Appendix A

Cascade Reservoir Watershed Advisory Group (WAG) and Technical Advisory Committee (TAC) Membership

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(Cascade Reservoir Watershed Advisory Group (WAG))
May 1998

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Appendix B

Beneficial Use Classifications and Water-Quality Standards and Criteria

Appendix B. Beneficial Use Classifications and Water-Quality Standards and Criteria

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

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

Once designated, beneficial uses are protected from impacts that may impair the use through application of numerical and narrative water-quality criteria. Prior to designation, undesignated waters shall be protected for beneficial uses, which includes all recreational use in and on the water and the protection and propagation of fish, shellfish and wildlife, wherever attainable.

Existing uses of waters that are not designated are also protected. Both federal and state rules protect existing uses through the antidegradation policy (See Idaho Code § 39-3603). Impacts to existing uses are best prevented through steps employed in the water-quality standards to protect designated uses.

Surface water beneficial use classifications are intended to protect the uses of the state's surface water. Designated beneficial uses for Idaho waterbodies are listed in the Water Quality Standards and Wastewater Treatment Requirements for the State of Idaho and are divided into five basic categories: aquatic life, recreation, water supply, wildlife habitat and aesthetics.

Aquatic life classifications apply to water bodies suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species. Aquatic species include cold water biota, warm water biota and salmonid spawning. Specific criteria include:

Cold Water Biota - aquatic species which have optimal growing temperatures below 18 °C. (IDAPA 16.01.02.100.02.a). Criteria: Numeric criteria for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia, turbidity and toxics (IDAPA 16.01.02.250.02.a and c).

Warm Water Biota - aquatic species which have optimal growing temperatures above 18 °C. (IDAPA 16.01.02.100.02.b). Criteria: Numeric criteria for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia and toxics (IDAPA 16.01.02.250.02.a and b).

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

Recreation classifications apply to water bodies water bodies suitable or intended to be made suitable for primary and secondary contact recreation. Specific criteria include:

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

Secondary Contact Recreation - activities which are not included in the primary contact category, such as fishing, boating, wading and other activities where ingestion of raw water is not probable (IDAPA 16.01.02.100.03.b). Criteria: Numeric criteria for fecal coliform bacteria (IDAPA 16.01.02.250.01.b).

Water supply classifications are for water bodies suitable or intended to be made suitable for agriculture, domestic and industrial uses.

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

Domestic Water Supply - Waters for use as drinking water supplies (IDAPA 16.01.02.100.01.b). Criteria: Numeric criteria for specific constituents and turbidity (IDAPA 16.01.02.250.03.a).

Industrial Water Supply - This use applies to all waters of the state (IDAPA 16.01.02.100.01.c). Criteria: General surface water-quality criteria (IDAPA 16.01.02.200).

Wildlife habitat classifications (IDAPA 16.01.02.100.04) are for waters suitable or intended to be made suitable for wildlife habitat and applies to all surface waters of the state. Criteria: General surface water-quality criteria (IDAPA 16.01.02.200).

Aesthetics classifications (IDAPA 16.01.02.100.05) are applied to all surface waters of the state. Criteria: General surface water-quality criteria (IDAPA 16.01.02.200).

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

Applicable Water-Quality Standards and Criteria

Numerical standards for pH (6.5 to 9.5 standard units) and temperature (Cold Water Biota: 22 °C daily maximum, 19 °C maximum daily average; Salmonid Spawning: 13 °C daily maximum, 9 °C maximum daily average, during time periods designated for salmonid spawning and incubation) have been established by the State of Idaho (IDAPA 16.01.02). The State of Idaho has established the following standards for minimum concentrations of dissolved oxygen in lakes and reservoirs. These parameters represent regulatory standards for Cascade Reservoir. "Dissolved oxygen concentrations exceeding 6 mg/L at all times. In lakes and reservoirs this standard does not apply to: (1) The bottom 20% of water depth in lakes and reservoirs where depths are thirty-five (35) meters or less, (2) Those waters of the hypolimnion in stratified lakes and reservoirs."

Narrative criteria have been established by the State of Idaho which indicate that surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses (IDAPA 16.01.02.200.06).

Coliform bacteria standards have also been established for state waters (IDAPA 16.01.01.250). These criteria are dependent on level of exposure (primary or secondary contact) and are applicable specified time periods as follows: For primary contact recreation (May 01 through September 30) fecal coliform bacteria colonies may not exceed:

- 500/100mL at any time
- 200/100mL in greater than 10% of the samples taken over a 30 day period
- a geometric mean of 50/100mL in a minimum of five samples taken over a 30 day period

For secondary contact recreation (applicable year round) fecal coliform bacteria colonies may not exceed:

- 500/100mL at any time
- 200/100mL in greater than 10% of the samples taken over a 30 day period
- a geometric mean of 50/100mL in a minimum of five samples taken over a 30 day period

Designated Beneficial Uses for Cascade Reservoir Subwatershed

Idaho has designated the following beneficial uses for specified water bodies within the Cascade Reservoir Watershed:

NORTH FORK PAYETTE RIVER - source to McCall.

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

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

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

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

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

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

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

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

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

All other water bodies within the watershed are unclassified. Undesignated waters shall be protected for beneficial uses, which includes all recreational use in and on the water and the protection and propagation of fish, shellfish and wildlife, wherever attainable. As noted, state water-quality standards require that all existing uses are fully protected.

Appendix C

Computer Modeling Summary

Appendix C. Computer Modeling Summary

In an effort to improve understanding of the effect management practices have on future water quality in Cascade Reservoir, a modeling effort was undertaken. Two models, the 2-D BETTER model and the 1-D Cascade model, were used to evaluate both immediate and long-term responses to reservoir management practices and watershed phosphorus reductions. The output data obtained from these models have been used to augment existing data and determine if the proposed phosphorus load reductions could be reasonably expected to have the desired beneficial effects. As the models differ in predictive capacity, and have unique characteristics, this report attempts to compare and contrast the models and their specific capabilities, and to define a framework of applicability for each model and the respective outputs obtained.

For both models, the reservoir geometry evaluated included the main water body, the five major tributary arms (North Fork Payette River, Mud Creek, Lake Fork, Boulder/Willow Creek, and Gold Fork River), and the outflow at the dam. In-reservoir geometry was obtained from the 1995 bathymetric sediment study (Ferrari, 1998).

2-D BETTER Model

The Box, Exchange, Transport, Temperature, and Ecology of a Reservoir (BETTER) model, (Bender, 1997) was designed to calculate flow exchange, heat budget and dissolved oxygen within a water body, and was adapted to account for site specific parameters unique to Cascade Reservoir. The BETTER model was calibrated using existing monitoring data (both in-reservoir and inflow) for the 1989, 1993, and 1994 water-years, which included dissolved oxygen (DO), inflow nutrient loading, temperature (reservoir, release, and inflow), and algae levels (derived from chlorophyll a and Secchi depth measurements) (Table 1, following document). The model was verified using monitoring data from water-year 1995. While these years represent average, above average, and below average precipitation levels, model predictions are based on a combination of all three years and are therefore representative of an average water year only. Model outputs include DO, algae levels, anaerobic sediment releases, and temperature on a depth-specific basis. North Fork Payette River was modeled as the main inflow to the reservoir, Lake Fork was combined with Mud Creek, and Boulder was combined with Willow Creek, while Gold Fork was evaluated separately.

The BETTER model is two dimensional, dividing the water body vertically into epilimnion and hypolimnion layers, and longitudinally into segments (Figure 1). A "floating layer" scheme was employed to ensure that all layers remain at established depths relative to the surface. This approach was used in an effort to allow direct comparison of model output with field data collected at set depths. It also allows the preservation of gradients that exist near the surface.

A significant limitation of this model is that output is available only for the time period extending from reservoir ice-out (day ~90) to ice-in (day ~270). Because it does not model reservoir conditions over an entire year, sequential runs cannot be used to predict changes in water quality over an extended time period.

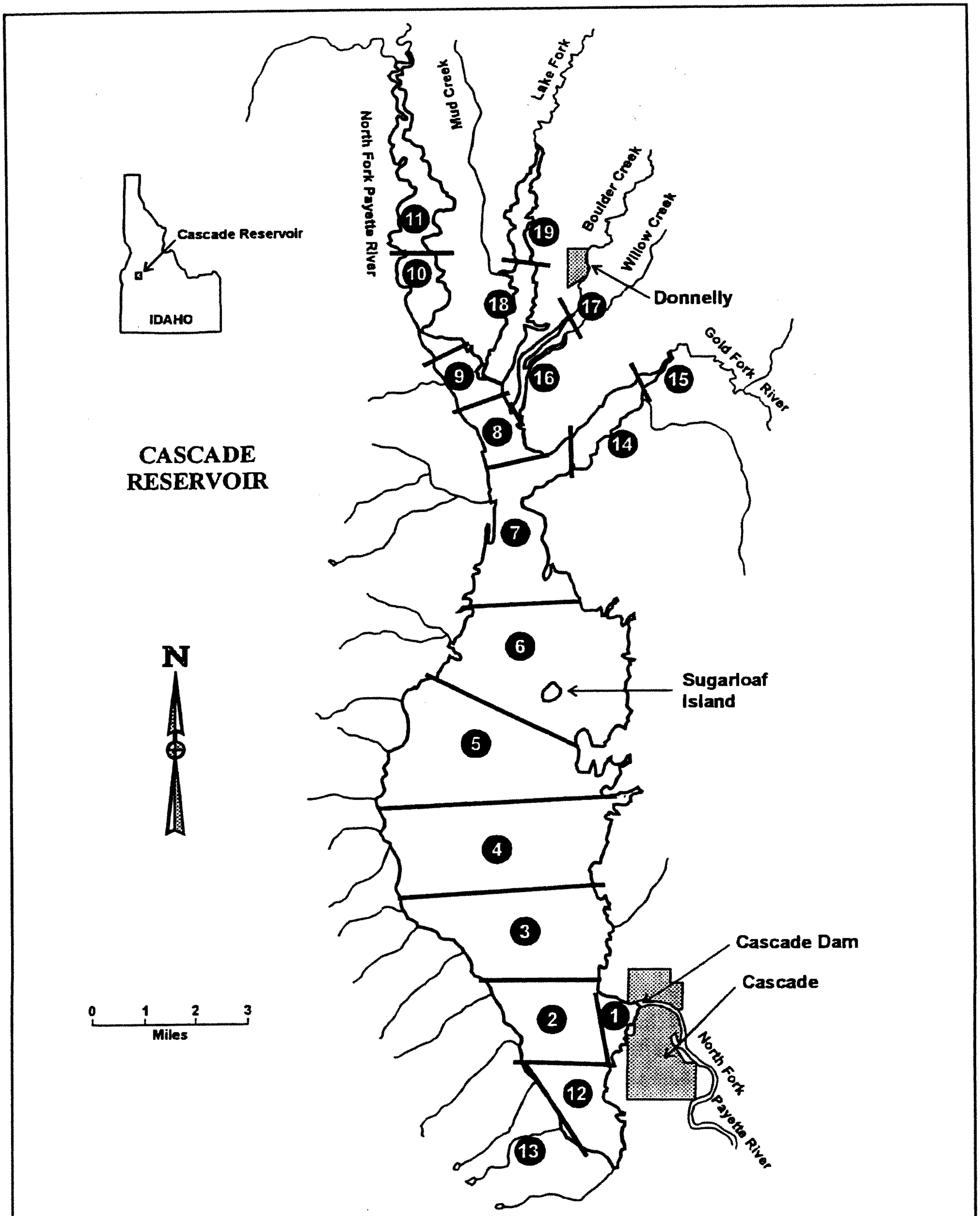

Figure 1 BETTER Model segmentation of Cascade Reservoir (from Bender, 1997).

Data inputs and outputs are defined in a 12-hour time step. Thus the effects of events lasting less than 12 hours (i.e. a 3 hour windstorm that mixes the water within the reservoir) are not within the model's predictive capability. Volume, downstream conveyance area, and surface interfacial area are calculated separately for each segment at each time step.

The primary objective for running the model was the evaluation of potential water-quality effects from proposed management options including: inflow loading reductions, chemical sealing of bed sediments, dredging the trashrack inlet channel, increased spillway discharge, aeration of reservoir water, and reservoir operational changes. Interpretation of the BETTER model output for each of the listed management options is summarized below and in the modeling fact-sheet on page 114 of this appendix.

A 50% reduction in nutrient and organic inflow loading showed only minimal effect on water quality within the reservoir over the single season modeled. This is not surprising as loading reductions would be expected to require more than a single season to show marked water-quality improvements due to the internal recycling of nutrients within the reservoir.

Chemical sealing of the reservoir bed-sediments to the degree that anaerobic nutrient release was removed entirely and sediment oxygen demand was reduced by half, showed improvement in the dissolved oxygen concentration (~2 mg/L increase) over a single season. The actual mechanism used to obtain the above reductions in sediment contributions was not identified directly, and no specific techniques available were modeled, so interpretation of these results should be made with some caution. The feasibility of such large-scale sealing is highly questionable given the current level of technology. Site-specific sealing in areas of higher sediment nutrient concentration (i.e. off Sugarloaf Island), perhaps a more logical undertaking, was not investigated.

Dredging the trashrack inlet channel (often referred to as the "glory-hole") to allow preferential removal of cooler, oxygen-deficient, bottom-water was not shown to be a viable option as increased temperatures from the remaining surface waters resulted in increased rates of organic decay and exacerbation of anaerobic conditions, leading to decreased overall water quality. This practice was also shown to result in higher concentrations of nutrients and organics being released downstream. These releases would have potentially negative effect on downstream water quality.

Increased spillway discharge showed no significant improvements in water quality. Currently, spillway discharges release mixed surface waters. Increase of spillway discharge was shown to result in the loss of oxygen-rich surface waters, increased temperature in the remaining waters, and lower overall DO levels; all of which would significantly decrease water quality and the available trout refuge.

Two major failings were identified for proposed aeration of reservoir water. First, systems modeled, although they were defined so as to represent state-of-the-art aeration equipment, were shown to increase DO levels only within the immediate vicinity of the equipment, so multiple aeration units would be required. Cost for such a project would be prohibitive. Second, if instrumentation were installed which would aerate the metalimnion of the entire reservoir, it would have to be lowered slowly over the course of the summer season as the position of the thermocline deepened. Model results showed this procedure would create a significant risk of re-suspension of bottom sediments, which would increase nutrient levels within the upper layers of the reservoir surface and potentially enhance algal growth.

Model output which simulated the effects of operational changes showed that higher pool volumes (400,000 acre-feet) could be expected to result in an increased volume of water suitable for fish habitat. However, the maintenance of a higher minimum pool volume would reduce the release options available for management of downstream water quality and flow volumes. Maintenance of lower minimum pool volumes (250,000 acre-feet) was shown to have a drastic, negative effect on both water quality and fish habitat as temperatures increased throughout the water column. Increased temperature resulted in increased rates of organic decay and faster depletion of dissolved oxygen. Fish would be compromised by both the increased temperature and lower DO, and substantial losses, especially in the late summer were predicted.

1-D Cascade Reservoir Model

The 1-D Cascade Reservoir Model (Worth, 1997) was designed to evaluate the water-quality impact of nutrient loading reductions within a watershed. The model currently in use was specifically designed to account for phosphorus loading and reductions within Cascade Reservoir. The Cascade model was calibrated using existing monitoring data (both in-reservoir and inflow) for the 1989, 1993, 1994 and 1995 water-years, which included: inflow nutrient loading (total nitrogen (TN), particulate organic nitrogen (PON), ammonia (NH_4) nitrate (NO_3), total phosphorus (TP), soluble reactive phosphorus (SRP), particulate organic phosphorus (POP)), DO, sediment oxygen demand (SOD), particulate organic carbon (POC), dissolved organic carbon (DOC), methane (CH_4), chlorophyl a, zoo-plankton (carnivorous and herbivorous), phytoplankton population estimates (biased to blue-green algae), Secchi depth, flow, and temperature (reservoir, release, and inflow). In addition, sediment phosphorus levels were also included from all available reservoir bed samples. The model was verified using monitoring data from water-year 1996 and the mean of water-years 1993 to 1996. While the calibration data years represent average, above average, and below average precipitation levels, model predictions are based on a combination of all four years. Therefore, long-term predictions represent the time required to reach the defined water-quality parameters given an average water year. Above average water years will most likely reduce the time required, while below average water years will extend the total time frame necessary. This model can be adjusted to reflect a defined type of water-year if necessary, but all predictions made to date were developed using this average-water-year prediction mechanism.

The Cascade model is one dimensional, dividing the water body vertically into epilimnion and upper, middle and lower hypolimnion layers. This approach was used in an effort to generate more accurate data within the reservoir profile whether stratified or well mixed. All tributaries were modeled collectively as "inflow".

An advantage of the Cascade model over the BETTER model is that output is available for an entire year. Thus "end" conditions for one year can be used as "initial" conditions for the following year for repeated iteration, making long-term water-quality prediction possible.

Data inputs and outputs for the Cascade model are defined in a 12-hour time step, and like the BETTER model, cannot account for the effects of events lasting less than 12 hours. Output parameters, which consist of all input parameters (Table I), are calculated separately for each layer at each time step for the epilimnion; upper, middle and lower hypolimnion; and sediment interface layers.

In contrast to the BETTER model, the primary objective for running the Cascade model was specifically the evaluation of potential water-quality effects from a range of phosphorus reduction levels within the watershed. The Phase I Total Maximum Daily Load (TMDL) for Cascade Reservoir (DEQ, 1996) specified that a 37% reduction of phosphorus loading was required for attainment of water-quality goals within the reservoir. The Cascade model was employed as a tool to investigate the applicability of this goal and its potential to result in the required in-reservoir water-quality parameters.

Phosphorus reductions of 20%, 37% and 50% were modeled over a 20 year time frame. All reduction effects were evaluated against a baseline condition defined as "no change in current phosphorus loading rate". The reductions modeled were selected as representing a range of reduction variables around the specified 37% reduction. Model output included an evaluation of changes in TP levels within the reservoir layers directly in contact with the sediment (lower hypolimnion), and the layer where the majority of algal growth takes place (epilimnion). Results in all reduction levels showed that the most marked change in water quality (decrease in water column TP) occurs during the first five years following attainment of the given load-reduction values. This initial, rapid improvement was followed in all simulated cases by a more gradual improvement in water quality over the remaining time period. TP levels in the epilimnion were observed to reach a steady state after approximately 10 years, while TP levels in the hypolimnion did not appear to reach a steady state within the time frame evaluated. Communication between the hypolimnion and the interfacial bed-sediments is predicted to result in an equilibrium release of adsorbed phosphorus that would continue (presumably) until the sediment phosphorus levels had declined to a concentration that could maintain equilibrium with the adjusted loading rate. Model output showed that greater concentrations of phosphorus were released in the spring and summer, when anaerobic conditions dominated on the reservoir floor.

The water-quality improvements observed with a 37% reduction were significant, and showed achievement of the water-quality objectives of 10 µg/L chlorophyll a, and 0.025 mg/L TP in the epilimnion after approximately 5 years of sustained 37% reduction. These levels of phosphorus were modeled and observed to result in attainment of dissolved oxygen ($\geq$ 6.0 mg/l in applicable waters) and pH (between 6.5 and 9.5 units)standards as outlined for the State of Idaho. The model results for 50% reduction showed a more rapid decrease in chlorophyll a and TP, while the 20% reduction showed a longer time period was required to reach water-quality objectives.

Attainment of water-quality objectives in the hypolimnion is expected to take a substantially longer time (15 to 20 years) depending on the recurrence of anoxic conditions and equilibrium release of phosphorus from the sediments. Algal blooms are predicted to occur with the proposed 37% reduction in nutrient loading, but not to the extent that they occur currently. Algal populations are predicted to shift from predominantly blue-green species to green species over the course of sustained reductions.

Overall, the Cascade model shows that the proposed 37% reduction in nutrient loading will result in substantial water-quality improvements over a reasonable time period. If necessary, the calibration of this model could be changed to reflect dry or wet water-years to determine the effect of precipitation on the long-term model results. Similarly, adjustments could be made to the input parameters to reflect most of the in-reservoir management options evaluated by the BETTER model, with the additional capability of predicting long-term effects.

Situation Comparison

Because the BETTER and Cascade models have different input, output and modeling mechanisms, their applicability to specific modeling efforts may vary. A brief comparison of the two models is outlined below for several possible scenarios.

The BETTER model is best suited to situations requiring site specific predictive information. For example, the reservoir bed sediments that have been extracted show elevated phosphorus content near Sugarloaf Island and the Poison Creek inflow. The affect of chemical sealing in an area-directed fashion has not been fully evaluated. The BETTER model would be well suited, on a short-term basis, to determine the outcome of such an undertaking on the water quality of the area immediately affected by chemical sealing, and on the water quality of the reservoir as a whole. Because of the longitudinally segmented reservoir geometry available with the BETTER model, inputs reflecting chemical sealing of bed-sediments within these specific areas could be added to the existing model parameters. Water-quality effects within the specified segments could then be modeled, as well as changes in water quality throughout the reservoir. Such site-specific input and manipulation is not possible with the Cascade model.

Similarly, this model would be well suited to evaluate the effect that aeration or installation of additional drainage would have on water quality within the more sluggish southern end of the reservoir. While the Cascade model could simulate placement of aeration equipment or additional drainage at the south end, water-quality effects would be evaluated on a total water-quality basis. Because of the predominant north to south flow induced within the reservoir by the tributaries and outflow, there is limited communication between the southern end and the major body of the reservoir. The immediate effects of such a project therefore may not be felt in a significant manner throughout the water body in general. An interpretation of the benefits of such an action would be difficult to make accurately, given only the Cascade model.

Conversely, if site-specific chemical sealant of the bed sediments were determined to be a viable option for the reservoir, but cost prohibited the application of chemical sealants at frequencies greater than once in every five years, the Cascade model would be the most applicable method of determining if this frequency would be adequate to result in improved water quality over an extended period of time. Application of chemical sealant to the areas described previously could be modeled in a general sense as an overall internal recycling reduction (the reduction in phosphorus loading would potentially be proportional to the relative percent area of the sealed sediments). Total phosphorus levels within the water column could be simulated over the five year period. The overall affect of repeated applications of sealants on reservoir water quality could in this way be achieved for a total water body assessment. While site specific effects and reductions would not be possible with the Cascade model, overall water quality resulting from generalized reductions could be evaluated for an extended time frame in a reasonably accurate manner.

Similarly, the affect of a single catastrophic event (a forest fire on West Mountain for example) could be evaluated over an extended period of time with the Cascade model, and the beneficial effects of BMPs on overall water quality could be evaluated over time. Such an approach would potentially decrease the time required by trial-and-error methods of on-the-ground phosphorus reduction, and allow management practices which promised the greatest reductions to be put into place within the impact area in a more timely fashion.

Because of the relatively complimentary nature of these two programs, a strong potential exists that they could be synthesized into a single powerful mechanism for site-specific prediction over an extended time frame. Potentially, the output values generated by the Cascade model for day 90 could be input to the BETTER model as initial settings. This model could then be run through the summer season to "ice-in" and output values re-entered to the Cascade model as initial settings for day ~270. This process could be repeated for a given number of iterations to cover the time frame required.

Because reservoir mixing usually occurs before ice-in, and extends through to nearly ice-out, significantly isolated changes would not be expected to occur within the reservoir to a substantial degree within this time period. During summer stratification, when inter-reservoir communication is suppressed by temperature differentials within the reservoir profile, site specific data would be the most valuable. Such a synthesis of the two models may therefore represent an important tool in water-quality evaluation.

This suggestion is not without some risk however, as the error inherent in each model separately, will be compounded in the combination of the two. Statistics have shown that such compound errors are more often the square of the individual errors than the sum. Predictions made using the combined output of both models together would therefore require careful interpretation of accuracy, and clear delineation of all assumptions made. In some cases, such interpretation may represent only a qualitative evaluation of a general trend.

Conclusions

Both the BETTER and the Cascade model have provided valuable information to the TMDL process for Cascade Reservoir.

The BETTER model has the significant capability of allowing simulation of management changes on a site-specific basis within the reservoir, but is limited to a single (~180 day) season of modeled output. The Cascade model has the valuable capability of allowing long-term predictions to be made through multiple iterations of modeling, but provides output on a more general, overall water-body basis.

The BETTER model has shown that while some proposed reservoir management options may have beneficial effects over a season (e.g. chemical sealing of bed sediments), further information is necessary to make a final, informed decision. Other management options (e.g. spillway releases or trashrack removal scenarios) have been shown to result in no water-quality benefits and the potential for further water-quality degradation.

The Cascade model has shown that the 37% phosphorus loading reduction proposed in the Phase I TMDL is an appropriate value that, if attained and maintained, should result in marked water-quality improvement over a reasonablely brief time frame (5 years), and attainment of water-quality goals over a slightly longer but still achievable time period (15 to 20 years).

A combination of the outputs of these two models may be able to provide more site-specific information over an extended time period, but would also carry a potentially wider range of uncertainty in the predicted outcome.

References:

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Idaho Division of Environmental Quality (DEQ); 1996 (January); *Cascade Reservoir Phase I Watershed Management Plan*; Idaho Division of Environmental Quality, Boise Regional Office, Boise, Idaho; 86 p + appendices.

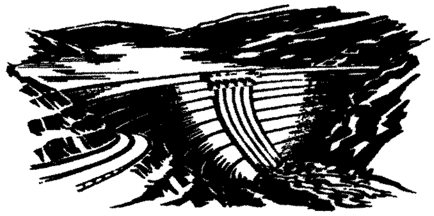
Worth, D.; 1997; *Cascade Reservoir Model: Model Simulations of External Reductions in Phosphorus Loading to Cascade Reservoir*; for Idaho Division of Environmental Quality, Boise Regional Office, Boise, Idaho; 17 p.

Table I. Model Comparison

Parameter	2-D BETTER Model	1-D Cascade Model
Reservoir geometry	depth divisions = top and bottom layer longitudinal = 19 ~North/South segments	upper, middle, lower hypolimnion and epilimnion
Model input and calibration parameters	reservoir geometry, dissolved oxygen, inflow nutrient loading, meteorology, anaerobic sediment releases, algae, temperature (reservoir, release, inflow)	temperature, phytoplankton as chlorophyll a, carnivorous and herbivorous zooplankton, algae population (biased to blue-green), DO, SOD, organic content (POC, DOC), CH_4, nitrogen (TN, PON, NH_4 NO_3), phosphorus (SRP, TP, POP), flow, and Secchi depth
Calibration data (water years)	1989, 1993, 1994	1989, 1993, 1994, 1995
Validation data (water years)	1995	1996 and 93-96 avg.
Model output parameters	dissolved oxygen, algae population, anaerobic sediment releases, temperature	temperature, phytoplankton as chlorophyll a, carnivorous and herbivorous zooplankton, algae population, DO, organic content (POC, DOC), CH_4, nitrogen (TN, PON, NH_4, NO_3) phosphorus (SRP, TP), SOD, and Secchi depth for upper, middle, lower hypolimnion, epilimnion, and sediment interfaces
Time step	12 hours	12 hours
Time cycle	reservoir ice-out (day 90) to ice-in (day ~270)	full year cycle with infinite iterations possible
Predictive life time	single season (~180 days)	infinite (sequential years)
Elevation oriented output	elevation in meters	based on relative position not exact elevation in meters
Site specific output	vertical layers and longitudinal segments	vertical layers
Reservoir management predictions	complete for management alternatives discussed in text	can be done for most management alternatives
Phosphorus reduction levels	possible short term only (one season)	completed for 20%, 37%, and 50% prediction reductions (over ~ 0 to 20 year time frame).

Table I. Model Comparison (cont.)

Parameter	2-D BETTER Model	1-D Cascade Model
Handicaps and advantages	predictions applicable to average water years only	predictions applicable to average water years only
	meteorological and monitoring data limitations	meteorologicalandmonitoringdatalimitations
	cannot be run sequentially because does not cover the entire year (~180 days)	can be run sequentially because time cycle is 365 days
	all phosphorus is assumed to be bioavailable (worst case scenario)	phosphorus is distinguishable as SRP and TP
	shows separate spring and fall blooms for a single season	does not show separate spring and fall blooms, only a single long-term bloom, because of biased plankton parameters. However, this method of simulation is believed to generate late summer concentration predictions which are more accurate than other methods
	segment-specific manipulation and evaluation are possible	whole water-body information only
	two vertical layers were simulated	four vertical layers and sediment interfaces were simulated
	water-quality data only was used for input, available for output	water quality and sediment nutrient data used for input, available for output
	operation requires substantial modeling skill	operation is relatively intuitive
	model currently resides at BOR, Denver	model currently resides at DEQ, Cascade



Cascade Reservoir Modeling Fact-Sheet

Many ideas have been proposed to improve water quality in Cascade Reservoir. Until recently it has been impossible to predict whether or not the solutions proposed would work effectively on such a large-scale project. With the development of computer models that simulate the reservoir and the watershed, new insight is available on which options are the most feasible for Cascade Reservoir. While computer models cannot say exactly how any of these options will perform, they can provide a general sense of what problems or benefits may result within the reservoir if the proposed management options were implemented. Computer modeling studies were conducted to investigate specific changes in the chemical aspects of water quality, for example phosphorus and dissolved oxygen concentrations, temperature and pH; as well as their combined effect on overall fish habitat and other beneficial uses through the proposed management options.

Water-quality Management Options Investigated

The main water-quality management projects proposed were chemical sealing of reservoir bed sediments, dredging of the trashrack inlet channel, increasing the volume of water discharged from the spillway, mechanical aeration of reservoir water, changes in reservoir management, and reduction of phosphorus levels in the water flowing into the reservoir. A summary of the modeling results for each of the listed management options is outlined below. The only two options that showed long-term, positive results were changes in reservoir management, and reduction of inflow phosphorus levels.

Chemical Sealing of Sediments

The practice of "chemical sealing" was proposed for Cascade Reservoir. This entails covering the bottom or "bed" sediments with aluminum hydroxide, and has been shown to reduce phosphorus release in some small lakes. When chemical sealing was modeled, it was predicted that only a complete (100%) seal of the sediments would improve dissolved oxygen levels within the reservoir, and only if the sealing was combined with reductions in phosphorus inputs to the reservoir. The current level of technology for chemical sealing procedures does not provide 100% effective seals, and has not been tried on large bodies of water like Cascade Reservoir, so there is a significant risk that the procedure would not work. In addition, it was estimated to cost between $7 and $11 million to complete. If reductions in phosphorus inputs to the reservoir were not achieved after the chemical sealing, it would have to be repeated periodically.

Dredging of the Trashrack Inlet Channel

Dredging the trashrack inlet channel (sometimes referred to as the "Glory-Hole") was proposed because it was thought that the removal of cold, deoxygenated bottom-water would improve water quality. Computer modeling predicted that when cold bottom water was removed, warmer surface water replaced it and raised the overall temperature of the reservoir water. These increased temperatures in turn caused higher rates of organic decay and even greater depletion of dissolved oxygen in the lower depths of the reservoir. Drawing off the bottom water was also predicted to result in higher concentrations of phosphorus and organics being released downstream. These releases would have a potentially negative effect on downstream water quality.

Increased Spillway Discharge

Increasing the spillway discharge was suggested because it would selectively remove warmer surface waters which encourage the growth of algae. When this option was modeled, no significant improvements in water quality were predicted. Surface water, in contact with the air and containing the majority of microscopic plant life, would be released in greater volume with this discharge option. The increased spillway discharge was predicted to result in the loss of the oxygen-rich surface water, increased temperature in the remaining water, and lower overall dissolved oxygen levels; all of which would significantly decrease water quality and the available fish habitat.

Aeration of Reservoir Water

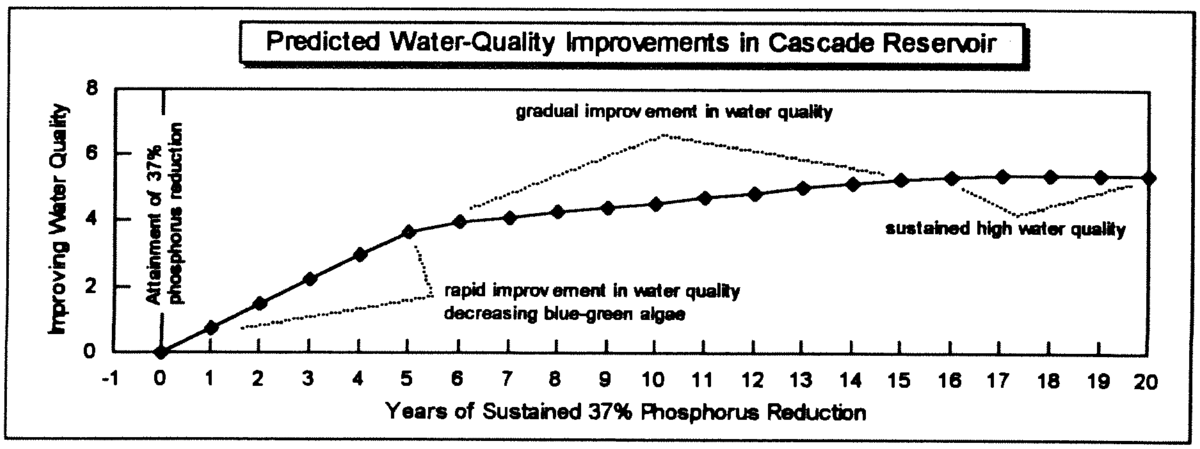
It was proposed that aeration equipment be placed in the reservoir to increase the oxygen content of the water and improve fish habitat. These types of mechanical aeration systems have been used successfully to improve the dissolved oxygen levels in small ponds nationwide. Computer modeling revealed two potential problems with the proposed mechanical aeration of the reservoir. First, because of the size of the reservoir, the aeration systems were predicted to increase dissolved oxygen levels only in the immediate vicinity of the equipment, so several large-scale aeration units would be required. The cost for such a project would be prohibitive. Second, the aeration equipment installed would have to be lowered slowly over the course of the summer season as the level and temperature of the reservoir water changed. Model results showed that this would create a significant risk of stirring up the bed sediments. The sediment that was suspended in the water would increase phosphorus concentrations in the upper layers of the reservoir surface, which would enhance the growth of algae.

Operational Changes

Computer models were also used to simulate the effects of keeping the reservoir levels higher than have been routinely maintained. The current minimum pool for Cascade Reservoir is 300,000 acre-feet. Model output which simulated higher pool volumes (400,000 acre-feet) predicted an increased volume of water where conditions were suitable for fish survival. However, maintaining the minimum pool volume at a higher level would potentially reduce the release options available for downstream water management. Maintenance of lower minimum pool volumes (250,000 acre-feet) was shown to have a drastic, negative effect on both water quality and fish habitat as temperatures increased throughout the water column. Increased temperature resulted in greater organic decay and lower dissolved oxygen. Fish would be at risk from both the increased temperature and lower dissolved oxygen, and substantial die-offs (especially in the late summer) were predicted.

Nutrient Reductions

Model simulations included an evaluation of changes in phosphorus contributions to the reservoir. Results showed that a marked improvement in water quality occurred during the first five years following attainment of a 37% phosphorus load reduction. The initial, rapid improvement was followed in by a more gradual improvement in water quality over a 15 year time period (as illustrated below). The water-quality improvements observed with the 37% reduction were significant, and showed achievement of the water-quality objectives of 10 mg/L chlorophyll a, and 0.025 mg/L total phosphorus in the reservoir water after approximately five years of sustained 37% reduction. Modeled phosphorus reductions of less than 37% did not show these same water-quality improvements.



Given the modeling results and the other considerations within the watershed that are discussed in the Cascade Reservoir Phase II Watershed Management Plan, a 37% reduction in phosphorus loading, combined with maintenance of an adequate minimum pool should result in improved water quality, attainment of water-quality objectives within the reservoir and restoration of beneficial uses.

Appendix D

Summary of Historical Water Quality for the Cascade Reservoir Watershed

Appendix D. Summary of Historical Water Quality for the Cascade Reservoir Watershed

Reservoir Water Quality

The water quality of Cascade Reservoir is of critical concern to the local population. Many private and rural subdivision water supplies utilize surface and ground water sources. Agricultural activities such as stock watering and irrigation, both within the watershed and in downstream communities, depend on the reservoir and local tributaries to meet usage needs. Increasing reliance on recreational activities by local economies represents a significant dependence on actual and perceived water quality within the watershed. The deterioration of water quality within Cascade Reservoir therefore affects not only the local population but a much wider area.

Continuing occurrences of noxious algal blooms, growth of aquatic weeds and fish kills have caused public concern since the 1970s. In 1993, pollutant loads and an unusual runoff pattern combined to produce dense mats of blue-green algae on the reservoir. In September, 23 cattle died as a result of ingesting toxins produced by the blue-green algae. As a result, health advisories were issued by DEQ discouraging contact with the reservoir water. Unfortunately, 1994 was a low water year. The high pollutant loads in 1993, combined with the reduced reservoir volume and lows flows of 1994 resulted in high overall total phosphorus concentrations within the water column. Dissolved oxygen levels decreased due to algal growth and decay, and warmer water temperatures produced by low water levels. This in turn led to anaerobic conditions at the water-sediment interface, increasing sediment phosphorus release. This series of events resulted in a substantial fish kill and impacted beneficial uses for both 1993 and 1994. These events served to focus and enlarge existing efforts for water-quality improvement within the reservoir. The apparent decline in water quality within the reservoir has largely been attributed to excessive nutrient loading from both point and nonpoint sources.

Nutrients

IDFG studies in 1968 (Irizarry, 1970) reported nutrient concentrations for two sites within the reservoir during May and June. Nitrate (nitrogen) concentrations ranged from 1.0 to 1.2 mg/L over three separate collection dates. Total phosphorus concentrations ranged from 0.005 to 0.04 mg/L. During the National Eutrophication Study (EPA, 1977), average reservoir concentrations of total phosphorus were observed to range from 0.019 to 0.031 mg/L, with slightly higher concentrations measured on the reservoir floor as compared to the surface. BOR monitoring of five separate stations during this same year show higher total phosphorus concentrations (0.02 to 0.35 mg/L) and nitrate (nitrogen) concentrations from 0.03 to 0.08 mg/L. Monitoring work reported by Clark and Wroten (1975) showed inorganic nitrogen levels from 0.020 to 0.273 mg/L and dissolved phosphorus levels from 0.01 to 0.315 mg/L. Total phosphorus was not reported. BOR monitoring from 1978 through 1982 (Zimmer, 1983) showed total phosphorus levels ranging from 0.018 to 0.102 mg/L, with the highest concentrations occurring near the reservoir bottom and in surface waters during August and September.

The seasonal increase in total phosphorus near the reservoir bottom and surface waters during late, hot summer months was observed in subsequent studies (Klahr, 1988; Klahr, 1989; Entranco, 1991;

Ingham, 1992; Worth 1993 and 1994) conducted from 1986 to 1994. It is currently observed in recent and ongoing monitoring by the DEQ. The most probable cause of increased total phosphorus levels at depth during summer months is sediment release triggered by anaerobic conditions within the lower levels of the water column. Such predicted releases have been substantiated by computer modeling (Worth, 1997) as shown in Figure 1, and have been observed to occur in laboratory studies using similar sediment matrices (Lindsay, 1979; Shannon and Brezonik, 1972; Sharpley *et al.*, 1984; Tiessen, 1995; Vollenweider, 1968).

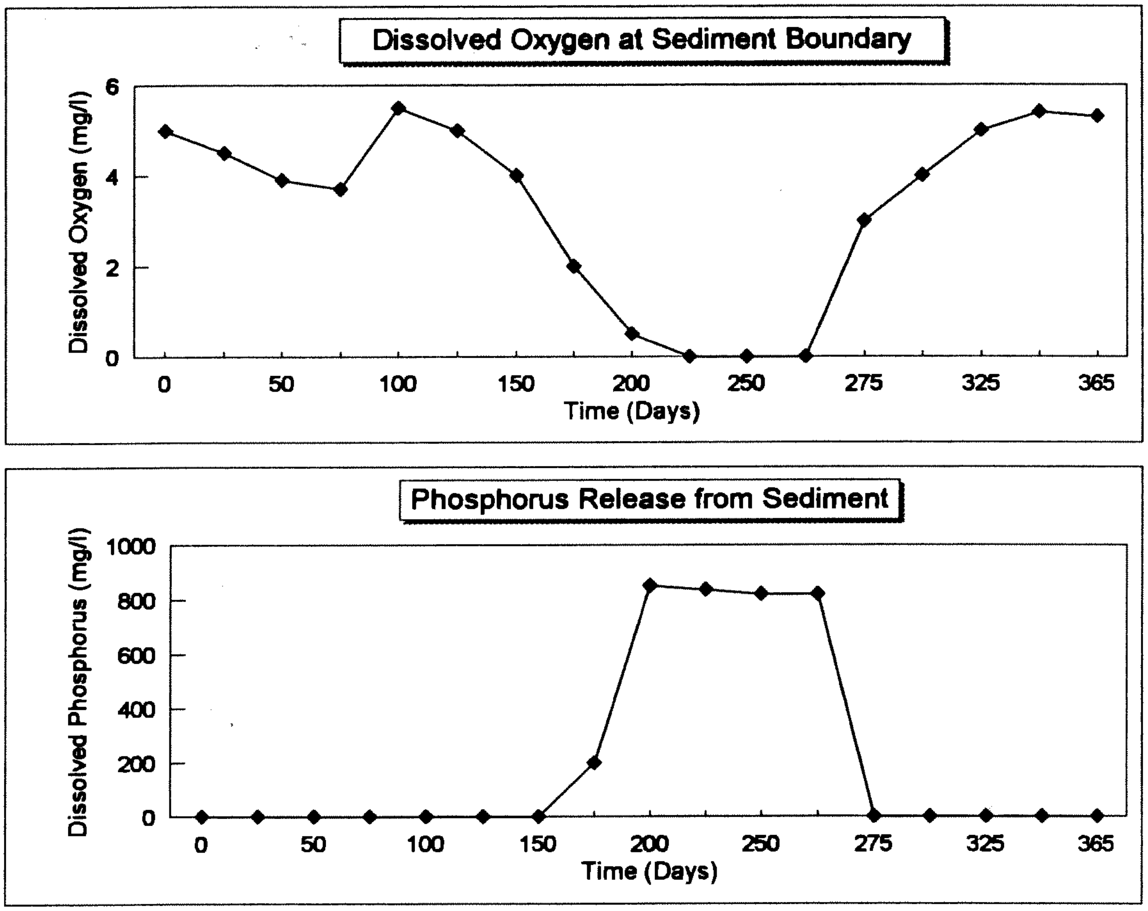


Figure 1 Relationship of low dissolved oxygen levels to sediment phosphorus release at the sediment-water interface.

Chlorophyll a

Chlorophyll a concentrations can be used as an indicator of algal growth and concentration. Monitoring data collected during the National Eutrophication Study (EPA, 1977) show average chlorophyll a concentrations that ranged from 7.0 to 10.1 μg/L, with highest concentrations present in September (14.3 μg/L). Clark and Wroten (1975) also reported peak concentrations present in August, where blue-green algae were the dominant phytoplankton species.

BOR monitoring from 1978 through 1982 (Zimmer, 1983) showed chlorophyll a concentrations that coincided well with high total phosphorus levels during summer months. Chlorophyll a levels were highest in August and September, averaging from 18 to 11 µg/L, respectively. Highest total concentrations observed during this period was 120 µg/L, recorded in August of 1978.

These and subsequent studies (Klahr, 1988; Klahr, 1989; Entranco, 1991; Ingham, 1992; Worth 1993 and 1994) conducted from 1986 to 1994, show a consistent seasonal trend similar to that defined by total phosphorus concentrations. Increasing chlorophyll a concentrations are observed beginning in May and reaching a maximum in August and September. The nutrient supply required to support continued growth of algal biomass (as defined by increasing chlorophyll a concentrations) is augmented by release of sediment-bound phosphorus during anoxic conditions and by resuspension of sediment during wind events. The mixing effect of strong winds on the reservoir result in temporary breakdown of thermal stratification and may deliver additional nutrients to the upper layers of the reservoir. Sunlight penetrates the surface waters and allows photosynthesis and nutrient uptake with algal growth.

Dissolved Oxygen

The earliest available records of dissolved oxygen monitoring are from the late 1960s and 1970s. These studies suggest that reservoir concentrations of hypolimnetic dissolved oxygen begin declining below state standards (6.0 mg/L) during hot summer months, with the lowest concentrations (<5.0 mg/L) occurring in late August and September (Irizarry, 1970; Clark and Wroten, 1975; BOR, 1975; EPA, 1977). Dissolved oxygen sags are observed to coincide with warm surface-water temperatures ($\geq$ 20 °C) occurring as a result of hot summer air temperatures, increased direct solar input to the reservoir and the relatively shallow depth of the reservoir.

More detailed studies performed during the 1980s showed low dissolved oxygen concentrations ($\leq$ 3.0 mg/L) present in July and persisting through August and September (Horner, 1980; Reininger *et al.*, 1983), with the lowest levels ($\leq$ 3.0 mg/L) occurring during summer stratification (July to September) and winter stagnation (February to March). Low dissolved oxygen levels during summer months serve to trigger the release of sediment-bound phosphorus (Figure 1). The low dissolved oxygen levels during winter stagnation could not be attributed completely to low input levels as winter dissolved oxygen levels for tributary inflow were approximately 10.0 mg/L.

Recent, representative dissolved oxygen levels are shown in Figures 2 and 3 for both a spring (pre-stratification) and summer (stratified) monitoring period. The reservoir typically stratifies during June and remains stratified until fall turnover in September or October. Lowest dissolved oxygen concentrations occur during stratified conditions when atmospheric re-aeration of the hypolimnion is inhibited. Dissolved oxygen levels are inversely correlated with both depth and temperature as can be seen in Figures 2 and 3. Dissolved oxygen levels decrease with increasing depth and temperature during stratified summer conditions.

Bacteria

A survey of bacteria concentrations within the reservoir conducted in 1974 (Clark and Wroten, 1975) found that bacteria counts within 30 feet of the shoreline were below state standards. Similar results were reported in 1974 (BOR, 1975). During a more extensive study of the reservoir conducted

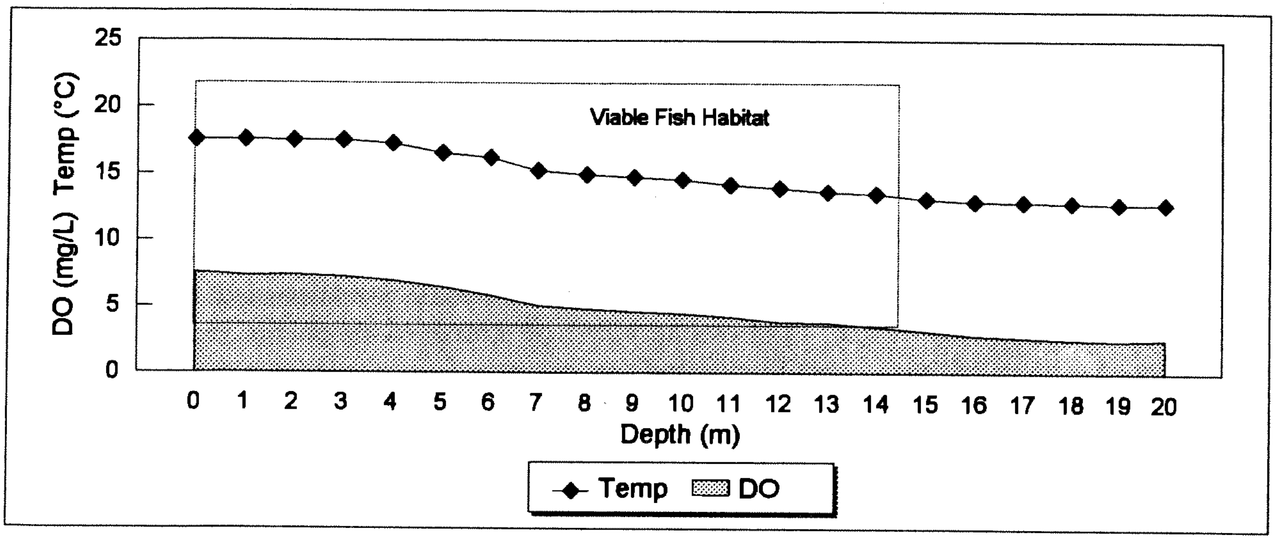


Figure 2. Correlation of temperature and dissolved oxygen levels with depth for spring monitoring.

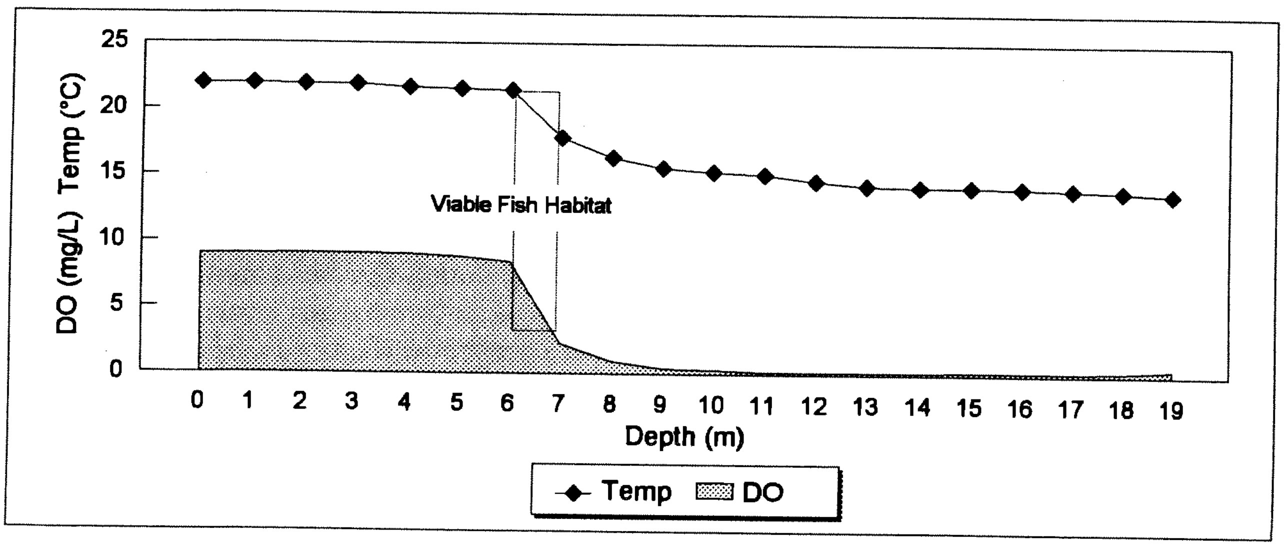


Figure 3. Correlation of temperature and dissolved oxygen levels with depth for summer monitoring.

between 1978 and 1983 (Zimmer, 1983), one violation (>500 counts/100mL) was observed in the Lake Fork arm of the reservoir. Mean counts of all sites combined exceeded the geometric mean standard (50 counts/100mL) in September, 1981. High average coliform counts were recorded in August of 1979 and September of 1981. Recent survey indicate that bacteria counts are below state standards based on 1994 to 1997 monitoring data and this information, combined with existing information on the tributary inflows, led the request for de-listing Cascade Reservoir for pathogens on the 1998 303(d) list.

Data Interpretation and Trend Analysis

While summer levels of total phosphorus and chlorophyll a vary markedly from year to year because of differences in runoff and internal recycling, an average of several years data can indicate specific trends and areas of concern. Long-term monitoring data are available at two sites within the reservoir, near the dam outlet and just above Sugarloaf Island (DEQ sites CWQ002 and CWQ005 respectively, See Figure 2, Appendix E). These sites are important indicators of reservoir conditions due to differences in spatial position along the inflow path of water entering the reservoir. Additional differences in depth and limnological conditions within the reservoir are present. The dam site is one of the deepest monitoring locations available within the reservoir and is close to the lower third of the reservoir where summer concentrations of chlorophyll a are typically high and dissolved oxygen concentrations are typically low. The Sugarloaf Island site is within the upper third of the reservoir where inflow is rapid and volume exchange occurs more frequently than in the lower areas of the reservoir. The data gathered from these two sites has been averaged to yield a comparison of historical data (1978 to 1982) and recent data (1993 to 1994) for total phosphorus, chlorophyll a concentration and Secchi depth (Figures 4, 5 and 6). These graphs show a distinct increase in total

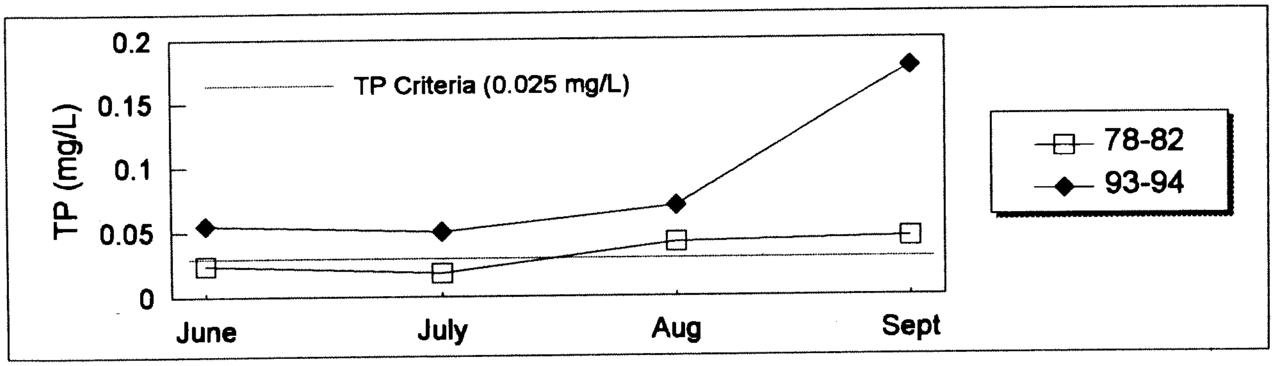


Figure 4. Correlation of historic (1978-1982) and recent (1993-1994) summer total-phosphorus (TP) levels for Cascade Reservoir.

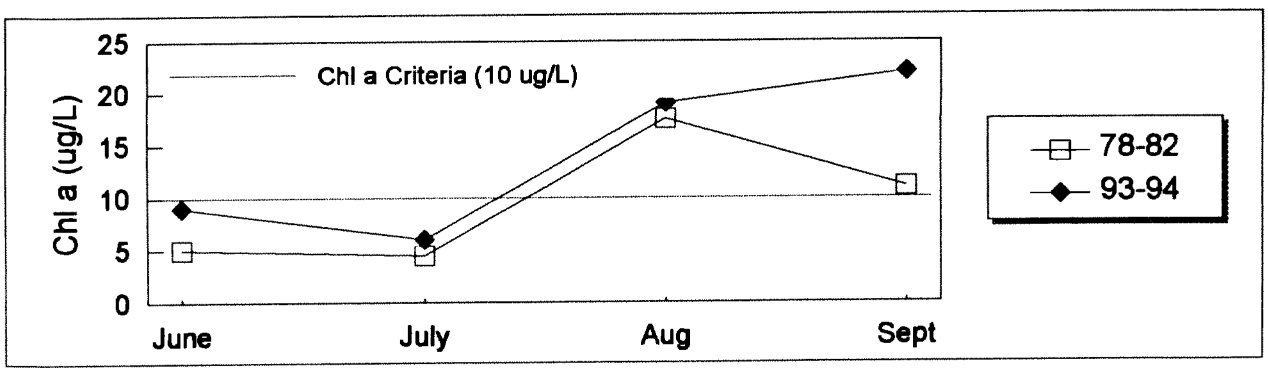


Figure 5. Correlation of historic (1978-1982) and recent (1993-1994) summer chlorophyll a (Chl a) levels for Cascade Reservoir.

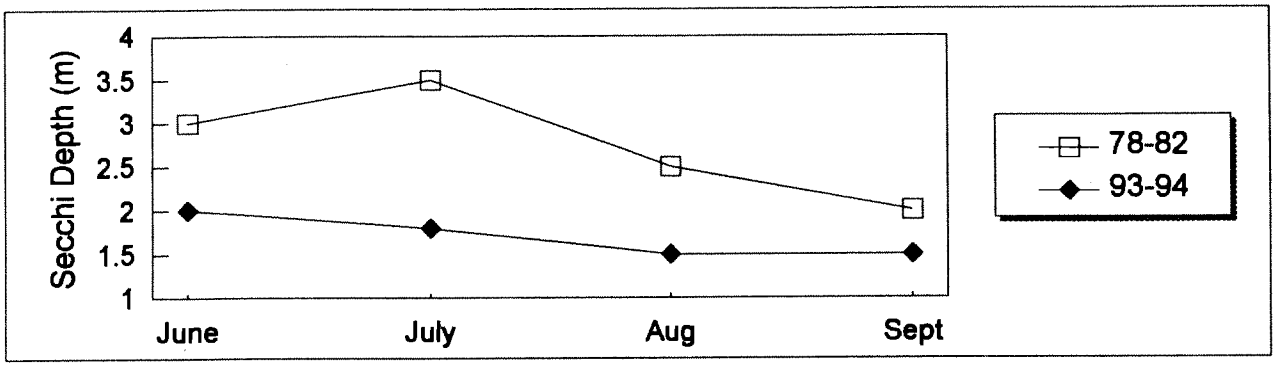


Figure 6. Correlation of historic (1978-1982) and recent (1993-1994) summer Secchi depth measurements for Cascade Reservoir.

phosphorus and chlorophyll a concentration and a corresponding decrease in Secchi depths from past to present monitoring years.

A yearly summer average (June through September) for each site shows similarly increasing trends for total phosphorus with corresponding increases in chlorophyll a over time (Figures 7 and 8). While average summer total phosphorus levels are observed to be lower in recent (1995-1996) than in previous years (1991-1994), they are still above the 0.025 mg/L goal established to restore water quality within the reservoir. The same holds true for chlorophyll a levels, which consistently remain above 10 μg/L. Chlorophyll a concentrations are typically higher and dissolved oxygen concentrations are typically lower at the Cascade Dam site than at the Sugarloaf Island site. Water column concentrations of total phosphorus are similar at the two sites and show a significant increase beginning in 1991. A representative depth-integrated dissolved-oxygen profile of both the Cascade Dam and Sugarloaf Island sites is presented in Figure 9. While the data utilized for this figure was collected in July of 1996, the observed trend is typical of the water years monitored.

Many factors, including wind effects, tributary inflows, hydraulic residence time and intra-annual monitoring frequencies may influence the observed differences at each site, however, the increase in both total phosphorus and chlorophyll a observed from 1978 to 1994 at both sites is of sufficient magnitude to override inherent environmental variability.

Tributary Water Quality

Historical tributary monitoring is not as extensive as historical reservoir monitoring. A survey was conducted in August of 1974 by BOR for selected sites (BOR, 1975). Observed data showed that dissolved oxygen levels generally exceeded state minimum standards for cold water biota (>6.0 mg/L) for North Fork Payette River, Lake Fork and several smaller tributaries along the west shore of the reservoir during the month. Associated water temperatures ranged from a high of 20 °C in Lake Fork to 5 °C for the west shore streams. Similar results were observed during a survey conducted from

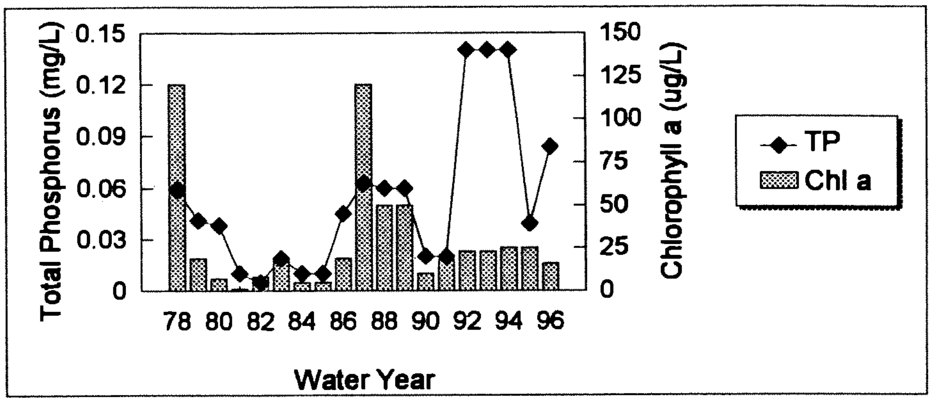


Figure 7. Changes in total phosphorus and chlorophyll a at the Cascade Dam monitoring site (CWQ002) from 1978 to 1996.

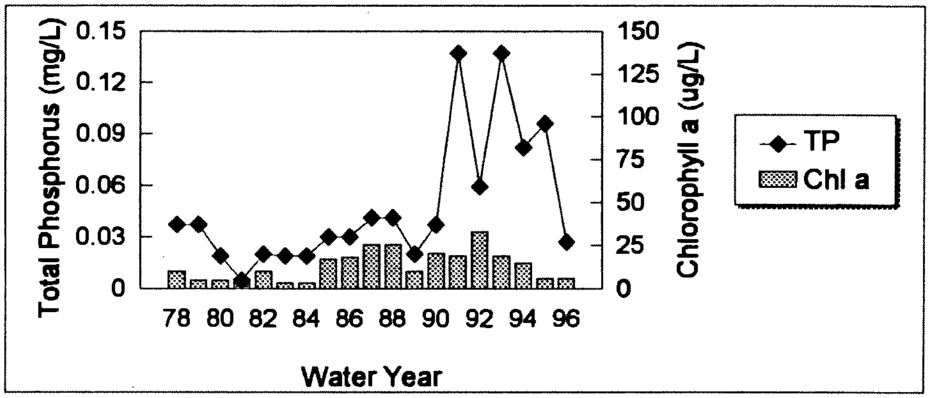


Figure 8. Changes in total phosphorus and chlorophyll a at the Sugarloaf Island monitoring site (CWQ005) from 1978 to 1996.

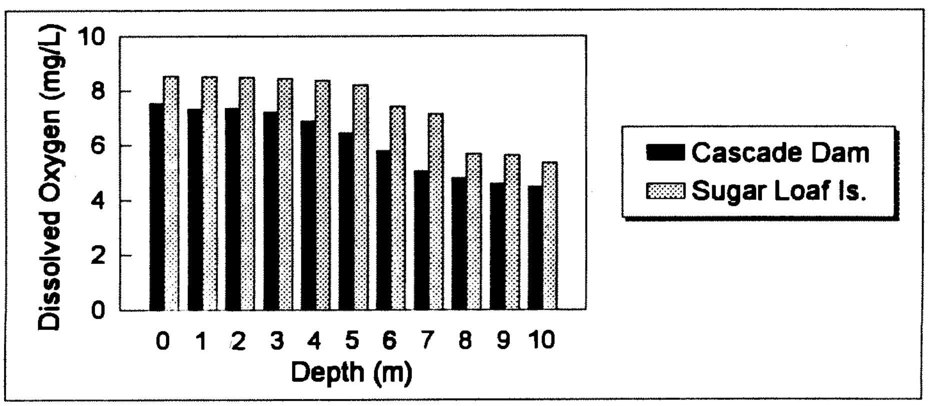


Figure 9. Depth-integrated dissolved oxygen profiles for the Cascade Dam (CWQ002) and the Sugarloaf Island (CWQ005) monitoring sites.

May to November of 1975 (Clark and Wroten, 1975), where recorded dissolved oxygen concentrations for Gold Fork, Lake Fork, Boulder Creek, Mud Creek and North Fork Payette River met state standards for cold water biota. A third study conducted in the winter of 1982 (Reininger,

1983) reported dissolved oxygen concentrations from selected tributaries varied between 9.7 and 10.1 mg/L at temperatures of 1 to 4 °C.

Further tributary monitoring conducted in 1989 (Entranco, 1991) and 1993 through 1996 (DEQ, 1994; 1995; 1996; 1998) show seasonal effects on dissolved oxygen and temperature. For illustration, monitoring data from a representative water year is plotted in Figures 10 and 11.

Seasonal variations show that dissolved oxygen levels in the tributaries to Cascade Reservoir are lower in the late winter, increase with the increased flows during spring-runoff events and then decrease as seasonal temperatures increase. Warmer air temperatures and recharge from flood-irrigation practices contribute to sharp increases in tributary temperatures during summer months. Tributaries lacking adequate riparian cover such as Boulder Creek, Mud Creek and Willow Creek generally show a more rapid increase in temperature and noticeable decrease in dissolved oxygen during summer months as compared to more highly vegetated streams.

Monitoring data suggest that Boulder, Gold Fork, Mud and Willow Creeks have higher concentrations of nutrients as compared to other major tributaries. With normalized stream flows, the contributed total and dissolved-phosphorus load from these tributaries far exceeds that delivered by the other major inflows. These streams drain large surface areas, and, with the possible exception of the upper Gold Fork drainage, flow toward the reservoir over relatively flat topography. This

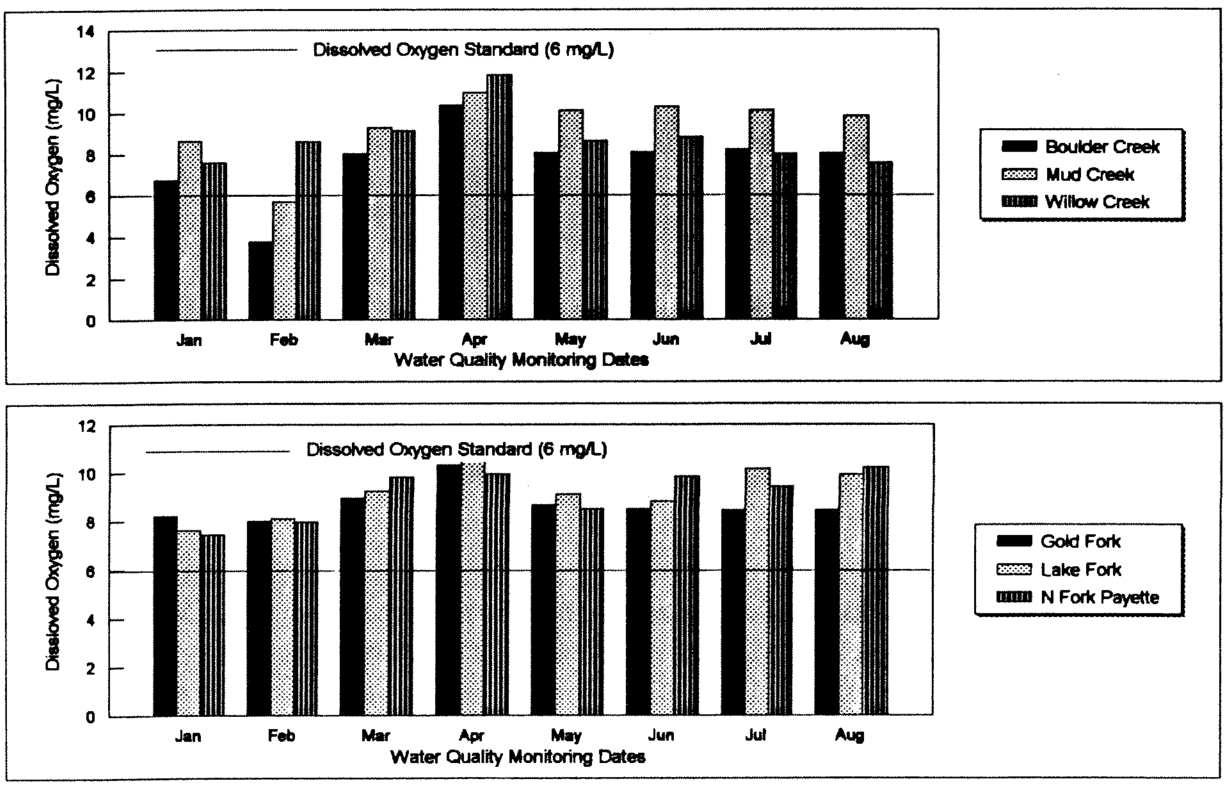


Figure 10. Seasonal variations in dissolved oxygen levels within major tributaries to Cascade Reservoir.

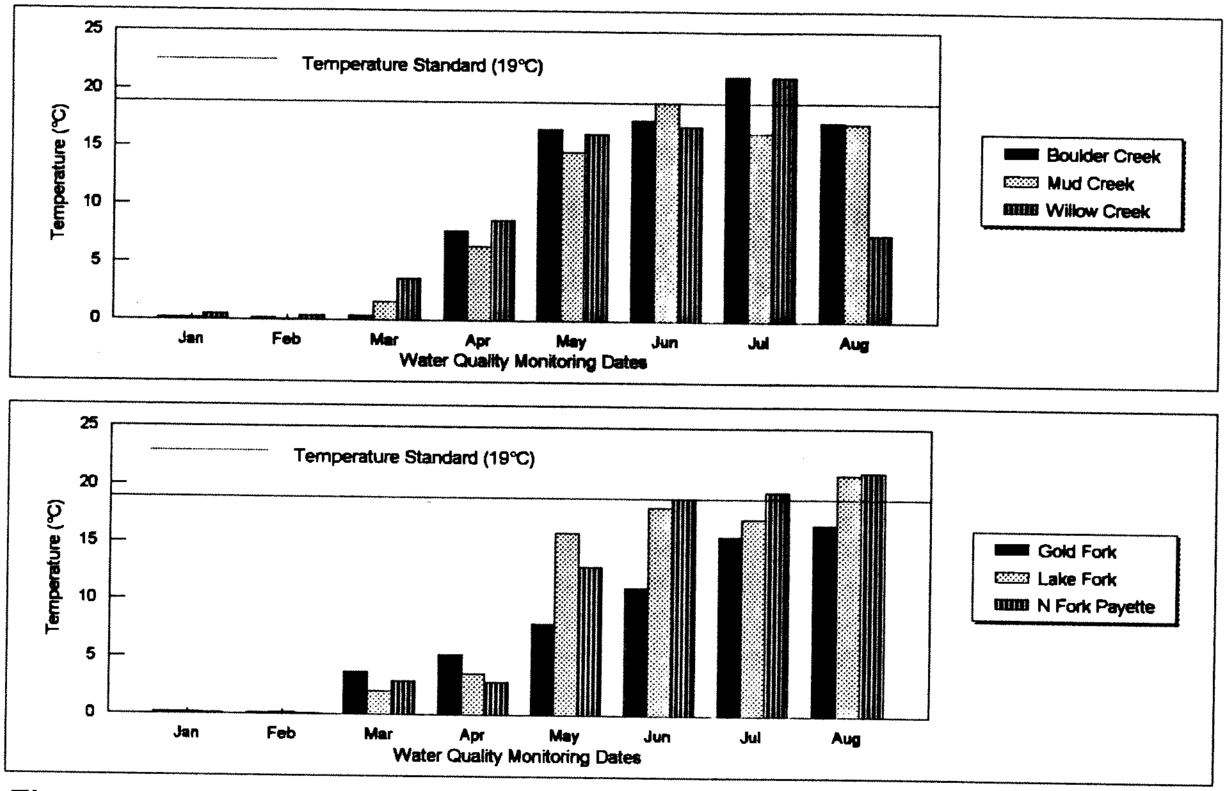


Figure 11. Seasonal variations in temperature within major tributaries to Cascade Reservoir.

allows spreading and warming of the flowing water, increasing its capacity for dissolution of nutrients. Wide, flat flood plains also increase the potential for significant transport of surface-deposited wastes which are typically rich in soluble forms of phosphorus and nitrogen. Increased thermal (solar) inputs also result in decreased dissolved oxygen levels. Tables 1-4, detailing total phosphorus load to the reservoir from tributary inflows as monitored for water years 1993 through 1996, are attached at the back of this appendix.

Overall, the dissolved oxygen levels monitored in major tributaries to the reservoir have generally been good. Only in very low water years (for example 1994) have the dissolved oxygen levels dropped chronically below the established fishery standards (>6.0 mg/l). Temperature standards, however, are periodically exceeded, with most exceedences occurring during the later summer months when air temperatures are higher.

Elevated bacteria counts were also reported (Clark and Wroten, 1975) for areas of the reservoir receiving direct inflow from these areas. A BOR study conducted in 1974 (BOR, 1975) showed several tributaries that exceeded state standards. These elevated levels were attributed to contamination by both animal and human wastes as tributary waters pass through heavily grazed areas and reservoir waters are enriched by septic systems located near the shorelines. At the time of this study, Boulder Creek coliform counts exceeded 9,000/100mL with fecal counts greater than 2,000/100 mL; Campbell Creek was reported to contain coliform counts of 2,400/100 mL. Both areas were heavily grazed at the time of the survey. Zimmer (1983) reported consistently high levels of coliform bacteria for the North Fork Payette River, Lake Fork, Boulder Creek and Gold Fork River from 1978 to 1982.

In a study conducted in 1984 and 1985 to determine the nutrient and bacterial loading attributable to recreational housing and livestock grazing conducted along the southwestern shore of the reservoir, samples were analyzed from both above and below sites for grazing and recreational housing (Lappin and Clark, 1986). Monitoring was conducted immediately following holiday weekends to determine peak recreational usage. High fecal coliform and fecal streptococcus counts were reported for monitored streams, with elevated counts occurring at sites immediately below recreational housing and grazed lands as compared to stream sites located above. The highest counts were recorded immediately below grazed areas (400 to 800/100 mL). Observed nutrient levels showed the same trend; increasing significantly at the sites below recreational housing and grazed lands, with the highest concentrations occurring immediately below the grazed areas. It should be noted that this survey was intended only as an indication of trends. Quantitative interpretation of the collected data should be made with extreme care due to the small number of samples taken. Background effects are difficult to screen out in a survey of this limited size. However, the results clearly indicate that land-use management practices have a significant impact on water quality in both the tributaries and the reservoir. The results obtained have been further validated by USFS monitoring conducted in streams flowing through grazing allotments along the western shores of the reservoir. While variability from stream to stream is high, an overall increasing trend from above to below the allotments is noticeable.

Point Source Monitoring

There are two point sources of pollution to Cascade Reservoir, the McCall wastewater treatment plant (WWTP) and the IDFG fish hatchery in McCall. Both sources discharge nutrients and other pollutants directly to North Fork Payette River upstream of Cascade Reservoir under NPDES permits. The WWTP processes approximately 1.8 million gallons per day (MGD) at full capacity. The average load is roughly 0.7 MGD. Peak flows of 2.3 MGD have been reported however, due to infiltration of ground water and snow-melt. Infiltration is estimated to contribute as much as 1.6 MGD to the base flow. Peak inflow occurs during spring runoff and snow-melt periods and declines during the remainder of the year.

Effluent water quality from the City of McCall WWTP has been routinely monitored since August 1981. Monthly reports are submitted characterizing the average and maximum concentrations of total and dissolved phosphorus, ammonia (nitrogen), total and suspended solids, total and fecal coliform bacteria, chlorine and biological oxygen demand. For the purposes of this document, the major pollutant of concern associated with the WWTP discharge is nutrients, predominantly phosphorus. Effluent concentrations vary seasonally and typically exceed ambient concentrations in North Fork Payette River. In sewage effluent, the majority of the entrained phosphorus is present as dissolved ortho-phosphate, a readily bioavailable form of phosphorus. Proportionately, greater than 85% of the total phosphorus in sewage effluent is in the form of dissolved ortho-phosphate, as compared to

<1% in sediment associated phosphorus. Dissolved ortho-phosphate concentrations in treated effluent range from 1.0 to 6.0 mg/L. Annual total phosphorus loading attributable to the treated effluent rose markedly from the early 1970's to 1988 due to increased population and recreational use. Since 1988, annual total phosphorus loading has remained relatively stable, ranging from 3815 kg to 4751 kg annually (Figure 12).

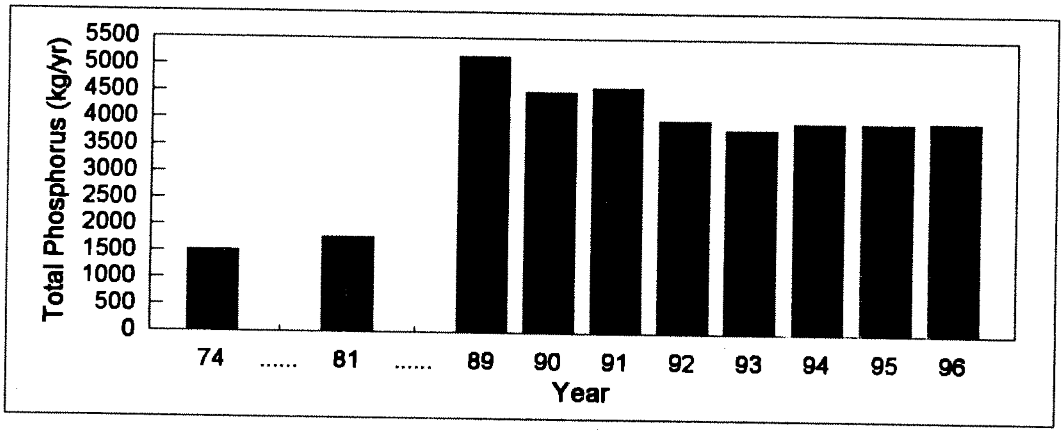


Figure 12. Annual total phosphorus loading from the City of McCall waste water treatment plant (1974 to 1996).

The IDFG Fish Hatchery requires flowing water for growth and maintenance of Chinook Salmon stock and discharges 12.9 MGD (20 cfs) to North Fork Payette River. The major pollutant of concern associated with the hatchery discharge is nutrients, again, predominantly phosphorus.

Analysis of hatchery effluent quality has been sporadically reported to DEQ since 1975. Data is limited and consists primarily of phosphorus concentrations measured in the inflow water diverted from the North Fork Payette River and effluent return water after passing through the hatchery. Ingham and Boyle (1991) monitored hatchery effluent approximately biweekly from July to September, 1988. Additional monitoring was conducted monthly from January to September, 1989, in conjunction with reservoir and watershed monitoring sponsored by the DEQ (Entranco, 1991).

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). This substitution was further augmented by changes in feeding practices. The combination of these changes has resulted in a substantially reduced phosphorus load following 1994. Pre-1994 total phosphorus loads were evaluated at 726 kg/yr (average). Post-1994 loads have been evaluated at 218 kg (average) total phosphorus annually, a 70% decrease.

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Table 1.0 Total Phosphorus Budget for Cascade Reservoir: Water Year 1993

		Cumulative TP Load in Kg								
Date	Int. Days	Boulder Creek	Gold Fork	Lake Fork	Mud Creek	North Fork Payette	Poison Creek	Willow Creek	West Mountain	Total
01-Oct	0	0	0	0	0	0	0	0	0	0
31-Oct	31	2	145	144	23	400	8	24	79	817
30-Nov	30	39	221	141	23	391	8	22	77	914
31-Dec	31	46	286	141	32	555	11	34	109	1,204
31-Jan	31	40	377	188	31	523	11	31	103	1,292
28-Feb	28	46	287	155	25	429	9	23	85	1,050
31-Mar	31	145	1063	483	78	1,342	27	87	264	3,463
12-Apr	11	2,512	370	341	199	636	10	122	113	4,293
27-Apr	15	733	724	393	102	1,113	18	123	71	3,260
12-May	15	362	1,165	1,434	36	1,925	31	18	507	5,446
24-May	12	446	3,416	820	39	3,751	68	30	890	9,393
03-Jun	10	283	1,959	703	20	7,681	54	106	288	11,040
22-Jun	19	301	1,245	1,586	41	1,896	27	101	183	5,352
20-Jul	28	156	436	10	30	417	7	56	69	1,174
17-Aug	28	274	321	49	329	347	6	426	64	1,811
14-Sep	28	119	35	128	73	1,058	9	48	109	1,569
30-Sep	17	51	158	43	21	268	2	6	14	562
Annual	365	5,554	12,208	6,759	1,104	22,732	306	1,257	3,023	52,639

Table 2.0 Total Phosphorus Budget for Cascade Reservoir: Water Year 1994

		Cumulative TP Load in Kg								
Date	Int. Days	Boulder Creek	Gold Fork	Lake Fork	Mud Creek	North Fork Payette	Poison Creek	Willow Creek	West Mountain	Total
01-Oct	0	0	0	0	0	0	0	0	0	0
19-Oct	18	21	78	53	11	206	1	7	14	389
17-Nov	29	43	457	328	41	324	11	27	106	1,325
15-Dec	28	185	1,354	357	82	806	16	58	154	2,995
12-Jan	28	144	146	51	49	582	5	49	44	1,066
01-Mar	48	18	186	83	56	537	11	60	106	1,046
15-Mar	14	37	711	16	18	202	3	19	31	1,034
22-Mar	7	39	42	11	9	66	1	32	8	206
29-Mar	7	172	134	22	55	127	4	190	35	736
05-Apr	7	70	296	46	70	336	2	362	19	1,199
12-Apr	7	99	336	115	50	195	6	38	57	890
18-Apr	6	39	326	53	11	274	10	6	94	803
25-Apr	7	69	164	67	21	438	6	3	56	819
05-May	10	32	279	124	13	354	6	5	62	870
10-May	5	20	174	464	2	1,800	15	1	148	2,609
23-May	13	54	162	55	7	598	7	8	65	948
07-Jun	15	54	100	42	4	278	4	27	34	536
20-Jun	13	8	113	5	15	203	4	11	41	397
12-Jul	22	10	156	7	2	291	1	28	11	505
08-Aug	27	23	40	15	63	389	7	31	67	628
12-Sep	35	38	32	3	38	414	2	1	20	546
30-Sep	18	19	16	2	19	213	1	1	10	281
Annual	364	1,195	5,301	1,919	638	8,629	123	962	1,182	19,827

Table 3.0 Total Phosphorus Budget for Cascade Reservoir: Water Year 1995

		Cumulative TP Load in Kg								
Date	Int. Days	Boulder Creek	Gold Fork	Lake Fork	Mud Creek	North Fork Payette	Poison Creek	Willow Creek	West Mountain	Total
01-Oct	0	0	0	0	0	0	0	0	0	0
20-Oct	19	6	25	3	4	180	0.3	1	5	226
15-Nov	26	21	80	19	34	203	1	6	21	385
07-Dec	22	42	61	35	24	210	1	20	47	440
11-Jan	35	72	289	126	80	711	9	33	107	1,419
15-Feb	35	185	214	100	48	541	13	34	182	1,303
28-Feb	13	103	119	140	31	537	17	44	175	1,150
15-Mar	15	138	451	167	48	703	19	47	202	1,758
28-Mar	13	80	196	38	20	414	4	25	28	802
11-Apr	14	291	489	153	67	891	5	67	87	2,045
25-Apr	14	181	623	166	38	913	6	73	230	2,224
10-May	15	265	973	308	20	1,825	23	57	244	3,692
23-May	13	194	703	434	2	1,928	45	17	297	3,574
08-Jun	16	235	604	199	3	1,705	17	13	325	3,085
27-Jun	19	240	432	178	16	1,382	9	49	449	2,746
11-Jul	14	129	190	62	55	244	4	42	262	984
23-Aug	43	148	23	45	165	807	13	88	274	1,550
07-Sep	15	36	18	66	61	420	2	25	51	677
26-Sep	19	40	10	39	26	365	2	28	33	542
30-Sep	4	9	2	8	5	77	0.47	6	7	114
Annual	364	2,413	5,504	2,288	749	14,057	191	676	3,028	28,716

Table 4.0 Total Phosphorus Budget for Cascade Reservoir: Water Year 1996

		Cumulative TP Load in Kg								
Date	Int. Days	Boulder Creek	Gold Fork	Lake Fork	Mud Creek	North Fork Payette	Poison Creek	Willow Creek	West Mountain	Total
26-Sep	0	0	0	0	0	0	0	0	0	0
18-Oct	22	44	165	95	25	240	5	23	89	681
18-Nov	31	107	334	213	56	783	26	52	113	1,658
13-Dec	25	519	1,672	684	60	1,076	86	63	178	4,252
22-Feb	71	705	1,417	444	510	1,993	19	568	130	5,767
03-Apr	41	1,054	986	660	762	1,823	17	332	121	5,739
25-Apr	22	176	2,980	524	113	2,453	129	50	904	7,200
08-May	13	107	379	326	19	658	5	16	37	1,543
24-May	16	207	1,267	291	37	1,827	23	71	163	3,864
05-Jun	12	219	1,264	480	8	1,323	30	34	209	3,536
20-Jun	15	184	540	427	10	1,392	14	25	100	2,679
03-Jul	13	125	366	131	9	427	26	26	180	1,263
18-Jul	15	77	45	7	26	174	10	54	68	451
31-Jul	13	28	26	7	18	451	3	19	21	569
23-Aug	23	49	8	42	23	234	4	21	28	404
25-Sep	33	35	35	67	28	233	4	23	31	453
Annual	365	3,635	11,484	4,397	1,706	15,087	402	1377	2,372	40,059

Appendix E

Monitoring Summary for the Cascade Reservoir Watershed

Appendix E. Monitoring Summary for the Cascade Reservoir Watershed

Cascade Reservoir and the surrounding watershed have been the focus of many studies over the past 30 years. Initial monitoring consisted of the evaluation of fish-habitat indicators by IDFG in 1968 and water-quality parameters in 1975 by the BOR. Historical monitoring was augmented by further studies conducted by the CRA, IDHW, CDHD, BOR, DEQ and others. Historical monitoring of water quality in Cascade Reservoir (Clark and Wroten, 1975; Klahr, 1988; Klahr, 1989; Entranco, 1991; Ingham, 1992; Worth 1993 and 1994) has indicated significant impairment resulting from excess nutrients entering the reservoir through tributary and diversion inflow and overland runoff. However, while there is an extensive list of historical monitoring available, a concerted watershed monitoring effort was not undertaken until the early 1990s, when routine, scheduled monitoring was initiated for specific inflow and inlake sites.

DEQ has continuously monitored the water quality in the Cascade Reservoir Watershed since 1993. Monitoring is scheduled to continue throughout the phased TMDL process to identify water-quality trends and attainment of water-quality objectives. Concurrent monitoring by USFS personnel (predominantly for tributaries in Gold Fork and West Mountain subwatersheds), and BOR (in-reservoir and created wetlands monitoring) has been ongoing and is scheduled to continue. Specific monitoring sites designated by these agencies may undergo revision to address budgetary changes, but will continue in the most extensive manner possible given availability of funding. A detailed monitoring plan is prepared and/or updated annually for Cascade Reservoir that outlines coordinated monitoring activities for the support, development and implementation of the TMDL allocation to improve reservoir water quality.

Background Information

The Idaho Water Quality Standards designate beneficial uses for Cascade Reservoir as: domestic and agricultural water supply, cold and warm water biota, salmonid spawning and primary/secondary contact recreation. Cascade Reservoir was designated as a Stream Segment of concern in 1989 due to impaired water quality and the perception that beneficial uses were no longer fully supported. Past studies indicate that the reservoir is hyper-eutrophic due to excessive nutrient loading, with phosphorus considered to be the limiting factor. Excessive algal blooms have been reported on Cascade Reservoir since the early 1970s. These algal blooms are the most conspicuous indicator of nutrient pollution problems.

Eutrophication of Cascade Reservoir has been attributed to excess phosphorus and other nutrients carried by various streams and rivers flowing into the reservoir. The source of this phosphorus has been linked to land-use activities within the watershed resulting in point and nonpoint sources of pollution. Point sources of pollution include the McCall Wastewater Treatment Plant and the McCall Fish Hatchery which discharge treated wastewater directly into the North Fork Payette River. These facilities are permitted under the EPA National Pollutant Discharge Elimination System (NPDES). Non-point sources of phosphorus include forested, agricultural and urban/suburban land use. Other important contributions of phosphorus are associated with erosion, stormwater runoff, recreation and septic tanks associated with shoreline development.

Long-term monitoring indicates phosphorus concentrations within the reservoir have increased since 1984 with a corresponding increase in algal production. Although phosphorus loading to the reservoir varies greatly depending on the annual rainfall and snowfall patterns, a comparison of the phosphorus budgets indicates that 80-90% of the phosphorus load is retained within the reservoir. As a result, much of the phosphorus loading accumulates in the reservoir sediments and provides a secondary source of enrichment for algal growth. Reducing the amount of phosphorus in runoff entering Cascade Reservoir is critical for long-term improvement of water quality.

Due to continued violations of water-quality standards, Cascade Reservoir was listed as a water-quality limited water body under section 303(d) of the Federal Clean Water Act (40 CFR Ch.1 130, 1987). The Clean Water Act stipulates that Total Maximum Daily Load (TMDL) allocations must be developed by those states designating a water body as "water-quality limited". A TMDL allocates the allowable amount of pollutants that can be effectively assimilated by a specific water body while continuing to meet state water-quality standards. The TMDL must include all potential sources of a designated pollutant of concern, including those derived as point, nonpoint and natural or background sources. DEQ initiated development of TMDL allocations for Cascade Reservoir in February 1994. Current monitoring projects were implemented under this effort. Historical monitoring projects for both tributary (inflow) and inlake sites (listed in Table 1) have allowed the identification of water-quality trends and the establishment of reasonable baseline conditions.

Table 1 Inlake and Tributary Studies of Cascade Reservoir Watershed

STUDIES OF TRIBUTARIES TO CASCADE RESERVOIR			
Year	**Conducted By**	**Parameters**	**Comments/Location**
1975	EPA[1]	Nutrients, DO , temperature, pH, bacteria	National Eutrophication Study
1975	DEQ[2]	Nutrients, DO , temperature, pH, bacteria	Boulder Cr., Gold Fork R., Lake Fork Cr., Mud Cr.
1980	BOR[3]	Nutrients, DO , temperature, pH, bacteria, stream flow	Expansion to biweekly sampling
1984-present	Boise Cascade[4]	Nutrients, DO , temperature, pH, bacteria, stream flow, suspended sediment	Trend monitoring, Gold Fork R.
1986	DEQ[5]	Nutrients, DO , temperature, pH, bacteria, stream flow, suspended sediment	Focused on streams primarily influenced by agriculture, Boulder Cr., Mud Cr., Lake Fork Cr.
1989	Entranco[6]	Nutrients, DO , temperature, pH, bacteria, stream flow, suspended sediment	Development of a water-quality management plan, all major tributaries
1991-present	BNF[7]	Stream flow, bacteria, nutrients	Monitor impacts to streams from grazing allotments on the Westside

STUDIES OF TRIBUTARIES TO CASCADE RESERVOIR			
1992-1994	DEQ and VSWCD[8]	Nutrients, DO , temperature, pH, bacteria, stream flow, suspended sediment, riparian condition	BMP effectiveness on Boulder Cr.
1993-present	DEQ[9]	Nutrients, DO, temperature, pH, bacteria, stream flow, suspended sediment	Determine mass loading from each tributary
1991-present	PNF[10]	Stream flow, bacteria, nutrients	Trend monitoring in Kennally Creek
INLAKE STUDIES OF CASCADE RESERVOIR			
1968	IDFG[11]	DO	Limnological & fisheries
1974	BOR[12]	DO , conductivity, temperature, nutrients, minerals, chlorophyll a	Concerns for low DO and nuisance algae
1975	DEQ[2]	DO , temperature, nutrients, minerals, chlorophyll a, phytoplankton, bacteria	Study coincided with issuance of the McCall NPDES permit
1975	EPA[1]	DO , temperature, conductivity, pH, nutrients, minerals, alkalinity, chlorophyll a, phytoplankton, bacteria	National Eutrophication Study
1978-present	BOR[13]	Phosphorus, chlorophyll a	Reservoir trend monitoring
1980-1982	IDFG[14]	DO	Develop criteria for winter storage to enhance fish survival
1988-1991	Citizens[8,15]	DO , temperature, nutrients, Secchi depth, chlorophyll a, phytoplankton	Citizen concern
1989	Entranco[6]	DO , temperature, conductivity, pH, Secchi depth, nutrients, chlorophyll a, phytoplankton, bacteria	Phase I Clean Lakes Grant funded study
1993-present	DEQ[16]	DO , temperature, conductivity, pH, Secchi depth, nutrients, chlorophyll a, phytoplankton, bacteria	Expand database to assist in the development of a restoration management plan

1 = EPA, 1977; 2 = Clark and Wroten, 1975; 3 = Zimmer, 1983; 4 = Glass, 1995; 5 = Klahr, 1988; 6 = Entranco, 1991; 7 = Fischer, 1995; 8 = Ingham, 1992; 9 = Worth, 1995; 10 = PNF, 1995; 11 = Irizarry, 1970; 12 = Bureau of Reclamation, 1974 and 1975; 13 = Zimmer, 1983; 14 = Horner and Riemand, 1981, Reininger *et al.*, 1982, Reininger *et al.*, 1993; 15 = Klahr, 1989; 16 = Worth, 1994.

The current monitoring activities discussed herein are consistent with guidelines for implementation of a phased TMDL for both point and nonpoint sources of pollution (EPA, 1991). Under the traditional TMDL process, the state is required to adopt and enforce specific numerical water-quality criteria that when implemented, would result in restoring full support of designated beneficial uses.

Monitoring Objectives

Water-quality monitoring objectives in support of the TMDL process include:

Objective 1	Evaluation of watershed nutrient sources, baseline conditions and reservoir loading.
Objective 2	Obtain adequate flow and pollutant load information during peak runoff season in order to more accurately determine phosphorus loading to the reservoir.
Objective 3	Obtain adequate temperature information on tributaries.
Objective 4	Evaluate the effectiveness of constructed wetlands and detention ponds in reducing phosphorus loading to the reservoir and/or tributaries.

Cascade Reservoir Inflows

Seven major subwatersheds have been identified that directly drain to Cascade Reservoir (Cascade Reservoir Phase II Watershed Management Plan, Figure 2.2). Water-quality monitoring has been conducted on the major tributaries for each subwatershed and several local streams and rivers related to specific timber management activities on endowment state lands and within the national forests. Specific inflow locations designated for DEQ water-quality monitoring are:

GF1	Gold Fork River	-116° 04' 03.63"W/44° 41' 15.00"N
LF1	Lake Fork @ Scheline Road	-116° 05' 03.45"W/44° 37' 18.43"N
BC1	Boulder Creek @ Hwy 55	-116° 00' 32.29"W/44° 43' 39.69"N
BC2	Boulder Creek @ Roseberry Ditch Diver.	-116° 00' 42.23"W/44° 46' 44.45"N
BC3	Boulder Creek @ Potter Road	-116° 01' 36.51"W/44° 50' 48.85"N
MC1	Mud Creek at Norwood Rd.	-116° 06' 31.42"W/44° 43' 39.69"N
WC1	Willow Creek at Old State Hwy	-116° 04' 03.04"W/44° 43' 02.13"N
PC1	Poison Creek at West Mtn. Rd. Crossing	-116° 06' 40.12"W/44° 39' 58.85"N
NFPR2	N. Fork Payette River @ Hartzell Bridge	-116° 00' 59.63"W/44° 46' 43.73"N

The current monitoring of nine inflow stations (Figure 1) by DEQ is designed to quantify nutrient contributions from each of the subwatersheds that drain into Cascade Reservoir. Each of these stations is monitored monthly. Flow, conductivity, pH, temperature and dissolved oxygen measurements are taken in the field and water samples are collected for analysis for the parameters listed in Table 2 below. Appropriate quality assurance measures including blanks, spikes and duplicate sampling are included in all monitoring performed.

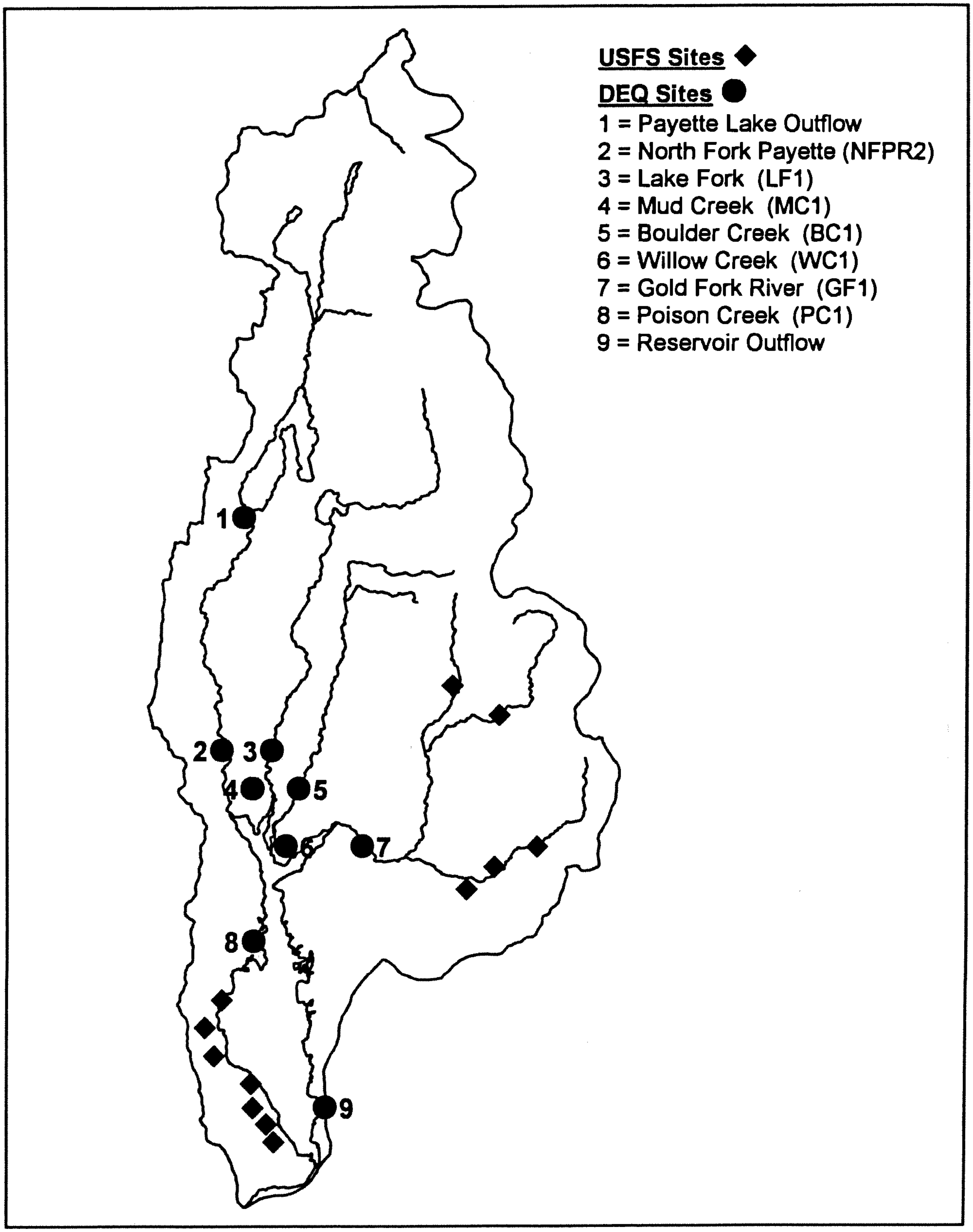

Figure 1 Location of inflow monitoring sites for Cascade Reservoir Watershed.

Table 2 Water-quality monitoring parameters for DEQ inflow stations

Analytical Parameters	Minimum detection limit- units	Methods
NO_2+NO_3 as N	0.005 mg/L	EPA Method 353.2
NH_4 as N, Total	0.005 mg/L	EPA Method 350.1
Total Kjedahl Nitrogen (TKN)	0.05 mg/L	EPA Method 351.2
Total Phosphorus	0.005 mg/L	EPA Method 365.4
Ortho-phosphate	0.001 mg/L	EPA Method 365.2
Suspended Sediment	2 mg/L	EPA Method 160.2
Total Solids	2 mg/L	
Chloride	0.9 mg/L	EPA Method 325.3
Fecal Coliform	2 cts/100 mL	Standard Methods
E. Coli	2 cts/100 mL	Standard Methods
Field Parameters	**Units**	
Flow	cfs	Electronic metering
Temperature	degrees Celsius	Point and continuous
Dissolved Oxygen	mg/L	Hydrolab Dissolved Oxygen Probe
Specific Conductivity	µ mhos	Hydrolab Conductivity Probe
pH	SU	pH meter

Nitrogen. The nitrogen:phosphorus ratio is an important indicator of the trophic condition of a water body. Although phosphorus is often the nutrient which limits the growth of algae in lakes and reservoirs, nitrogen is also an important nutrient. The balance of these two nutrients can influence the type of algae species that grow and dominate a lake or reservoir. While water-quality data from Cascade Reservoir suggests that phosphorus supply is largely responsible for the prevalence of algae, the quantity and concentrations of nitrogen entering the reservoir may also contribute to the growth of algae blooms.

Phosphorus. Eutrophication of Cascade Reservoir has been attributed to excess phosphorus within the water column. Both total and dissolved (ortho-phosphate) are monitored in tributary inflow samples. Both are important indicators of nutrient loading for while soluble forms of phosphorus are more readily available for algal uptake and have greater potential to stimulate growth, particulate forms of phosphorus bound to organic particles and sediments generally comprise the largest source of phosphorus enrichment. Although, particulate forms of phosphorus are kinetically less available for algal uptake, mineralization, microbial activity can convert significant portions of this phosphorus to more soluble forms over time, further enhancing the pool of phosphorus available for algal uptake and growth.

Sediment. Information collected on the sediment/solids mass within inflow samples allows not only interpretation of physical transport and delivery mechanisms for sorbed phosphorus, but also an indirect evaluation of riparian health and streambank erosion processes.

Bacteria. Historically, bacterial contamination has been only infrequently monitored. Data gathered has usually been obtained in conjunction with issues related to sanitary disposal of waste water from septic tanks (Table 1). Monitoring efforts initiated in 1993 provide an expanding data base on bacterial contamination that was not previously available. This information can be used to evaluate both septic and sewer impacts on water quality as well as bacterial contamination resulting from animal wastes.

Flow. Stream-flow measurements are critical to the development of a total annual load for the watershed. They also provide chronological distributions of pollutant delivery. Studies have shown (Entranco Engineers, 1991; Worth, 1993 and 1994) that large amounts of phosphorus enter the reservoir during snowmelt. While this period varies from year to year, it generally occurs during March for snow on the valley floor and mid-May to mid-June for peak runoff from the surrounding mountains. Additional monitoring events during snowmelt periods have been added to routine, monthly monitoring to provide enhanced information on the levels of phosphorus delivered to the reservoir during that time.

Temperature. Temperature is an important indicator of stream quality. Temperature is affected by riparian cover, thermal inputs, flow alterations, ambient temperatures, groundwater recharge and direct sunlight. Obtaining temperature measurements at each of the inflow sites provides information on diurnal temperature variations and information on average daily temperatures. Temperature information can also give some indication of the extent of dissolution of sorbed phosphorus from suspended sediment within the water column.

Dissolved Oxygen. Dissolved oxygen concentration is a fundamental measure of the ability of a waterbody to support aquatic life. Ambient water-quality monitoring indicates that Cascade Reservoir experiences periodic low dissolved oxygen levels during the summer months. Instream dissolved oxygen levels provide a measure of input levels to the reservoir. Elevated temperatures and algal productivity influence dissolved oxygen levels.

Conductivity. Conductivity measurements provide information on the concentration of dissolved solids and buffer capacity of tributary waters. The ion strength and conductivity also influence the form of dissolved metals and other trace constituents in the water column.

pH. The acidity or basicity of natural waters has significant impact on wildlife, plant and fishery populations. The pH also influences the charge state of dissolved trace metals and sorption-desorption mechanisms of sediment-bound phosphorus.

In addition to existing DEQ monitoring, the BNF, Cascade District began monitoring the smaller tributaries on the west side of the reservoir in 1991, and in Gold Fork subwatershed (by both BNF and PNF) (Figure 1). This monitoring has continued through 1998. The streams are monitored to determine the effects of grazing conducted under permits issued on lands managed by the BNF. Monitoring includes stream flow rates, nutrients (total phosphorus, dissolved ortho-phosphate), bacteria (fecal coliform) and physical data (temperature and DO). Measurements are taken above and below the grazing allotments to estimate relative differences ascribed to grazing management.

Boulder Creek Hydrography Delineation and Monitoring. Hydrology of the landscape within this subwatershed is extremely complex due to natural geologic features, presence of extensive wetlands and manmade canals. These physical features create a patchwork of different land uses and hydrologic conditions that affect runoff and related water quality throughout the watershed. These intra-basin differences, however, are not readily distinguished by current method of monitoring water quality as a single aggregate outflow. Consequently, the resulting loading estimates may provide little information concerning which specific portions of a heterogeneous landscape within a watershed actually contribute a greater proportion of nutrients. In addition, the effectiveness of the selection and implementation of BMPs can be greatly enhanced through identification of small sub-basins that can be linked to high sources of nutrients within the larger watershed.

A pilot project targeting the Boulder/Willow subwatershed has been initiated and will be ongoing. The subwatershed has been partitioned into smaller subsets based on hydrologic boundaries (natural and manmade), landscape features and land-use practices to aid in the identification of critical sub-basins. Three separate monitoring sites have been designated along Boulder Creek to evaluate water management practices and related water-quality impacts based on priority of their individual contribution to the net export of watershed nutrients (Ingham, 1992).

Ground Water Monitoring

With the exception of bacterial surveys, very few studies have evaluated the importance of ground water as a nutrient source for Cascade Reservoir. Zimmer (1983) reported concentrations of dissolved ortho-phosphate frequently exceeded concentrations of surface inflows, indicating shallow ground water could be an important source of nutrient loading to the reservoir. Shallow ground water within the watershed is often heavily impacted by agricultural recharge from flood irrigation practices. Good estimates of the total loading impact of shallow ground water are not available due to the significant variability of shallow, perched aquifers within the region. Estimates of deep, natural ground-water loading impacts have been established at 2102 kg/year for the total watershed. This is discussed in detail in section 3.3.1 of the Cascade Reservoir Phase II Watershed Management Plan.

Lappin and Clark (1986) conducted an intensive study of bacteria contamination in surface and ground water related to recreational housing and cattle grazing along the reservoir southwest shore. The area of study included high density use of summer cabins.

Point Source Monitoring

There are two point sources of pollution to Cascade Reservoir, the McCall wastewater treatment plant (WWTP) and the IDFG fish hatchery in McCall. Both sources discharge nutrients and other pollutants directly to North Fork Payette River, upstream of Cascade Reservoir under NPDES permits. Effluent water quality from the City of McCall WWTP has been routinely monitored since August 1981. Monthly reports are submitted characterizing the average and maximum concentrations of total and dissolved phosphorus, ammonia (nitrogen), total and suspended solids, total and fecal coliform bacteria, chlorine and biological oxygen demand.

Analysis of hatchery effluent quality has been sporadically reported to DEQ since 1975. Data is limited and consists primarily of phosphorus concentrations measured in the inflow water diverted from the North Fork Payette River and effluent return water after passing through the hatchery. Ingham and Boyle (1991) monitored hatchery effluent approximately biweekly from July to September, 1988. Additional monitoring was conducted monthly from January to September, 1989, in conjunction with reservoir and watershed monitoring sponsored by the DEQ (Entranco, 1991).

In-Reservoir Monitoring

Several inlake monitoring sites have been established (Figure 2). CWQ sites as shown in Figure 2 were established by DEQ. Additional GAR sites were established and monitored by the BOR. Four sites (CWQ002, CWQ005, CWQ007, CWQ012), are monitored routinely during summer months by DEQ. The remaining CWQ sites are monitored on an as needed basis as indicated by inlake and inflow water quality.

CWQ002	100' from east shore above dam	-116° 03' 09.61"W/44° 31' 22.70"N
CWQ004	Near Hurd Creek on western shore	-116° 08' 26.48"W/44° 35' 04.65"N
CWQ005	Westernmost tip of Surgarloaf Is.	-116° 05' 34.80"W/44° 38' 36.50"N
CWQ007	Center of res., near Poison Creek	-116° 05' 59.10"W/44° 39' 35.90"N
CWQ009	Near North/Lake Fork confluence	-116° 07' 05.23"W/44° 41' 54.46"N
CWQ010	Center of Lake Fork arm	-116° 06' 11.70"W/44° 42' 12.46"N
CWQ011	Center of Gold Fork arm	-116° 05' 00.20"W/44° 40' 28.43"N
CWQ012	Center of res., near VanWyck Creek	-116° 05' 00.20"W/44° 32' 32.50"N

DEQ inlake monitoring is carried out monthly and includes all water-quality parameters discussed previously for inflow monitoring with additional depth distribution measurements for temperature, dissolved oxygen, conductivity, pH and phosphorus. Chlorophyll a and phytoplankton samples are also taken at these locations to monitor algal distribution and relative organism population counts (respectively). Concurrent Secchi depth measurements are recorded at each site. Appropriate quality assurance measures including blanks, spikes and duplicate sampling are included in all monitoring performed.

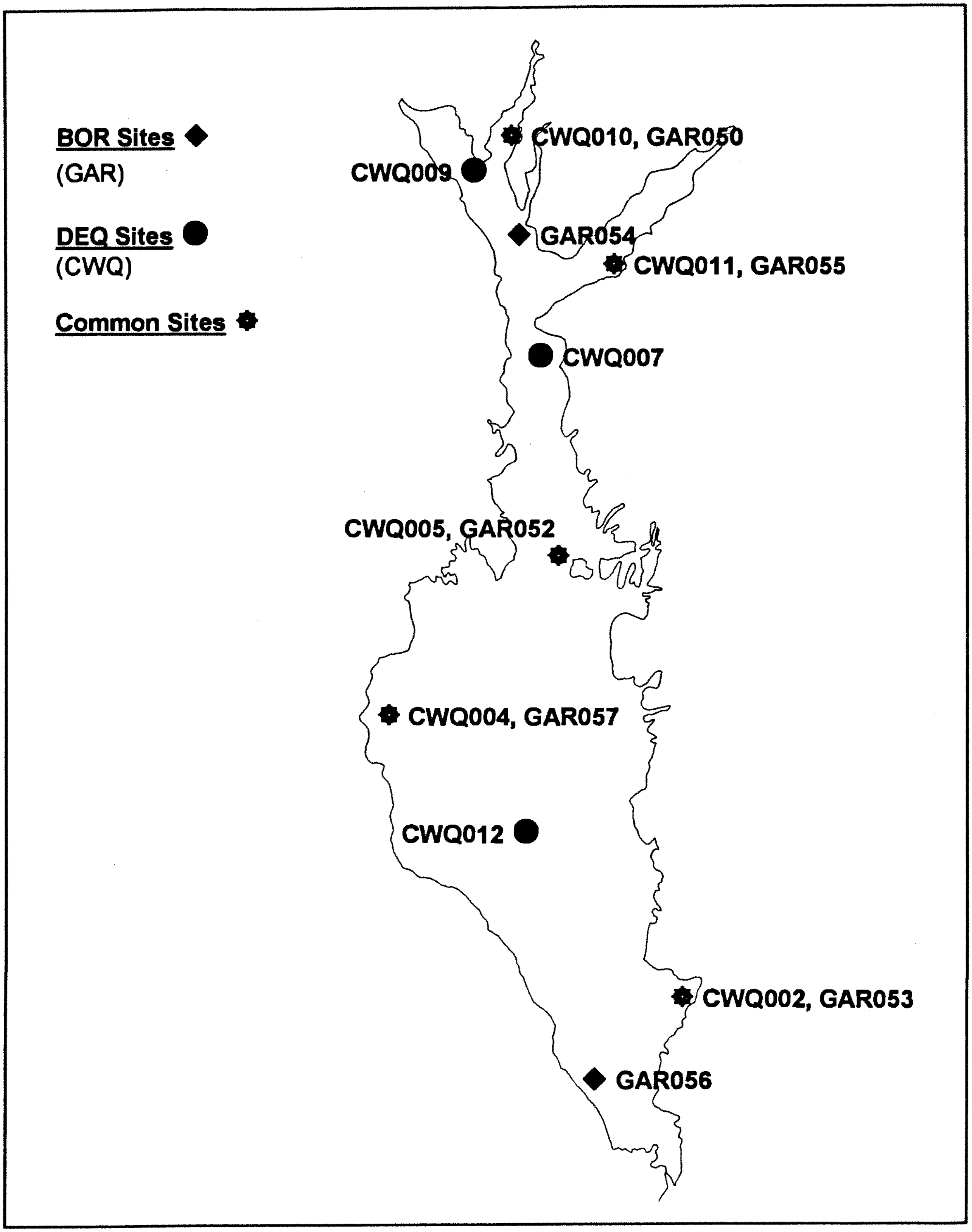

Figure 2 Location of in-reservoir monitoring sites for Cascade Reservoir.

Determining nutrient levels in the reservoir establishes baseline conditions, phosphorus storage and recycling capacity information for reservoir model development. Measuring the oxygen and temperature levels provides the information necessary to determine when the lake is stratified and when it is mixed. Winter dissolved oxygen is measured periodically during the months when ice covers the reservoir as an assessment of winter fish habitat and potential oxygenation levels of reservoir water at ice-out.

Constructed Wetlands/Detention Ponds

In 1995, six wetlands (see Figure 2.12, Cascade Reservoir Phase II Watershed Management Plan) were constructed by DEQ and BOR . Each of the wetlands has a variable quality of source water, retention time and different design characteristics as dictated by the local topography.

The created wetland project was initiated to evaluate the practical feasibility and effectiveness of using wetlands as management practices to improve water quality and provide habitat benefits in the Cascade Reservoir watershed. Since wetland characteristics can vary considerably according to site conditions and mechanisms, information derived from real wetland projects is essential in developing realistic criteria for undertaking wetland projects at other sites and to determine appropriate methods to integrate wetlands as part of coordinated, long-term watershed management plans.

The wetland investigation utilizes small wetland systems that were constructed to intercept water from tributary streams and overland inflows near Cascade Reservoir. Wetland sites were established by using fairly simple, inexpensive construction methods and by adapting the design approach and system configuration according to the conditions at each site. Characteristics of the selected sites represent distinct water management strategies and techniques that could be applied either at a larger scale or at other locations in the contributing watershed area.

Monitoring of the wetlands for nutrient and sediment removal as well as other parameters is being conducted over a three year hydrologic cycle (October-September) with timing specific to the construction of each designated site. Monitoring is designed to quantitatively determine reduction in the export of phosphorus and sediments using a paired upstream and downstream sampling technique. The three year design is necessary to segregate transient changes in nutrient uptake efficiency resulting from construction/disturbance and more stable post-construction conditions. The three years allows vegetation to become established and also accounts for normal, seasonal variations in inflow and outflow volumes. A project report will be prepared at the end of the third year to summarize the wetland water-quality transformation processes, estimate phosphorus and sediment removal and characterize habitat associated with the created wetlands.

Monthly or biweekly monitoring is scheduled during the summer months of each water year for the parameters shown in Table 2, with the addition of chlorophyll a monitoring. Flow, pH, conductivity, temperature and dissolved oxygen are measured at each inflow and outflow site. Appropriate quality assurance measures including blanks, spikes and duplicate sampling are included in all monitoring performed.

Annual sediment deposition is measured using sediment traps or cross-section surveys to estimate the amount of sediment deposited within the wetlands. Phosphorus associated with this deposited sediment can be estimated by phosphorus fraction techniques.

Soil and Sediment Analyses

Studies of Cascade Reservoir have identified sediment bound phosphorus as an important source of this limiting nutrient (EPA, 1977; Zimmer, 1983; Entranco, 1991; Chapra, 1990). Efforts to measure and quantify phosphorus sources and distribution of sediments have been conducted (Worth, 1993) to enhance accuracy and utility of a simulation model previously developed for Cascade Reservoir (Chapra, 1990; Worth, 1997). Ongoing studies will provide a direct measure of the quantity and form of phosphorus available in the sediments of Cascade Reservoir.

Watershed Soil Monitoring. Soil erosion estimates were initially made by the U.S. Soil Conservation Service based on a field survey in 1988. This survey focused on some of the larger tributary rivers to Cascade Reservoir. Additional data on rates of erosion have since been collected by USFS studies for Gold Fork, West Mountain and southern North Fork Payette River subwatersheds since this initial survey. Potential phosphorus loads associated with these sediments were quantified to the extent possible.

Further studies have been undertaken by DEQ (Worth, 1993) to analyze the phosphorus content of surface soils representing the major soils series (Rasmussen, 1981). Major soil series of interest include Archabal, Gestrin, Roseberry, Donnel and Melton. Submerged soils, soils collected from stream cross sections, and reservoir sediment samples were collected for comparison of their phosphorus content with surrounding soils in the watershed.

Watershed soil phosphorus content was evaluated by both USFS and DEQ monitoring personnel. Soil-type to soil-type phosphorus content was not found to be statistically different, as the sample to sample variability was high. The only significant differences identifiable for soil phosphorus content within the watershed was between the A and C horizons sampled. The A horizon soils showed significantly higher concentrations of both bioavailable and total phosphorus (4.9 and 617 mg/kg of soil, respectively), than the C horizon soils (2.5 and 417 mg/kg of soil, respectively). Stream bottom sediments showed phosphorus levels that were 50% (average) lower than the C horizon soils, indicating that fine particles with high levels of adsorbed phosphorus are preferentially transported in stream flow once sediment enters the channel. Stream bottom sediments from the western side of the reservoir showed significantly higher levels of both bioavailable and total phosphorus than those collected on the eastern side of the watershed (Gold Fork River). It can be observed from these studies that total phosphorus levels are commonly orders of magnitude higher than the related bioavailable phosphorus levels, with bioavailable phosphorus accounting for between 1.0 and 0.1% of the total phosphorus associated with the sediment.

In-reservoir Sediment Monitoring. To determine levels and distribution (both spatial and depth) of phosphorus within reservoir bed-sediments, sediment samples were collected from over 40 sites within the reservoir. Samples were collected in 10 cm depth-increments that ranged from the surface (0-10 cm) to 40-50 cm (total sediment depth). Available data show that phosphorus concentrations decrease with increasing depth. The greatest phosphorus concentrations are distributed within the top 10 cm of the reservoir bed sediments. Both the total phosphorus and the bioavailable phosphorus data echo this trend, indicating that deeply buried sediments do not represent a significant source of total or bioavailable phosphorus for the overlying water column. The most logical explanation for this trend is that the available or loosely-bound ortho-phosphate within the older (deeper) sediments has already leached to the water column, leaving the lower sediment layers somewhat depleted of available ortho-phosphate relative to sediments that were deposited more recently. Sediment phosphorus distribution was observed to be relatively static across the reservoir.

Local soil characteristics and erosion of surface materials can have a significant impact on the phosphorus loading rates of a watershed. Sediment bound phosphorus may contribute more than 60% of the estimated phosphorus load to Cascade Reservoir. Efforts to reduce phosphorus should be targeted only to those areas where phosphorus loads exceed the natural levels contributed by soils.

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Appendix F

Best Management Practices and Current Implementation Measures for the Cascade Reservoir Watershed

Appendix F. Best Management Practices and Current Implementation Measures for the Cascade Reservoir Watershed

BMPs are measures or a combination of measures that have been determined to be the most effective and practical means of preventing or reducing contamination to ground water and/or surface water pollution from point and nonpoint sources. The objective in implementing BMPs is to achieve water-quality goals and protect the beneficial uses of the water body.

Implementation of BMPs and other pollution control measures is the most significant step in the achievement of water-quality objectives within the reservoir and the support of beneficial uses. The phased TMDL process for Cascade Reservoir is unique in that implementation of pollutant control projects was initiated concurrently with the assessment of annual load and the drafting of the watershed management plan. In this respect, steps toward the solution of water-quality problems were taken before a firm, quantitative definition of the reductions necessary were in place. While this may have resulted in some inefficiency initially, it has doubtless reduced the overall time frame required for attainment of water-quality objectives within the watershed.

Local participants in water-quality management projects have shown extraordinary commitment to improving conditions within the reservoir and watershed. Many major, and countless smaller projects have been completed to date. Many others are currently in progress or pending. It is hoped that the current pace of implementation will be accelerated or (at minimum) maintained with the development of the formal implementation plan. This plan is currently scheduled for completion within 18 months of the approval of the Cascade Reservoir Phase II Watershed Management Plan.

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

The identification of nutrient reduction projects is a critical step in the implementation process, one dependant upon local input and experience in order to operate efficiently. Projects to date have been identified by a number of organizations and individuals representing a variety of land-use activities. Specific projects involve the following practices:

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

When projects are identified they are referred to the appropriate agencies for possible funding.

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

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

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

The following sections on recommended BMPs and implementation measures to date are divided into the identified nonpoint source categories of forestry, agricultural, and urban/suburban land use. While intended to represent currently recommended and utilized BMPs, these lists should not be interpreted as exhaustive or all-inclusive. Knowledgeable and reasonable efforts to achieve water-quality objectives should be employed by all pollutant sources. Existing BMP options and practices should be updated as new information, practices and technology become available.

Appendix F-1 (Forestry)

Recommended Forestry BMPs

1. **Logging Roads**
   - Standards and Use
   - Planning, Design and Location
   - Construction and Drainage
   - Maintenance and Closure

2. **Streamside Management**
   - Streamside Protection Zone (SPZ) Boundaries
   - Harvesting within SPZs
   - Conifer Regeneration
   - Idaho Stream Protection Rules

3. **Timber Harvesting**
   - Harvest System Design
   - Site Preparation Drainage
   - Reforestation Requirements
   - Winter Requirements

4. **Hazardous Substances Requirements**
   - Pesticides
   - Herbicides

5. **Stream Crossings**
   - Legal Requirements
   - Design
   - Installation

Appendix F-1(Forestry)

Forestry Implementation Measures In-Progress/Pending

Roads and Timber Harvest

The effectiveness of the approved BMPs in relation to ***phosphorus*** as a nonpoint source has not been well established through monitoring. Table 1 lists examples of sediment-reduction BMP's for roads.

Table 1 Examples of Sediment BMP Effectiveness for Roads

Area Treated Treatment	Percent Sediment Reduction	Treatment Cost	Cost Effectiveness (tons/$1000.00)	Reference
Road Cut/Fill Slopes				
Hydro mulch Road cut/fill slope	30%	$850/ac	2.10	Burroughs & King (1989)
Slash filter & windrow Hydro mulch Road cut slope	84%	$1,350/ac	4.00	Burroughs & King (1989)
Slash Filter windrow Hydro mulch Road fill slopes	97%	$5,176/ac	1.16	Burroughs & King (1989) Cook & King (1983)
Timbered grid structure	90%	$18,000/ac	0.62	Unpublished Report - Cascade/Krassel RD
Road Surface/Prism				
Dust Abatement - oil	85%	$.50/linear ft	n/a	Burroughs & King (1989)
4 inch Gravel	92%	$7.58/linear ft	n/a	Foltz & Truebe (1994)
Asphalt Paving	97%	$23.50/linear ft	n/a	Burroughs & King (1989)
Armor Ditch Line	92%	$4.96/linear ft	n/a	Burroughs & King (1989)
Road Closure				
Road closure	75%	$2.00/linear ft	n/a	Harvey & Burton (1991)
Road Decommission	n/a	$1.07/linear ft	n/a	Harr & Nichols (1993)

Road improvements on USFS land can be accomplished in three ways: associated with timber harvest, general road maintenance, or outside funding such at a 319 Grant. Future timber sale plans have the opportunity to focus on treatment of existing road sediment sources and follow BMPs during new construction. General road maintenance funding is limited and declining within the USFS lands, but each Forest can prioritize road maintenance activities on an annual basis. Boise Cascade Corporation regularly maintains forest roads and has made a commitment to actively improve road systems.

(County road management is discussed in the Urban/suburban section of this appendix, Section F-3.)

Grazing on Forested Lands
Best management practices (BMPs) for grazing are the same practices used by the Agricultural Source Plan. Tier 1 lands (riparian areas adjacent to streams) and Tier 3 lands (uplands not irrigated) are the two categories that occur on forested lands. Some BMPs that could be used to reduce phosphorus input include, but are not limited to:

- Grazing management plans
- Off-site water developments
- Decreased riparian area use to reduce bank erosion
- Decreased access to stream channel

Schedule
Forest landowners in the Cascade Reservoir watershed have been implementing sediment reduction activities since 1994. A schedule of recent and on-going activities is summarized in Table 2 below. In the 1997 fiscal year, the Forestry Sub-Committee of the TAC received a Section 319 Grant from EPA/DEQ for $100,000 for further implementation of sediment/phosphorus reduction projects. These projects were implemented and monitored beginning in the Spring of 1997 in the Gold Fork River subwatershed.

Table 2 Implementation Schedule for Forestry Source Plan

Description	Location	Date	Funding Source (See Constraints)
Verify modeled road segments Complete BCC grazing plan	Gold Fork	1997	319 Grant (1997) or by ownership
Construction & implementation	Gold Fork	1997	319 Grant (1997) or by ownership
Verify modeled road segments and other sources	All other watersheds	1998	319 Grant (1998-99) or by ownership
Construction & implementation	All other subwatersheds	1998-2005	319 Grant (1998-99) or by ownership
Check on progress & schedule	All subwatersheds	2000-2005	All Managers
Monitoring	Gold Fork All Other All Subwatersheds	1997 1998-99 1997-2005	319 Grant (1997) 319 Grant (1998-99) or by ownership

Higher priority will be given to areas that have the greatest potential for reduction in sediment. An additional benefit of the projects will be improvement of bull trout habitat in the headwaters of the Gold Fork River and improvement of other fish habitat in all tributary waters. Maintenance and road improvement projects will be the responsibility of individual land owners.

Revision of the Boise National Forest, Cascade Reservoir Allotment occurred in 1993/1994. The allotment is located along the toe-slope of West Mountain on the west side of the reservoir. The Allotment Management Plan was revised into a rest-rotation system with other BMPs. Revision of the Boise Cascade Corporation, Gold Fork grazing permit has been completed and implemented in 1998. The revision includes a modification of the grazing plan.

Implementation Constraints by Ownership

All land owners place a high priority on implementation of projects that treat sources of sediment/phosphorus within the Cascade Reservoir watershed. Each ownership will place a high priority on treatment of identified sources as funding becomes available but the following constraints are realistic parameters that must be considered during the implementation phase.

Boise Cascade Corporation. Improvements on Boise Cascade land are not subject to any approval process. Implementation, however, is subject to availability of funds. Boise Cascade annually budgets funds for road improvements and improvements in Cascade Reservoir will be given high priority. Maintenance of other Boise Cascade roads will, however, be necessary and can affect the amount of effort expended in the Cascade Reservoir watershed. In particular, major storm events that take out many roads may necessitate giving maintenance and repair of storm-impacted roads precedence over refinements in the Cascade Reservoir road system. Although such activities may not benefit Cascade Reservoir, the activities will be necessary to provide access to company lands and to reduce sediment effects on aquatic resources in other basins.

Idaho Department of Lands. Funds for implementation come from two (2) sources both of which are tied to the harvest of forest products:

- Major improvements (i.e. bridges, graveling, surfacing, etc.) are appraised directly against the value of the timber harvested.
- Minor improvements and routine maintenance are funded through a deferred maintenance account which accumulates at a rate of 1% of the net value of all timber harvested.

Maintenance projects are prioritized on an annual basis and accomplished as funds are available. Since the Department has maintenance responsibilities outside the Cascade Reservoir watershed in any given year, all or none of the available funds may be exhausted elsewhere.

U.S. Forest Service - Boise and Payette National Forests. The Forest Service will continue to follow Land and Resource Management Plans to implement activities. Those activities include: timber harvest, road management, grazing, prescribed fire, watershed improvements, fish habitat improvements and others. The identification of sources of sediment/phosphorus, treatments and implementation of treatments will occur concurrently with activities. Activity plans are finalized and implemented as funds become available. Required NEPA and Endangered Species Act analyses will be necessary before implementation is possible. Scheduling of project implementation is determined by funding and priority on each Forest. Partnership and cooperative efforts will be developed on a project-by-project basis.

Appendix F-2 (Agriculture)

Recommended Agricultural BMPs

TIER 1 - RIPARIAN/WETLAND SYSTEMS

1. **Planned Grazing Systems - High Potential**
   - Deferred Grazing
   - Pasture and Hayland Management
   - Trough or Tank
   - Proper Woodland Grazing
   - Spring Development
   - Fencing
   - Proper Grazing Use, Riparian

2. **Planned Grazing Systems - Low Potential**
   - Deferred Grazing
   - Fencing
   - Heavy Use Area Protection
   - Proper Grazing Use, Riparian
   - Spring Development
   - Pasture and Hayland Management
   - Trough or Tank
   - Proper Woodland Grazing
   - Nutrient Management
   - Pest Management

3. **Non-Grazing Systems - High Potential**
   - Fencing
   - Livestock Exclusion
   - Spring Development
   - Trough or Tank

4. **Non-Grazing - Low Potential**
   - Fencing
   - Livestock Exclusion
   - Spring Development
   - Trough or Tank

5. **Structural Systems**
   - Grade Stabilization Structures
   - Streambank and Shoreline Protection
   - Stream Channel Stabilization
   - Structures for Water Control
   - Channel Vegetation

6. **Vegetation Systems**
   - Streambank and Shoreline Protection
   - Stream Channel Stabilization
   - Channel Vegetation
   - Filter Strip
   - Ephemeral Watercourse Planting

7. **Wetland Development Restoration**
   - Wetland Development Restoration Pond
   - Structure for Water Control
   - Channel Vegetation
   - Filter Strip
   - Sediment Basin

8. **Waste Management and Handling**
   - Waste Management Systems
   - Waste Utilization

TIER 2 - LOWLAND: MOSTLY IRRIGATED CROP AND PASTURE LAND

1. **Grazing Systems**
   - Irrigation Water Management
   - Nutrient Management
   - Pest Management
   - Deferred Grazing
   - Fencing
   - Livestock Exclusion
   - Pasture and Hayland Planting
   - Pasture and Hayland Management
   - Planned Grazing Systems
   - Proper Grazing Use
   - Proper Woodland Grazing
   - Pond
   - Trough or Tank

2. **Cropland Systems**
   - Chiseling and Subsoiling
   - Conservation Cropping Sequence
   - Conservation Tillage
   - Critical Area Planting
   - Filter Strip
   - Irrigation Water Management
   - Nutrient Management
   - Pest Management
   - Irrigation Systems

3. **Non-Grazing Systems**
   - Fencing
   - Livestock Exclusion
   - Grade Stabilization Structures

4. **Irrigation Structures and Water Systems**
   - Diversion
   - Irrigation Pit/Regulating Reservoir
   - Irrigation Storage Reservoir
   - Irrigation Systems
   - Irrigation Water Conveyance
   - Pipeline

5. **Water Structure Systems**
   - Pond
   - Pipeline
   - Spring Development
   - Fencing
   - Trough or Tank

6. **Wetland Development Restoration**
   - Wetland Development Restoration Pond
   - Structure for Water Control
   - Channel Vegetation
   - Filter Strip
   - Sediment Basin

7. **Waste Management and Handling**
   - Waste Management Systems
   - Waste Storage Pond or Structure
   - Waste Utilization

TIER 3 - UPLAND GRAZING LAND: MOSTLY NON-IRRIGATED

1. **Planned Grazing Systems**
   - Pasture and Hayland Management
   - Pasture and Hayland Planting
   - Planned Grazing Systems
   - Proper Grazing Use
   - Proper Woodland Grazing
   - Nutrient Management
   - Pest Management
   - Fencing
   - Pond
   - Trough or Tank
   - Stock Trails and Walkways
   - Livestock Exclusion

2. **Cropland Systems**
   - Chiseling and Subsoiling
   - Conservation Cropping
   - Conservation Tillage
   - Critical Area Planting
   - Filter Strip
   - Irrigation Water Management
   - Nutrient Management
   - Pest Management
   - Irrigation Systems

3. **Non-Grazing Systems**
   - Grade Stabilization Structures
   - Brush Management
   - Range Seeding
   - Pasture and Hayland Planting
   - Nutrient Management
   - Pest Management

4. **Water Structures Systems**
   - Pipeline
   - Pond
   - Spring Development
   - Stock Trails and Walkways
   - Trough or Tank
   - Fencing

5. **Waste Management and Handling**
   - Waste Management Systems
   - Waste Storage Pond or Structure
   - Waste Utilization

RANCHETTE ACREAGES

1. **Planned Grazing Systems**
   - Pasture and Hayland Management
   - Pasture and Hayland Planting
   - Planned Grazing Systems
   - Proper Grazing Use
   - Proper Woodland Grazing
   - Nutrient Management
   - Pest Management
   - Fencing
   - Pond
   - Trough or Tank
   - Stock Trails and Walkways
   - Livestock Exclusion

2. **Non-Grazing Systems**
   - Grade Stabilization Structures
   - Brush Management
   - Pasture and Hayland Planting
   - Nutrient Management
   - Pest Management
   - Fencing
   - Livestock Exclusion

3. **Cropland Systems**
   - Chiseling and Subsoiling
   - Critical Area Planting
   - Filter Strip
   - Irrigation Water Management
   - Nutrient Management
   - Pest Management
   - Irrigation Systems

4. **Irrigation Structures and Water Systems**
   - Diversion
   - Irrigation Pit/Regulating Reservoir
   - Irrigation Storage Reservoir
   - Irrigation Systems
   - Irrigation Water Conveyance
   - Pipeline

5. **Water Structure Systems**
   - Pond
   - Pipeline
   - Spring Development
   - Fencing
   - Trough or Tank

6. **Wetland Development Restoration**
   - Wetland Development Restoration Pond
   - Structure for Water Control
   - Channel Vegetation
   - Filter Strip
   - Sediment Basin

7. **Waste Management and Handling**
   - Waste Management Systems
   - Waste Storage Pond or Structure
   - Waste Utilization

Appendix F-2 (Agriculture)

Agricultural Implementation Measures In-Progress/Pending

For agricultural activities there are no required BMPs. Consequently, agricultural activities must use knowledgeable and reasonable efforts to achieve water-quality objectives. Generally, voluntary implementation of BMPs would be considered a knowledgeable and reasonable effort. A list of recommended BMP component practices, which when selected for a specific site become a BMP, has been published in the Idaho Agricultural Pollution Abatement Plan (1991). To facilitate use of these practices, the state formerly provided cost share incentives through the State Agricultural Water Quality Program (SAWQP). SAWQP projects were directed at improving water quality through control of nonpoint source pollution at the subwatershed level using BMPs developed by the NRCS. Cost share funds were dispersed to private landowners through local Soil Conservation Districts. Contracts with landowners required that BMPs be implemented for 10 years, but changes in management practices should provide longer term benefits.

Although SAWQP funding is no longer available, the VSWCD previously developed and implemented SAWQP projects in three of the critical drainages of Cascade Reservoir: Boulder Creek, Willow Creek, and Mud Creek, which comprise roughly 18% of the total watershed draining to Cascade Reservoir. An implementation plan was developed for each drainage, outlining the critical acres contributing nutrients and sediment to local streams based on the erosion potential of soils (VSWCD, 1991). Priority was given to implementation of BMPs that reduce phosphorus. A summary of the projects planned or implemented as of May 1998 follows. Table 3 summarizes BMPs selected within each drainage area.

The Boulder Creek SAWQP project was initiated in 1991, and established a goal of reducing phosphorous loading from agricultural sources by 50%. This was to be accomplished by treating 6,826 critical acres with BMPs. Critical acres in a state agricultural water-quality project are defined as those areas where BMPs should be implemented to improve water quality. Implementation of agricultural BMPs is voluntary and generally requires a cost share match by the local landowner. In the recent past it has taken several years to negotiate, design, approve and fully implement BMPs. Cooperative agreements with DEQ provide evaluation of BMP effectiveness.

The Willow Creek and Mud Creek SAWQP were initiated in 1995 and were established with the goal of reducing phosphorus loading from agricultural sources by 50%. This involved treating 8,526 critical acres in Mud Creek and 1,411 critical acres in Willow Creek. Additional projects are needed to address agricultural practices in the Lake Fork Creek, Gold Fork River, North Fork Payette River and Cascade subwatersheds.

With the cancellation of the SAWQP project, alternative funding sources are being pursued. Potential funding sources may be tied to creation or protection of riparian areas or wildlife habitat, irrigation improvements for greater conservation of available water supplies, and others.

Table 3 VSWCD Agricultural BMPs Planned or Implemented as of October 1995

BMPs	Units Planned or Implemented		
	Boulder Creek	Mud Creek	Willow Creek
Chiseling, subsoiling (ac)	155	574	
Critical Area Planting (ac)	7		
Channel Vegetation (lf)			500
Conservation Cover (ac)	28		
Conservation Tillage (ac)		499	
Conservation Cropping Sequence (ac)		539	10
Deferred Grazing (ac)	45		
Fencing (lf)	17,300	6,900	9,200
Fertilizer Application (ac)	250	1,062	
Heavy Use Area Protection (ea)	3	4	2
Irrigation System Sprinklers (ac)	278	3676	341
Irrigation Water Conveyance (lf)	20,250	142,727	12,500
Irrigation Water Management (ac)	135	4,271	260
Liming (ac)	176	1,566	
Livestock Exclusion (ac)	235	4	24
Nutrient Management (ac)	425	1,566	
Soil Tests (ea)	16	46	
Spring or Water Development (ea)	3	39	
Pasture and Hayland Management (ac)	498	5,057	106
Pasture and Hayland Planting (ac)	205	1,722	
Planned Grazing Systems (ac)	169	288	
Proper Grazing Use (ac)	46		511
Ponds (ea)	4	1	
Water Control Structures (ea)	5	2	1
Woodland Improvement No Cost Share (ac)	43		
Wildlife Wetland Habitat Management No Cost Share (ac)	7		

Appendix F-3 (Urban/Suburban)

Recommended Urban/Suburban BMPs

Urban/suburban land-use sources fall into three separate categories: stormwater runoff, septic/sewer sources and recreational activities.

Upgrading failing septic systems to meet required codes, or replacement of existing septic systems with sewer hookups are recommended practices for reduction of pollutant loads. Once replaced with sewer hookups, septic tanks should be pumped out and collapsed.

BMPs for both urban and recreational facility stormwater runoff are outlined in the following documents:

1) Technical Memorandum: *Stormwater Retrofit Options for Valley County* (1996)

2) Technical Memorandum: *Procedures and Recommendations for Subwatershed Prioritization of Stormwater BMPs* (1997)

3) *Handbook of Valley County Stormwater Best Management Practices* (1997)

For convenience, a short summary of each document follows.

Stormwater Retrofit Options for Valley County provides a list of applicable BMPs, prioritized retrofit projects, and other recommendations for improving both water quantity and water quality on a subwatershed basis. The scope of the project also includes ways of addressing existing practices and natural features, as well as anticipated future preventative measures. The identified options are based on a two-day field survey conducted in the spring of 1996 throughout the County. The retrofit options and recommendations were subdivided into five main categories: urbanized areas, agricultural areas, residences in surrounding hills, property located at waterside, and transportation corridors.

Procedures and Recommendations for Subwatershed Prioritization of Stormwater BMPs describes a process for prioritizing stormwater BMPs by subwatershed based on the prevailing and site suitable physical conditions. The document is considered a planning tool for assisting in the selection of the most cost effective BMPs by subwatershed. The prioritization procedure ranked BMPs on overall subwatershed characteristics. Final BMP selection is however, more dependent upon site-specific conditions. The technical memorandum concluded that most BMPs are applicable in various portions of all subwatersheds.

Handbook of Valley County Stormwater Best Management Practices is recognized as the technical reference for developers, contractors, design professionals, local agency officials and staff responsible for design, construction, maintenance or the review and approval of stormwater treatment facilities/devices. The BMPs that are contained in the Handbook are those considered appropriate for the physical and climatic conditions of Valley County. Also, the Handbook is a necessary companion for the two previously described technical memorandums.

The majority of BMPs contained in Chapter 4 of the Handbook pertain to controlling pollution at the source; Chapter 5 of the Handbook contains residential and commercial development source treatment measures (summarized in Tables 4 and 5). Source control measures focus on minimizing or eliminating the source of pollution so that pollutants are prevented from contacting runoff or entering the drainage system. Permanent or treatment control measures are designed to remove pollutants after being taken up by runoff.

Treatment controls tend to be more expensive than source controls. Time is the major cost factor associated with minimizing disturbance, preserving vegetation, and other site management measures. However, the cost factor associated with additional time for minimizing or preserving must be considered within context of reduced needs for costly treatment mitigation and operation and maintenance expenditures. For example, the sediment removal effectiveness of preserving native vegetation (BMP #3) and hence keeping phosphorus in place is 100 %.

Storm water management plans for new development should encourage sustaining pre-development runoff volumes through the use of source control BMPs. A local storm water management plan should focus not only on water quantity, but also *water quality*. Storm water management plans vary and include design strategies to protect sensitive open space areas, minimizing site disturbances, and using the land's natural treatment functions.

Existing site topography and vegetation can often be effective in naturally treating and disposing of volume and quality of stormwater runoff, when left undisturbed or intact as much as possible. Typically, non-disturbed dips and depressions within a site are able to collect and store water, coupled with the site's existing vegetation, that provides a filter function for both pollutants and sediment. This natural drainage system works jointly to also regulate water quantity. When a site's hydrology is altered by the loss or the compaction of topsoil; impervious coverage by paving, asphalting, or concreting; post-development drainage, if not controlled through either *source* or *treatment control BMPs,* causes increased runoff. It may not necessarily be the individual development site, but rather, the cumulative effect of numerous site developments that causes a greater volume, and hence, an impact to nearby and local water bodies.

Table 4 Permanent Controls, considerations and comparative cost and applicability taken from the Handbook for Valley County Stormwater BMPs (1997).

BEST MANAGEMENT PRACTICES		CONSIDERATIONS				COMPARATIVE COST & APPLICABILITY*			
No.	Name	Phosphorus Removal (>35% effective)	Sediment Removal (>70% effective)	Area Required	Water Availability	Relative Capital Cost per Acre Served	Relative O&M Cost* Routine	Relative O&M Cost* Non-Routine	Primary Treatment Mechanism(s)
38	Vegetated Swale		X	X	X	low	low	mod	Sedimentation/ filtration
39	Vegetative Filter Strip		X	X	X	low	low	mod	Sedimentation/ filtration
40	Sand Filter	X	X			moderate	mod	mod	Sedimentation/ filtration
43	Infiltration Trench	X	X			low to mod	mod	high	Infiltration
44	Infiltration Basin	X	X	X		low to mod	low	mod	Infiltration
45	Wet Pond	X	X			moderate	low	mod	Sedimentation/ biological uptake
47	Wet Extended Detention Pond	X	X		X	moderate	low	mod	Sedimentation
48	Dry Extended Detention Pond			X		moderate	low	mod	Sedimentation/ biological uptake
49	Constructed Wetland	X		X	X	mod to high	high	high	Sedimentation/ filtration
52	Oil/Water Separator					high	low	high	Sedimentation/ infiltration

* Based on the Boise City Public Works Department: Stormwater BMPs Guidance, 1997.

Table 5 Construction/temporary controls, considerations, and comparative cost and applicability taken from the Handbook (1997).

BEST MANAGEMENT PRACTICES		CONSIDERATIONS				COMPARATIVE COST & APPLICABILITY*			
No.	Name	Phosphorus Removal (>35% effective)	Sediment Removal (>70% effective)	Slope Protection	Sediment Collection/ Runoff Diversion	Relative Capital Cost per Acre Served	Relative O&M Cost*		Expected Life based on Longevity Data from Handbook
							Routine	Non-Routine	
3	Preserving Existing Vegetation	X	X	X	X	low	low	low	Becomes Permanent
11	Mulching	X	X	X		moderate	mod	mod	6-8 Months
13/14	Geotextiles & Mats		X	X		high	mod	mod	6-8 Months
22	Check Dams		X			moderate	low	mod	½ -1 Year
24	Straw Bale Barrier		X		X	low	high	high	3 Months
25	Silt Fence		X		X	moderate	mod	mod	2-6 Months
26	Vegetative Buffer Strip		X		X	low	low	low	50 Years
27	Sediment Trap		X		X	low	mod	low	6-18 Months
30	Earth Dike		X		X	moderate	low	mod	2-25 Years
31	Perimeter Dike/Swale		X		X	moderate	low	low	18 Months

*Based on Boise City Public Works Department: Stormwater BMPs Guidance, 1997

Appendix F-3 (Urban/Suburban)

Urban/Suburban Implementation Measures In-Progress/Pending

Stormwater runoff management

Existing conditions suggest that urban land contributes a disproportionate load of phosphorus from a relatively small area of the landscape. Future development without planning and control measures in place will only increase pollutant loading. BMP devices, facilities and systems that are constructed should be selected based on suitable site conditions and targeted pollutant removal effectiveness. More significantly, BMP retrofit projects (summarized in Table 6) should be targeted for urban land and transportation components throughout the Willow Creek, Mud Creek, Cascade, and North Fork of the Payette River subwatersheds. In minimizing impacts to storm water runoff and protecting against further reservoir eutrophication, the selected BMPs should maximize the removal of nutrients from runoff and/or trapping of sediment in-place.

In an effort to address stormwater runoff issues on a watershed scale, the *Handbook of Valley County Stormwater BMPs* (1997) was prepared and has been adopted as a technical reference by resolution by Valley County, and by ordinance by the City of McCall. Applicable ordinances have either been updated or revised to encourage the use of the Handbook for storm water treatment control. Public education has increased substantially in the last two years with the publication of several information brochures (e.g., *User Guide to Reservoir Protection, Site Planning and New Construction Considerations for Water Quality*). Technical education for contractors: "Valley County Storm Water Pollution Prevention Training" has also occurred. The following items are recommended by the Urban/Suburban Sub-committee:

1. Estimate the cost-benefit ratio of potential retrofit options from the "Stormwater Retrofit Options for Valley County"; base prioritization on retrofitting McCall drainage basins 9, 11 and 13, and the cities Cascade and Donnelly. McCall drainage basins 9, 11 and 13, and the cities Cascade and Donnelly, are the greatest potential contributors of total phosphorus and suspended solids based on the current land uses. The greatest cost-benefit can be expected in the Willow Creek, Mud Creek, Cascade, and North Fork of the Payette River subwatersheds.

2. Encourage continued water-quality monitoring to document trends toward meeting water-quality standards. Revise the monitoring strategy and plan to better characterize nonpoint source loading contributed from McCall drainage basins 9, 11 and 13, and the cities Cascade and Donnelly. Future decisions to retrofit BMPs in drainage basins or catchments, believed to be contributing a greater amount of pollutant loading, can be more readily justified with water-quality data.

3. Improve county roads that are immediately adjacent or within the floodplain of Cascade Reservoir or any of its tributaries. Improvements on county roads should be based on a prioritized inventory of all public and private roads and highways. A comprehensive inventory was completed by the Valley County Engineer (1997). Many locations with erosion, predominantly those associated with unimproved roads, were observed during the inventory. Reducing sediment derived from nearby

Table 6 Potential Retrofit BMPs By Watershed

Category/Potential BMPs	Payette Lake	Lake Fork	N. Fork Payette	Mud Creek	Boulder Creek	Gold Fork	Willow Creek	West Side	Cascade
Urbanized Areas									
Stormwater Inlets	X				X			X	X
Wetlands/Swales									X
Ditch Maintenance	X				X			X	X
Construction Erosion Control	X	X	X	X	X	X	X	X	X
Addition Erosion Control	X	X				X			
Raised Roadways	X	X	X	X	X				
Clearing Limits	X	X	X	X	X	X	X	X	X
Wet Ponds	X	X			X	X			
Modify Culverts					X				
Bacterial Control	X								
Agricultural Areas									
Traditional Erosion Control				X	X	X	X		
Fencing			X	X	X		X	X	X
Revegetate				X	X		X		
Filter Strips				X	X	X	X		
Wet Ponds			X	X	X		X		
Ditch Maintenance					X	X	X		X

Table 6 Potential Retrofit BMPs By Watershed (continued).

Category/Potential BMPs	Payette Lake	Lake Fork	N. Fork Payette	Mud Creek	Boulder Creek	Gold Fork	Willow Creek	West Side	Cascade
Streambank Erosion			X	X	X		X		
Surrounding Hills									
Road Stabilization	X	X			X	X			
Slope Protection	X	X			X	X			
Topsoil Addition	X	X			X	X			
Detention Pond	X	X			X	X			
Waterside Property									
Filter Strips	X	X	X	X	X	X	X	X	X
Wetlands	X						X	X	X
Biofiltration Swales			X	X	X		X		
Road Stabilization	X							X	
Berms	X							X	X
Transportation Corridors									
Old State Highway							X		
Street Sweeping	X			X	X		X	X	X
Bridge Maintenance			X	X	X				

roadways would ultimately decrease the amount of sediment loading to the reservoir.

4. Encourage the sewering of the South Lake Recreation and Sewer District or the West Mountain subdivisions. Many of the developed parcels and, hence, their respective septic tank systems in the West Mountain subwatershed are pre-1985 and are out of compliance. Reduced septic tank effluent from pre-1985 septic systems would decrease waste loading to Cascade Reservoir.

5. Support the City of Donnelly facilities plan for the wet-extended detention basin project IF properly designed for a water-quality design storm. Donnelly has the potential to contribute to further surface water-quality impacts to Cascade Reservoir due to its close proximity. A large-scale detention basin would benefit the watershed since it would detain storm water runoff from the city, as well as from the agricultural runoff from adjacent and up-gradient fields.

Preventing Future Impacts

The Handbook should serve as a means of implementing consistent, county-wide site design treatment considerations. As public awareness increases, a broader public acceptance should follow. Rising public awareness can only occur through additional technical education for contractors, developers and land owners. The cities should be proactive and encourage more comprehensive strategies for storm water planning and management. The strategy for preventing future impacts consist of three components. The following items are recommended by the Urban/Suburban Sub-committee:

1. Encourage municipalities throughout Valley County to implement development design strategies that are source-control oriented (i.e., on-site detention program, minimizing directly connected impervious areas, site fingerprinting, local urban forestry, etc.). It is not the individual site development, but rather, the cumulative effect that generates runoff volume during a storm event. Through design, the natural and landscaped site drainage system can work effectively to soak, filter and temporarily pond precipitation. The site drainage system withdraws a small share of the potential cumulative whole, keeping it from running off-site. For example, local on-site detention programs require developers and land owners to manage storm water runoff on commercial, industrial, and often high-density residential sites. These local programs protect water quality through advocating and enforcing when necessary, the assurance that rates of post-development runoff from a given site do not exceed the rate of pre-development runoff.

2. Encourage the adoption of a county-wide erosion and sediment control ordinance that includes provisions for performance standards that allow for a combination removal of both total phosphorus and total suspended solids. Performance standards for removal effectiveness should at least exceed 30% total phosphorus and 70% total suspended solids. Suspended solids cause many problems for water quality in addition to increasing concentrations of total phosphorus in the water column. Also, total suspended solid is a much easier constituent to monitor and the improvement to water moving through a treatment measure will literally be visible to the public. Reduction of suspended solids in runoff will result in broader improvements in water quality because BMP selection will not only be driven by total phosphorus removal effectiveness.

3. Municipalities throughout Valley County should encourage the set aside and/or donation of sensitive lands that possess intact riparian vegetation, 'classified' wetlands, steep slopes, and areas of highly erodible soil types. The varying natural environment includes many areas of the landscape that are well suited for intensive urban development. There are however, other areas which have a low tolerance for this same type of intensive development. These "sensitive" parts of the landscape, when radically altered, lose their function as natural collection, filtering and storage systems. Kept intact, the natural landscape provides these several functions free of charge to society. If properly accounted for early in the design process, sensitive open space can be used as natural treatment areas for adequately dispersed runoff from impervious surfaces such as pavement, asphalt, concrete, compacted soils and rooftops.

Valley County Road and Drainage Management

The Valley County Road Department (the County) currently manages approximately 430 miles of public road. Two hundred, twenty-five (225) miles of road managed by the County are located within the Cascade Reservoir watershed.

Maintenance priorities are based on traffic volumes and safety. Priorities in descending order according to classification are: school bus routes; principle routes; and other roads. The County has been conducting traffic volume counts at 172 locations for more than seven years and are now conducting speed studies at selected locations. That data can provide the basis for setting maintenance priorities. The Road Department is developing a computerized road surface management system. That system will expand the parameters used to set future maintenance priorities to include roadway and roadside conditions and efficiency in investing maintenance dollars. All of the routes with a current average traffic volume in excess of 200 vehicles per day are paved. That includes all the major and minor connectors and other principle routes. Only 30% of the publicly maintained roads are paved.

The County has developed a strategy for improving roads surfaced with aggregates and native materials. Gradient and terrain are parameters used in addition to traffic volume and safety for setting priorities to upgrade those roads. Crushed rock materials 3-4 inches deep are added where road gradients exceed 5% or where the road is locating in rolling terrain with cut banks and fill slopes along the road. The scope of this annual work is limited to availability of personnel, equipment, materials and finances.

The Road Department also maintains the drainage system along public roads. Their policy is to keep the water off the road surface, prevent it from traveling along the side of the road, and to allow surface waters to follow natural swales without diversion. The maintenance of the drainage system is limited to the jurisdictional limits of the right of way.

Keeping the road surfaces in good condition with frequent blading, limiting or eliminating snow removal on certain roads, limited use of sanding materials, and limited use of dust abatement products rounds out the picture of current maintenance practices.

Improving road surfaces with asphalt or crushed rock contributes to the goals of phosphorus removal. The Department's primary concern must remain on traffic and safety. Forty percent (40%) of the Department's system is outside of the Cascade Reservoir watershed. Those roads compete equally for the available maintenance funds. There are no funds available for improving low priority roads with projects aimed solely at phosphorus reduction. Valley County has submitted a proposal for 1999 319 Grant funding to surface and improves roads in the immediate vicinity of Cascade Reservoir. Roads that will be improved if funded are those identified as contributors of significant phosphorus through sediment transport during snow-melt and storm events.

The Valley County Road Department is supported by the Highway User Fund and proceeds from the U.S. Forest Service. The USFS proceeds have been the primary source of funds but they are declining. Road maintenance will likely also decline unless supplementary financial resources are developed.

Valley County has been involved in the development of the _Handbook of Valley County Stormwater Best Management Practices_ (1997) with the Urban/Suburban Work Group. This Handbook has not yet been accepted by the County as an ordinance to address the TMDL for new building and road developments. This Handbook is available for use. The hope is that the TMDL issue will be addressed in the County Comprehensive Plan and in the future through ordinances.

Septic/sewer Upgrades

A number of septic and sewer improvement projects have been undertaken within the watershed. The North Lake Recreational Sewer and Water District was formed and is currently providing sewer service to over 500 subdivision residences aggregated around the north end of the reservoir, identified as a significant source of concern in Phase I. By mid-1998, additional residences are expected to be connected to sewer and disconnected from their septic tanks. The North Lake Sewer District connections expect to contribute a 38% *reduction* from the revised Phase I estimate. Table 7 shows the predicted loading reductions given the proposed septic-to-sewer conversions scheduled for 1998.

A second sewer district has been proposed for the southwest shore and is currently seeking sources of funding to establish service. The southwest location has a high ground-water table, evidence of ground-water contamination, a high density of septic tanks and poor soil types.

The City of McCall has installed new and upgraded existing sand filters within existing treatment facilities. In addition, the J-Ditch project, currently in progress, represents a major step in the eventual, 100% removal of the McCall wastewater treatment plant effluent from the NFPR called for in the Phase I document. This project will allow treated effluent from the City of McCall to be mixed with "clean" water and applied at agronomic rates to pasture and crop land during the summer irrigation season. Additional effluent collected during non-irrigation season months will be retained in storage lagoons constructed by the City of McCall. Stored effluent will be land-applied the following irrigation season. Currently, the system as designed will be able to remove all treated effluent from the NFPR during the irrigation season. Work on the winter storage lagoons is on-going. Total (100%) removal of treated effluent from the NFPR will be possible with the completion

Table 7 Sewer Upgrade Total Phosphorus Load Reduction Estimate

	Name	# Septic Tanks	Summer Use Days	Average Use Days							Soil Retention Factor*	Estimated Load Based on Total P Output @ Coef. Value ++		
				Person Use	Pre-1995 # of Tanks	Seasonal Capita/yr	Winter Use Days	Person Use	Occupied # Units	Permanent Capita/yr		1.8 kg/yr High	0.9 kg/yr Med	0.3 kg/yr Low
1	NF Payette R	67	150	4	40	68	215	3	20	36	0.1	165	82	27
2	Mud Creek	11	150	4	7	11	215	3	3	6	0.1	27	14	5
3	Lake Fork Cr	53	150	4	32	52	215	3	16	28	0.1	130	65	22
4	Boulder Cr	53	150	4	32	52	215	3	16	28	0.1	130	65	22
5	Willow Cr	0	150	4	0	0	215	3	0	0	0.1	0	0	0
6	Gold Fork Cr	0	150	4	0	0	215	3	0	0	0.1	0	0	0
7	Cascade	317	150	4	190	313	215	3	95	168	0.1	779	389	130
8	West Mtn.	610	150	4	366	602	215	3	183	323	0.1	1499	749	250
	TOTALS	1111			667	1096			333	589		2729	1365	455

* Soil Retention Factor estimates the adsorption capacity of soils to trap P. Groundwater tables, age of septic systems and soil types affect the retention capacity. Retention values range from 0-1.0; 0=no retention and 1.0=100% retention of P.

++ Typical literature values for P inputs from septic tanks with no phosphate detergent restrictions (Uttomark et al., 1974).

kg/yr TP/single DU/person	@ Effluent Concentrations		
	20 mg/L	15 mg/L	8 mg/L
Septic Output Coefficients	1.0441	0.7831	0.4176

TOTALS		1.8 kg/yr High	0.9 kg/yr Med	0.3 kg/yr Low
	Winter	954	477	159
	Summer	1775	888	296
	%1994 TP	10.8	5.7	2.0
	%1993 TP	6.8	3.5	1.2
	%1989 TP	4.3	2.2	0.7

Soil type, average age of septic system and soil retention factor were considered in the above assessment.

of winter storage lagoons by the City of McCall.

The City of Donnelly has also upgraded their wastewater treatment system. Winter storage lagoons have been constructed and existing lagoons upgraded, aeration and disinfection of waste has been added, and the total area of land application has been increased to 135 acres.

Recreational Management Measures
A mobile pumpout facility has been installed on Cascade Reservoir. This station helps to reduce nutrient loading to the reservoir by providing a contained area for the disposal of wastes that were previously dumped directly into the water. The dump station has been in operation since 1996 and is currently located in the southern portion of the reservoir.

Significant stormwater runoff improvements have been completed at the Blue Heron Campground, and both the Snowbank and Cabarton day-use area facilities by the BOR. Improvements include the installation of staged stormwater runoff filtration systems for the removal/reduction of both sediment and petroleum products. Stormwater management improvements are currently under consideration for the City Ramp and Crown Point facilities.

References:

Brown and Caldwell; 1996 (October); *Stormwater Retrofit Options for Valley County, Technical Memorandum*; Brown and Caldwell Engineering; Boise, Idaho; 9 p + attachments.

Brown and Caldwell; 1997 (March); *Procedures and Recommendations for Subwatershed Prioritization of Stormwater Best Management Practices in Valley County, Technical Memorandum*; Brown and Caldwell Engineering; Boise, Idaho; 26 p + attachments.

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Costs associated with this publication are available
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DEQ: 250, 84254, 12/98
Cost per copy: $7.21. Printed on recycled paper.