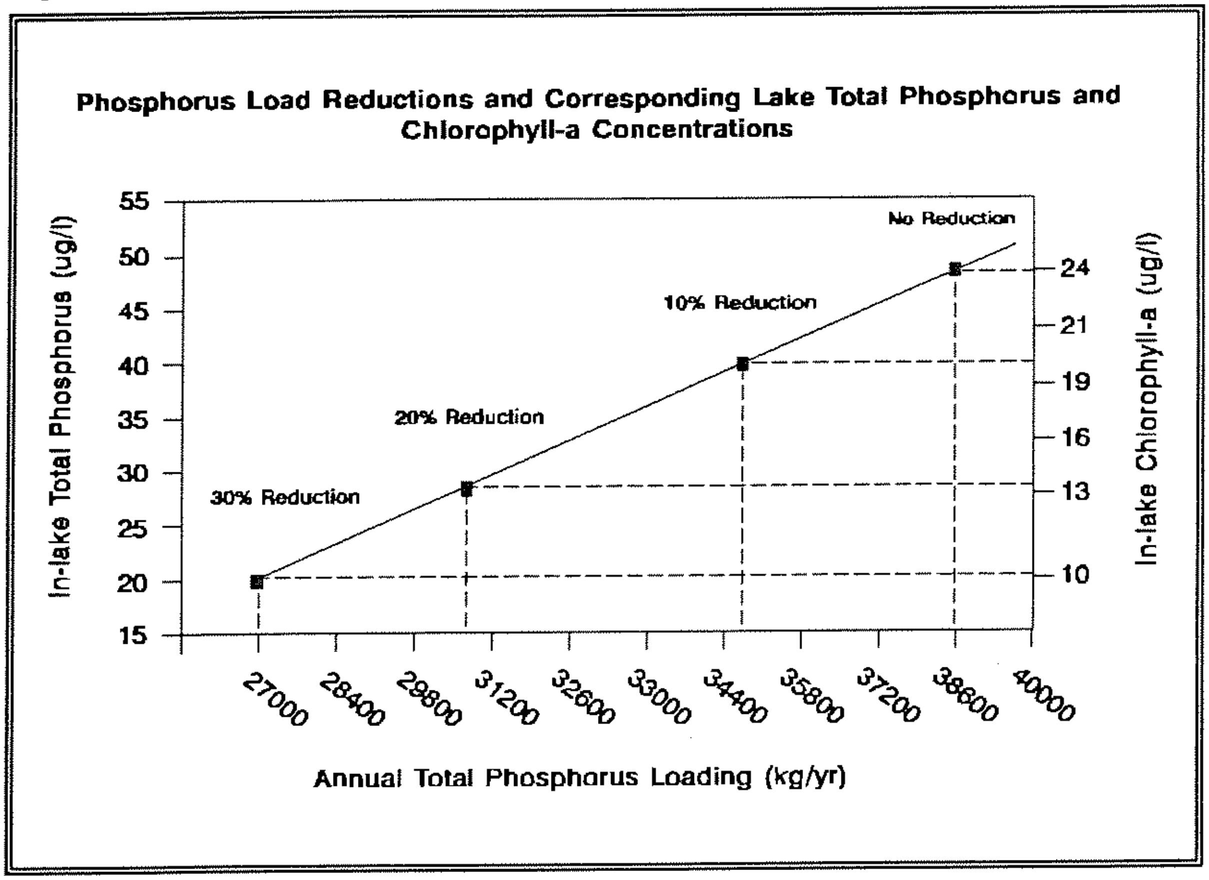
An annual load allocation has been established for Cascade Reservoir to reduce external contributions of total phosphorus (measured in kg/yr) now entering the reservoir from point and nonpoint sources. The method for determining the load allocation is based on scientific data that indicate there is a direct relationship between the amount of total phosphorus entering the reservoir (external loading) and the concentration of total phosphorus measured in the reservoir water column. A computer model (Chapra, 1990) was used to simulate changes in reservoir total phosphorus and chlorophyll a concentrations in response to changes in total phosphorus contributed by the subwatersheds.

Entranco (1991) used the 1989 phosphorus loading data as the most current data available for the model analysis. While measured precipitation amounts were near normal for that water year (October 1988 to September 1989), measured runoff from the subwatersheds may not accurately reflect "normal" conditions due to the effects of prior years of drought. Runoff may have been less than normal because precipitation and snowmelt replenished dry soils rather than draining to streams.

Results of the 1989 model are being utilized because this is the best information currently available. Model simulations were conducted using 1989 data to establish the relationship between total phosphorus loading from the subwatersheds and corresponding reservoir concentrations of total phosphorus and chlorophyll a. The model results are depicted in Figure 4.3 and predict that reservoir total phosphorus and chlorophyll a increase as the amount of total phosphorus entering the reservoir increases. This relationship also indicates that a 30% reduction from the average measured load (for 1981, 1989, 1993 and 1994) would achieve the desired chlorophyll a concentration of 10 μg/l and provide improvement in water quality. Wetzel (1983) suggests that this concentration is necessary to maintain lakes and reservoirs in a mesotrophic condition. Reservoir phosphorus concentrations would also attain the desired level of 0.025 mg/l (EPA, Quality Criteria for Water 1986). It is estimated that by sustaining a 30% reduction in phosphorus loading over a five year period, desired concentrations for chlorophyll a and phosphorus will be attained in Cascade Reservoir.

Due to limitations in the existing model capabilities, the load allocation will be re-evaluated using an improved reservoir model for Phase II of the Watershed Management Plan. The revised model will include modifications to better simulate internal phosphorus recycling and improve sensitivity to changes in the phosphorus contributed by the subwatersheds.

Figure 4.3 Relationship between reservoir total phosphorus and annual phosphorus loading.



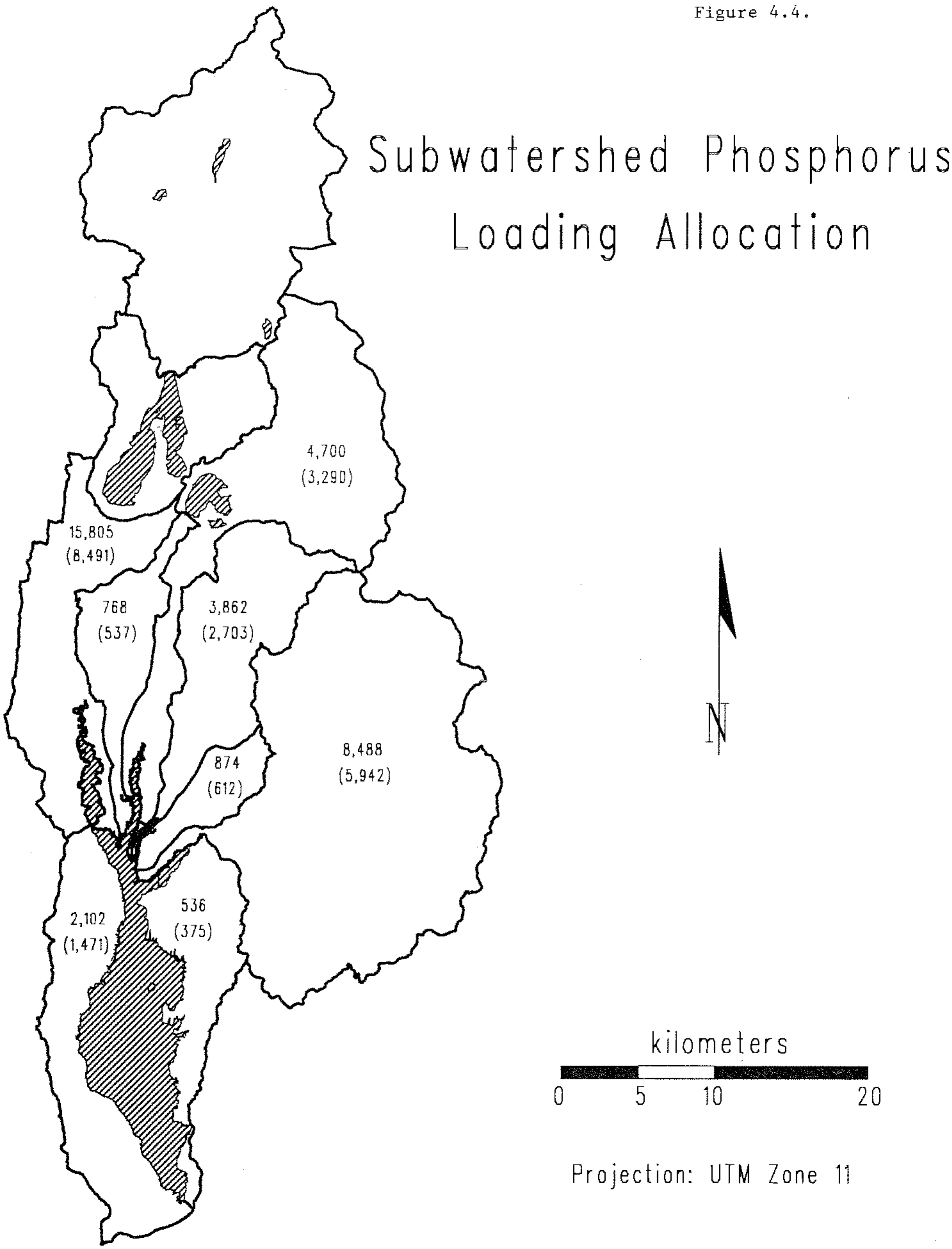
4.1.1 Margin of Safety

A 30% reduction of the phosphorus load will achieve water quality standards and restore beneficial uses in Cascade Reservoir and its tributaries. In addition, a margin of safety is required under EPA's TMDL guidance. This plan calls for a 7% margin of safety. A 37% reduction can be achieved by complete removal of the City of McCall wastewater treatment plant effluent from the North Fork Payette River and a 30% reduction from the nonpoint sources in each subwatershed.

4.1.2 Subwatershed Allocation

Using the 37% reduction goal, a preliminary load allocation for each subwatershed has been determined. Figure 4.4 shows average phosphorus contribution from each subwatershed and the load allocation after applying a 30% reduction to all subwatersheds except North Fork Payette River. In the North Fork Payette River subwatershed the load allocation reflects full removal of the City of McCall's average phosphorus contribution (3,675 kg/yr) and a 30% reduction for all other sources (3,639 kg/yr). Table 4.1 shows average measured load and phosphorus reduction goals by subwatershed.

Figure 4.4.


Subwatershed Phosphorus Loading Allocation
4,700
(3,290)
15,805
(8,491)
768
(537)
3,862
(2,703)
874
(612)
8,488
(5,942)
2,102
(1,471)
536
(375)
N
kilometers
0
5
10
20
Projection: UTM Zone 11

The decision to seek the same percentage reduction from nonpoint sources in each subwatershed was based on comments received during a series of public meetings in 1994 and 1995. With this approach, subwatersheds contributing the largest amount of phosphorus will need to achieve the greatest reductions. For example sources in the Gold Fork subwatershed, with an average load of 8,488 kg/yr, will need to reduce their phosphorus contribution to the reservoir by 2,546 kg/yr. Sources in the Cascade subwatershed, which only contributes an average of 536 kg/yr, will need to reduce their phosphorus load by 161 kg/yr.

Success in reducing the current annual load of total phosphorus will be measured by comparing the individual subwatershed allocations with the measured contributions monitored at or near the mouth of the major tributaries.

Table 4.1 Average measured load and reduction goals by subwatershed.

Subwatershed	Measured Phosphorus Load[a] (kg/yr)	37% Phosphorus Reduction Goal[b] (kg/yr)
North Fork Payette River		
McCall Wastewater Treatment Plan	3,675	3,675
Other Sources	12,130	3,639
Mud Creek	768	230
Lake Fork Creek	4,700	1,410
Boulder Creek	3,862	1,158
Willow Creek	874	262
Gold Fork River	8,488	2,547
Cascade	536	161
West Mountain	2,102	630
Totals	37,135	13,712 =37% of Measured Load

[a] Four year mean load (1989, 1991, 1993, 1994).

[b] The reductions for each subwatershed assume 30% non-point source phosphorus reductions and complete removal of McCall's effluent from the North Fork Payette River.

4.2 Citizen Involvement

The most effective way to achieve reduction goals is for the community to determine the most appropriate phosphorus reduction strategies. A citizen involvement program, consisting of the CRCC, a TAC and subwatershed work groups, was established so the community can provide direction and leadership in developing and implementing this plan (Figure 4.5). The CRCC is composed of seven local citizens appointed by the Southwest Idaho Regional Office of DEQ to represent the following major interest groups in the community. The CRCC includes members representing:

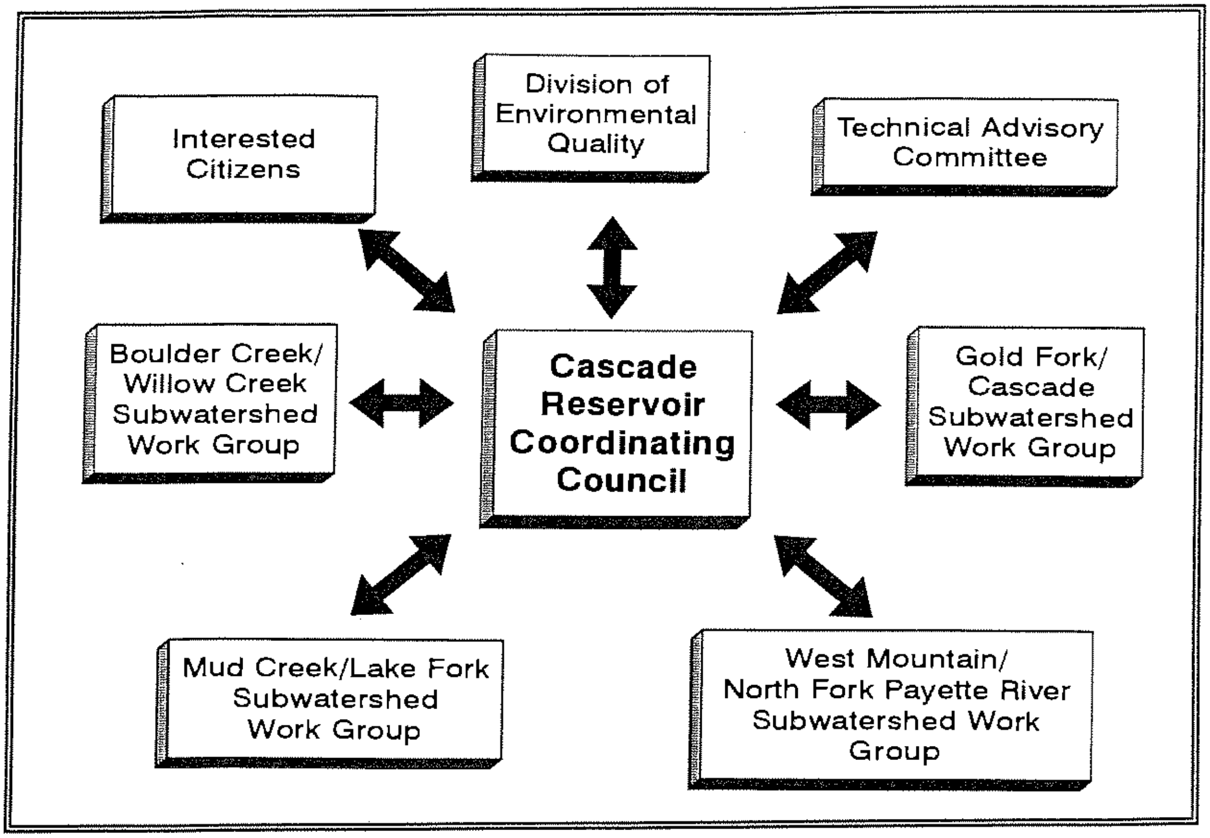
- the Valley County Commission
- the City of Cascade or Donnelly
- sporting or recreational interests
- timber interests
- agricultural interests
- the Cascade Reservoir Association, and
- citizens at large.

CRCC members work directly with their respective interest groups to provide direction to DEQ in developing and implementing a watershed management plan. They also help identify funding needs and sources of support for specific projects that may be implemented. The CRCC assists with management plan implementation by setting priorities for expenditure of restoration funds. The CRCC will periodically review progress toward phosphorus reduction goals.

The TAC, consists of local, state and federal agency, industry and municipal scientific and engineering staff. The TAC is responsible for reviewing proposed projects to ensure projects are consistent with phosphorus reduction goals, are scientifically sound, and that monitoring follows scientifically accepted procedures. Members of the Cascade Reservoir TAC represent:

- Idaho Division of Environmental Quality-SWIRO
- U.S. Forest Service Payette National Forest
- Idaho Soil Conservation Commission
- U.S. Forest Service Boise National Forest
- Valley Soil and Water Conservation District
- Idaho Power Company
- Boise Cascade Corporation
- U.S. Natural Resources Conservation Service
- Idaho Department of Water Resources
- U.S. Fish and Wildlife Service
- Idaho Department of Agriculture
- Idaho Department Fish and Game
- U.S. Environmental Protection Agency
- U.S. Bureau of Reclamation
- Central District Health Department
- Payette Lakes Water and Sewer District
- West Central Highlands Resource Conservation and Development
- Idaho Department of Lands

Figure 4.5 Citizen involvement program for the Cascade Reservoir Restoration Project.



Subwatershed work groups have been formed at the local level to identify and help implement nutrient control measures. These groups represent a variety of interests including landowners (homeowner associations or individuals), city or county governments, federal and state land managers, businesses, irrigation companies and recreational interests. Subwatershed work groups are responsible for identifying potential sources of nutrients and specific projects to reduce nutrients at their source within the subwatersheds.

The eight subwatersheds have been grouped into four subwatershed work groups according to common land use activities, water quality problems and irrigation management practices:

North Fork Payette River/West Mountain
Lake Fork Creek/Mud Creek
Boulder Creek/Willow Creek
Gold Fork River/Cascade (includes Kennally Creek)

Subwatershed work groups have been meeting since early 1993. The Boulder Creek/Willow Creek and Gold Fork River/Cascade work groups have been the most active. They met regularly throughout 1994 and early 1995. They identified and established priorities among more than 40 potential phosphorus reduction projects. Status reports summarizing accomplishments of the Gold Fork River/Cascade and Boulder Creek/Willow Creek subwatershed work groups are included in Appendix J.

4.3 Phosphorus Reduction Strategy

DEQ, in cooperation with state and federal agencies and the community, has established an initial phosphorus reduction strategy. Phosphorus reductions that can be achieved by this strategy were estimated by source for each subwatershed. The following sections include descriptions of the institutional framework for water quality management and the approach used to estimate the phosphorus reductions that may be achieved by implementing the strategy.

4.3.1 Point Source Reductions

Control of point sources of pollution must be consistent with TMDL objectives. Consistency is ensured by incorporating specific requirements into NPDES permits issued by the EPA. The two point sources subject to an NPDES permit in Cascade Reservoir watershed are the City of McCall's wastewater treatment plant and IDFG's McCall Fish Hatchery.

The City of McCall is currently developing an alternative method for wastewater disposal using land application of treated effluent (J.U.B Engineers, Inc., 1995). The City plans to upgrade its wastewater treatment facilities in two phases. DEQ has recently recommended modifications to the City of McCall's NPDES permit to achieve water quality standards in Cascade Reservoir. A 100% reduction in the current effluent contribution of phosphorus from the McCall treatment plant is recommended. In addition, the Idaho legislature provided the city with a special appropriation contingent on the city reducing phosphorus in its effluent by 95%. The proposed 100% reduction of phosphorus from the McCall treatment plant is consistent with the management strategy of this phased Watershed Management Plan because it would result in an effective long term elimination of a known significant source of phosphorus.

The McCall Fish Hatchery has implemented changes in facility operation and maintenance to reduce phosphorus inputs to Cascade Reservoir. Current contributions account for less than 1% of the annual total phosphorus load. Staff will attempt to further improve maintenance and operation for additional phosphorus removal. A maintenance and operation plan will be submitted as part of a formal NPDES permit renewal.

Estimated Phosphorus Reductions

The City of McCall NPDES permit requires monitoring of phosphorus concentrations in the effluent weekly from mid-September through May and three times per week June through mid-September. Reductions anticipated from removal of McCall's wastewater discharge from the North Fork Payette River were estimated by averaging the phosphorus load in McCall's effluent for 1981, 1989, 1993 and 1994, the same years used to estimate average subwatershed loads. The average load for these four years is 3,675 kg/yr.

IDFG changed its operation of the McCall Fish Hatchery to reduce phosphorus concentrations in the effluent. Monitoring conducted by IDFG indicates that phosphorus load from the hatchery's effluent has been reduced by about 508 kg/yr as a result of the changes.

4.3.2 Nonpoint Source Reductions

The process to control nonpoint source pollution is identified in the Idaho Water Quality Standards and Wastewater Treatment Requirements (Section 350). Nonpoint source activities are required to operate according to state approved BMPs, or in the absence of approved BMPs, activities must be conducted using "knowledgeable and reasonable efforts to minimize water quality impacts" (Subsection 350.02.a). If monitoring indicates a violation of standards despite use of approved BMPs or knowledgeable and reasonable efforts, then BMPs for the nonpoint source activity must be modified by the appropriate agency to ensure protection of beneficial uses (Subsection 350.02.b.ii). This process is known as the "feed back loop" in which BMPs or other efforts are periodically monitored and modified if necessary to ensure protection of beneficial uses.

Agriculture

For agricultural activities there are no required BMPs. Consequently, agricultural activities must use knowledgeable and reasonable efforts to achieve water quality standards. Generally, voluntary implementation of BMPs would be considered a knowledgeable and reasonable effort. A list of recommended BMP component practices developed by the Natural Resource Conservation Service (NRCS), which when selected for a specific site become a BMP, has been published in the Idaho Agricultural Pollution Abatement Plan (1993). To encourage use of these practices, the state provides cost share incentives through the State Agricultural Water Quality Plan (SAWQP.) Cost share funds are made available to private landowners through local Soil Conservation Districts. Contracts with landowners require that BMPs be implemented for 10 years, but changes in management practices should provide longer term benefits.

The Valley Soil and Water Conservation District (VSWCD) developed and implemented SAWQP projects in three of the critical subwatersheds of Cascade Reservoir: Boulder Creek, Willow Creek, and Mud Creek (VSWCD, 1992; 1995a; 1995b). These subwatersheds comprise roughly 18% of the total watershed draining to Cascade Reservoir. An implementation plan has been developed for each subwatershed outlining the critical acres contributing nutrients and sediment to local streams based on the erosion potential of soils (VSWCD, 1991). Priority is being given to implementation of BMPs that reduce phosphorus, including protection and restoration of riparian areas. Appendix I includes a list of the BMPs adopted by VSWCD for use in SAWQP projects in the Cascade watershed and a summary of the BMPs planned or implemented as of October 1995.

The Boulder Creek SAWQP project was initiated in 1991, and established a goal of reducing phosphorous loading from agricultural sources by 50%. To achieve this goal, it was deemed necessary to treat 85% of the critical acres and 50% of the non-critical acres with BMPs. Implementation of agricultural BMPs is voluntary and requires a 25% cost share match by the local landowner. In the recent past it has taken several years to negotiate, design, approve and fully implement BMPs. Contracting agreements with the landowners stipulate that BMPs remain in place for ten years. DEQ evaluates BMP effectiveness under cooperative agreements with VSWCD.

The Willow Creek and Mud Creek SAWQP projects were initiated in 1995 and were also established with the goal of reducing phosphorus loading from agricultural sources by 50%, by treating 85% of the critical and 50% of the noncritical acres in each SAWQP project area. There are 8,526 critical acres in the Mud Creek subwatershed and 1,411 critical acres in the Willow Creek subwatershed.

Implementation of SAWQP projects within the watershed is the main vehicle for voluntarily achieving phosphorus reductions on agricultural lands. In addition, funds appropriated by the Idaho legislature have been provided to VSWCD for cost share for BMPs on agricultural lands not currently eligible for SAWQP funds. Additional SAWQP projects are needed to address agricultural practices in the Lake Fork Creek, Gold Fork River, North Fork Payette River and Cascade subwatersheds.

Estimated Phosphorus Reductions

Phosphorus load reductions attributable to implementation of agricultural BMPs were estimated assuming that BMPs will be implemented on 85% of all critical agricultural acres and 50% of all noncritical agricultural acres in each subwatershed. This assumption is consistent with the goals established for the existing SAWQP projects. Total agricultural acres and critical agricultural acres in each subwatershed were obtained from maps prepared by the NRCS in 1989 (Table 4.2). The phosphorus load, prior to BMP implementation, was estimated by multiplying acres of each agricultural land use (irrigated pasture, non-irrigated pasture, non-irrigated crops, irrigated crops and rangeland) by estimated load per acre. Load per acre for each land use was estimated by Entranco (1991).

The load associated with each land use was then reduced by the following percentages assuming treatment of 85% of critical acres and 50% of noncritical acres in each subwatershed.

Land use	Phosphorus Load kg/ac/yr	Percentage Phosphorus Reduction
Irrigated Pasture	0.2672	70
Non-irrigated Pasture	0.1336	30
Irrigated Crops	0.2834	10
Non-irrigated Crops	0.1012	30
Rangeland	0.1012	25
Urban	0.2832	40

The percentages are NRCS estimates of the phosphorus reduction that can be achieved with full implementation of BMPs on treated acres. For Phase II, DEQ will work with VSWCD to verify and improve the estimated reductions and to further define a strategy for incorporating agricultural phosphorus reductions in the overall phosphorus reduction strategy for the watershed.

Table 4.2 Total acres and critical acres by land use and subwatershed.

Subwatershed/Land Use	Critical Acres Agriculture	Total Acres
North Fork Payette River		
Forest		12,756
Irrigated Cropland	3	183
Irrigated Pasture	3,335	6,426
Non-irrigated Pasture	2	1,393
Range	809	5,641
Urban		3,405
Water		149
Wildlife		536
Subtotals:	4,149	30,489
Mud Creek		
Forest		646
Irrigated Cropland	590	1,572
Irrigated Pasture	6,574	11,056
Non-irrigated Pasture		35
Range		
Urban		1,301
Water		12
Wildlife		81
Subtotals:	7,164	14,703
Lake Fork Creek		
Forest		39,653
Irrigated Cropland		
Irrigated Pasture	4,208	7,689
Non-irrigated Cropland		
Non-irrigated Pasture	281	1,331
Range		
Urban		974
Water		103
Wild Life		127
Subtotals:	4,489	49,877

Subwatershed/Land Use	Critical Acres Agriculture	Total Acres
Boulder Creek		
Forest		17,292
Irrigated Cropland	214	267
Irrigated Pasture	6,357	7,724
Non-irrigated Cropland	253	346
Non-irrigated Pasture	424	947
Range	6	144
Urban		886
Water		108
Wildlife		75
Subtotals:	7,254	27,789
Willow Creek		
Forest		2,439
Irrigated Cropland	112	581
Irrigated Pasture	1,206	3,110
Non-irrigated Cropland	1	127
Non-irrigated Pasture	4	835
Range		365
Urban		655
Water		1
Wildlife		36
Subtotals:	1,323	8,149
Gold Fork River		
Forest		93,874
Irrigated Cropland	118	231
Irrigated Pasture	238	717
Non-irrigated Cropland	142	156
Non-irrigated Pasture	306	1,607
Urban		398
Water		53
Wildlife		119
Subtotals:	804	97,155

Subwatershed/Land Use	Critical Acres Agriculture	Total Acres
Cascade		
Forest		6,318
Irrigated Cropland	596	1,226
Irrigated Pasture	2,786	5,690
Non-irrigated Pasture	78	2,060
Range	196	196
Recreation		129
Urban		2,173
Water		68
Wildlife		531
Subtotals:	3,656	18,391
West Mountain		
Forest		22,909
Irrigated Pasture	41	538
Recreation		565
Urban		2,997
Water		37
Wildlife		535
Subtotals:	41	27,581

Forest Practices

The Idaho Forest Practices Act was passed in 1974 (revised 1992; Title 38, Chapter 13, Idaho Code). Rules that implement the Act establish required minimum BMPs for forest practices to protect state water quality. In addition to logging, forest practices include road construction, slash management and other activities associated with logging. The rules, which govern activities on Forest Service, private and state lands, primarily address surface erosion and stream channel protection. Reductions in the export of nutrients are not directly addressed. Moreover, forestry BMPs do not address the export of nutrients and sediment caused by land disturbing activities that occurred prior to 1974.

The Forest Service does not currently recognize the TMDL process as being appropriate for addressing nonpoint sources of sediment, as it relates to phosphorus. However, BNF and PNF have agreed to reduce the phosphorus load to the extent possible. A joint phosphorus reduction plan (Appendix E) has been developed, which describes how they will attempt to achieve reductions during Phase I of the Watershed Management Plan (BNF and PNF 1996). Appendix E also includes a summary of a watershed analysis currently being conducted by BCC in the Gold Fork River subwatershed. DEQ will continue to work with the National Forests and BCC to develop more detailed implementation plans for Phase II of the Watershed Management Plan.

In addition to identifying specific sediment control actions in the plan, the Forests have identified several questions that they believe need to be answered to effectively achieve the 30% reduction goal:

1. What specific activities contribute phosphorus and how?
2. What form of phosphorus is delivered to streams?
3. How can current and future management activities be modified to decrease the amount of phosphorus generated or transported to streams?
4. How much phosphorus is present in a given amount of sediment?
5. What are background phosphorus levels from forest lands?

BNF and PNF have also identified the need for a method to determine sediment and phosphorus yield from specific problem areas and development of a list of forestry BMPs and treatments with an estimate of their effectiveness in reducing phosphorus loading.

Estimated Phosphorus Reductions

The load attributable to forest land was estimated based on measured load at the BNF boundary in 1992, 1993 and 1994. The data is on file at the Cascade Ranger District office in Cascade. The average of the highest and lowest annual loads measured in the Gold Fork River was divided by the total number of acres draining into the River to estimate the phosphorus load per acre from forested lands. All of the area draining to the Gold Fork River at the forest boundary is forested. The estimated load of 0.062 kg/acre/yr was multiplied by the number of forested acres in each subwatershed to estimate load from forest lands.

Once the phosphorus load was estimated, a 30% reduction was applied to arrive at the reduction goal for forest lands. As more information and analysis becomes available the 30% reduction goal will be modified in Phase II to reflect actual watershed conditions and achievable reductions. Reductions to date were estimated by BNF and PNF (1996).

Septic Tanks

Two areas adjacent to the reservoir have been identified as potential nutrient sources due to inadequate treatment of septic tank effluent: 1) subdivisions aggregated at the north end of the reservoir in the vicinity of the Boulder Creek, Gold Fork River and Lake Fork Creeks, and 2) subdivisions located along the southwest shore of the reservoir. Both locations have high ground water tables, evidence of ground water contamination, a high density of septic tanks and poor soil types.

North Lake Recreational Sewer and Water District (NLSWD) was established in 1995 around the north end of the reservoir to implement a central collection and treatment system. Construction is expected to be completed by 1997. Upon completion, all existing and future dwellings will be required to connect to the central collection system and remove existing septic systems from use. Central District Health Department (CDHD) has established a policy that requires any permits issued for new or replacement systems within the District be effective only until the sewer is operational.

In November 1995, residents of an area along the southwest shore of the reservoir voted to form South Lake Recreational Sewer and Water District (SLSWD). The board of the new sewer district will formulate a plan for a collection and treatment system and will then seek funding for construction. In the interim, CDHD has established a policy precluding the issuance of any new septic permits in the West Mountain area and requiring that replacement systems be pressurized or use holding tanks. Any systems with interim permits will be required to hook up to the sewer system as soon as it is available.

Estimated Phosphorus Reductions

Phosphorus load entering the reservoir from septic tanks (1,917 kg/yr) was assumed to come entirely from septic tanks around the reservoir as described in Section 3.3 and shown in Table 3.3. The load reduction attributable to sewer hookups in NLSWD and SLSWD was estimated by assuming that all existing residences around the lake (estimated at 1,392) have septic tanks, that each tank discharges the same amount of phosphorus, and that the discharge from all residences within the current boundaries of NLSWD and SLSWD will be eliminated when hookups are complete. An estimated 1,125 existing residences are within the boundaries of the Districts. Reductions achieved to date are those attributed to NLSWD, which is under construction.

In addition to reducing existing phosphorus load, the sewer districts will prevent future load associated with development of many lots around the reservoir. In NLSWD, about 40% of existing lots have septic tanks and about 60% remain to be developed in the future.

Stormwater Management

At present, there are no ordinances governing the treatment of nonpoint sources of urban runoff in Valley County. The CDHD has recently directed staff to provide comments on stormwater treatment for newly platted developments in Valley County. Valley County has begun to include stormwater management in its review of proposed developments. A review of stormwater BMPs will be conducted in conjunction with county officials, DEQ and CDHD to develop BMP guidelines, and possibly ordinances, specific to Valley County conditions. The review will include an inventory of existing sources of stormwater, and consideration of potential new sources associated with new developments, to identify appropriate treatment or prevention alternatives. Examples of possible treatment alternatives include use of grassy swales, detention ponds and catchment basins. Results will be included in Phase II of the Watershed Management Plan.

Estimated Phosphorus Reductions

Potential phosphorus reductions that could be achieved by implementation of stormwater management BMPs were estimated based on information from EPA (1993). Total phosphorus load from urban lands was first reduced by the estimated benefits resulting from construction of NLSWD and SLSWD. The benefits attributable to stormwater management measures was estimated as 40% of the remaining load.

Other Phosphorus Reduction Measures

In 1995 the BOR constructed three water quality improvement projects on lands adjacent to the reservoir. The projects consist of constructed wetlands and impoundments to increase phosphorus uptake by plants and decrease the amount of sediment transported to the reservoir. BOR plans to construct additional improvement projects in 1996.

DEQ is currently evaluating the feasibility of constructing large scale detention structures on the North Fork Payette River, Gold Fork River and Lake Fork Creek. A structure at any of these sites presents an opportunity to reduce sediment entering the reservoir and to increase plant uptake of phosphorus by enhancing existing wetlands. An engineering feasibility study for these sites is scheduled to be completed in 1996. If large scale detention structures prove infeasible for either technical or financial reasons, DEQ will evaluate other treatment alternatives to achieve the phosphorus reductions attributed to these ponds.

Estimated Phosphorus Reductions

Phosphorus reductions from the BOR projects were estimated by the BOR (Jeff McLaughlin, written communication 1995). BOR estimated the load associated with each project from estimated phosphorus concentrations and flows, and estimated phosphorus reduction at 50% of the load during the summer months and 30% during the winter months. The three projects constructed in 1995 will reduce phosphorus entering the reservoir by an estimated 20 kg/yr.

The potential phosphorus reductions attributable to large scale detention structures were estimated for Gold Fork River and North Fork Payette River. These two sites were chosen because they had the highest potential for wetlands development, both had good structural engineering sites available and neither subwatershed had achieved a 30% reduction with implementation of other land use BMPs. A detention pond was assumed to remove 20% of the phosphorus from water passing through the system. Therefore, the phosphorus load reduction was calculated as 20% of the load, after subtracting phosphorus reductions attributable to other projects in the subwatershed.

4.3.3 Summary of Estimated Phosphorus Reductions

Table 4.3 summarizes phosphorus reductions that have been achieved to date, and future reductions needed to achieve the 37% reduction goal. Table 4.4 shows who is responsible for implementing major water quality improvement projects and expected completion dates.

Table 4.3 Phosphorus reductions to date and necessary future reductions needed to achieve 37% reduction goal.

Land Use Type	Phosphorus Reductions to Date (kg/yr)	Future Phosphorus Reductions Needed to Achieve 37% Goal (kg/yr)	Total Required Phosphorus Reductions to Achieve 37% Goal (kg/yr)	% Goal Achieved to Date
North Fork Payette River			3,639.00	16.20%
Nonpoint Source		3,049.50		
Forest	33.30			
Agriculture				
SAWQP	0.00			
Other	0.00			
Septic	48.20			
McCall Fish Hatchery	508.00			
McCall wastewater treatment plan	0.00	3,675.00		
Subtotals:	589.50	6,724.50		
Mud Creek			230.40	101.22%
Nonpoint Source		0.00		
Forest	0.00			
Agriculture				
SAWQP	141.00			
Other	0.00			
Septic	92.20			
Subtotals:	233.20	0.00		

Land Use Type	Phosphorus Reductions to Date (kg/yr)	Future Phosphorus Reductions Needed to Achieve 37% Goal (kg/yr)	Total Required Phosphorus Reductions to Achieve 37% Goal (kg/yr)	% Goal Achieved to Date
Lake Fork Creek			1,410.00	15.38%
Nonpoint Source		1,193.20		
Forest	0.00			
Agriculture				
SAWQP	0.00			
Other	0.00			
IDFG Detention Pond	30.00			
Septic	186.80			
Subtotals:	216.80	1,193.20		
Boulder Creek			1,158.60	16.95%
Nonpoint Source		962.20		
Forest	0.00			
Agriculture				
SAWQP	80.00			
Other	17.00			
IDFG Detention Pond	64.00			
Septic	35.40			
Subtotals:	196.40	962.20		
Willow Creek			262.20	209.84%
Nonpoint Source		0.00		
Forest	0.00			
Agriculture				
SAWQP	0.00			
Other	196.00			
Septic	354.20			
Subtotals:	550.20	0.00		

Land Use Type	Phosphorus Reductions to Date (kg/yr)	Future Phosphorus Reductions Needed to Achieve 37% Goal (kg/yr)	Total Required Phosphorus Reductions to Achieve 37% Goal (kg/yr)	% Goal Achieved to Date
Gold Fork River			2,546.40	28.45%
Nonpoint Source		1,821.92		
Forest	2.08			
Agriculture				
SAWQP	0.00			
Other	640.00			
Septic	82.40			
Subtotals:	724.48	1,821.92		
Cascade			160.80	112.38%
Nonpoint Source		0.00		
Forest	2.00			
Agriculture				
SAWQP	0.00			
Other	29.00			
Septic	97.70			
BOR Detention Ponds	52.00			
Subtotals:	180.70	0.00		
West Mountain			630.60	15.54%
Nonpoint Source		532.80		
Forest	60.00			
Agriculture				
SAWQP	0.00			
Other	0.00			
Septic	0.00			
BOR Detention Ponds	38.00			
Subtotals:	98.00	532.60	10,038.00	
TOTALS:	2789.28	10,923.72	13,713.00	20.34%

Table 4.4 Major water quality improvement projects, responsible agency and expected completion date.

Project Name	Responsible Agency	Expected Completion
North Lake Sewer & Water District	NLSWD	1997
South Lake Sewer & Water District	SLSWD	to be determined
City of McCall Wastewater Treatment Plant	McCall	1998
Boulder Creek SAWQP	VSWCD	1991 to 1996 to initiate 21 contracts
Mud Creek SAWQP	VSWCD	1995 to 2000 to initiate 32 contracts
Willow Creek SAWQP	VSWCD	1995 to 2000 to initiate 26 contracts
Non-SAWQP Agricultural BMP's	VSWCD	1995 to 1996 for contracts
Bureau of Reclamation Detention Ponds	BOR	1998 (3 completed in 1995)
Idaho Dept. of Fish and Game Detention Ponds	IDFG	1996 (2 completed in 1995)
Additional SAWQPs	VSWCD	2000 to 2005
Stormwater Management	Cities and County	1996 to 2001

Estimated phosphorus reductions attributable to the proposed management strategy are preliminary and represent the best estimates available at this time. Both the estimated phosphorus reductions and the preferred reduction measures will be adjusted in Phase II as better information is obtained. In particular, results from ongoing studies should significantly improve estimates of achievable phosphorus reductions on forest lands.

4.4 Future Nonpoint Source Phosphorus Reduction Measures

Phase II of the Plan will include an evaluation of other possible phosphorus reduction measures that could be implemented to achieve the reduction goal, including improvements to irrigation water delivery systems and management of reservoir operations to reduce internal recycling.

4.4.1 Irrigation Water Management

Irrigation practices are another potential agricultural source of sediment and phosphorus in the Cascade Reservoir watershed. DEQ, in cooperation with the Idaho Department of Water Resources, has initiated an evaluation of the irrigation practices and water conveyance and drainage system in the watershed. This effort will result in recommendations for changes to structures and practices and possible treatment alternatives that will help improve both water management and water quality. Recommendations will be available in 1996. IDWR has some cost share funds available to assist water delivery systems with structural improvements. Potential benefits from improvements to irrigation systems include reduced sediment from erosion and increased instream flows due to improved water management. In addition to providing water quality benefits, increases in instream flows could improve water temperature and DO for fish during the hot summer months by allowing more cool water to reach the reservoir and could provide refuge for fish in the tributaries.

4.4.2 Reservoir Operations

DEQ will work with BOR to evaluate reservoir operations to identify opportunities to improve water quality. Internal recycling of phosphorus from reservoir sediment is a significant source of phosphorus in the reservoir water column. Fluctuation of the water level in the reservoir is likely to increase internal recycling.

In February 1995, BOR issued a Finding of No Significant Impact and Final Environmental Assessment that administratively established a minimum conservation pool of 300,000 acre-feet for the Reservoir. That amount was recommended by IDFG to improve fish survival during the winter. The minimum conservation pool also provides water quality benefits. DEQ will continue to work closely with BOR to ensure maintenance of the conservation pool. In addition, DEQ and IDFG are evaluating the adequacy of the pool for protecting water quality and improving fish habitat during the summer.

4.5 Compliance Strategy

DEQ will rely upon existing authorities and voluntary implementation of additional phosphorus reduction measures to achieve the goals and objectives of this plan. Attainment of water quality standards for Cascade Reservoir will require a significant long term coordinated effort from all pollutant sources throughout the watershed.

For point source discharges of pollutants subject to NPDES permits, DEQ will ensure achievement of water quality goals established in this plan through water quality certifications provided in Section 401 of the CWA.

For nonpoint sources, the feed back loop will be used to achieve water quality goals, as described in Section 4.3.2. DEQ, in cooperation with other agencies, will conduct monitoring to evaluate the effectiveness of site specific BMPs and other restoration projects in reducing phosphorous loading. If BMPs prove ineffective they will be modified to ensure effectiveness of existing and future projects. Any modifications to required BMPs for forest practices will be subject to state rule-making requirements.

If BMPs for nonpoint sources are not implemented adequately using a voluntary approach, DEQ will use existing regulatory authorities to seek water quality improvements. Adequate implementation requires that enough reduction measures be installed (for example, BMPs installed on 85% of critical agricultural acres and 50% of noncritical acres) and that they be properly maintained. Phase II of the plan will include criteria for determining adequate implementation.

Under existing authorities, DEQ may investigate potential violations of the Idaho Water Quality Standards and Wastewater Treatment Requirements and if a violation has occurred, may pursue either administrative or civil enforcement actions. In addition, DEQ will work closely with the CRCC, applicable resource agencies and affected parties to review the existing authorities and determine if there is a need for additional regulatory requirements for nonpoint source activities to achieve the goals of the plan. A "Bad Actor" law, is one of the alternatives that will be reviewed.

DEQ's regulatory and enforcement authorities are generally set forth in the Idaho Environmental Health and Protection Act of 1972, as amended (Idaho Code Sections 39-101 *et. seq.*). Section 4.3 generally describes the existing regulatory requirements for point and nonpoint sources.

4.6 Innovative Approaches and Pollutant Trading

This phase of the plan seeks a 30% reduction of phosphorus load from nonpoint sources in each subwatershed and elimination of McCall's wastewater treatment plant effluent from the North Fork Payette River. It may be more cost effective to eliminate or reduce certain significant pollutant sources, rather than reduce phosphorus from all sources equally. It is also possible that certain projects may present exceptional opportunities for achieving significant reductions, thus allowing other nonpoint sources to seek less than a 30% reduction. If a particular source is unable to achieve its phosphorus reduction goal, other sources may need to make larger reductions to make up the difference. This is known as pollutant trading. The CRCC and the subwatershed work groups will be instrumental in identifying high priority and cost-effective load reduction projects that can be used for pollutant trading. Opportunities for pollutant trading may be identified from the evaluation of costs and benefits of various treatment measures that will be prepared for Phase II of the plan.

4.7 Phase II of the Cascade Reservoir Watershed Management Plan

The phased approach to development and implementation of the Cascade Reservoir Watershed Management Plan provides the opportunity for further analysis of the available data to improve understanding of the factors that affect water quality. Phase II of the plan will fill some of the current data and analysis gaps, which will allow development of a more accurate load allocation, better estimation of the benefits associated with management alternatives and development of a more effective implementation plan. Specifically, Phase II will include the following work:

- additional data collection and analysis, including reservoir modeling, to better characterize the assimilative capacity of the reservoir and understand the dynamics of internal recycling of phosphorus;
- further evaluation of use attainability;
- further evaluation and revision of the load allocation;
- estimation of the costs and benefits of potential phosphorus reductions measures; and
- evaluation and revision of the overall implementation strategy and implementation plan.

Any changes to the plan will be prepared in cooperation with affected parties including opportunities for peer review. Monitoring of both implementation of phosphorus reduction measures and of resulting water quality changes will continue throughout development and implementation of Phase II.

4.7.1 Data Collection and Analysis

Tables 4.5 and 4.6 summarize the monitoring and data analysis gaps that DEQ has identified during preparation of Phase I of the plan. These gaps will be addressed in Phase II to the extent that funding is available.

Table 4.5 Monitoring needed to better characterize reservoir conditions.

Type	Description
Winter DO	Determine winter levels of DO in the reservoir.
Vertical Nutrient Stratification	Determine how phosphorus and nitrogen concentrations change with depth in the reservoir.

Table 4.6 Additional data analysis needed to better characterize the watershed.

Analysis	Description
Watershed Soil Phosphorus	Determine phosphorus distribution in watershed soils.
Background Phosphorus	Determine background phosphorus in soils and other natural sources.
Internal Recycling	Improve understanding of how internal recycling affects the reservoir.
Sedimentation Rates	Investigate the rate at which the reservoir fills with sediment.
Phosphorus in Reservoir Sediments	Determine quantity and type of phosphorus stored in reservoir sediments.
Sediment Sources and Transport	Determine sources of sediment and evaluate travel time to the reservoir for Gold Fork subwatershed.
Phytoplankton Composition	Determine differences in phytoplankton species over time and their relationship to trophic states.
Beneficial Use Status of Tributary Streams	Complete analysis of beneficial use reconnaissance data to determine use status of streams.
Reservoir Hydrology	Determine influence of hydrology on phosphorus loading rate.
Re-evaluation of Load and In-lake Chlorophyll a and Total Phosphorus	Model will be run based on more than one year of data.
Beneficial Use Attainability	To determine if reservoir is capable of supporting beneficial uses.
Adequacy of Minimum Conservation Pool	The minimum conservation pool was established based on a 1984 IDFG recommendation for winter fish survival. IDFG and DEQ will jointly re-evaluate the minimum conservation pool for summer fish survival and improved water quality.

4.7.2 *Implementation Issues*

Completion of ongoing projects and further assessment of restoration alternatives in Phase II will provide information needed to improve the implementation plan. Phase II will better address the following questions:

- What are the relative costs and phosphorus reduction benefits of various restoration measures?
- What phosphorus reductions can be realistically achieved on forest lands?
- Are there any measures that can be used to reduce internal recycling of phosphorus?
- Is construction of one or more large scale detention structures feasible and cost effective?
- What specific measures can be taken to reduce phosphorus load from urban runoff/stormwater?
- Should each subwatershed be held to a 30% reduction in load from nonpoint sources, or is there a more cost effective approach?
- Is the current minimum conservation pool adequate to help protect water quality and fish?

4.7.3 *Other Issues*

There are several outstanding issues that must be addressed to ensure the success of restoration efforts. DEQ will work with the community and affected agencies to resolve these issues during development and implementation of Phase II. The issues include:

- Current state law provides irrigation water users with a broad exemption from compliance with state environmental requirements. Improvements to irrigation practices and structures will be sought on a voluntary basis, but there are few incentives for participation.
- Current water law appears to provide disincentives to improving irrigation efficiency. Improved irrigation efficiency could provide for increased instream flows, which benefit both water quality and fish. There are currently no minimum instream flows in any tributaries in the Cascade Reservoir watershed.
- Phosphorus reduction benefits for the proposed management actions are estimates. Additional actions may be needed if they prove to be less beneficial than expected.
- The community is concerned about the social and economic costs of proposed phosphorus reduction actions, particularly how the local economy and way of life will be affected.

The community will object to restoring the reservoir if it requires significant changes in land use in the watershed. They are particularly concerned about costs to individual, private landowners.

5.0 Cascade Reservoir Restoration Implementation Actions and Monitoring Plan

5.1 Implementation Actions

Efforts to restore beneficial uses and meet water quality standards in Cascade Reservoir are based on a cooperative watershed approach. This means that all the stakeholders within the watershed boundaries work cooperatively with state and federal agencies, on a voluntary basis, to reduce phosphorus loads entering Cascade Reservoir, thus improving conditions for restoring uses and meeting water quality standards.

In response to community interest, the Idaho legislature has appropriated funds for nutrient control measures in the Cascade Reservoir watershed. The legislature appropriated $2,350,000 in State Fiscal Year (SFY) 95 and $900,000 in SFY 96 for the restoration effort. In each of those years, $200,000 was designated for monitoring and support of a satellite office in Cascade and the balance was designated for planning and implementation projects.

DEQ has been and will continue working with the CRCC, TAC, subwatershed work groups and other state, federal and local agencies to identify nutrient control projects for implementation using SFY 95 and SFY 96 funds. In addition, local government and the citizens have initiated a variety of nutrient control projects such as upgrading sewage treatment facilities and establishing new sewer districts. This section summarizes the projects that are currently being planned or implemented.

Identifying nutrient reduction projects has been the principal responsibility of the subwatershed work groups. The Boulder Creek/Willow Creek and Gold Fork River/Cascade work groups have each identified possible projects that could be implemented to reduce phosphorus in those watersheds. When projects are identified they are referred to the appropriate agencies for possible funding. Individual projects involve the following practices:

- Streambank erosion control/restoration
- Canal/ditch delivery upgrades
- Irrigation management upgrade (from gravity to sprinkler)
- Irrigation pumpback system
- Wetland construction
- Reservoir shoreline erosion control
- Sediment pond settling and removal
- Stormwater management
- Surface erosion control

Implementation of these practices is expected to reduce phosphorus entering the reservoir by reducing phosphorus entering drainage systems, reducing soil erosion, and filtering and settling irrigation water. Monitoring will document the effectiveness of these practices to reduce phosphorus loading. It should be noted that implementation depends on cooperation of the affected landowner and availability of funding. Some of the activities are more cost effective than others and DEQ anticipates implementation of the more cost effective projects first, although again, this depends on landowner participation.

Below are phosphorus reduction activities by subwatershed that are currently being planned or implemented. Included are tentative implementation dates where available, funding sources and responsible implementing agency. Figure 5.1 shows the schedule for implementation projects completed to date or planned for 1996 and 1997.

5.1.1 Gold Fork River/Cascade Subwatersheds

- Cascade Reservoir Pumpout Station (Planned): The VCWC has proposed installing a mobile boat pumpout station on Cascade Reservoir to provide dumping facilities for boats on the reservoir. The pumpout facility would reduce nutrient loading to the reservoir by providing a disposal facility for boats that currently dump wastewater directly into the reservoir. DEQ has committed $7,500 and Valley County has committed $2,500 for this project. VCWC has received approval for $30,000 in federal funding for the project under the Clean Vessel Act. The pumpout station will be operating in the reservoir in 1996.

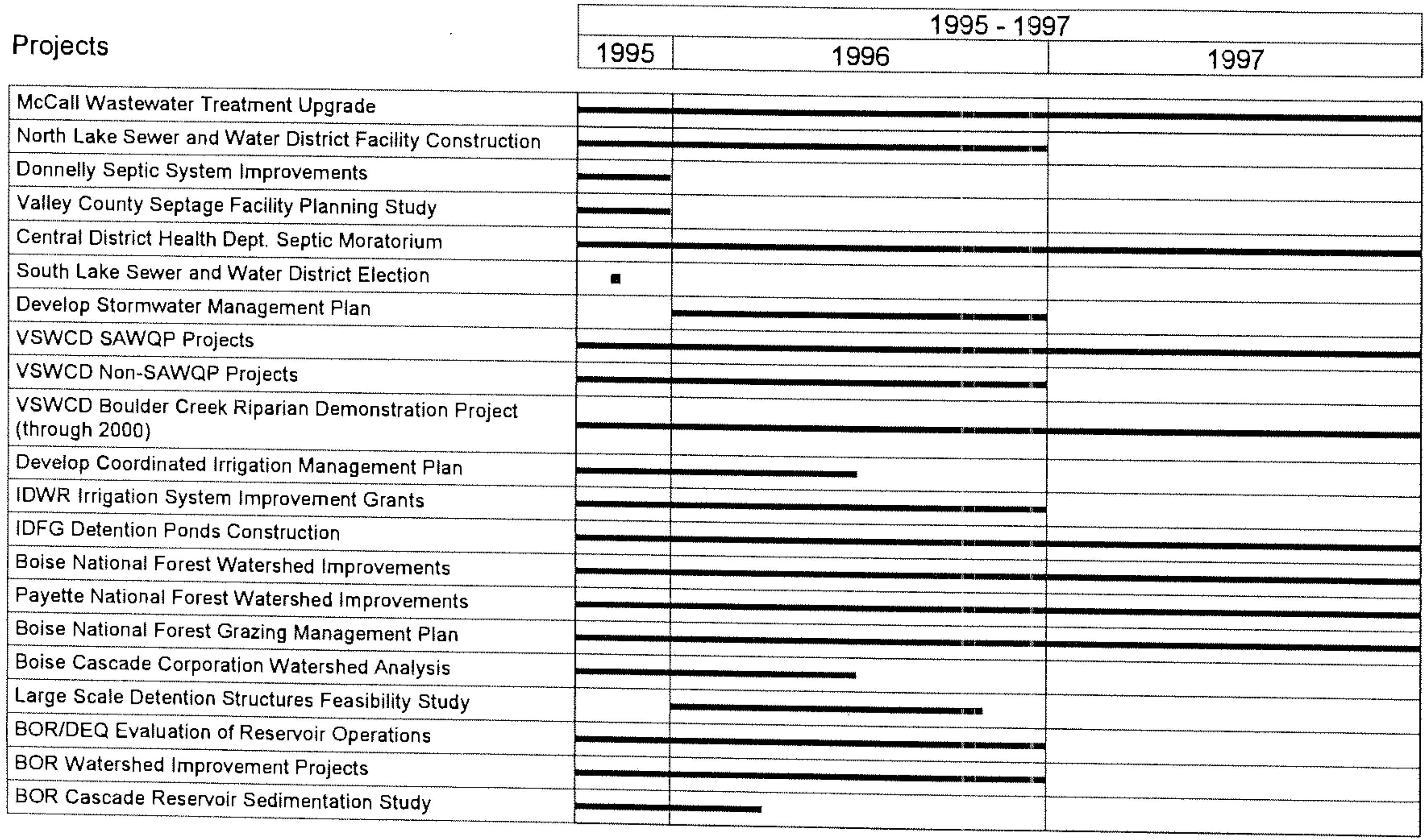
- Boise National Forest Road and Watershed Rehabilitation (On-going): The BNF has completed a road and watershed inventory in the upper portions of Gold Fork River, associated with the Spruce Creek timber sale. As part of this assessment, the Forest identified several rehabilitation projects within the sale area. The timber sale prescribes BMPs far above those currently specified by the Idaho Forest Practices Act, including riparian set-backs, road surfacing, elimination of creek crossings and special harvest prescriptions, aimed at reducing surface erosion and protecting stream channels. Funds generated by the sale of timber are financing these measures and they are being implemented concurrent with the timber sale contract.

- Boise National Forest Tire Pressure (Complete): The BNF is conducting a pilot study of the effects of low tire pressure on logging trucks and equipment in an attempt to reduce road surface erosion. Results will be available from Boise National Forest in 1996.

- Boise Cascade Corporation Road Inventory (On-going): BCC is conducting a road inventory on their lands in the Gold Fork River drainage. Results should be available in 1996.

- Boise Cascade Watershed Analysis (On-going): BCC, in cooperation with DEQ, BNF and PNF, IDFG and other interested parties, has initiated a large scale watershed analysis for the entire Gold Fork River basin. The analysis will evaluate the amount of sediment contributions from 1) roads, 2) bank erosion, including grazing effects, 3) surface erosion and 4) mass wasting. Background rates of sediment input and rates associated with land

Figure 5.1 Schedule for selected water quality improvement projects.



management activities will be estimated. Phosphorus concentrations of soils will be evaluated to help interpret results. The analysis will also address hydrology, bedload transport, riparian condition, stream shading and fish habitat. The project will develop approaches to controlling major phosphorus loads and a monitoring plan to determine the effectiveness of actions. BCC has committed $125,000 for this effort. Additional funds will be committed to implementing the selected approach. The analysis is expected to be complete in early 1996.

5.1.2 Boulder Creek/Willow Creek Subwatersheds

- Boulder Creek SAWQP (On-going): VSWCD has SAWQP projects in Boulder and Willow Creeks. These projects seek to improve water quality by implementing BMPs and changing agricultural practices on 6,826 critical acres. Since 1991, VSWCD has approved nine contracts for BMP implementation on 885 critical acres in the Boulder Creek project area. Appendix F includes a summary of the BMPs planned or implemented to date in the Boulder Creek subwatershed. SAWQP projects are appropriated by the legislature from the Water Pollution Control Account. A total of $734,453 was awarded to the District for Boulder Creek projects.

- Willow Creek SAWQP (On-going): The Willow Creek SAWQP project began in the spring of 1995. No contracts with landowners for implementation of BMPs have been approved yet in the Willow Creek project area. Two applications are pending. The project seeks implementation of BMPs on 1,411 critical acres. A total of $295,150 was awarded to the District for Willow Creek projects.

- North Lake Recreational Sewer and Water District (On-going): Home owners on the western edge of the Boulder Creek/Willow Creek subwatershed have voted to form the North Lake Recreational Sewer and Water District and have approved a $4.5 million bond for construction of facilities. Three stream crossings were constructed in 1995. Winter storage facilities and a segment of the pressure sewer line will be constructed in the fall of 1995. Phase II, design and construction of the remaining collection and transmission systems, will begin in 1996.

- Boulder Creek Riparian Demonstration Project (On-going): A riparian demonstration project is currently under way in the Boulder Creek subwatershed. This project seeks to demonstrate beneficial water quality impacts and reductions in phosphorus loading from implementation of improved grazing management practices in the riparian zone of influence, such as rotation grazing. Funds for this project are from a federal grant program established under Section 319 of the CWA. VSWCD is administrating $39,453 for this project. The demonstration project will be completed in 2000.

- Donnelly Wastewater Treatment System Improvements (On-going): The City of Donnelly is upgrading their wastewater treatment system. Improvements include construction of a winter storage lagoon, upgrades to existing lagoons, addition of aeration and disinfection of waste and an increase in the area used for land application of wastewater. The project will be completed in 1996.

- Detention Ponds (Complete): An agricultural water detention pond was built on Ivan Phelps property under IDFG's Habitat Improvement Program. The pond will treat runoff from about 600 acres to reduce phosphorus and will also create wildlife habitat. The project was built at a cost of $21,000 and was completed in December 1994.

- Idaho Department of Lands Road Improvements (Planned): The Idaho Department of Lands plans to surface the road to Boulder Reservoir. This will reduce the erosion from the road and reduce the phosphorus associated with the sediment from erosion. This project will be completed in 1996.

5.1.3 Lake Fork Creek/Mud Creek Subwatersheds

- Mud Creek SAWQP (On-going): The Mud Creek project began in the spring of 1995. VSWCD is the responsible agency. This project seeks to improve water quality by implementing BMPs and changing agricultural practices on 8,224 critical acres. Seven contracts with landowners for implementation of BMPs on 1,366 critical acres have been approved. Appendix F includes a summary of the BMPs planned or implemented to date in the Mud Creek subwatershed. A total of $1,521,720 is available for pollution abatement projects through this program.

- J-Ditch Lateral (Proposed): VSWCD is working with irrigators served by J-Lateral Ditch to reach agreement on a plan to replace the open ditch with a pipe and convert flood-irrigated lands to sprinklers. The District conducted an engineering study of the project in fall 1995. Sources of funds for this project are still being investigated. If agreements can be reached with all effected landowners and funding can be identified, the J-Ditch conversion could begin in 1996. This project could treat up to 3,784 critical acres.

5.1.4 North Fork Payette River/West Mountain Subwatersheds

- City of McCall Wastewater Treatment System (Planned): A two phase plan has been approved by the City of McCall for upgrade of the City's wastewater treatment system to remove their discharge from the North Fork Payette River (J-U-B Engineers, Inc., 1995) Phase I involves upgrade of existing and construction of new sand filters, construction of a pipeline and land application of wastewater during the cropping season. Phase II involves construction of a lagoon to store winter discharge. Funding for Phase I is anticipated to include $1,020,000 appropriated by the Idaho legislature, a local contribution of about $3,140,000 supported by a low interest loan from the state and $1,500,000 in supplemental grant funds from the state. The City of McCall is currently working with the BOR to obtain about $5,600,000 in grant funds for Phase II. The balance would be obtained from local sources. Phase I construction began late in 1995 and is slated for completion in late 1996. Phase II is scheduled for completion in 1998.

- Septic Tank Moratorium (On-going): CDHD implemented a moratorium on new septic tanks in portions of Valley County based on public health concerns and impacts to Cascade Reservoir. In November 1995, residents around the south and west sides of the reservoir voted two to one in favor of establishing South Lake Recreational Sewer and Water District.

- Boise National Forest Grazing Management (Complete): The BNF has changed the grazing management of their west side allotments based on water quality monitoring results and to comply with Idaho water quality standards. This involved eliminating flood irrigation, reducing allotment capacity by 62% and fencing of reservoir shoreline. Allotment capacity is measured by the number of cattle and the length of time they spend on the allotment. The Forest Service is continuing to monitor water quality from the allotments. This management strategy was implemented partially in 1994 and fully in 1995.

- Big Payette Lake Water Quality Study (On-going): A water quality study of Big Payette Lake has been initiated by the Big Payette Lake Water Quality Council to preserve the high quality water that currently exits. This study has been funded jointly by private donations, federal Clean Lakes funds (CWA, Section 314), and state funds appropriated by the Idaho Legislature for implementation of the watershed management program. Managing Big Payette Lake to insure continued high quality water may help to reduce phosphorus entering Cascade Reservoir from the North Fork Payette River.

5.1.5 General Phosphorus Reduction Activities

- Sediment Controls on Forest Lands (Ongoing): BNF and PNF have jointly developed an interim plan that identifies sediment reduction actions completed to date and planned for forest lands. The interim plan is included in Appendix E. Results of the cooperative watershed study in the Gold Fork River subwatershed should provide answers to questions relating to sediment, phosphorus and forestry practices. With this information the Forest Service will develop a more detailed control plan in 1996 (see 5.1.1).

- Evaluation of Reservoir Operations (On-going): DEQ and BOR are jointly evaluating reservoir operations to determine if there may be opportunities to minimize internal recycling of phosphorus or otherwise improve water quality through structural or operational measures. The agencies are evaluating options using the BETTER reservoir model. The evaluation and recommendations will be completed in 1996.

- Large Scale Detention Structures (Proposed): DEQ has contracted with an engineering firm to evaluate the feasibility of constructing large scale detention structures in the watershed. Potential sites include Gold Fork River, Lake Fork Creek and North Fork Payette River. If a feasible site is identified, the contractor will estimate potential costs and benefits and may provide a preliminary design. DEQ plans to spend an undetermined amount, not to exceed $200,000, for this effort. Implementation depends on findings of the feasibility study and acquisition of funds.

- Idaho Department of Fish and Game Detention Ponds (On-going): Funding is available for cost sharing construction of agricultural water detention ponds through IDFG's Habitat Improvement Program. Detention ponds will treat runoff to reduce phosphorus and will also create wildlife habitat. IDFG is administering a total of $100,000 cost share funds for detention ponds, in cooperation with DEQ. The first pond was constructed in the Boulder Creek/Willow Creek subwatershed (See discussion in Boulder Creek/Willow Creek subwatershed).

- Agriculture BMP Cost Share Projects (On-going): VSWCD has agreed to provide planning, design and implementation assistance for projects identified by subwatershed work groups that are not eligible for funding under SAWQP. These cost share funds are being administered by VSWCD, in cooperation with DEQ. The 1994 Idaho Legislature appropriated $250,000 for this effort. The District has already received application for projects that exceed the available funds.

- Water Delivery System Improvements (On-going): IDWR has established a cost-share program for construction of improvements to water delivery systems. Construction projects proposed by Mahala Ditch Company, Gold Fork River Irrigation Company/Center Irrigation District , Boulder Creek Irrigation Company and Roseberry Irrigation District have been approved. Additional project proposals will be accepted for construction in 1996. A total of $231,000 is available for this effort. IDWR is administering this project in cooperation with DEQ.

- Bureau of Reclamation Improvement Projects (On-going): The Gold Fork River/Cascade subwatershed work group has identified twelve possible water quality improvement projects on BOR lands adjacent to the reservoir. The BOR is constructing six water quality improvement projects on BOR lands, as described below. DEQ will provide up to $92,000 in cost share funds for construction of projects, of which about $58,000 will be used for these projects. BOR is providing design services and about $102,000 for construction costs. Additional projects will be designed for 1996 and will be constructed subject to availability of BOR funds.

    - Hot Springs (Hembry Creek) is a constructed wetland consisting of three small ponds with a total surface area of about five acres.

    - Duck Creek North is a constructed wetland consisting of a pond with a total surface area of about four acres.

    - Duck Creek Osprey Point is a constructed wetland consisting of a pond with a total surface area of about 5 acres.

    - Willow Creek improvements include two instream impoundments, passable to spawning rainbow trout; two upstream sediment ponds; and streambank stabilization.

- Mallard Bay is an existing shallow bay of the reservoir, heavily vegetated primarily with cattails, that dries up each year. An impoundment will be constructed to maintain the water at a constant level.

- Old State Highway improvements consist of an impoundment to create a permanent wetland with a surface area of about 6 acres, slope stabilization, several smaller sediment ponds and diversion of stream flow over former pasture to provide overland treatment.

- Valley County Septic Tank Waste Disposal (On-going): Valley County is conducting a study to evaluate the feasibility of a county-wide treatment and disposal facility for septic tank waste. Currently a large part of the County's septage is treated at the City of McCall's wastewater treatment plant. DEQ provided funds for this study from the wastewater grant program. Implementation depends on the findings of the study and availability of funding.

- Stormwater BMP's (Planned): An engineering firm under contract with DEQ will be developing stormwater BMPs specific to Valley County. The BMPs will assist the County in developing stormwater management ordinances. This project will be supported with funds from the SFY 95 appropriation for nutrient control measures. The cost and schedule are under development.

- Cascade Reservoir Sedimentation Study (On-going): DEQ and BOR are jointly funding a survey of the reservoir to update reservoir storage capacity data and to determine sedimentation rates. This information will be used to evaluate the adequacy of the current minimum conservation pool and for a water quality model that is being developed by BOR and DEQ to identify and evaluate reservoir operation alternatives for improving water quality. The agencies are each providing $62,500 for the reservoir survey. The survey will be complete in 1996.

- Irrigation Management Plan (On-going): DEQ entered into a contract with a consultant for development of a coordinated irrigation management plan for the irrigated acreage in the watershed. Work on this contract should be completed by July of 1996. The plan will recommend improvements to irrigation water delivery systems that will reduce phosphorus and sediment loading to the reservoir. DEQ provided $169,000 for this effort.

- Public Outreach (On-going): DEQ and VSWCD each conduct public outreach activities to keep the community informed of progress on the Cascade Reservoir restoration project. VSWCD publishes a newsletter to update property owners about the availability of agricultural cost share funds through the SAWQP projects. DEQ, in cooperation with the CRCC, conducts periodic public meetings to keep the public informed about the project and provide opportunities for public comments.

- Home*A*Syst Program (Planned): DEQ, in cooperation with the Idaho Association of Soil Conservation Districts and VSWCD, will be providing individual property owners with work sheets and fact sheets to help them determine and address potential sources of pollution on their property under the Home*A*Syst program. Funding from EPA under Section 319 of the CWA has been made available to develop and distribute a booklet on the program. Fact/work sheets are being developed on 13 potential sources of contamination, including grazing on ranchettes. The information will be available for distribution in 1996.

- Phosphorus Sorption Study (On-going): The University of Idaho, Soil Science Division, is conducting a study to evaluate the phosphorus sorption capacity of soils in the watershed. Results will be used for planning land application of wastewater and other similar projects that depend on soil treatment of water. DEQ provided $38,289 for this effort. The project will be complete in 1996.

Tables 5.1 and 5.2 show the restoration projects funded by the Idaho Legislature's SFY 95 and SFY 96 appropriations. Figure 5.2 shows how the SFY 95 appropriation was spent, including both restoration projects, monitoring and support for the Cascade Satellite Office. For SFY 96, the Idaho legislature appropriated $700,000 for nutrient control measures, of which $120,545 has been designated for approved projects. The TAC and CRCC continue to review proposed projects for possible funding using the remaining $579,455 of uncommitted SFY 96 funds. Figure 5.3 shows the state funds that have been made available for cost share for water quality improvement projects from the beginning of the Boulder Creek SAWQP projects through SFY 95. Federal cost share funds have been contributed by the U.S. Fish and Wildlife Service, BOR, and the Consolidated Farm Service Agency.

Table 5.1 Use of Cascade Reservoir Restoration Project SFY 95 state funds.

Project	Funding	Status
Upgrade City of McCall Treatment Facilities	$1,020,000	Phase I scheduled for construction in 1996
Water Delivery System Construction Grants	$231,000	Four projects approved for funding; additional projects will be considered through 1996
Nutrient Control Measures		
a. Irrigation management plan	$169,000	Scheduled for completion 7/96
b. Detention ponds	$100,000	IDFG lead; two ponds constructed in 1995
c. Non-SAWQP nutrient reduction projects	$250,000	VSWCD lead; applications exceed available cost share funds
d. Large scale detention systems; stormwater BMPs	$250,000	Scope of work and schedule under development
Sediment Plan		
a. Model sediment dynamics	$37,000	Scheduled for completion in 1996
b. Reservoir sedimentation survey	$62,500	BOR lead; scheduled for completion in 1996

Table 5.2 Use of Cascade Reservoir Restoration Project SFY 96 state funds.

Project	Funding	Status
BOR Nutrient Control Projects	$92,000	Cost share for design and construction of projects; 1995/96
Reservoir Boat Pumpout Facility	$7,500	Valley County Waterways Commission lead; install in 1996
South Lake Recreational Sewer and Water District	$4,500	CDHD lead; assistance with organizational costs
Fish Saving Proposal	$6,545	Cascade High School lead; demonstration project to enhance fish survival
Radionuclides Study	$10,000	Cost share for analysis to identify sources of sediment by land use in Gold Fork subwatershed
Uncommitted Funds	$579,455	CRCC and TAC reviewing project proposals

Cascade Reservoir Restoration Project

Use of SFY95 Funds
Total = $2,350,000

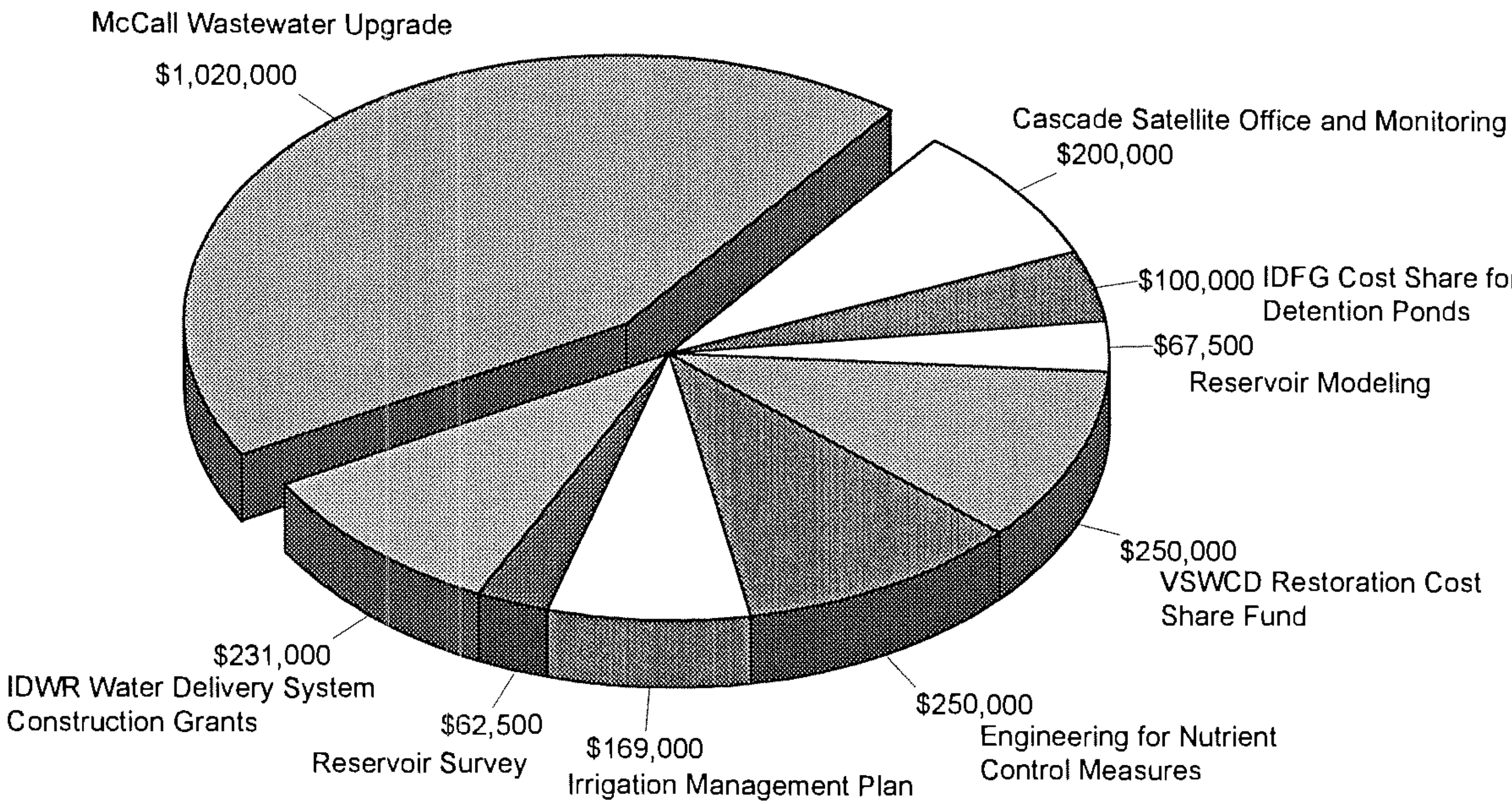


Figure 5.2.

Cascade Watershed

State Water Quality Improvement Cost Share Funds
Total = $3,132,323

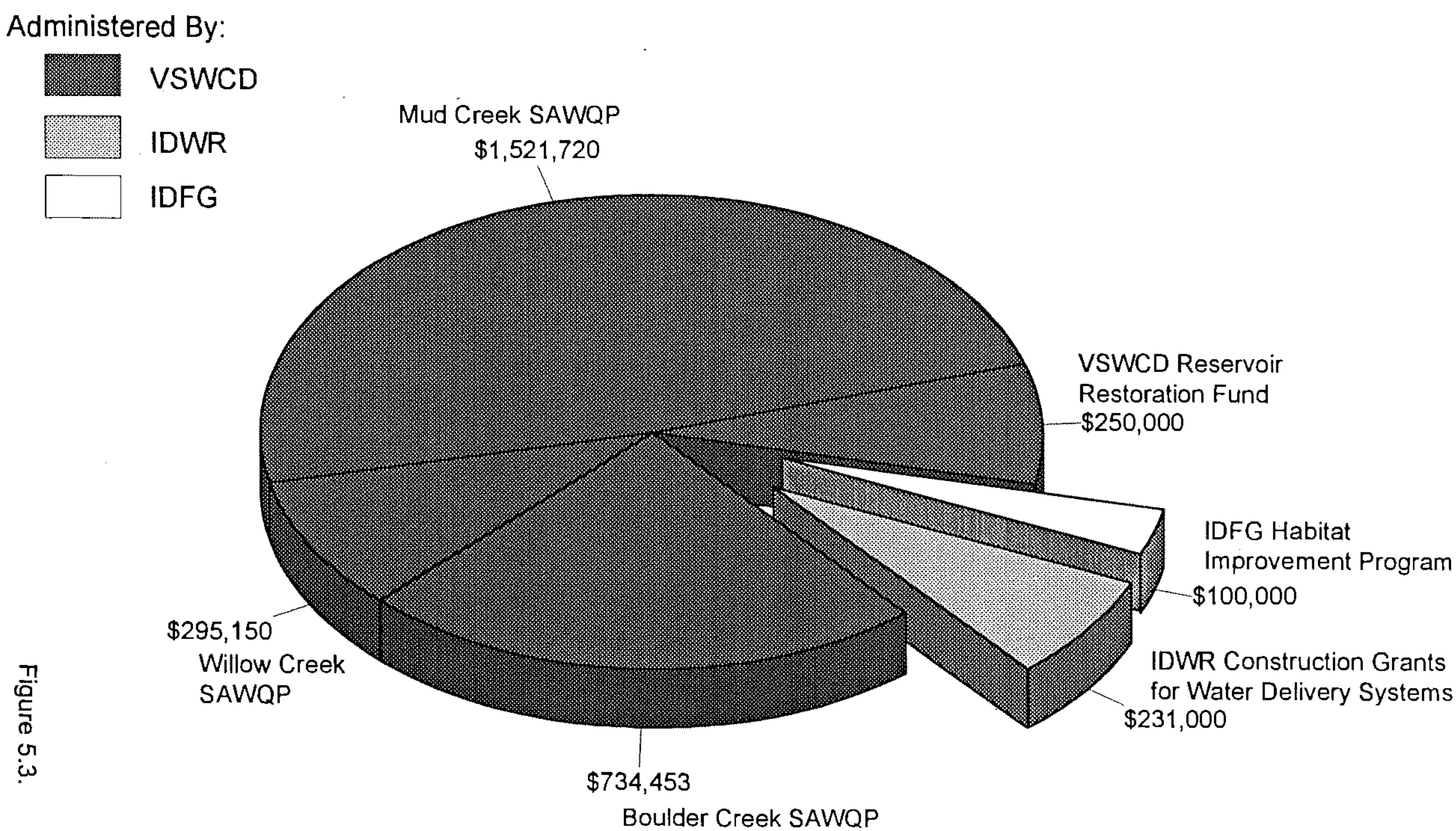


Figure 5.3.

5.2 Monitoring

DEQ has been involved in an extensive cooperative monitoring program with the BNF, PNF, VSWCD, and BOR since 1993 to generate a more accurate picture of the phosphorus dynamics in Cascade Reservoir and the surrounding watershed. This is reflected in the analysis that is currently underway (Section 4.7.1, Table 4.5, Table 4.6) on the data collected to date. DEQ will continue to monitor various aspects of Cascade Reservoir and its watershed.

There are three essential components to the Cascade monitoring framework:

1. Implementation Monitoring: to determine if water quality improvement projects were implemented as indicated and were installed correctly;

2. BMP Effectiveness Monitoring: to determine if BMP's are as effective in reducing phosphorus or sediment as estimated and if they are working as intended; and

3. In-reservoir Phosphorus Reduction Monitoring: to determine if phosphorus and chlorophyll a concentrations in the reservoir meet the goals set forth in this plan.

Table 4.4 displays the schedule for implementation of phosphorus reduction measures and Table 5.3 shows who will be responsible for monitoring implementation and BMP effectiveness. Generally, the agency responsible for implementing a project or BMP is also responsible for implementation and effectiveness monitoring. In a few instances DEQ will be assisting other agencies in completing the effectiveness monitoring. DEQ will continue to be responsible for in-reservoir water quality monitoring. Appendix D is DEQ's monitoring plan for in-reservoir, tributary, and effectiveness monitoring. It describes sampling methods, locations, frequency, quality control provisions and reporting. Completion of all of the monitoring depends on availability of future funds, irrespective of agency. DEQ will continue to coordinate overall monitoring throughout the watershed, directly through contract grants and indirectly through the TAC. This will also be the vehicle by which DEQ will track implementation monitoring, through contract quarterly reports and semi-annual agency reports.

Table 5.3 Agency responsibilities for BMP implementation and effectiveness monitoring.

Project Name	BMP Implementation and Effectiveness monitoring responsibility
North Lake Sewer & Water District (NLSWD)	Implementation by NLSWD
South Lake Sewer & Water District (SLSWD)	Implementation by SLSWD
City Of McCall Wastewater Treatment Plant	Implementation by EPA, effectiveness by City of McCall
Boulder Creek SAWQP	Implementation by VSWCD, effectiveness in cooperation with DEQ
Mud Creek SAWQP	Implementation by VSWCD, effectiveness in cooperation with DEQ
Willow Creek SAWQP	Implementation by VSWCD, effectiveness in cooperation with DEQ
Non-SAWQP Program BMP	Implementation by VSWCD, effectiveness will be done through other SAWQP projects
Bureau of Reclamation Detention Pond	Implementation by BOR, effectiveness in cooperation with DEQ
Idaho Dept. of Fish & Game Detention Ponds	Implementation by IDFG, effectiveness by DEQ

VSWCD has initiated three different SAWQP projects in the Cascade watershed, in the Boulder Creek, Willow Creek and Mud Creek subwatersheds. A Plan of Operations for each SAWQP project (VSWCD, 1992; 1995a; 1995b) details how and when BMP implementation and effectiveness monitoring will occur. VSWCD will conduct 100% implementation monitoring, to insure all BMP's contracted are installed or implemented. This will occur annually to check contract compliance, confirm that BMPs have been installed or performed according to standards and specifications and assess the need for BMP modifications. BMP effectiveness monitoring will target at least one structural and one management or vegetation practice per SAWQP project each year.

Both the PNF and BNF include monitoring sections as part of their project plans, Environmental Assessments or Environmental Impact Statements. These project specific monitoring plans describe how implementation and BMP effectiveness monitoring will occur. Generally, a fully integrated plan is utilized, one that measures project impact on water chemistry, physical habitat and biology. The Spruce Creek Timber Sale Environmental Impact Statement contains a Watershed Monitoring section under Monitoring. A copy of this is included in Appendix E. Other watershed monitoring plans will be developed by BCC and both National Forests, as new sources are identified through their watershed analysis and as restoration measures are implemented.

6.0 Acronyms/Abbreviations

Acronyms	Full Name
BCC	Boise Cascade Corporation
BMP	Best Management Practices
BNF	Boise National Forest
BOD	Biochemical Oxygen Demand
BOR	U.S. Bureau of Reclamation
CDHD	Central District Health Department
CFR	Code of Federal Regulations
CWA	Clean Water Act
CRCC	Cascade Reservoir Coordinating Council
DEQ	Idaho Division of Environmental Quality
DISS.-PO_4	Dissolved Ortho Phosphorus
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish & Game
IDHW	Idaho Department of Health & Welfare
LA	Load Allocation
IDWR	Idaho Department of Water Resources
NLSWD	North Lake Recreational Sewer and Water District
NPDES	National Pollutant Discharge Elimination System
NRCS	National Research Conservation Service
P	Phosphorus
PNF	Payette National Forest
QA/QC	Quality Assurance/Quality Control
SAWQP	State Agricultural Water Quality Program
SLSWD	South Lake Recreational Sewer and Water District
TAC	Technical Advisory Committee
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
UTM	Universal Transverse Mercator
VCWC	Valley County Waterways Commission
VSWCD	Valley Soil & Water Conservation District
WLA	Waste Load Allocation
WWTP	Wastewater Treatment Plant
WY	Water Year

Abbreviations	Unit
yr	year
ft	foot
acre	acre
mg	milligram
m	meter
ug	microgram
°C	degrees Celsius
mgd	million gallons per day
kg	kilogram
acre-ft	acre-foot
km	kilometer
mi	mile
cfs	cubic feet per second
l	liter
ha	hectare
T	ton
ml	milliliter

7.0 Units Conversion Table

LENGTH	mm.	cm.	in.	ft.	yd.	m.	km.	mi.
millimeters	1.0	10.0	25.4	304.8	914.40	1,000.0	1,000,000	1,609,347
centimeters	0.1	1.0	2.54	30.48	91.44	100.0	100,000	160,935
inches	3.94e-02	0.3937	1.00	12.0	36.00	39.4	39,370	63,360
feet	3.28e-03	0.0328	0.0833	1.0	3.00	3.2808	3,280.8	5,280
yards	1.09e-03	0.01093	0.0278	0.33333	1.00	1.0936	1,093.6	1,760
meters	1.00e-03	0.01	0.0254	0.3048	0.9144	1.0	1,000	1,609.3
kilometers	1.00e-05	1.00e-04	2.54e-05	3.05e-04	9.150e-04	0.001	1.0	1.6093
miles	6.21e-07	6.21e-06	1.06e-05	1.89e-04	5.68e-04	6.21e-04	0.61237	1.0

AREA	cm2	in2	ft2	m2	acres	km2	mi2
sq. centimeter	1	6.452	929	1.0e+05	40,465,284	1.0e+11	2.59e+10
square inches	0.155	1	144	1,550	6,272,640	1.55e+09	4.014e+09
square feet	1.08e-03	0.00694	1	10.76	43,560	10,763,900	27,878,400
square meters	1.0e-03	6.45e-04	0.0929	1	4,047	1.0e+07	2,589,998
acres	2.47e-08	1.59e-07	2.3e-05	2.47e-04	1	247.1	640
sq. kilometer	1.0e-09	6.45e-10	9.29e-08	1.0e-05	4.047e-03	1	2.59
square miles	3.86e-11	2.49e-10	3.59e-08	3.86e-07	1.563e-03	0.3861	1

VOLUME	cm3	in3	l	us. gal.	ft3	m3	acre-ft
cubic cent.	1	16.39	1,000	3,785.4	28,317.00	1.0e+07	1.23e+09
cubic inches	0.06102	1	61.0234	231	1,728.00	61,023.00	75,271,680
liters	0.001	0.01639	1	3.7854	28.317	1,000.00	1,233,490
U.S. gallons	2.64e-04	0.00433	0.26417	1	7.4805	264.17	325,851.00
cubic feet	3.53e-05	5.7e-04	0.03531	0.13368	1	35.3145	43,560.00
cubic meters	1.0e-05	1.64e-05	0.001	0.00388	0.02832	1	1,233.49
acre feet	8.11e-10	1.3e-8	8.1e-07	3.07e-06	2.296e-05	8.107e-04	1

VOLUME/TIME	usgal/day	usgal/min	l/sec	acre-ft/day	ft3/sec	m3/sec
U.S. gallons/day	1	1,440.00	22,824	325,850	646,317	22,824,288
U.S. gallons/minute	6.94e-04	1	15.85	226.28	448.83	15,850
liters/second	4.38e-05	0.063	1	14.28	28.32	1,000
acre feet/day	3.07e-06	0.004	0.07	1	1.98	70.05
cubic feet/sec.	1.55e-06	0.002	0.04	0.50	1	35.31
cubic m/sec.	4.31e-08	6.31e-05	0.001	0.01	0.03	1

Source data Steven's (1978)

(Please note scientific notation example: 1000 = 1.0e+3)

8.0 Glossary

Aeration - a process by which a water body secures oxygen directly from the atmosphere, the gas then entering into the biochemical oxidation reactions in the water.

Aerobic - life or processes that require the presence of molecular oxygen.

Adsorption - the adhesion of one substance to the surface of another.

Alluvium - the deposition of sediment by a river at any point along its course.

Ambient - surrounding, external, or unconfined conditions.

Anaerobic - processes that occur in the absence of molecular oxygen

Anoxia - the condition of oxygen deficiency.

Anthropogenic - caused or produced through the agency of man.

Assimilative Capacity - the rate at which an aquatic system must consume and remove impurities from water to maintain water quality.

Beneficial Uses - any of the various uses of water, including, but not limited to domestic water supplies, industrial and agricultural water supplies, cold water biota, recreation, wildlife habitat, and aesthetics.

Biomass - the weight of biological matter, often measured in terms of grams per square meter of surface area.

Chlorophyll a - a photosynthetic pigment reflecting green light and imparting the typical green color to plants; chlorophyll a is found in all autotrophic plants.

Coliform bacteria - a group of bacteria predominantly inhabiting the intestines of man and animals but also found in soil. Coliform bacteria and commonly used as indicators of the possible presence of pathogenic organisms.

Colluvium - material transported to a site by gravity.

Critical Acres - in a State Agricultural Water Quality Project area, those areas where BMPs should be implemented to improve water quality.

Effluent - treated or untreated wastewater that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Eutrophic - a body of water of high photosynthetic activity and low transparency.

Fauna - the entire animal life of a given region, habitat or geological stratum.

Fecal Streptococci - a species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

Flora - the plant life of a given region, habitat, or geological stratum.

Hydrology - the science dealing with the properties, distribution, and circulation of water.

Hypolimnion - the cold bottom water zone below the thermocline in a lake.

Igneous - formed by solidification of molten magma.

Influent - a tributary stream to a wastewater treatment plant.

Infusion - the continuous slow introduction of one content into another.

Intergravel D.O. - dissolved oxygen found in the substrate (usually gravel) of a stream, which is needed to support fish and macroinvertebrates during early life stages.

Limnology - scientific study of fresh water, especially the history, geology, biology, physics and chemistry of lakes.

Mesotrophic - a trophic state in which a lake or reservoir tends to be moderately productive, but nuisance algae blooms do not occur because the nutrient supply is limited.

Nonpoint Source - a geographical area on which pollutants are deposited, dissolved or suspended in water applied to or incident on that area, the resultant mixture being discharged into waters of the state.

Noxious - physically or chemically harmful or destructive

Orthophosphate - a form of soluble inorganic phosphorus which is directly utilizable for algal growth.

Pelagic - The open areas of lake or reservoir.

Photic Zone - the surface zone of the sea or a lake having sufficient light penetration for photosynthesis.

Phytoplankton - microscopic algae and microbes that float freely in open water of lakes and oceans.

Point Source Pollution - the type of water quality degradation resulting from the discharges into receiving waters from sewers and other identifiable "points".

Residuum - the by product of a geological process.

Riparian - living or located on the bank of a natural watercourse.

Secchi Disc - a black and white disc, 20 cm in diameter, used to measure the transparency of water.

Selective Withdrawal - the ability to draft water from a reservoir from differing dam elevations

SNOTEL - Snow survey telemetry which uses the principle of radio transmission by meteor burst. Radio signals are aimed skyward where trails od meteorites reflect or re-radiate the signals back to earth.

Stagnation - the absence of mixing in a waterbody

Stratification - organization of a lake into horizontal layers due to differences in temperature.

Synclinal - a folded rock structure in which the sides dip toward a common line or plane.

Thermocline - a horizontal temperature discontinuity layer in a lake in which the temperature falls by at least 1°C per meter of depth.

Total Suspended Solids (TSS) - the material retained on a 45 micron filter after filtration.

Trophic State - level of growth or productivity of a lake as measured by phosphorus content, chlorophyll a concentrations, amount of aquatic vegetation, algal abundance and water clarity.

Trophic State Index - A system used by many states for classification of the degree of eutrophication exhibited by a lake or reservoir. The index combines measures of phosphorus, chlorophyll a levels and water clarity (transparency) to provide a frame of reference for comparing measurements over time.

Turbidity - a measure of the extent to which light passing through water is reduced due to suspended materials.

Watershed - a region bounded peripherally by the surrounding topography which ultimately drains to a common lake or stream.

Water Quality Modeling - the input of variable sets of water quality data to predict the response of a lake or stream.

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