Cascade Reservoir Watershed

Phase III Water Quality Management Plan and TMDL Five-Year Review

Idaho Department of Environmental Quality

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Abbreviations, Acronyms, and Symbols

§303(d)	Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired waterbodies required by this section
§	Section (usually a section of federal or state rules or statutes)
AWS	agricultural water supply
BAG	Basin Advisory Group
BMP	best management practice
BOR	United States Bureau of Reclamation
BURP	Beneficial Use Reconnaissance Program
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
cfs	cubic feet per second
CWA	Clean Water Act
CWAL	cold water aquatic life
DEQ	Department of Environmental Quality
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
I.C.	Idaho Code
IDAPA	Refers to citations of Idaho administrative rules
km^2	square kilometer
LA	load allocation
LC	load capacity
m	meter
mi^2	square miles
mg/L	milligrams per liter
MOS	margin of safety
NA	not assessed
NB	natural background
nd	no data (data not available)
NFS	not fully supporting
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	primary contact recreation
SBA	subbasin assessment
SCR	secondary contact recreation
SFI	DEQ's stream fish index

SHI DEQ's stream habitat index

SMI DEQ's stream macroinvertebrate index

TMDL total maximum daily load

TP total phosphorus

TSS total suspended solids

t/y tons per year

USDA United States Department of Agriculture

USFS United States Forest Service

WAG Watershed Advisory Group

WBAG Waterbody Assessment Guidance

WLA wasteload allocation

Executive Summary

This document presents a five-year update of the Cascade Reservoir subbasin assessment/ total maximum daily load (SBA/TMDL). The findings of the Phase I and II TMDLs for Cascade Reservoir Watershed clearly indicate that recreation, coldwater aquatic life, and agricultural water supply are not fully supported in Cascade Reservoir. The majority of negative effects in the tributary streams were observed to occur near their inflow to the reservoir. The Cascade Reservoir subwatershed, hydrologic unit code (HUC) 17050123, encompasses the North Fork Payette River Subbasin from below Payette Lake to Cascade Dam (Figure 1).

This document addresses the water bodies in the Cascade Reservoir Subbasin that are on Idaho's current and most recent draft 2008 §303(d) list. This five-year review has been developed to comply with Idaho Statute 39-3611(7). The review describes the existing TMDL(s); beneficial use support status; pollutant sources; current water quality data; and recent pollution control actions in the Cascade Reservoir Subbasin, located in West Central Idaho. The TMDLs subject to five-year review are shown in Table A.

Table A. TMDLs subject to Five-Year Review

Waterbody (assessment unit)	Pollutants	TMDL Approval Year	Implementation Plan Activities	Water Quality Trend
Cascade Reservoir ID17050123SW007_05 ID17050123SW007L_0L	pH, total phosphorus	1996/1999	Some	Improving
West Mtn Tributaries to Cascade Reservoir ID17050123SW007_02	Total phosphorus, pH	1996	Some	Improving
Gold Fork River ID17050123SW008_05	Total phosphorus	1996	Some	Improving
Boulder Creek ID17050123SW011_03	Total phosphorus	1996	Some	Static
Boulder/Willow Creek ID17050123SW011_02	Total phosphorus	1996	Some	Static
Mud Creek ID17050123SW015_03	Total phosphorus	1996	Many	Improving

Section 1. Introduction

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

Idaho Statute 39-3611(7) requires a five-year cyclic review process for Idaho TMDLs:

> The director shall review and reevaluate each TMDL, supporting subbasin assessment, implementation plan(s) and all available data periodically at intervals of no greater than five (5) years. Such reviews shall include the assessments required by section 39-3607, Idaho Code, and an evaluation of the water quality criteria, instream targets, pollutant allocations, assumptions and analyses upon which the TMDL and subbasin assessment were based. If the members of the watershed advisory group, with the concurrence of the basin advisory group, advise the director that the water quality standards, the subbasin assessment, or the implementation plan(s) are not attainable or are inappropriate based upon supporting data, the director shall initiate the process or processes to determine whether to make recommended modifications. The director shall report to the legislature annually the results of such reviews.

This report is intended to meet the intent and purpose of Idaho Statue 39-3611(7). The report documents the review of an approved Idaho TMDL and implementation plan and provides consideration of the most current and applicable information in conformance with Idaho Statute 39-3607, evaluation of the appropriateness of the TMDL to current watershed conditions, implementation plan evaluation, and consultation with the Watershed Advisory Group (WAG). Final decisions for TMDL modifications, if any, are made by the Department of Environmental Quality (DEQ) Director. Approval of TMDL modifications is decided by the U.S. Environmental Protection Agency, in consultation with DEQ.

The goals of this and the preceding phases of the Cascade Reservoir Watershed TMDL are to achieve state of Idaho water quality standards for nutrients and sediment in the reservoir and listed stream segments, to minimize impacts on water quality in downstream waters, and to restore and maintain a healthy and balanced biological community for the full support of designated and presumed beneficial uses. The load allocations and targets are the required load reductions for nutrients (specifically total phosphorus).

The loading analysis in Phases I and II quantified pollutant sources and allocated responsibility for load reductions needed to return §303(d)-listed waters to a condition of meeting water quality standards. This document updates these load allocations and assesses progress toward TMDL implementation for Cascade Reservoir.

Within the Cascade Reservoir Watershed, there are six water quality-limited assessment units (AUs) identified on the Idaho 2008 draft §303(d) list. Figure 1 shows the subwatersheds in which these streams are located within the Cascade Reservoir Watershed.

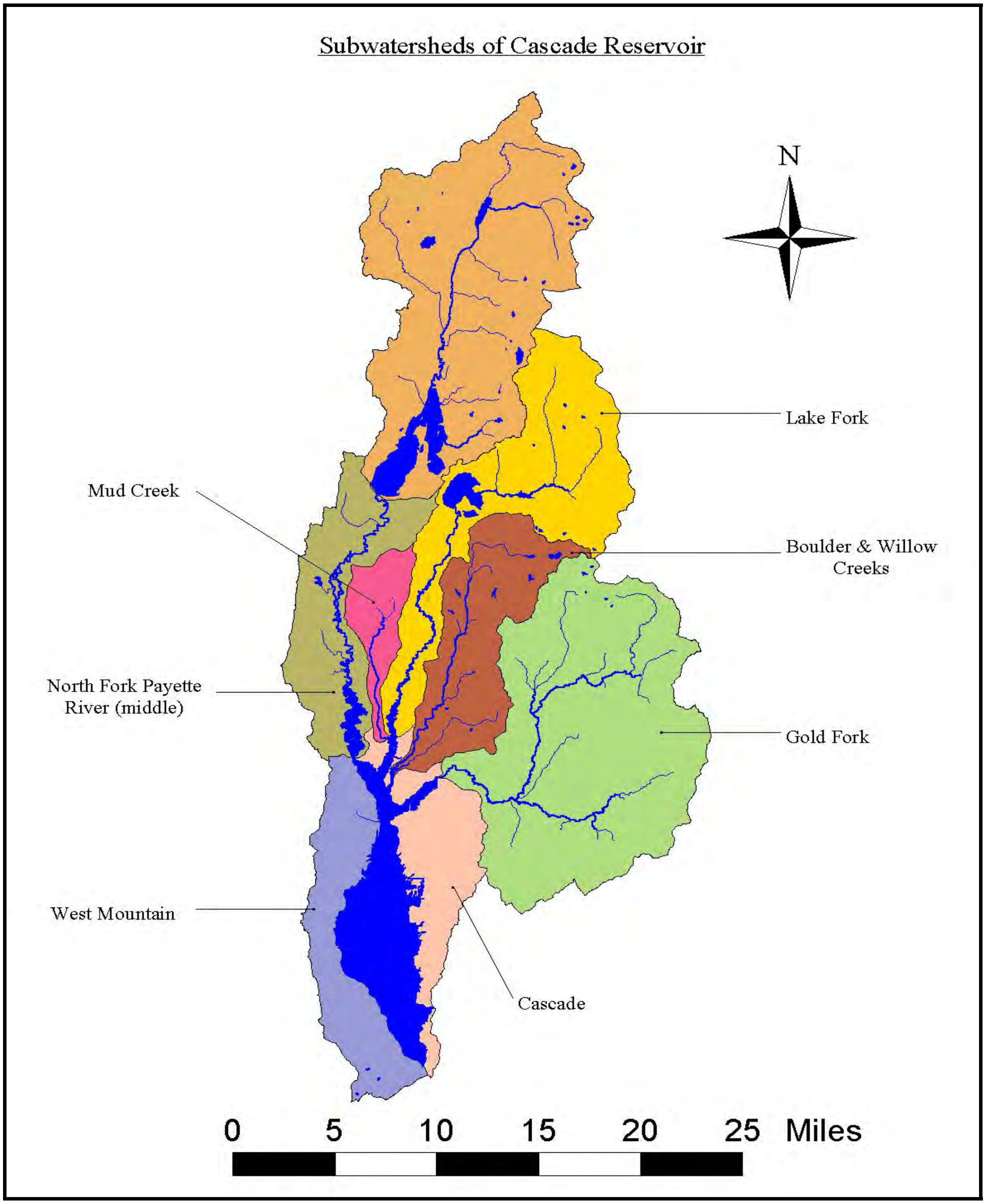

Figure 1. Location of the Cascade Reservoir Watershed and associated tributary streams

Table 1 details each §303(d)-listed AU that already has a TMDL now subject to five-year review, and six additional AUs that have been identified as impaired.

Table 1. Status of water quality-limited streams in Cascade watershed.

2008 Integrated Report Section 4: Existing EPA-approved TMDLs for Five Year Review, Cascade Reservoir Watershed				
Assessment Unit	**Water Body**	**Impairment Cause**	**Approval Date**	**Water Quality Trend**
ID17050123SW007_02	Cascade Reservoir-West Mtn Tributaries	Phosphorus (total)	5/13/1996	Improving
ID17050123SW007_05	Cascade Reservoir (Gold Fork Arm)	Phosphorus (total)	5/13/1996	Improving
ID17050123SW007L_0L	Cascade Reservoir	Phosphorus (total)	5/13/1996	Improving
ID17050123SW008_05	Gold Fork – 5th order	Phosphorus (total)	5/13/1996	Improving
ID17050123SW011_02	Boulder/Willow Creek – 1st and 2nd order irrigated sections	Phosphorus (total)	5/13/1996	Static
ID17050123SW011_03	Boulder Creek – Louie Creek to Cascade Reservoir	Phosphorus (total)	5/13/1996	Static
ID17050123SW015_03	Mud Creek – 3rd order	Phosphorus (total)	5/13/1996	Improving
ID17050123SW007_02	Cascade Reservoir-West Mtn Tributaries	pH	4/19/1999	Improving
ID17050123SW007L_0L	Cascade Reservoir	pH	4/19/1999	Improving

2008 Integrated Report Section 5: Additional Impaired Waters, Cascade Reservoir Watershed		
Assessment Unit	**Water Body**	**Impairment Cause**
ID17050123SW008_05	Gold Fork – 5th order	Sediment
ID17050123SW011_02	Boulder/Willow Creek – 1st and 2nd order irrigated sections	Unknown (biota habitat assessment)
ID17050123SW011_03	Boulder Creek – Louie Creek to Cascade Reservoir	Sediment, Temperature
ID17050123SW012_03	Lake Fork – Little Payette Lake to Cascade Reservoir	Unknown – nutrients suspected
ID17050123SW015_02	Mud Creek – 1st and 2nd order	Bacteria, Sediment, Nitrogen (total), Unknown – nutrients suspected
ID17050123SW015_03	Mud Creek – 3rd order	Ammonia (un-ionized), Unknown (based on low habit/biota assessment scores), Bacteria, Sediment

About Assessment Units

Before 2002, impaired waters were defined as stream segments with geographical descriptive boundaries. In 2002, DEQ modified the structure and format of Idaho’s 303(d) list by combining it with the 305(b) report, required by the CWA to inform Congress of the state of Idaho’s waters. This modification included identifying stream segments by AUs instead of non-uniform stream segments, and defining the use support of stream AUs as belonging to one of five categories, each of which is published as a section in the integrated report. Assessment units (AUs) now define all the waters of the state of Idaho. These units and the methods used to describe them can be found in the WBAG II (Grafe, et al., 2002). AUs are groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs— even if ownership and land use change significantly, an AU remains the same. Because AUs are a subset of water body identification numbers, there is now a direct tie to the water quality standards (WQS) for each AU, so that beneficial uses defined in the WQS are clearly tied to streams on the landscape.

To facilitate comparisons between the 1998 303 (d) list and the 2002 Section 5 "impaired waters" category in the Integrated Report, a crosswalk from the 1998 303(d) list to the new AUs was included in the 2002 Integrated Report. A copy of the report is available from the DEQ Web site at http://www.deq.state.id.us/water/data_reports/surface_water/monitoring/2002.cfm#2002final. The boundaries from the 1998 303(d)-listed segments have been transferred to the new AU framework using an approach quite similar to how DEQ has been writing SBAs and TMDLs. All AUs contained in any listed segment were carried forward to the 2002 303(d) listings in Section 5 of the integrated report (DEQ, 2005). Any AU not wholly contained within a previously listed segment, but partially contained (even minimally), was also included on the 303(d) list. This was necessary to maintain the integrity of the 1998 303(d) list and continuity with the TMDL program. The *Cascade Reservoir* subbasin water bodies listed on the 2002 303 (d) list are included in this report, but the review is focused on the water bodies included in the draft 2008 303(d) list.

If new monitoring data indicate full support, only the AU represented by the data will be removed (de-listed) from the 303(d) list (Section 5 of the integrated report).

Subbasin Assessment – Watershed Characterization

Physical and Biological Characteristics

Cascade Reservoir is located in the Payette River Basin of west central Idaho (Figure 2). Major tributaries to the reservoir include the North Fork Payette River (NFPR), Mud Creek, Lake Fork, Boulder Creek, Willow Creek, and Gold Fork River, all of which discharge into the northern end of the reservoir. The overall watershed is divided into separate subwatersheds on the basis of drainage areas to these tributaries. In addition, the West Mountain subwatershed drains into the west side of Cascade Reservoir, and the Cascade Reservoir subwatershed drains into the east side of the reservoir. As listed in the Phase II TMDL, there are twelve subwatersheds within the Cascade Reservoir Watershed, seven of which drain more or less directly into Cascade Reservoir (Figure 1).

The Cascade Reservoir Watershed (part of HUC 17050123) is located in a moderately high elevation valley between West Mountain and the Salmon River Mountains. The area of direct drainage to Cascade Reservoir included in this watershed management plan covers approximately 276,000 acres. A major portion of the watershed is steeply-sloped forested land, while the area immediately adjacent to the reservoir and major tributaries is predominantly shallow-sloped agricultural land. Elevation of the valley floor and reservoir lies at about 4,850 feet.

Cascade Reservoir was created in the spring of 1949 by the Bureau of Reclamation to provide storage for irrigation and also provide flood control. The reservoir is 21 miles long, 4.5 miles wide at the widest point, and is relatively shallow, measuring 26.5 feet in average depth.

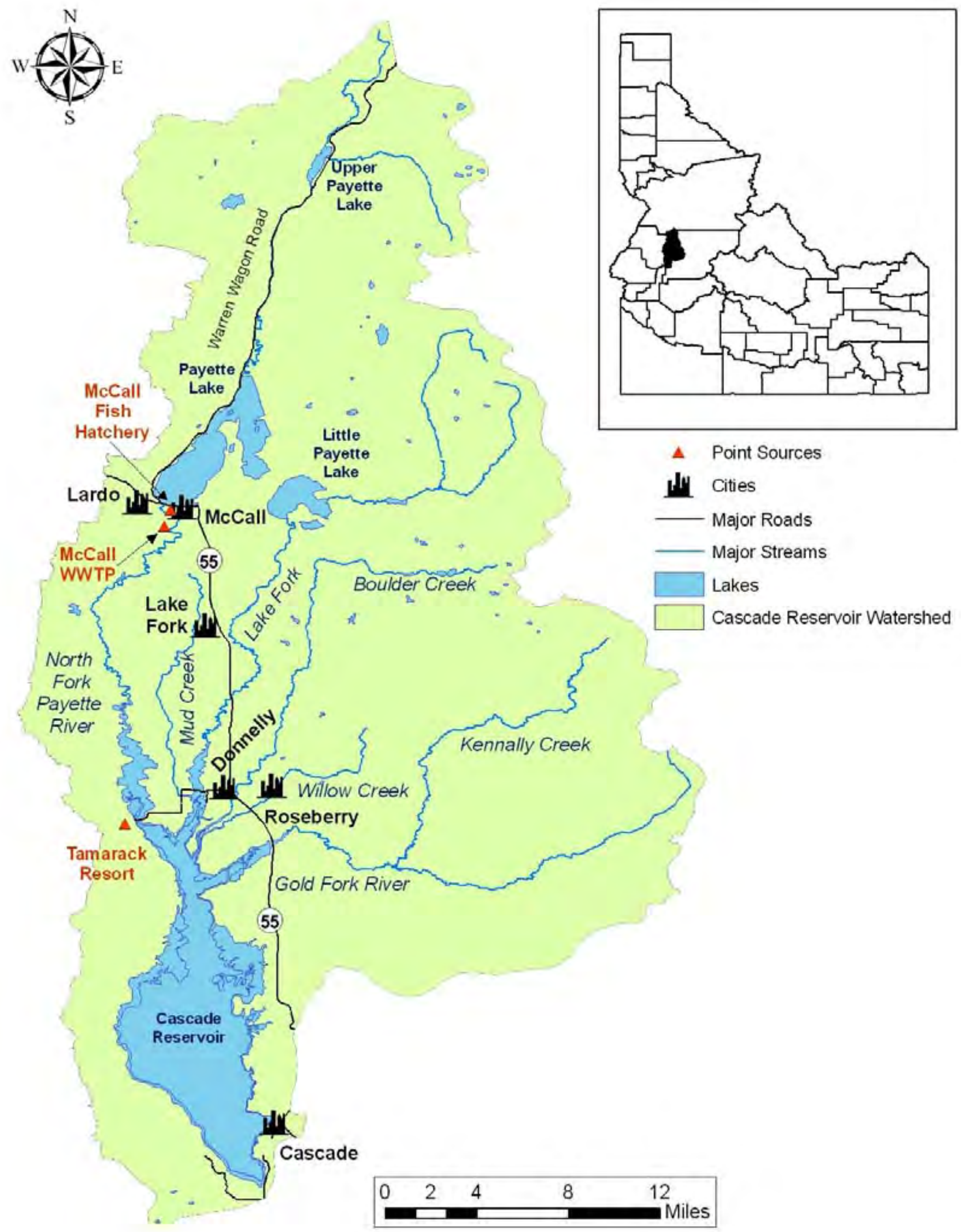

Figure 2. Cascade Reservoir Watershed

Ownership

The watershed is predominantly forested (approximately 65%), with both public (US Forest Service [USFS] and State of Idaho) and private ownership (Table 2). Much of the private land is used for agricultural purposes, predominantly cattle ranching. Only a small amount of private land is used for crops. Urban and residential areas make up roughly 13% of the total land area.

Table 2. Land use acreage within the Cascade Reservoir Watershed*

Drainage Area	Acres	% of Watershed Area
Forest (public and privately owned)	179,808	65
Agriculture (irrigated crop and pasture, non-irrigated pasture, rangeland, and other)	61,419	22
Urban/Suburban (urban/city area, subdivisions, impact area)	35,154	13
Total Drainage Area	276,381	100%

*Figures reflect land use changes through 2007.

Historically, land use in the watershed was primarily forestry/timber and agricultural with a small amount of residential property. Land use trends have recently shown a decrease in agricultural land use and an increase in land designated as subdivisions and rural ranchettes.

Changes to Subbasin Characteristics: Land Use Changes – 1999 through 2007

Data collected within the Cascade Reservoir Watershed show diminishing agricultural and forestry land use and increasing urban/suburban land use trends. Valley County Planning and Zoning Conditional Use Permit applications were reviewed at the end of 2007. Table 3 illustrates the reduction of forestry lands and agricultural lands by subwatershed.

The TMDL land use category most affected by these changes is agriculture, which showed a 7.5% decrease in acreage. This changed TMDL allocations of total phosphorus loads. The values in Table 3 indicate that 4,594 acres that converted into urban-suburban land use acres were previously agricultural lands. Forest lands decreased by 2.2%.

Table 3. Acres of land use changed from agriculture or forestry to urban/suburban, 2000 through 2007, by subwatershed

Change in Land use	Subwatershed							
	Boulder-Willow	Cascade	Gold Fork	Lake Fork	Mud Ck	NFPR	West Mtn.	Total
Agriculture to Urban/Suburban	2,029	589	176	888	84	158	670	4,594
Forest to Urban/Suburban	1,012	67	16	5	0	4	2,832	3,936
TOTAL								8,530

Section 2. TMDL Review and Status

Water quality studies have identified that phosphorus is the pollutant of concern within the watershed. Nuisance algal growth resulting from nutrient loading has impaired the designated beneficial uses of the reservoir, specifically, recreation and agricultural water supply. In order to restore beneficial uses, a TMDL was established in 1998 to reduce the amount of phosphorus entering the reservoir. This section summarizes the components of that TMDL.

Targets

Table 4 identifies the target concentrations for dissolved oxygen, total phosphorus, chlorophyll-*a*, and pH identified in the TMDL that would provide for meeting water quality standards in the watershed. Loading analyses were performed for tributaries that had adequate water quality data available. In order to attain and protect water quality within the watershed, numeric targets for nutrients and chlorophyll-*a* were identified and load reductions required to meet these targets were determined. The findings from the Phase I and II TMDLs (DEQ, 1996 and 1998) showed that total phosphorus was the nutrient of concern for the reservoir. It is assumed that the attainment of these targets will result in support of beneficial uses within both the reservoir and tributary segments and will contribute to attainment of beneficial use support in the Cascade Reservoir Watershed. Also assumed is that attainment of total phosphorus and chlorophyll-*a* targets will lead to attainment of dissolved oxygen and pH criteria.

Table 4. Targets for Cascade Reservoir Watershed

Pollutant	Concentration Target
Dissolved Oxygen	Greater than 6.0 mg dissolved oxygen/L, except in hypolimnion of stratified lakes and reservoirs and the bottom 20% of water depth in lakes and reservoirs with less than 35 m depth (IDAPA 58.01.02. 250.02.a)
Nutrients	Surface waters shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. No greater than 0.025 mg/L total phosphorus in-reservoir water column concentration (IDAPA 58.01.02.200.06 [narrative] and target established by the Phase I and II TMDL [numeric] DEQ, 1996 and 1998). Chlorophyll-*a* in-reservoir water column concentration no greater than 10 ug/L (target established by the Phase I and II TMDL [numeric] DEQ, 1996 and 1998)
pH	No less than 6.5 and no greater than 9.0 standard units (IDAPA 58.01.02. 250.01.a)

The targets for the reservoir were never delineated as to where in the reservoir they applied. In 2008, DEQ received a grant from EPA to determine target application locations. Recommendations were made to apply reservoir targets at the monitoring site by the dam (CWQ02) and the monitoring site by Sugarloaf Island (CWQ05), in order to have a deep forebay site and a mid-reservoir site. DEQ determines whether the targets are being met by looking at data from the period when the reservoir is most vulnerable to nuisance algae growth. This period is typically August to early September.

This target location selection is consistent with many other reservoir target applications. The selection locations give a good indication of average reservoir conditions and take nutrient processing into account. In particular, DEQ is looking at total phosphorus and chlorophyll-*a* targets. Dissolved oxygen and pH criteria are linked to these targets.

Targets for the tributaries with TMDLs (West Mountain tributaries, Gold Fork, Mud Creek, and Boulder/Willow Creek) were also never explicitly laid out in the Cascade Reservoir Watershed TMDL. The reservoir target of 0.025 mg/L of phosphorus is being used for the tributaries, and the phosphorus target and pH criteria are being used for the West Mountain tributaries TMDL.

Control and Monitoring Points

DEQ monitors near the mouths of the major tributary inflows and at two sites on Cascade Reservoir (shown in Figure 3). Monitoring was conducted biweekly for the tributaries in 2007 and biweekly to monthly for the tributaries and reservoir in 2008.

Figure 3. Monitoring locations on Cascade Reservoir

Total Maximum Daily Load

In-lake water quality targets are based on numerical standards for phosphorus (0.025 mg/L in-lake total phosphorus concentration), chlorophyll-*a* (10 micrograms per liter [µg/L] in-lake chlorophyll-*a* concentration), and dissolved oxygen (concentrations exceeding 6 mg/L at all times, with the exception of the bottom 20% of water depth in lakes and reservoirs where depths are 35 meters or less and those waters of the hypolimnion in stratified lakes and reservoirs). These targets, based on water-quality modeling efforts, were set to achieve full support of designated beneficial uses (specifically fishing, swimming, boating, and agricultural water supply) throughout the watershed. Pollutant loads were allocated in terms of kilograms per year (kg/yr) total phosphorus for each subwatershed. It was assumed that pollutant reductions in inflowing waters would result in support of beneficial uses in 303(d)-listed tributaries.

Reductions required are based on assessment of the maximum in-lake load that can be sustained without beneficial use impairment. Reductions were assessed at the level required to achieve the in-lake water-quality objectives for phosphorus concentration. Load capacity is divided among load allocations, wasteload allocations, and natural background. The load capacity was determined using water quality modeling and actual data on nutrient loading to the reservoir. The loads were determined for an average water year.

Due to changes in land use occurring within the watershed, some adjustments to the load allocations identified in the Phase II TMDL were necessary. Total reductions required in phosphorus loading from agricultural lands use have been decreased by 849 kg/year, and total phosphorus loading reductions from forest lands use have been decreased by 161 kg/year. Total reductions required in phosphorus loading from urban/suburban land use have been increased by 773 kg/year due to changes in land use.

Table 5 and Table 6 identify the wasteload and load allocations (respectively) identified by the TMDL process. The loads from nonpoint sources include natural and background total phosphorus loading.

Table 5. Wasteload Allocations From Point Sources in the Cascade Reservoir Watershed

Wasteload Type	Location	Load Allocation	NPDES[1] Permit Number
McCall Wastewater Treatment Plant	On North Fork Payette River in McCall, Idaho	0 kg/year total phosphorus	ID0020231
Idaho Fish and Game Fish Hatchery	On North Fork Payette River in McCall, Idaho	218 kg/year total phosphorus	ID0025089

[1]National Pollutant Discharge Elimination System

Table 6. Load Capacity and Load Allocations for Total Phosphorus in the Cascade Reservoir Watershed

Subwatershed/other category	Load Capacity (kg/yr)	Natural background (kg/yr)	Nonpoint Sources (kg/yr)	Point Sources (kg/yr)
West Mountain	1667	984	683	
Cascade Subwatershed	463	254	209	
Gold Fork	6071	4704	1367	
Boulder/Willow	3026	922	2104	
Lake Fork	2743	600	2143	
Mud Creek	722	167	555	
North Fork	8982	3445	5319	218
Septic	1365			
TOTAL	25,039	11,076	12,380	218

Load Allocation and Load Capacity

The total phosphorus load capacity calculated for Cascade Reservoir was approximately 25,000 kg/year, roughly 70% of the total phosphorus load measured. In order to not exceed the load capacity, a 30% overall total phosphorus load reduction is required.

Wasteload allocations (Table 7) assigned by the Phase I and II TMDLS reflect full (100%) removal of the City of McCall's wastewater treatment plant (WWTP), and the changes in feeding management practices already in place for the Idaho Fish and Game (IDFG) fish hatchery. Load allocations assigned by the Phase I and II TMDLs reflect a 30% reduction of all nonpoint source total phosphorus loads. In all nonpoint-source load allocations, a 30% reduction of the total load (management load plus natural and/or background load) was determined to be possible from management sources alone. The time frames established in the TMDL for achieving these reductions are shown in Table 8.

Table 7. Wasteload point source allocations for Cascade Reservoir Watershed

Source	Pollutant	Allocation	Time Frame for Meeting Allocations
McCall Wastewater Treatment Plant	On North Fork Payette River in McCall, Idaho	100% removal of discharge (3,947 kg/yr)	Completed
IDFG Fish Hatchery	On North Fork Payette River in McCall, Idaho	70% reduction from 727 kg/year to 218 kg/year total phosphorus	Completed

Table 8. Time Frame for Meeting Total Phosphorus Allocations in the Cascade Reservoir Watershed

Source	Pollutant	Time Frame for Meeting Allocations
Forestry Sources	Total phosphorus	Completed
Agricultural Sources	Total phosphorus	2013
Urban/Suburban Sources	Total phosphorus	2013

Margin of Safety

An extra 7 % total phosphorus reduction was added to the overall 30% phosphorus reductions required for the watershed. This 7% reduction was specifically for point sources to ensure that beneficial uses would be restored.

Natural Background

Natural sources of phosphorus are present within the watershed and contribute to the total phosphorus load measured within the reservoir and the tributaries. This natural loading is an important factor in the consideration of implementation strategy as it represents a phosphorus source that cannot be easily addressed by best management practices. The calculation of natural contribution was specific to slope and vegetative cover throughout the subwatersheds.

Seasonal Variation

Seasonal variability of flow and delivered phosphorus load is high. Concurrent evaluation of time/delivery plots for total phosphorus loading show that between 70% and 80% of the total phosphorus load is delivered to the reservoir during spring snow-melt and related precipitation events. Both represent increased sediment-bound total phosphorus and orthophosphate delivery and result in both long-term and immediately available phosphorus sources (respectively) within the reservoir water column. These time periods should be heavily targeted in any implementation strategy.

Reserve

When this TMDL was written, no reserve for future growth was made. Due to the critical nature of the beneficial use impairment, a reserve capacity for total phosphorus was not established for this TMDL. If a new source wishes to discharge phosphorus load to the reservoir or watershed, the discharge will have to be offset by additional reductions in excess of the required 30% elsewhere in the watershed.

New sources will be required to meet the loading reductions for the land on which they intend to locate, in addition to meeting a requirement for no-net-increase in loading as described above. Pollutant trading could fulfill this requirement.

Section 3. Beneficial Use Status

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses. The *Water Body Assessment Guidance*, second edition (Grafe et al. 2002) gives a detailed description of beneficial use identification for use assessment purposes.

Existing uses under the CWA are “those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.” Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing and presumed uses).

Undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called “presumed uses,” DEQ will apply the numeric cold water aquatic life criteria and primary or secondary contact recreation criteria to undesignated waters.

Beneficial Uses

Beneficial uses for Cascade Reservoir watershed are shown in Table 9.

Table 9. Beneficial Uses for Cascade Reservoir Subwatersheds

Assessment Unit	Uses	Type of Use (designated, presumed)
Cascade Reservoir	Cold water aquatic life, domestic water supply, salmonid spawning, primary contact recreation	designated
Gold Fork River	Cold water aquatic life, domestic water supply, salmonid spawning, primary contact recreation, special resource water	designated
Boulder/Willow Creek	Cold water aquatic life, primary contact recreation	presumed
Lake Fork Creek	Cold water aquatic life, domestic water supply, salmonid spawning, primary contact recreation, special resource water	designated
Mud Creek	Cold water aquatic life, primary contact recreation	presumed

Summary and Analysis of Current Water Quality Data

Implementation of TMDLs within the watershed was initiated with the Phase I TMDL process and is yielding water quality improvements. Mean summertime total phosphorus and chlorophyll-*a* concentrations in the reservoir show decreasing concentration trends since implementation of the Phase I TMDL started in 1994. Excessive algae growth has also been observed to occur over less of the reservoir surface.

Cascade Reservoir Water Column Data

Water column data is available for a number of sites in the Cascade Reservoir Watershed since 1975. Routine DEQ monitoring started in 1989 and increased in frequency with the advent of toxic algae growth in 1993. Seven routine monitoring sites representing all major tributary inflows to the reservoir were sampled on a monthly basis from 1993-2003 and 2007-2008. In addition, in-lake monitoring sites have been sampled during the spring-fall time period. Additional data collection has occurred via long-term Bureau of Reclamation reservoir monitoring.

Monthly monitoring indicates that the vast majority of nutrient loading to the reservoir and the related water quality impacts occur during the summer growing and irrigation season (April through September). Sediment loading is bimodal, with a major peak at the initiation of spring runoff and a lesser peak observed during the irrigation season. Low dissolved oxygen concentrations observed during late summer are commonly inversely correlated with water column total phosphorus concentrations, due to the anoxic release of adsorbed phosphorus from bottom sediments.

Available data show that through 1995, growing season total phosphorus concentrations in-reservoir were two times the target identified by the TMDL process of 0.025 mg/L total phosphorus. Recent total phosphorus data shows that water quality is getting closer to the target concentration.

Chlorophyll-*a* data shows a decreasing trend since the start of implementation in 1994 (Table 10). When compared to pre-implementation data, those data collected subsequent to implementation show an improving water quality trend within the reservoir.

Composited data from the two monitoring sites in the reservoir is shown in Table 10.

Table 10. Average Total Phosphorus and Chlorophyll-*a* Concentrations in August and September (composite of data from the monitoring stations at Sugarloaf Island and the Dam)

Pollutant/Analyte	1993	2000	2008
Mean total phosphorus concentration (mg/L)	0.05	0.03	0.03
Mean chlorophyll-*a* concentration (ug/L)	29.15	20.5	16.5

Status of Beneficial Uses

While data collected subsequent to TMDL implementation show a decreasing trend in total phosphorus, concentrations are still routinely in excess of the target (0.025 mg/L). Water column chlorophyll-*a* concentrations are also above the 10 ug/L target. During late July and

August, dissolved oxygen and temperature violations have been recorded in the reservoir for every sampling year. In 2008, dissolved oxygen and temperature violations were seen in August although not throughout the water column. Elevated pH was also seen in August 2008 at depths close to the surface, indicating algal activity. Overall, as shown in Table 10, these conditions demonstrate an improving trend in water quality within the reservoir.

Based on the water quality trends identified since 1994, DEQ concludes that the implementation of the Cascade Reservoir Watershed Water Quality Management Plan is resulting in water quality improvements both in-reservoir and in the tributary systems, increased support of designated beneficial uses, and improved resiliency of the reservoir. Full implementation is projected to result in routine attainment of water quality targets and full support of designated beneficial uses.

Tributaries

In this section, data for tributaries to the reservoir are discussed. If beneficial uses such as cold water aquatic life or recreation are impaired for a particular stream, then it will be necessary to do further analysis and potentially develop a TMDL for that AU. A conservative phosphorus target of 0.025 mg/L, the same phosphorus target as for the reservoir, is used for the tributaries.

Similar decreasing nutrient trends as in the reservoir are reflected in many of the tributary drainages, with overall nutrient concentrations going down, particularly in the larger volume streams. This decrease in nutrients in the large volume streams is important because it means that overall nutrient loading to the reservoir has substantially decreased. The North Fork Payette River, in an average water year, typically represents 46% of the inflow to the reservoir. The Gold Fork River watershed represents approximately 25% of the inflow, and Lake Fork Creek represents 13% of the inflow to the reservoir (DEQ, 1996).

However, the Boulder Creek drainage, representing approximately 10% of the inflow to the reservoirs, has not had significant decreases in in-stream concentrations, and current DEQ Beneficial Use Reconnaissance Program (BURP) data does not show Boulder Creek supporting beneficial uses in the middle and lower reaches. Mud Creek (approximately 1% of the inflow) has shown a slight decrease in nutrient input, but DEQ BURP data also shows impairment of beneficial uses. The data in Table 11 compares 1993, 2000, and 2007 total phosphorus concentrations for the Cascade Reservoir Watershed tributaries. The 2003-2007 total phosphorus averages for each of the tributaries, along with the two reservoir monitoring sites, are shown in Figure 4.

The TMDL targets are protective of the designated beneficial uses within the watershed; therefore, until the targets are routinely met, full support of beneficial uses cannot be assumed. However, the improving water quality observed indicates that the magnitude of water quality impairment is decreasing. This improving trend translates to better overall habitat and use conditions, and is therefore representative of improving status conditions for designated beneficial uses.

Table 11. Mean total phosphorus concentrations observed in tributaries to Cascade Reservoir from April to September in 1993 (pre-implementation), 2000 (partial implementation), and 2007 (partial implementation).

Tributary Monitoring	1993	2000	2007
Average total phosphorus concentration	0.063 mg/L	0.056 mg/L	0.044 mg/L
Total phosphorus concentration range	0.033 to 0.270 mg/L	0.016 to 0.21mg/L	0.007 to 0.155

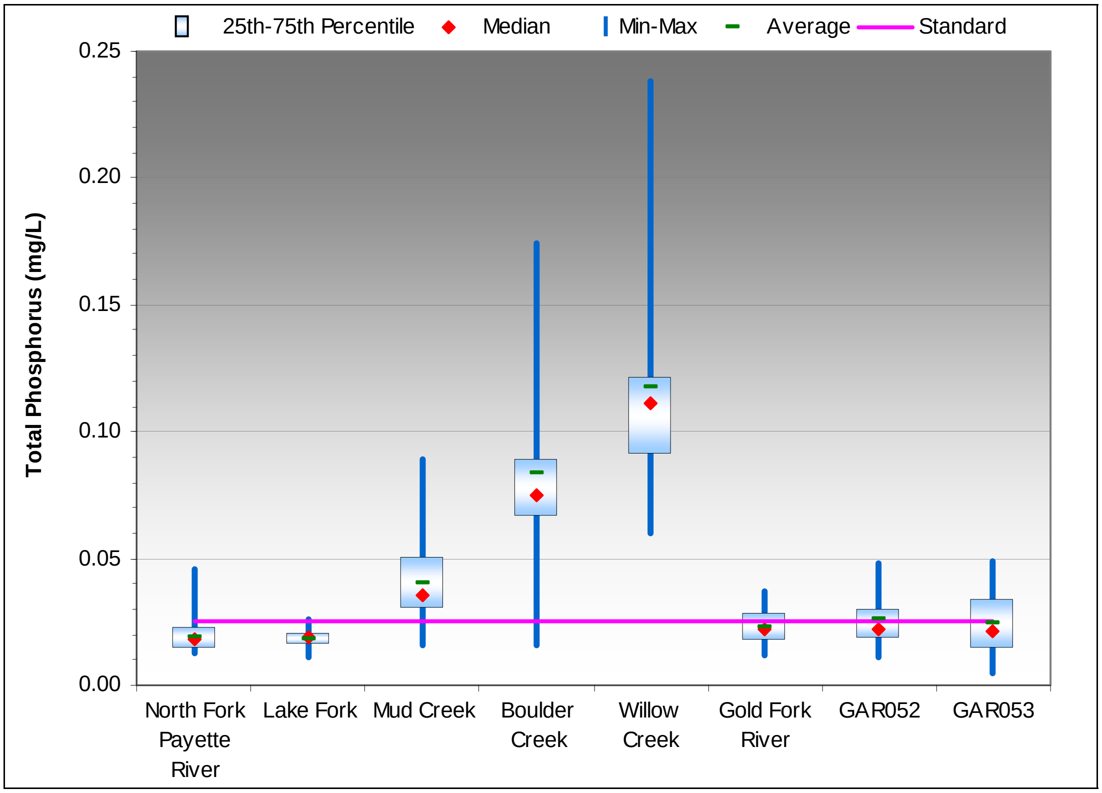

Figure 4. Comparison of total phosphorus concentrations in the Cascade Reservoir Watershed (2003-2007, May 1-September 30)

West Mountain Tributaries

A TMDL for total phosphorus and pH is in place for tributaries to Cascade Reservoir on the west side of the reservoir. In general, tributaries on the west side of Cascade Reservoir are small volume streams and flow through forested land. Data is available from Poison Creek, which flows through Tamarack Resort's golf course and development. Other streams in this area flow through forested areas and through small residential subdivisions. Areas to the North of Tamarack are part of the North Lake Sewer District, and many septic systems have been decommissioned as residents connect to the sewer system. Areas to the south are still on septic systems.

The Idaho State Department of Agriculture did not sample Poison Creek (a surrogate stream for the West Mountain tributaries) in 2007, so DEQ sampled the creek in 2008. Results showed that the mean total phosphorus concentration over the May-September sampling season was 0.055 mg/L (median= 0.054 mg/L). In 2000, before Tamarack Resort was developed, the mean total phosphorus concentration was 0.062 mg/L (median= 0.052 mg/L). There have been no pH violations in the past five years. DEQ recommends delisting AU ID17050123SW007_02 for pH in the next 303(d) listing cycle.

Gold Fork

The section of Gold Fork River from below the diversion dam to the mouth (AU ID17050123SW008_05) is listed for sediment on the 303(d) list. A DEQ stream habitat survey in 2006 showed habitat impairment. Over the past 15 years, a decreasing trend in total phosphorus has been evident, as shown in Figure 5.

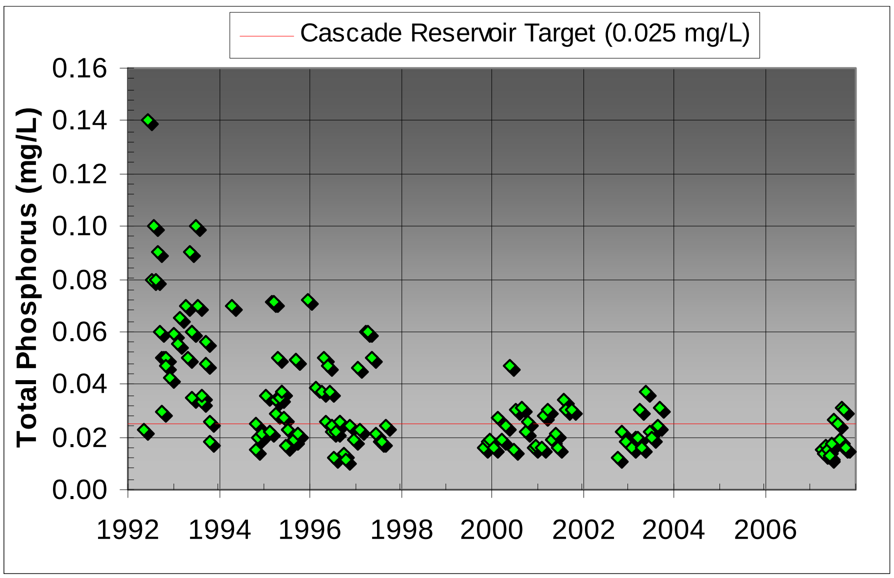

Figure 5. Gold Fork Total Phosphorus Concentrations

The DEQ Gold Fork monitoring site, which is upstream from some of the agricultural land due to access issues, showed a mean total phosphorus concentration of 0.019 mg/L in 2007. Nutrient levels in the Gold Fork are relatively low, ranging from 0.012 mg/L to 0.032 mg/L of total phosphorus. This seasonal average is below the target of 0.025 mg/L. Actual loading into the reservoir may be higher due to the phosphorus contribution from lands downstream from the monitoring site.

DEQ stream inventories upstream from the listed section (upstream from the diversion dam) showed full support of beneficial uses. In the 303(d)-listed section of Gold Fork Creek, suspended sediment data showed low levels, ranging from 0.5 mg/L to 7.7 mg/L. Bedload sediment is suspected to be the primary sediment source to the 5th order reach and is transported mainly during high flows.

DEQ personnel investigated stream bank stability in the 5th order section of Gold Fork Creek. Banks were 38% stable, which is well below the target level of at least 80%. A bank erosion study was initiated, and DEQ recommends that these results be used to develop a sediment TMDL for Gold Fork Creek in 2009.

Boulder/Willow

Boulder Creek downstream of Louie Creek is listed on the draft 2008 303(d) list for temperature, sediment, habitat, and flow alteration. Boulder Creek already has a TMDL for phosphorus in place. Willow Creek is listed for impaired beneficial uses based on low DEQ stream inventory scores for habitat and cold water aquatic life metrics.
The Boulder/Willow Creek subwatersheds represent approximately 10% of the total inflow into the reservoir in an average water year. These watersheds are interrelated due to hydrology and the water delivery systems.
No trends in nutrient data are readily apparent since implementation started in 1994 (Figure 6). Nutrient concentrations in Boulder and Willow Creeks are relatively high compared to the rest of the watershed, ranging from 0.051 mg/L to 0.155 mg/L in 2007. Approximately 40% of the implementation goal for agricultural implementation has been met. Further improvements in the city of Donnelly's stormwater drainage over the next couple of years will help decrease nutrient loading to Boulder Creek.

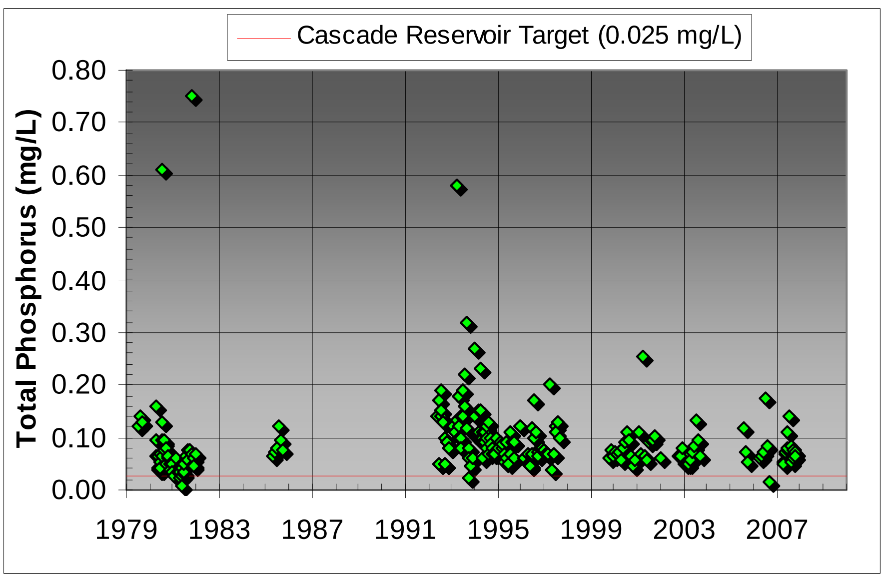

Figure 6. Total Phosphorus Concentrations in Boulder Creek

The Idaho Department of Agriculture noted that while suspended sediment levels were low, the stream substrate appeared to be armored due to sand-sized particles and that this was likely due to stream bank erosion (ISDA 2007). DEQ conducted a stream bank erosion inventory in the Boulder Creek drainage in 2008. Overall, stream bank stability in the section of Boulder Creek downstream of Louie Creek was estimated at 67%, which is below the recommended target of at least 80%. Willow Creek was also investigated for stream bank stability and showed greater than 80% stable banks, which meets the bank stability target. DEQ recommends developing a sediment TMDL for Boulder Creek in 2009.

In-stream temperatures in Boulder Creek violated the instantaneous temperature standard of 22 degrees Celsius. Additional temperature monitoring with a temperature logger is recommended for Boulder Creek from Louie Creek downstream to the mouth. A TMDL will be developed if Boulder Creek is in violation of the temperature standard for cold water aquatic life more than 10% of the time during the summer.

In 2007, dissolved oxygen (DO) levels in Boulder Creek and Willow Creek were in violation of the state standard for DO from late June through early September. Flows during this time were below 5 cubic feet per second (cfs) and generally around 1 cfs. Overall, the water quality data, specifically the low DO levels, show that beneficial uses are not supported in Boulder and Willow Creeks.

In Willow Creek, the 2007 mean total phosphorus concentration was 0.095 mg/L. Implementation of the phosphorus TMDL in place for Willow Creek should eventually result in attainment of beneficial uses. The recent 303(d) listing of the AU based on habitat/bioassessment scores for AU17050123SW011_02 (the 1st and 2nd order irrigated sections of Boulder and Willow Creek) is not warranted since there is already a TMDL in place (AU17050123SW011_02). This is a listing error, and this AU is recommended for delisting in the next integrated report cycle.

Lake Fork Creek

DEQ stream surveys above Little Payette Lake showed full support of beneficial uses. Lake Fork Creek below Little Payette Lake is listed for an unknown pollutant. Nutrient data showed low levels of total phosphorus in Lake Fork Creek (Figure 7). Dissolved orthophosphorus, the biologically available form of phosphorus, showed a decreasing trend from the mid 1990s. Prior to 2007, the average dissolved orthophosphorus concentration was 0.013 mg/L, and in 2007, the concentration was 0.006 mg/L.

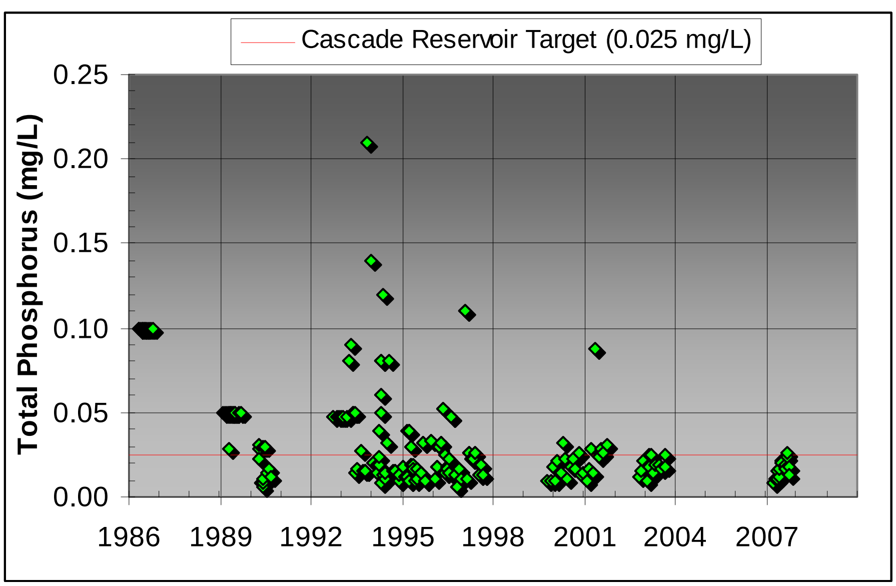

Figure 7. Lake Fork Creek Total Phosphorus Concentrations

In 2007, data was collected that showed DO in Lake Fork Creek below 6 mg/L (the Idaho minimum standard for DO) (ISDA 2007). Temperature data during that time did not show exceedance of the state standard. The field notes from the Idaho State Department of Agriculture for that data collection event state that macrophytic vegetation was present in the sampling transect. DEQ has noted the same characteristics but noted that the vegetation is not present throughout the channel, just in a short section below a deep pool and above a riffle. In 2008, depressed DO conditions were not seen. Lake Fork Creek has a substantial amount of water diverted from it in the summer. Lack of flow appears to be the primary factor leading to aquatic life impairment and low DO. DEQ recommends that Lake Fork Creek be listed for flow alteration.

Mud Creek

Mud Creek is listed on the 303(d) list for bacteria, sediment, nutrients (ammonia and total nitrogen, in addition to phosphorus), and dissolved oxygen. A TMDL is in place for phosphorus.

The ammonia concentrations in Mud Creek ranged from 0.01 to 0.04 mg/L, far below the ammonia criteria, which are set at a level such that exceeding them would adversely affect young fish. DEQ recommends that Mud Creek be delisted for ammonia. Total nitrogen/total phosphorus (TN/TP) ratios are used to determine whether a stream system's aquatic plant growth is limited by phosphorus or nitrogen. TN/TP ratios less than 7 indicate a nitrogen-limited system whereas TN/TP ratios greater than 7 indicate a phosphorus-limited system. Mean TN/TP ratios in Mud Creek are greater than 7, indicating a phosphorus-limited system. Excess nutrients can lead to excess aquatic plant growth and low dissolved oxygen (DO). In 2007, DO levels ranged from 6.95 to 10.29, which exceeds the 6 mg/L minimum level required by the state DO criteria. It is recommended that Mud Creek be delisted for DO in the next cycle of the Integrated Report 303(d) list. Excess nutrients do not appear to be causing depressed DO levels.

The Idaho Department of Agriculture did not sample for nitrogen constituents in 2007, so DEQ sampled for these in 2008. The average total nitrogen concentration was 0.56 mg/L. Since total nitrogen concentrations are not the main factor influencing nuisance algae growth and these concentrations are not linked to depressed DO, DEQ will recommend delisting Mud Creek for total nitrogen in the next 303(d) list cycle.

Phosphorus concentrations in Mud Creek averaged 0.04 mg/L over the growing season, which is slightly above the 0.025 mg/L reservoir total phosphorus target. Concentrations appear to have decreased since the mid-1990s.

Suspended sediment levels in Mud Creek were low, but stream substrate appears to be predominantly sand. A stream bank stability inventory was conducted on parts of Mud Creek. The results showed that stream banks were 68% stable. A sediment TMDL based on stream bank erosion is recommended to ensure that excess sediment does not impair beneficial uses in the creek. This TMDL would be developed in coordination with the watershed advisory group (WAG) in 2009.

In 2008, a sample from the 3rd order streams of the Mud Creek subwatershed had 466 E. coli organisms/100 ml, which is in violation of the primary contact recreation standard for bacteria. This primary contact standard is designed to protect people from illness during activities that might involve ingestion of water such as swimming. DEQ will take five bacteria samples during the summer season to see if the five-sample geometric mean standard is met. If not, a TMDL will be developed for bacteria for Mud Creek.

DEQ stream inventory results from 2003 indicate that beneficial uses are not supported in Mud Creek. Although conditions have improved in Mud Creek with the implementation of the Cascade Reservoir TMDL, additional implementation may be necessary to ensure that water quality improves enough to support beneficial uses.

North Fork Payette River

Overall, total phosphorus concentrations have decreased in the North Fork Payette River (from the outlet of Payette Lake to Cascade Reservoir) since the 1990s as shown in Figure 8, from an average concentration of 0.05 mg/L in the mid-1990s to an average of 0.023 mg/L in 2007. Dissolved orthophosphorus concentrations have decreased from an average of 0.023 mg/L in 1994 to 0.004 mg/L in 2007.

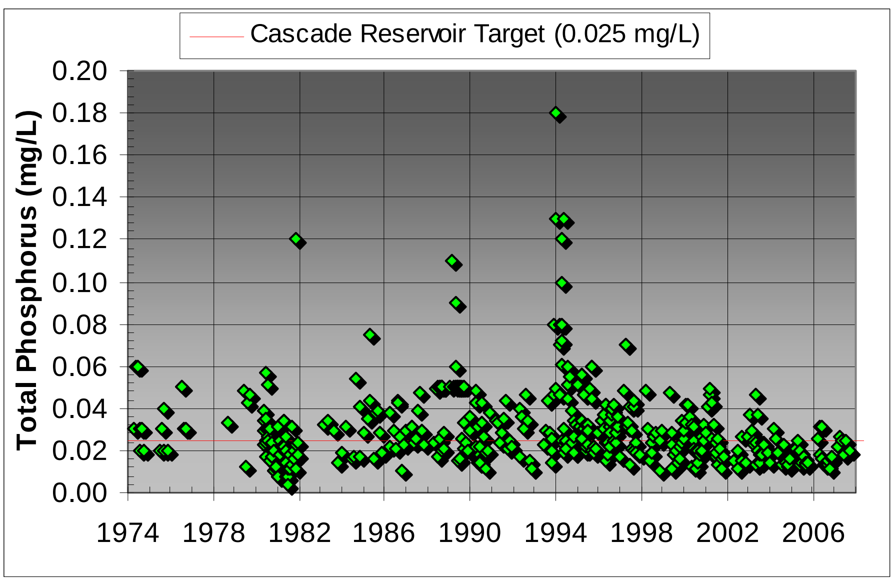

Figure 8. North Fork Payette River at Hartzell Bridge Total Phosphorus Concentrations

Conclusions About Beneficial Use Status

Table 12 shows the beneficial use status of several tributaries to Cascade Reservoir. While water quality improvements have been seen in some of the tributaries to Cascade Reservoir, beneficial use impairment exists in others, and TMDL development or additional investigation is recommended for those. The designated beneficial uses listed in Table 9 were evaluated as appropriate for those AU. For tributaries with TMDLs, implementation has begun in every watershed although implementation is not complete. Improvements have been seen in most watersheds except Boulder Creek.

Table 12. Beneficial Use Summary for Assessment Units With Recommended Changes to the 303(d) List (2008 Draft Integrated Report, Section 5)

Assessment Unit	Water Body	Suspected Impairment Cause	Recommended Changes to Next Integrated Report	Justification
ID17050123SW008_05	Gold Fork – 5th order	Sediment	Develop a TMDL for sediment in 2009	Unstable streambanks
ID17050123SW011_02	Boulder/Willow Creek – 1st and 2nd order irrigated sections	Habitat	Delist—a TMDL is already in place for this assessment unit	TMDL for phosphorus is already in existence.
ID17050123SW011_03	Boulder Creek – Louie Creek to Cascade Reservoir	Habitat, Flow alteration, Sediment, Temperature	Develop TMDL for sediment and possibly for temperature if necessary in 2009	Unstable streambanks, coldwater temperature criteria and dissolved oxygen violations
ID17050123SW012_03	Lake Fork – Little Payette Lake to Cascade Reservoir	Habitat, Unknown – nutrients suspected	List for habitat and flow alteration in section 4c, no TMDL recommended	Low instream nutrient concentrations
ID17050123SW015_02	Mud Creek – 1st and 2nd order	Habitat, Bacteria, Sediment, Nitrogen (total), Unknown – nutrients suspected	Develop TMDL for sediment, delist for nitrogen, investigate bacteria and develop a TMDL if necessary in 2009	Unstable streambanks, low nitrogen (phosphorus is limiting factor in algal growth), high bacteria concentration during summer months
ID17050123SW015_03	Mud Creek – 3rd order	Ammonia (unionized), Habitat, Bacteria, Sediment	Delist for ammonia, develop TMDL for sediment, investigate bacteria and develop a TMDL if necessary in 2009	Unstable streambanks, ammonia meets aquatic life criteria, high bacteria concentration during summer months

Section 4. Summary of Implementation Efforts

Many different government and private entities coordinated efforts to write the implementation plan (DEQ, 2000). The plan is divided into three different pollutant source categories: agricultural, urban/suburban and forestry.

Implementation Strategies and Implementation Time Frame

An implementation plan for the Phase II TMDL was completed in 2000 (DEQ, 2000), and implementation is estimated to be 70% complete at this time. The original goal for completion of the implementation goal was 2013, which appears to be within reach. With the completion of the J-Ditch project combined with the reductions accomplished by the Idaho Fish and Game (IDFG) Fish Hatchery, 100% of the total point source reduction goal has been accomplished. The total of measured and estimated nonpoint source reductions (including reductions resulting from septic-to-sewer upgrades) equals 58% of the nonpoint source goal. Please refer to the *Implementation Plan for the Cascade Reservoir Watershed Phase II Water Quality Management Plan* for further details of the implementation strategies being undertaken and estimated costs associated with the individual strategies.

The expected time frame for meeting water quality standards and attaining full support of beneficial uses within the Cascade Reservoir Watershed was identified in the Phase II TMDL as 15 years from the completion of implementation, with improving water quality seen 5 years from the completion of implementation. Water column concentrations of in-reservoir total phosphorus and chlorophyll-*a* are already nearing the water quality targets identified by the Phase II TMDL.

Within the Cascade Reservoir Watershed, implementation proceeded concurrently with the TMDL process; thus, a considerable number of pollution control measures have already been implemented.

Responsible Parties

Many different entities came together to implement the TMDL. They are identified in the following pollutant source group sections.

Planned and Accomplished Activities

The implemented activities are discussed in the following sections.

Point Sources

At the time of the Phase I and Phase II TMDLs, there were two point sources of pollution to Cascade Reservoir: the McCall wastewater treatment plant (WWTP) and the IDFG fish hatchery in McCall. Both sources discharged directly to the North Fork Payette River (NFPR) upstream of Cascade Reservoir under National Pollutant Discharge Elimination System (NPDES) permits. A detailed discussion of these point sources is available in the

Phase II TMDL (DEQ, 1998
www.deq.idaho.gov/water/data_reports/surface_water/tmdls/cascade_reservoir/cascade_reservoir.cfm)

McCall Wastewater Treatment Plant J-Ditch Project

Major pollutants of concern associated with the WWTP discharge are nutrients, predominantly phosphorus. Effluent pollutant concentrations vary seasonally and typically exceed ambient concentrations in the NFPR. Since 1988, annual total phosphorus discharge from the WWTP loading had remained relatively stable, ranging from 3,815 kg to 4,751 kg annually. In 2001, the WWTP completed a project to remove 100% of its effluent from the NFPR. Since that time, there has been no consistent discharge from this facility to NFPR. This project, named after the J-Ditch irrigation canal it replaces, allows treated effluent from the City of McCall to be mixed with clean water and applied at agronomic rates to pasture and crop land in the Mud Creek drainage during the summer irrigation season. The completion of the J-Ditch project represents 100% removal of the WWTP effluent from NFPR, as called for in the Phase I and II TMDLs.

Currently, the city of McCall is going through the process of planning for a new WWTP facility. The city is considering a proposal that would involve discharging treated effluent to the NFPR and setting up a pollutant trading network to offset those discharges. This trading network would need to be approved by DEQ, the Cascade Reservoir WAG, and EPA to ensure that the trades would offset any nutrient additions to the NFPR.

Idaho Fish and Game Fish Hatchery at McCall

The IDFG Fish Hatchery also discharges wastewater to the NFPR. Modifications to food type and feeding practices in 1994 and installation of a sediment pond to treat discharge water in 1999 resulted in a 70+% reduction in hatchery-related total phosphorus load. Current contributions of phosphorus from the hatchery account for less than 1% of the total load.

Major pollutants of concern associated with the hatchery discharge are nutrients; again, predominantly phosphorus. In 1994, the fish food being used (1.7% phosphorus by weight) was replaced by a food type with lower phosphorus content (0.7% phosphorus by weight). The combination of this food change, along with changes in feeding practices, has resulted in a substantially reduced phosphorus load since 1994. Pre-1994 total phosphorus loads from this source were evaluated at 726 kg/yr (average). Post-1994 total phosphorus loads were evaluated at 218 kg (average) annually.

A unique combination of agricultural and urban/suburban efforts has been completed by agricultural land users in the Mud Creek subwatershed and the City of McCall. Effluent collected during non-irrigation months is retained in storage lagoons constructed by the City of McCall and then land-applied during the following irrigation season. Agricultural land users participating in this project originally used sub-flood irrigation practices. To date, all participants have installed on-farm sprinkler systems. Because the mixed effluent is applied at agronomic rates, no adverse inputs or additional phosphorus loading within the Mud Creek subwatershed are projected to occur. The users have 20-year contracts, which will be up for renewal in 2016.

Nonpoint Source Control Efforts

Water quality improvement projects within the watershed have been divided into separate subwatersheds. Each of these subwatersheds was given a priority ranking, depending on how much phosphorus was being delivered from it to the reservoir, its proximity to the reservoir, cost-benefit analyses, and other factors. The subwatersheds were ranked in order of priority (highest to lowest) as follows: Boulder/Willow Creeks, West Mountain Tributaries, Lake Fork Creek, Gold Fork Creek, Mud Creek, and Cascade (the NFPR is not currently ranked). Within each subwatershed, projects are divided into three primary categories based on land use: forestry, agriculture, and urban/suburban. Some nonpoint source implementation projects currently underway are discussed in the source group-specific sections that follow.

Forestry Control Efforts

The major source of anthropogenic total phosphorus loading from forested lands in the watershed was identified as road-related sediment runoff and transport. The U.S. Forest Service, Idaho Department of Lands, and the major private forestry landholder at the time – Boise Cascade – focused implementation efforts primarily on road improvements and secondarily on grazing management. In 2002, forestry nonpoint sources achieved 100% of their implementation reduction goal for total phosphorus.

Forest Roads

Implementation measures completed for forestry sources specific to forest roads include treating more than 109 miles of road, including 81 miles graveled, 0.1 miles paved, 3.5 miles closed, and 24.7 miles of drainage upgrades. Estimated percentages of reduction in sediment and total phosphorus are shown in Table 13.

Table 13. Estimated percentages of reduction in anthropogenic sediment and total phosphorus resulting from implementation of forest best management practices (BMPs) from 1994 though 2007.

Watershed	Sediment Reduction	Total Phosphorus Reduction
Boulder/Willow	84%	84%
Gold Fork	81%	81%
North Fork Payette	80%	80%
West Mountain Tributaries	87%	86%
Watershed-wide Average	82%	82%

Grazing Management

Implementation measures completed specific to grazing management on forested allotments included a joint effort between Idaho Department of Lands (IDL), US Forest Service (USFS), Boise Cascade Corporation (BCC), and other private landowners to update and correlate grazing management plans. Nearly 100% of grazing allotments on public forested lands are now under grazing management plans. Dramatic improvements in stream bank vegetation have been observed in areas where grazing management plans have been put in place or updated, especially in the Gold Fork and West Mountain subwatersheds.

The total phosphorus reductions realized through implementation of improved grazing management on forested lands were estimated from the known efficiencies of best management practices (BMPs) in place, as well as determined from monitoring data. Treatment of additional road segments will continue, as part of timber harvest activities or separately from those activities.

Agricultural Control Efforts

The agricultural implementation plan was written by representatives from DEQ, Boise National Forest (BNF), Idaho State Department of Agriculture (ISDA), Natural Resources and Conservation Service (NRCS), West Central Highlands Resource Conservation & Development Council, Idaho Soil Conservation Commission, and the Valley County Soil and Water Conservation District.

Treatment Prioritization

The Valley County Water and Soil Conservation District, ISDA, Idaho Soil Conservation Commission, and NRCS, in coordination with private landowners, have been instrumental in agricultural implementation. Acres for agricultural treatment were divided into a tiered system in which Tier 1 acres (those within 150 feet on either side of the steam channel) were identified as the first priority for treatment and implementation. Tier 2 acres (irrigated uplands) have been identified as the second priority for treatment and implementation. Tier 3 acres (non-irrigated uplands) have been identified as the last priority for treatment and implementation. Treatment of agricultural lands includes both irrigation and grazing management. Implementation of new BMPs has been accomplished on a total of 1,829 acres of Tier I agricultural lands and 10,319 acres of Tier II agricultural lands.

Grazing and Irrigation Management

For implementation projects on private lands, contracts were developed with private landowners to provide cost-share for implementation of the conservation plan and approved BMPs. Within Tier 1 acreage, the following practices were applied: fencing, use exclusion, and tree/shrub establishment. The systems applied within Tier 2 include the following practices: tree/shrub planting, use exclusion, wetland wildlife habitat management, upland wildlife habitat management, and pest management. The total phosphorus reductions realized through implementation on agricultural lands were estimated from known efficiencies of BMPs in place. Table 14 shows the number and percentage of acres treated in each watershed.

Table 14. Agricultural acres treated and/or cost shared by subwatershed through December 2007.

Subwatershed	# Tier 1 Acres Treated	% Tier 1 Acres Treated	# Tier 2 Acres Treated	% Tier 2 Acres Treated	# Tier 3 Acres Treated	% Tier 3 Acres Treated	Total Acres Treated
Boulder/Willow	244	38%	2,352	44%	60	No treatment required	2,596
Cascade	94	13%	180	5%	0	No treatment required	274
Gold Fork	213	24%	371	12%		No treatment required%	584
Lake Fork	130	13%	1163	28%	0	0%	1293
Mud Creek	1114	>100%	6,253	100%	110	No treatment required	7167
NF Payette	34	3%	0	0%	0	No treatment Required	34
West Mountain	0	0%	0	0%	0	0%	0
Totals	**1829**	**29%**	**10319**	**39%**	**0**	**<1%**	**11,948**

Urban/Suburban Control Measures

Responsible parties for urban/suburban measures include the city of Donnelly, the city of McCall, the city of Cascade, Valley County Road Department, landowners/homeowners, and real estate developers.

Stormwater Management

Indirect treatment measures (constructed wetlands) for the City of McCall, installed previously, are being maintained to treat stormwater discharging to the NFPR. Direct stormwater treatment measures (Vortechs technology, sand and gravel filters) for the City of McCall were installed in the Legacy Park area. This facility is being maintained to treat stormwater discharge to Big Payette Lake. An additional Vortechs system has been installed in the Art Roberts Park drainage area to treat stormwater discharging to Big Payette Lake. These systems are estimated to reduce up to 75% of total phosphorus. A street-sweeping program has been initiated and maintained to remove traction materials distributed throughout the winter. These materials are being removed from streets and gutters and deposited in a location where they will not be entrained in snowmelt flows and carried into the stormwater system. The Handbook of Stormwater BMPs for City and Counties has been adopted by Valley County. In addition, Valley Water and Soil Conservation District provides comments on drainage plans for proposed real estate developments.

The City of Donnelly is working on improving stormwater drainage. A curtain drain was installed on the north end of town and is designed to intercept the lateral movement of ground water (the water table is very high in Donnelly) and direct it into Boulder Creek. This will prevent the drainage system from being overwhelmed and spilling over during storm events and snowmelt. By the end of 2008, a storm pipe drainage will be put in place along West Roseberry Road and this drain will run through a Vortechs filter before discharging into Boulder Creek.

Roadway Improvements

Numerous street and drainage improvements associated with road improvements to Highway 55 within the City of McCall have been accomplished. Drainage and surface improvements on county roads (watershed-wide) have been completed; however, as new roads are built in subdivisions, more road improvements may be necessary. Subsection 319 grants were obtained for road paving and drainage improvements on West Mountain Road in the Campbell Creek area and on Lakeshore Drive.

The total phosphorus reductions realized through implementation on urban/suburban lands have been estimated from known efficiencies of BMPs in place.

Other Nonpoint Source Control Efforts

Many other pollutant control efforts have been accomplished by state and federal agencies and private land owners in the watershed. A brief summary of some of these efforts follows.

US Bureau of Reclamation

Projects for shoreline erosion management are being maintained and are functioning well. Funding for additional projects is being actively sought. Created wetlands in the near-shore area of Cascade Reservoir have reduced nutrient, bacteria, and sediment loading. Over 3,000 linear feet of bank have been stabilized since 2000. These areas are mainly around Arrowhead Point, the Boulder Creek arm, and the Lake Fork arm.

Idaho Parks and Recreation

A program to use chipping as a method of downed/damaged tree disposal has been introduced by Lake Cascade State Park. The chips are used as mulch and to reduce erosion in heavy use areas. Leaking or poorly sealed vault toilets have been decommissioned in Van Wyck central and Van Wyck north and replaced by a composting toilet and a standard vault toilet. Improved stormwater runoff treatment and drainage systems have been completed for some facilities, including the Van Wyck boat launch, which diverts stormwater runoff to a sediment basin before discharging to the reservoir.

Valley Soil Conservation District/DEQ

The Valley Water and Soil Conservation District and DEQ initiated an education outreach program, Lake A Syst, to reach homeowners on the east side of the reservoir. Lake A Syst provides information on how to manage homeowner activities, including landscaping and construction, to minimize impact on the reservoir.

In addition, DEQ sponsors an annual stormwater erosion education workshop for construction contractors and real estate developers.

Summary of Total Phosphorus Reductions

Total phosphorus reductions for nonpoint sources are estimated from efficiencies of BMPs in place. Monitoring will continue, to validate estimated reductions in total phosphorus loading.

The overall reduction goal for point source loading identified by the Phase II TMDL is 4,455 kg/year total phosphorus reductions. With the completion of the J-Ditch project (described on page 23), estimated point source reductions from this project equal 3,947 kg/year. When combined with the previous reductions accomplished by the IDFG Fish Hatchery, 100% of the total point source reduction goal has been accomplished.

The overall reduction goal for nonpoint source load is 11,141 kg/year total phosphorus reductions. The total of measured and estimated nonpoint source reductions (including reductions resulting from septic-to-sewer upgrades) equals 6,421 kg/year (approximately 58% of the nonpoint source reduction goal). Overall, between point and nonpoint source reductions, 70% of the load reduction goals have been met.

Future Strategy

Implementation must continue to occur in order to reach the total phosphorus load reduction goals. Continued agricultural and urban/suburban implementation projects similar to the ones already implemented will help achieve the TMDL goals. The water quality results indicate that implementation is on track and show that there are opportunities for nutrient reductions still available in the Boulder and Willow Creek watersheds.

Section 5. Five Year Review Conclusions and WAG Involvement Summary

Implementation of management changes and BMPs by point and nonpoint sources within the Cascade Reservoir Watershed has resulted in water quality improvements. Exceedances of the TMDL targets have occurred less frequently since the start of implementation, and median water column total phosphorus and chlorophyll-*a* concentrations have consistently decreased in all years since 1994 except 2001 (an exceptional drought year). When compared to pre-implementation data, those data collected subsequent to implementation unquestionably show an improving water quality trend within the reservoir. While water quality targets are not met consistently within the reservoir, the improving water quality observed indicates that the magnitude of water quality impairment is decreasing. This improving trend translates to better overall habitat and use conditions, and is therefore representative of improving status conditions for designated beneficial uses.

Table 12 outlines the changes to the integrated report and recommendations for future TMDLs for tributaries to Cascade Reservoir.

Based on the water quality trends identified since 1994, it is the conclusion of DEQ that the implementation of the Cascade Reservoir Watershed Water Quality Management Plan is resulting in water quality improvements both in-reservoir and in the tributary systems, increased support of designated beneficial uses, and improved resiliency of the reservoir. Full implementation is projected to result in routine attainment of water quality targets and full support of designated beneficial uses. Therefore, it is recommended that the current level of implementation be continued as outlined in the Cascade Reservoir TMDL Implementation Plan (DEQ, 2000).

Public Process

Throughout this phased TMDL process, local experience and participation have been and will continue to be invaluable in the identification of water quality issues and reduction strategies appropriate on a local scale. The public committees created for the Cascade Reservoir Watershed, the Cascade Reservoir Watershed Advisory Group (WAG), and the Cascade Reservoir Technical Advisory Committee (TAC), have been involved in the review and assessment of all phased TMDL documents including this five-year review. A more detailed discussion of the overall public process associated with this phased TMDL is available in the Phase I and II documents (DEQ, 1996 and 1998).

No significant comments or concerns were raised regarding this document. It was suggested that more detail be provided on how to achieve the rest of the implementation goal. This will be done in future TMDL development related to tributaries such as Boulder Creek and Gold Fork River.

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Glossary

305(b)	Refers to section 305 subsection “b” of the Clean Water Act. 305(b) generally describes a report of each state’s water quality, and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.
§303(d)	Refers to section 303 subsection “d” of the Clean Water Act. 303(d) requires states to develop a list of waterbodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.
Acre-Foot	A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.
Adsorption	The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules
Aeration	A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.
Aerobic	Describes life, processes, or conditions that require the presence of oxygen.
Algae	Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
Anoxia	The condition of oxygen absence or deficiency.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Aquatic	Occurring, growing, or living in water.
Assimilative Capacity	The ability to process or dissipate pollutants without ill effect to beneficial uses.
Bedload	Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic biota, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.
Beneficial Use Reconnaissance Program (BURP)	A program for conducting systematic biological and physical habitat surveys of waterbodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers
Best Management Practices (BMPs)	Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation’s water resources.
Community	A group of interacting organisms living together in a given place.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. EPA develops criteria guidance; states establish criteria.
Cubic Feet per Second	A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.
Cultural Eutrophication	The process of eutrophication that has been accelerated by human-caused influences. Usually seen as an increase in nutrient loading (also see Eutrophication).
Decomposition	The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.
Designated Uses	Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.
Discharge	The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen (DO)	The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.
Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
E. coli	Short for *Escherichia Coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans. Their presence is often indicative of fecal contamination.
Ecology	The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.
Ecological Integrity	The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996).
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Effluent	A discharge of untreated, partially treated, or treated wastewater into a receiving waterbody.
Environment	The complete range of external conditions, physical and biological, that affect a particular organism or community.
Erosion	The wearing away of areas of the earth's surface by water, wind, ice, and other forces.
Eutrophic	From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.
Eutrophication	1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.
Exceedance	A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.
Existing Beneficial Use or Existing Use	A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Feedback Loop	In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.
Fixed-Location Monitoring	Sampling or measuring environmental conditions continuously or repeatedly at the same location.
Flow	See Discharge.
Focal	Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.
Fully Supporting	In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).
Fully Supporting Cold Water	Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions (EPA 1997).
Fully Supporting but Threatened	An intermediate assessment category describing waterbodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a “not fully supporting” status.
Geographical Information Systems (GIS)	A georeferenced database.
Grab Sample	A single sample collected at a particular time and place. It may represent the composition of the water in that water column.
Gradient	The slope of the land, water, or streambed surface.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.
Hydrologic Basin	The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).

Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.
Hydrologic Unit Code (HUC)	The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.
Hydrology	The science dealing with the properties, distribution, and circulation of water.
Impervious	Describes a surface, such as pavement, that water cannot penetrate.
Influent	A tributary stream.
Inorganic	Materials not derived from biological sources.
Instantaneous	A condition or measurement at a moment (instant) in time.
Irrigation Return Flow	Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.
Limnology	The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.
Load Allocation (LA)	A portion of a waterbody's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Loading Capacity (LC)	A determination of how much pollutant a waterbody can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.

Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.
Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.
Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a waterbody, such that aquatic plants take up and store an abundance in excess of the plants' current needs.
Macro-invertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Margin of Safety (MOS)	An implicit or explicit portion of a waterbody's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving waterbody. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Metric	1)A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.
Milligrams per liter (mg/L)	A unit of measure for concentration in water, essentially equivalent to parts per million (ppm).
Monitoring	A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a waterbody.
Mouth	The location where flowing water enters into a larger waterbody.
National Pollution Discharge Elimination System (NPDES)	A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition A condition indistinguishable from that without human-caused disruptions.

Nitrogen An element essential to plant growth, and thus is considered a nutrient.

Nonpoint Source A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA) A concept and an assessment category describing waterbodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable A concept and an assessment category describing waterbodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

Not Fully Supporting Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Not Fully Supporting Cold Water At least one biological assemblage has been significantly modified beyond the natural range of its reference condition (EPA 1997).

Nuisance Anything, which is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Nutrient Cycling The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Organic Matter Compounds manufactured by plants and animals that contain principally carbon.

Ortho-phosphate A form of soluble inorganic phosphorus most readily used for algal growth.

Oxygen-Demanding Materials	Those materials, mainly organic matter, in a waterbody that consume oxygen during decomposition.
Parameter	A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.
Pathogens	Disease-producing organisms (e.g., bacteria, viruses, parasites).
Perennial Stream	A stream that flows year-around in most years.
Periphyton	Attached microflora (algae and diatoms) growing on the bottom of a waterbody or on submerged substrates, including larger plants.
Pesticide	Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.
pH	The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.
Phased TMDL	A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a waterbody. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.
Phosphorus	An element essential to plant growth, often in limited supply, and thus considered a nutrient.
Plankton	Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.
Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution A very broad concept that encompasses human-caused changes in the environment that alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Primary Productivity The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour.

Quantitative Descriptive of size, magnitude, or degree.

Reach A stream section with fairly homogenous physical characteristics.

Reconnaissance An exploratory or preliminary survey of an area.

Reference A physical or chemical quantity whose value is known, and thus is used to calibrate or standardize instruments.

Reference Site A specific locality on a waterbody that is minimally impaired and is representative of reference conditions for similar waterbodies.

Resident A term that describes fish that do not migrate.

Respiration A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riparian Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a waterbody.

River A large, natural, or human-modified stream that flows in a defined course or channel, or a series of diverging and converging channels.

Runoff The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.

Sediments Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.

Species

1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.

Spring Ground water seeping out of the earth where the water table intersects the ground surface.

Stagnation The absence of mixing in a waterbody.

Stratification A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).

Stream A natural watercourse containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.

Stream Order Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.

Storm Water Runoff Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces.

Subbasin A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA) A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6^{th} field hydrologic units.

Surface Fines Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 mm depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.

Surface Runoff Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.

Surface Water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.
Suspended Sediments	Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.
Total Maximum Daily Load (TMDL)	A TMDL is a waterbody's loading capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual basis. TMDL = Loading Capacity = Load Allocation + Wasteload Allocation + Margin of Safety. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several waterbodies and/or pollutants within a given watershed.
Tributary	A stream feeding into a larger stream or lake.
Trophic State	The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll-*a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.
Total Suspended Solids (TSS)	The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Greenborg, Clescevi, and Eaton 1995) call for using a filter of 2.0 micron or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.
Toxic Pollutants	Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.
Tributary	A stream feeding into a larger stream or lake.
Trophic State	The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll-*a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.
Wasteload Allocation (WLA)	The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a waterbody.
Waterbody	A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column	Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.
Water Pollution	Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.
Water Quality	A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.
Water Quality Criteria	Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.
Water Quality Limited	A label that describes waterbodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.
Water Quality Limited Segment (WQLS)	Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."
Water Quality Management Plan	A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.
Water Quality Modeling	The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.
Water Quality Standards	State-adopted and EPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses.
Water Table	The upper surface of ground water; below this point, the soil is saturated with water.

Watershed	1) All the land that contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region, which contributes water to a point of interest in a waterbody.
Waterbody Identification Number (WBID)	A number that uniquely identifies a waterbody in Idaho ties in to the Idaho Water Quality Standards and GIS information.
Wetland	An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Appendix A. Unit Conversion Chart

Table A1. Metric - English unit conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Flow Rate	Cubic Feet per Second (ft^3/sec)[1]	Cubic Meters per Second (m^3/sec)	1 ft^3/sec = 0.03 m^3/sec 1 m^3/sec = ft^3/sec	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[2]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 kg
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 ° C = 37.4 °F

[1] 1 ft^3/sec = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 ft^3/sec.
[2] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water

Appendix B. Cascade Reservoir Watershed Data

Table B.1 Lake Fork Creek Data

Date	Lake Fork Total Phosphorus (mg/L)
01-Oct-92	0.016
01-Nov-92	0.016
01-Dec-92	0.016
01-Jan-93	0.016
01-Feb-93	0.016
01-Mar-93	0.016
12-Apr-93	0.019
27-Apr-93	0.026
12-May-93	0.029
24-May-93	0.005
03-Jun-93	0.008
22-Jun-93	0.018
20-Jul-93	0.018
17-Aug-93	0.022
14-Sep-93	0.017
19-Oct-93	0.013
19-Oct-93	0.013
17-Nov-93	0.034
15-Dec-93	0.026
12-Jan-94	0.005
01-Mar-94	0.02
15-Mar-94	0.021
22-Mar-94	0.028
29-Mar-94	0.023
05-Apr-94	0.047
12-Apr-94	0.037
13-Apr-94	0.019
18-Apr-94	0.029
25-Apr-94	0.025
03-May-94	0.034
10-May-94	0.021
23-May-94	0.034
07-Jun-94	0.005
21-Jun-94	0.023
12-Jul-94	0.009
08-Aug-94	0.013
14-Sep-94	0.012
19-Oct-94	0.01
15-Nov-94	0.005
06-Dec-94	0.005
11-Jan-95	0.007
15-Feb-95	0.005

Date	Lake Fork Total Phosphorus (mg/L)
28-Feb-95	0.006
15-Mar-95	0.011
28-Mar-95	0.005
11-Apr-95	0.005
25-Apr-95	0.005
27-Jun-95	0.005
11-Jul-95	0.005
07-Sep-95	0.005
26-Sep-95	0.005
12-Dec-95	0.009
11-Feb-96	0.005
21-Feb-96	0.005
02-Apr-96	0.007
24-Apr-96	0.006
07-May-96	0.005
23-May-96	0.014
04-Jun-96	0.006
19-Jun-96	0.005
02-Jul-96	0.005
17-Jul-96	0.007
30-Jul-96	0.006
22-Aug-96	0.006
24-Sep-96	0.005
23-Oct-96	0.005
18-Nov-96	0.005
19-Dec-96	0.005
23-Jan-97	0.005
24-Mar-97	0.007
16-Apr-97	0.005
13-May-97	0.005
10-Jun-97	0.005
08-Jul-97	0.005
05-Aug-97	0.007
02-Sep-97	0.005
05-Apr-07	0.007
17-Apr-07	0.0025
03-May-07	0.008
17-May-07	0.0025
31-May-07	0.006
14-Jun-07	0.008
28-Jun-07	0.011
10-Jul-07	0.007
09-Aug-07	0.009
22-Aug-07	0.0025
06-Sep-07	0.0025
19-Sep-07	0.01

Date	Lake Fork Total Phosphorus (mg/L)
04-Oct-07	0.008
16-Oct-07	0.0025

Table B.2 Gold Fork Total Phosphorus Data

Date	Gold Fork Total Phosphorus (mg/L)
01-Oct-92	0.03
01-Nov-92	0.033
01-Dec-92	0.037
01-Jan-93	0.0463
01-Feb-93	0.05
01-Mar-93	.058
13-Apr-93	0.024
27-Apr-93	0.036
12-May-93	0.023
24-May-93	0.02
24-May-93	0.0025
03-Jun-93	0.013
22-Jun-93	0.032
20-Jul-93	0.024
17-Aug-93	0.032
17-Aug-93	0.023
14-Sep-93	0.041
14-Sep-93	0.045
19-Oct-93	0.03
19-Oct-93	0.031
13-Apr-94	0.024
05-Apr-07	0.012
17-Apr-07	0.013
03-May-07	0.015
17-May-07	0.007
31-May-07	0.008
14-Jun-07	0.009
28-Jun-07	0.014
10-Jul-07	0.015
09-Aug-07	0.011
22-Aug-07	0.0025
06-Sep-07	0.0025
19-Sep-07	0.01
04-Oct-07	0.01
16-Oct-07	0.009

Table B.3 North Fork Payette River Total Phosphorus

Date	North Fork Payette River Total Phosphorus (mg/L)
04-Apr-74	0.03
08-May-74	0.06
04-Jun-74	0.06
10-Jul-74	0.02
07-Aug-74	0.03
10-Sep-74	0.03
09-Oct-74	0.02
25-Jun-75	0.02
22-Jul-75	0.03
27-Aug-75	0.04
23-Sep-75	0.02
04-Nov-75	0.02
12-Jul-76	0.05
10-Aug-76	0.03
15-Sep-76	0.03
29-Aug-78	0.033
24-May-79	0.048
29-Jun-79	0.012
01-Aug-79	0.043
28-Aug-79	0.046
01-May-80	0.034
09-May-80	0.039
13-May-80	0.029
23-May-80	0.023
28-May-80	0.025
02-Jun-80	0.03
08-Jun-80	0.035
15-Jun-80	0.017
21-Jun-80	0.024
29-Jun-80	0.057
03-Jul-80	0.03
09-Jul-80	0.027
16-Jul-80	0.051
30-Jul-80	0.025
13-Aug-80	0.015
26-Aug-80	0.03
11-Sep-80	0.017
24-Sep-80	0.024
10-Oct-80	0.01
23-Oct-80	0.01
06-Nov-80	0.02
19-Nov-80	0.011

Date	North Fork Payette River Total Phosphorus (mg/L)
08-Dec-80	0.012
22-Dec-80	0.008
06-Jan-81	0.008
14-Jan-81	0.031
09-Feb-81	0.018
18-Feb-81	0.025
07-Mar-81	0.022
20-Mar-81	0.022
05-Apr-81	0.02
18-Apr-81	0.034
25-Apr-81	0.034
02-May-81	0.022
16-May-81	0.02
22-May-81	0.027
29-May-81	0.008
05-Jun-81	0.014
12-Jun-81	0.01
19-Jun-81	0.008
26-Jun-81	0.004
09-Jul-81	0.011
24-Jul-81	0.018
10-Aug-81	0.011
29-Aug-81	0.013
12-Sep-81	0.031
28-Sep-81	0.02
10-Oct-81	0.016
28-Oct-81	0.12
10-Nov-81	0.011
21-Nov-81	0.023
06-Dec-81	0.018
20-Dec-81	0.024
15-Mar-83	0.032
19-Apr-83	0.034
09-Aug-83	0.029
21-Oct-83	0.014
14-Dec-83	0.019
13-Mar-84	0.031
12-Jun-84	0.016
19-Jul-84	0.017
14-Aug-84	0.054
18-Oct-84	0.041
25-Oct-84	0.017
17-Jan-85	0.028
10-Mar-85	0.035
10-Apr-85	0.075
08-May-85	0.044

Date	North Fork Payette River Total Phosphorus (mg/L)
24-Jun-85	0.016
22-Jul-85	0.038
19-Aug-85	0.039
23-Sep-85	0.028
28-Oct-85	0.019
18-Mar-86	0.022
09-Apr-86	0.038
28-May-86	0.029
25-Jun-86	0.021
29-Jul-86	0.044
22-Aug-86	0.043
17-Sep-86	0.027
02-Oct-86	0.01
19-Nov-86	0.023
16-Dec-86	0.029
25-Mar-87	0.031
15-Apr-87	0.031
27-May-87	0.024
24-Jun-87	0.026
22-Jul-87	0.039
26-Aug-87	0.047
22-Sep-87	0.029
27-Oct-87	0.023
27-Apr-88	0.024
27-May-88	0.049
20-Jun-88	0.017
06-Jul-88	0.05
25-Jul-88	0.026
26-Jul-88	0.05
04-Aug-88	0.05
17-Aug-88	0.05
23-Aug-88	0.02
29-Aug-88	0.05
14-Sep-88	0.05
28-Sep-88	0.028
21-Oct-88	0.021
30-Jan-89	0.05
21-Feb-89	0.11
20-Mar-89	0.05
17-Apr-89	0.09
26-Apr-89	0.06
02-May-89	0.05
08-May-89	0.05
15-May-89	0.05
24-May-89	0.015
31-May-89	0.05

Date	North Fork Payette River Total Phosphorus (mg/L)
06-Jun-89	0.05
20-Jun-89	0.05
21-Jun-89	0.016
05-Jul-89	0.05
26-Jul-89	0.026
07-Aug-89	0.05
28-Aug-89	0.033
10-Sep-89	0.05
25-Sep-89	0.021
25-Oct-89	0.024
13-Nov-89	0.02
11-Dec-89	0.029
04-Jan-90	0.036
26-Mar-90	0.043
10-Apr-90	0.048
17-Apr-90	0.022
18-Apr-90	0.043
22-Apr-90	0.031
29-Apr-90	0.014
06-May-90	0.015
22-May-90	0.014
29-May-90	0.018
29-May-90	0.022
11-Jun-90	0.015
26-Jun-90	0.014
17-Jul-90	0.043
24-Jul-90	0.033
13-Aug-90	0.027
27-Aug-90	0.027
18-Sep-90	0.011
24-Sep-90	0.019
23-Oct-90	0.02
26-Nov-90	0.038
27-Mar-91	0.034
16-Apr-91	0.033
21-May-91	0.024
17-Jun-91	0.028
30-Jul-91	0.035
26-Aug-91	0.044
30-Sep-91	0.021
28-Oct-91	0.025
25-Nov-91	0.022
14-Apr-92	0.04
04-May-92	0.017
01-Jun-92	0.036
07-Jul-92	0.03

Date	North Fork Payette River Total Phosphorus (mg/L)
10-Aug-92	0.046
01-Sep-92	0.034
14-Oct-92	0.015
18-Nov-92	0.011
08-Jun-93	0.023
06-Jul-93	0.029
10-Aug-93	0.044
08-Sep-93	0.028
05-Oct-93	0.014
19-Oct-93	0.02
02-Nov-93	0.026
17-Nov-93	0.08
09-Dec-93	0.046
15-Dec-93	0.18
11-Jan-94	0.049
12-Jan-94	0.13
01-Mar-94	0.07
15-Mar-94	0.08
22-Mar-94	0.046
29-Mar-94	0.08
05-Apr-94	0.12
05-Apr-94	0.072
12-Apr-94	0.061
18-Apr-94	0.1
26-Apr-94	0.025
03-May-94	0.019
04-May-94	0.03
10-May-94	0.13
24-May-94	0.023
07-Jun-94	0.024
07-Jun-94	0.025
20-Jun-94	0.021
06-Jul-94	0.045
12-Jul-94	0.06
02-Aug-94	0.051
08-Aug-94	0.055
13-Sep-94	0.024
14-Sep-94	0.039
12-Oct-94	0.024
19-Oct-94	0.019
20-Oct-94	0.019
01-Nov-94	0.034
15-Nov-94	0.027
15-Nov-94	0.027
06-Dec-94	0.032
07-Dec-94	0.032

Date	North Fork Payette River Total Phosphorus (mg/L)
11-Jan-95	0.051
11-Jan-95	0.051
15-Feb-95	0.031
15-Feb-95	0.031
28-Feb-95	0.026
28-Feb-95	0.056
15-Mar-95	0.056
15-Mar-95	0.056
28-Mar-95	0.034
28-Mar-95	0.034
11-Apr-95	0.03
11-Apr-95	0.03
25-Apr-95	0.046
25-Apr-95	0.046
02-May-95	0.02
10-May-95	0.032
23-May-95	0.032
06-Jun-95	0.02
08-Jun-95	0.022
27-Jun-95	0.023
27-Jun-95	0.023
10-Jul-95	0.032
11-Jul-95	0.029
11-Jul-95	0.029
03-Aug-95	0.049
23-Aug-95	0.06
23-Aug-95	0.06
07-Sep-95	0.045
07-Sep-95	0.02
07-Sep-95	0.045
26-Sep-95	0.022
26-Sep-95	0.022
16-Oct-95	0.019
06-Nov-95	0.021
04-Dec-95	0.028
12-Dec-95	0.028
12-Dec-95	0.028
21-Feb-96	0.034
21-Feb-96	0.034
02-Apr-96	0.037
02-Apr-96	0.037
09-Apr-96	0.03
24-Apr-96	0.042
24-Apr-96	0.042
06-May-96	0.015
07-May-96	0.024

Date	North Fork Payette River Total Phosphorus (mg/L)
07-May-96	0.024
23-May-96	0.025
23-May-96	0.025
04-Jun-96	0.024
04-Jun-96	0.024
05-Jun-96	0.018
19-Jun-96	0.022
19-Jun-96	0.022
02-Jul-96	0.031
02-Jul-96	0.031
17-Jul-96	0.034
17-Jul-96	0.034
17-Jul-96	0.028
30-Jul-96	0.04
30-Jul-96	0.04
07-Aug-96	0.037
22-Aug-96	0.04
22-Aug-96	0.04
23-Aug-96	0.04
03-Sep-96	0.042
24-Sep-96	0.025
24-Sep-96	0.025
23-Oct-96	0.024
23-Oct-96	0.024
28-Oct-96	0.028
18-Nov-96	0.031
18-Nov-96	0.031
21-Nov-96	0.036
19-Dec-96	0.017
19-Dec-96	0.017
11-Mar-97	0.048
02-Apr-97	0.031
16-Apr-97	0.07
16-Apr-97	0.07
13-May-97	0.031
13-May-97	0.031
19-May-97	0.033
03-Jun-97	0.013
10-Jun-97	0.041
10-Jun-97	0.041
08-Jul-97	0.029
08-Jul-97	0.021
09-Jul-97	0.029
05-Aug-97	0.044
05-Aug-97	0.041
05-Aug-97	0.044

Date	North Fork Payette River Total Phosphorus (mg/L)
02-Sep-97	0.02
02-Sep-97	0.02
09-Sep-97	0.024
09-Oct-97	0.019
13-Nov-97	0.018
17-Mar-98	0.048
20-Apr-98	0.03
18-May-98	0.015
15-Jun-98	0.024
06-Jul-98	0.019
03-Aug-98	0.027
10-Sep-98	0.028
20-Oct-98	0.01
17-Nov-98	0.025
14-Dec-98	0.029
20-Apr-99	0.047
20-May-99	0.028
08-Jun-99	0.023
08-Jun-99	0.011
08-Jul-99	0.018
04-Aug-99	0.02
08-Sep-99	0.014
19-Oct-99	0.016
25-Oct-99	0.022
16-Nov-99	0.024
22-Nov-99	0.034
21-Dec-99	0.026
28-Dec-99	0.029
18-Jan-00	0.033
24-Jan-00	0.033
08-Feb-00	0.042
22-Feb-00	0.042
20-Mar-00	0.036
24-Apr-00	0.032
25-Apr-00	0.012
16-May-00	0.0205
23-May-00	0.025
07-Jun-00	0.021
20-Jun-00	0.031
10-Jul-00	0.011
18-Jul-00	0.02
21-Aug-00	0.014
24-Aug-00	0.02
26-Sep-00	0.018
10-Oct-00	0.027
23-Oct-00	0.019

Date	North Fork Payette River Total Phosphorus (mg/L)
07-Nov-00	0.02
29-Nov-00	0.025
05-Dec-00	0.032
20-Dec-00	0.028
30-Jan-01	0.041
20-Feb-01	0.046
21-Mar-01	0.049
03-Apr-01	0.026
23-Apr-01	0.043
03-May-01	0.017
21-May-01	0.032
11-Jun-01	0.017
19-Jun-01	0.019
02-Jul-01	0.024
24-Jul-01	0.026
06-Aug-01	0.013
21-Aug-01	0.021
20-Sep-01	0.016
27-Sep-01	0.011
18-Oct-01	0.017
02-May-02	0.015
17-Jun-02	0.011
15-Jul-02	0.02
19-Aug-02	0.015
03-Sep-02	0.027
13-Nov-02	0.014
18-Dec-02	0.027
23-Jan-03	0.037
27-Feb-03	0.029
26-Mar-03	0.025
01-Apr-03	0.023
23-Apr-03	0.024
12-May-03	0.013
13-May-03	0.046
09-Jun-03	0.02
20-Jun-03	0.037
07-Jul-03	0.014
15-Jul-03	0.018
04-Aug-03	0.024
04-Aug-03	0.024
26-Aug-03	0.018
15-Sep-03	0.024
15-Sep-03	0.023
18-Nov-03	0.019
18-Nov-03	0.019
17-Dec-03	0.014

Date	North Fork Payette River Total Phosphorus (mg/L)
02-Mar-04	0.03
12-Apr-04	0.026
24-May-04	0.019
12-Jul-04	0.013
10-Aug-04	0.023
08-Sep-04	0.014
18-Oct-04	0.012
08-Nov-04	0.013
06-Dec-04	0.016
14-Feb-05	0.021
07-Mar-05	0.021
18-Apr-05	0.025
17-May-05	0.02
06-Jun-05	0.013
15-Jun-05	0.014
12-Jul-05	0.017
24-Aug-05	0.014
15-Sep-05	0.013
22-Sep-05	0.014
04-Apr-06	0.026
12-Apr-06	0.031
03-May-06	0.018
16-May-06	0.031
05-Jun-06	0.016
06-Jul-06	0.013
09-Aug-06	0.013
10-Aug-06	0.013
06-Sep-06	0.013
06-Sep-06	0.015
16-Oct-06	0.011
06-Nov-06	0.016
04-Dec-06	0.017
05-Mar-07	0.022
02-Apr-07	0.027
14-May-07	0.025
05-Jun-07	0.018
03-Jul-07	0.025
05-Sep-07	0.02

Table B.4 Mud Creek Data

Date	Mud Creek Total Phosphorus (mg/L)
01-Oct-92	0.0285
01-Nov-92	0.0285
01-Dec-92	0.0285
01-Jan-93	0.0285

Date	Mud Creek Total Phosphorus (mg/L)
01-Feb-93	0.0285
01-Mar-93	0.0285
13-Apr-93	0.033
27-Apr-93	0.033
12-May-93	0.039
24-May-93	0.01
03-Jun-93	0.014
22-Jun-93	0.029
20-Jul-93	0.026
17-Aug-93	0.05
14-Sep-93	0.026
19-Oct-93	0.025
19-Oct-93	0.024
17-Nov-93	0.048
15-Dec-93	0.047
12-Jan-94	0.034
01-Mar-94	0.053
15-Mar-94	0.066
22-Mar-94	0.055
29-Mar-94	0.075
05-Apr-94	0.064
12-Apr-94	0.064
13-Apr-94	0.033
18-Apr-94	0.059
03-May-94	0.051
10-May-94	0.053
24-May-94	0.062
07-Jun-94	0.041
20-Jun-94	0.02
11-Jul-94	0.009
08-Aug-94	0.016
14-Sep-94	0.007
19-Oct-94	0.005
15-Nov-94	0.013
06-Dec-94	0.015
11-Jan-95	0.032
15-Feb-95	0.028
28-Feb-95	0.029
28-Mar-95	0.017
11-Apr-95	0.032
25-Apr-95	0.012
27-Jun-95	0.011
11-Jul-95	0.018
07-Sep-95	0.016
26-Sep-95	0.01
12-Dec-95	0.06

Date	Mud Creek Total Phosphorus (mg/L)
11-Feb-96	0.018
21-Feb-96	0.018
02-Apr-96	0.027
24-Apr-96	0.026
07-May-96	0.008
23-May-96	0.016
04-Jun-96	0.014
19-Jun-96	0.012
02-Jul-96	0.012
17-Jul-96	0.025
30-Jul-96	0.034
22-Aug-96	0.013
24-Sep-96	0.019
23-Oct-96	0.013
18-Nov-96	0.014
19-Dec-96	0.02
23-Jan-97	0.025
24-Mar-97	0.024
16-Apr-97	0.019
13-May-97	0.016
10-Jun-97	0.013
08-Jul-97	0.014
05-Aug-97	0.021
02-Sep-97	0.017
17-Apr-04	0.011
05-Apr-07	0.016
03-May-07	0.011
17-May-07	0.007
31-May-07	0.011
14-Jun-07	0.0155
28-Jun-07	0.015
10-Jul-07	0.014
09-Aug-07	0.011
22-Aug-07	0.0025
06-Sep-07	0.0025
19-Sep-07	0.0065
04-Oct-07	0.008
16-Oct-07	0.0025

Table B.5 Willow Creek Data

Date	Willow Creek Total Phosphorus (mg/L)
01-Oct-92	0.046
01-Nov-92	0.046
01-Dec-92	0.046

Date	Willow Creek Total Phosphorus (mg/L)
01-Jan-93	0.046
01-Feb-93	0.046
01-Mar-93	0.046
13-Apr-93	0.057
27-Apr-93	0.062
12-May-93	0.061
24-May-93	0.115
03-Jun-93	0.051
22-Jun-93	0.06
20-Jul-93	0.07
17-Aug-93	0.06
14-Sep-93	0.037
19-Oct-93	0.053
19-Oct-93	0.035
17-Nov-93	0.059
15-Dec-93	0.094
12-Jan-94	0.087
01-Mar-94	0.124
15-Mar-94	0.25
22-Mar-94	0.198
29-Mar-94	0.16
05-Apr-94	0.069
12-Apr-94	0.093
13-Apr-94	0.057
18-Apr-94	0.105
25-Apr-94	0.1
03-May-94	0.084
10-May-94	0.089
23-May-94	0.107
06-Jun-94	0.082
20-Jun-94	0.101
12-Jul-94	0.127
08-Aug-94	0.2
14-Sep-94	0.064
19-Oct-94	0.044
15-Nov-94	0.036
06-Dec-94	0.052
11-Jan-95	0.083
15-Feb-95	0.107
28-Feb-95	0.07
15-Mar-95	0.072
28-Mar-95	0.025
11-Apr-95	0.041
25-Apr-95	0.042
27-Jun-95	0.101
11-Jul-95	0.161
07-Sep-95	0.074

Date	Willow Creek Total Phosphorus (mg/L)
26-Sep-95	0.043
12-Dec-95	0.145
21-Feb-96	0.047
03-Apr-96	0.039
24-Apr-96	0.05
07-May-96	0.037
23-May-96	0.052
04-Jun-96	0.103
19-Jun-96	0.084
02-Jul-96	0.162
17-Jul-96	0.157
30-Jul-96	0.158
22-Aug-96	0.083
24-Sep-96	0.04
23-Oct-96	0.032
18-Nov-96	0.039
19-Dec-96	0.05
23-Jan-97	0.077
24-Mar-97	0.071
16-Apr-97	0.05
13-May-97	0.102
10-Jun-97	0.131
08-Jul-97	0.147
05-Aug-97	0.138
02-Sep-97	0.073
05-Apr-07	0.035
17-Apr-07	0.018
03-May-07	0.029
17-May-07	0.014
31-May-07	0.026
14-Jun-07	0.026
28-Jun-07	0.023
10-Jul-07	0.036
09-Aug-07	0.035
22-Aug-07	0.014
06-Sep-07	0.016
19-Sep-07	0.014
04-Oct-07	0.018
16-Oct-07	0.014

Table B.6 Boulder Creek Data

Date	Boulder Creek Total Phosphorus (mg/L)
12-May-92	0.051
12-May-92	0.051

Date	Boulder Creek Total Phosphorus (mg/L)
09-Sep-92	0.05
06-Oct-92	0.058
16-Nov-92	0.066
14-Jan-93	0.088
17-Feb-93	0.099
15-Mar-93	0.116
23-Mar-93	0.067
12-Apr-93	0.037
13-Apr-93	0.027
27-Apr-93	0.038
27-Apr-93	0.043
27-Apr-93	0.043
12-May-93	0.046
24-May-93	0.029
25-May-93	0.013
25-May-93	0.013
03-Jun-93	0.04
03-Jun-93	0.04
03-Jun-93	0.037
22-Jun-93	0.102
22-Jun-93	0.102
22-Jun-93	0.075
20-Jul-93	0.084
20-Jul-93	0.084
20-Jul-93	0.05
17-Aug-93	0.047
14-Sep-93	0.04
19-Oct-93	0.034
15-Dec-93	0.105
15-Dec-93	0.105
12-Jan-94	0.081
01-Mar-94	0.083
14-Mar-94	0.1
22-Mar-94	0.101
29-Mar-94	0.087
05-Apr-94	0.062
13-Apr-94	0.078
13-Apr-94	0.037
18-Apr-94	0.066
03-May-94	0.067
11-May-94	0.073
12-Jul-94	0.066
19-Oct-94	0.06
15-Nov-94	0.057
06-Dec-94	0.063
11-Jan-95	0.084
15-Feb-95	0.077

Date	Boulder Creek Total Phosphorus (mg/L)
28-Feb-95	0.047
15-Mar-95	0.047
28-Mar-95	0.019
11-Apr-95	0.023
25-Apr-95	0.028
27-Jun-95	0.05
11-Jul-95	0.059
07-Sep-95	0.057
26-Sep-95	0.037
12-Dec-95	0.055
11-Feb-96	0.036
21-Feb-96	0.023
02-Apr-96	0.027
24-Apr-96	0.024
07-May-96	0.018
23-May-96	0.016
04-Jun-96	0.034
19-Jun-96	0.034
02-Jul-96	0.056
17-Jul-96	0.098
30-Jul-96	0.102
22-Aug-96	0.079
24-Sep-96	0.046
18-Nov-96	0.042
19-Dec-96	0.044
23-Jan-97	0.035
24-Mar-97	0.032
16-Apr-97	0.017
13-May-97	0.041
10-Jun-97	0.072
08-Jul-97	0.076
05-Aug-97	0.084
02-Sep-97	0.066
05-Apr-07	0.019
17-Apr-07	0.014
03-May-07	0.02
17-May-07	0.019
31-May-07	0.021
14-Jun-07	0.026
28-Jun-07	0.034
10-Jul-07	0.039
09-Aug-07	0.023
22-Aug-07	0.01
06-Sep-07	0.013
19-Sep-07	0.015
04-Oct-07	0.015
16-Oct-07	0.012

Table B.7 GAR053 Reservoir Data

GAR053

date	depth (m)	results
04-Jun-74	0.3048	0.05
10-Jul-74	0.9144	0.02
07-Aug-74	0.9144	0.04
10-Sep-74	0.9144	0.03
25-Jun-75	0.9144	0.03
22-Jul-75	0.3048	0.03
27-Aug-75	0.9144	0.02
23-Sep-75	0.9144	0.02
12-Jul-76	0.3048	0.01
10-Aug-76	0.3048	0.03
15-Sep-76	0.9144	0.02
29-Aug-78	0.9144	0.056
24-May-79	0.9144	0.038
29-Jun-79	0.9144	0.025
28-Aug-79	0.9144	0.064
11-Jun-80	0.9144	0.021
17-Jul-80	0.9144	0.011
21-Aug-80	0.9144	0.037
23-Sep-80	0.9144	0.065
27-May-81	0.9144	0.012
30-Jun-81	0.9144	0.005
23-Jul-81	0.9144	0.007
27-Aug-81	0.9144	0.012
21-Sep-81	0.3048	0.032
03-Aug-82	0.9144	0.007
07-Sep-83	0.9144	0.017
21-Aug-84	0.9144	0.011
22-Aug-85	1.00584	0.027
05-Aug-86	1.00584	0.014
08-Sep-86	1.00584	0.078
11-Aug-87	1.00584	0.006
15-Sep-87	1.00584	0.12
10-Aug-88	1.00584	0.07
07-Sep-88	1.00584	0.052
01-Aug-89	1.00584	0.021
12-Sep-89	1.00584	0.043
06-Sep-90	1.00584	0.024
05-Aug-91	1.00584	0.019
03-Sep-91	1.00584	0.028
13-Aug-92	1.00584	0.091
08-Sep-92	1.00584	0.078

23-Aug-93	1.00584	0.048
14-Sep-93	1.00584	0.057
04-Aug-94	1.00584	0.047
08-Sep-94	1.00584	0.071
09-Aug-95	1.00584	0.019
11-Sep-95	1.00584	0.0335
11-Sep-95	1.00584	0.029
07-Aug-96	1.00584	0.016
07-Aug-96	1.00584	0.016
18-Sep-96	1.00584	0.041
18-Sep-96	1.00584	0.041
18-Aug-97	0.97536	0.029
18-Aug-97	0.97536	0.029
23-Sep-97	1.00584	0.054
23-Sep-97	1.00584	0.054
12-Aug-98	1.00584	0.005
12-Aug-98	1.00584	0.01
22-Sep-98	1.00584	0.017
22-Sep-98	1.00584	0.017
08-Sep-99	1.00584	0.025
09-Aug-00	1.00584	0.011
06-Sep-00	1.00584	0.061
08-Aug-01	1.00584	0.016
01-Aug-02	1.00584	0.011
09-Sep-02	1.00584	0.028
01-Aug-03	1.00584	0.005
02-Sep-03	1.00584	0.019
10-Aug-04	1.00584	0.013
08-Sep-04	1.00584	0.014
03-May-05	1.00584	0.022
01-Jun-05	1.00584	0.016
06-Jul-05	1.00584	0.0075
20-Jul-05	1.00584	0.022
09-Aug-05	1.00584	0.021
06-Sep-05	1.00584	0.0265
10-May-06	1.00584	0.0465
07-Jun-06	1.00584	0.02
24-Jul-06	1.00584	0.012
09-Aug-06	1.00584	0.034
05-Sep-06	1.00584	0.043
06-Aug-07	1.00584	0.044
05-Sep-07	1.00584	0.049

Table B.8 Reservoir Chlorophyll-a Data

Date	Activity Depth (Meters)	GAR052	GAR053
01-Aug-03	4.99872	6.1	7
01-Aug-03	2.98704	7.1	5.8
01-Aug-03	1.00584	7.1	7
02-Sep-03	2.98704	7.5	7.2
02-Sep-03	1.00584	7.8	5.4
02-Sep-03	4.99872	6.9	7.4
10-Aug-04	4.99872	7.2	7.1
10-Aug-04	2.98704	7.2	7.2
10-Aug-04	1.00584	7.2	7.2
08-Sep-04	2.98704	7.6	7.4
08-Sep-04	4.99872	7.2	7.4
08-Sep-04	1.00584	7.9	7.7
08-Aug-05	2.98704	7.7	6.2
08-Aug-05	4.99872	6.6	1.3
09-Aug-05	1.00584	8	7.9
06-Sep-05	2.98704	7.6	7.2
06-Sep-05	4.99872	7.4	6.9
06-Sep-05	1.00584	8.5	6
09-Aug-06	2.98704	7.5	6
09-Aug-06	1.00584	7.8	4.1
09-Aug-06	4.99872	4.8	7.8
05-Sep-06	1.00584	7.8	5.8
05-Sep-06	2.98704	6.8	9.9
05-Sep-06	4.99872	6.2	4.9
06-Aug-07	1.00584	5.6	6
06-Aug-07	2.98704	5.4	1
06-Aug-07	4.99872	5.3	5.7
05-Sep-07	2.98704	5.8	6.3
05-Sep-07	4.99872	5.4	6
05-Sep-07	1.00584	6.2	5.8

Table B.9 Cascade Reservoir 2008 TP and Chl-a Data

GAR053 2008 TP(mg/L)	GAR053 chl-a (ug/L)	GAR052 2008 TP (mg/L)	GAR052 chl-a (ug/L)
0.042	7.9	0.036	6.9
0.03	2.7	0.028	3.6
0.029	11.2	0.021	5.3
0.016	5.2	0.013	7.9
0.029	5.7	0.017	5.1
0.028	7.9	0.026	9
0.032	8.3	0.027	8.1
0.034	17.2	0.044	20.9
0.032	13.2	0.035	19.6