Snake River - Hells Canyon

Total Maximum Daily Load (TMDL)

Submitted - July 2003
Revised - June 2004

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Acknowledgements

Thousands of hours have been expended in the preparation of this document by volunteers, state and federal agency personnel and many others. We gratefully acknowledge the time and effort that have been dedicated by so many individuals and organizations whose help and support have been indispensable. Their continuing support is very much appreciated, indeed, critical to the success of this project.

We would like to acknowledge the efforts of local citizens, county governments, local industries, municipalities, soil and water conservation districts (SWCDs), watershed councils, irrigation districts and companies, tribal entities (including the Nez Perce, Shoshone-Paiute), local Watershed Advisory Groups, Idaho Power Company, the states of Oregon and Idaho including Oregon Department of Fish and Wildlife (ODFW), Oregon Water Resources Department (OWRD), Oregon Department of Agricultural (ODA), Idaho Department of Fish and Game (IDFG), Idaho Department of Health and Welfare (IDHW), Idaho Department of Agriculture (IDA), various environmental entities including Idaho Rivers United, the Hells Canyon Preservation Council, Trout Unlimited, Oregon Trout, Friends of Brownlee, and others, and Federal entities including the US Environmental Protection Agency (US EPA), US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), US Bureau of Reclamation (USBR), US Forest Service (USFS), US Geological Survey (USGS), US Department of Agriculture (USDA), and numerous others.

The help we have received in collecting and evaluating data, and in developing and reviewing this TMDL has been invaluable! Local citizens, governments, municipalities and industries throughout the Snake River Basin have been instrumental in guiding the development of this TMDL.

On behalf of the IDEQ and ODEQ we wish to expressly acknowledge the Snake River – Hells Canyon Public Advisory Team, the InterAgency Project Team, and all the workgroups for the countless hours they have invested in this process. Over the past two years these dedicated individuals have spent an extraordinary amount of time discussing challenging issues, reviewing draft documents, and driving over long roads often in inclement weather to attend meetings. Their value of their guidance, insight, and experience cannot be measured. We would like to extend our heartfelt gratitude to all of these individuals and look forward to a continued opportunity to work together as this project progresses.

We would like to extend special thanks to the family of Dr. Lyle M. Stanford, especially his son Alan, for allowing us access to Dr. Stanford's books, notes, pictures and Ph.D. dissertation. Dr. Stanford's work provided us with a snapshot of the condition of the SR-HC TMDL reach between 1939 and 1942. His efforts were a resource for water quality data and assessments, and his photographs (many of which appear in this document) allowed us a virtual tour of the system as it existed over 60 years ago. Dr. Stanford's work has been invaluable to this effort, and the efforts made to give us access are deeply appreciated.

Finally, we thank the citizens of Idaho, Oregon and surrounding states for their support of water quality in the Snake River and their expressed concern and participation in its restoration.

Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Abstract

The federal Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters (33 USC § 1251.101). For waters identified as not meeting water quality standards and listed as impaired according to Section 303(d) of the Clean Water Act, states and tribes must develop a total maximum daily load (TMDL) for the pollutants causing impairment, set at a level to achieve water quality standards. The Snake River – Hells Canyon TMDL has been developed to comply with Idaho and Oregon's responsibilities within the Clean Water Act and state-specific TMDL schedules. This TMDL describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Snake River – Hells Canyon Subbasin located in southwestern Idaho and eastern Oregon. This TMDL consists of three major sections: 1) subbasin assessment, 2) loading analysis and allocation, and 3) water quality management or implementation plan(s).

The scope of the this TMDL extends from where the Snake River intersects the Oregon/Idaho border near Adrian, Oregon (Snake River mile (RM) 409) to immediately upstream of the inflow of the Salmon River (RM 188) (Hydrologic Unit Codes (HUCs) 17050115, 17050201 and 17060101, and a small corner of 17050103). This includes the Hells Canyon Complex reservoirs: Brownlee, Oxbow and Hells Canyon. The overall reach has been divided into smaller segments based on similar hydrology, pollutant delivery and processing mechanisms, and operational, management or implementation strategies. These include the following: the *Upstream Snake River* segment which extends from where the river intersects the Oregon/Idaho border near Adrian, Oregon (RM 409), downstream to Farewell Bend (RM 335). The *Brownlee Reservoir segment* includes Brownlee Reservoir from Farewell Bend (RM 335) to Brownlee Dam (RM 285). The *Oxbow Reservoir* segment includes Oxbow Reservoir from the outflow of Brownlee Reservoir below Brownlee Dam (RM 285) to Oxbow Dam (RM 272.5). The *Hells Canyon Reservoir* segment includes Hells Canyon Reservoir from the outflow of Oxbow Reservoir below Oxbow Dam (RM 272.5) to Hells Canyon Dam (RM 247). The *Downstream Snake River* segment includes the Snake River from below Hells Canyon Dam (RM 247) to immediately upstream of the Salmon River inflow (RM 188). Within these segments all designated beneficial uses and all listed pollutants from both states have been addressed by the TMDL with the exception of mercury. The following summary identifies the basic findings of the assessment and analysis process.

Bacteria. The Snake River is listed from RM 409 to 347 for bacteria. Analysis has shown that bacteria 303(d) listings are not indicated given the available data. Designated uses are not impaired due to elevated bacteria levels within any of the listed segments. Based on these findings, the TMDL recommends that the mainstem Snake River from RM 409 to 347 be delisted for bacteria by the State of Idaho.

Mercury. The Snake River is listed from RM 409 to 188 for mercury. The mercury TMDL for the Snake River- Hells Canyon reach has been postponed to 2006 in a US EPA approved action due to the fact that essentially no water column data are currently available to this effort.

Nutrients, Nuisance Algae and Dissolved Oxygen. The Snake River is listed from RM 409 to 272.5 for nutrients. Available data show excessive total phosphorus concentrations in the Upstream Snake River segment (RM 409 to 335) of the SR-HC reach. Nuisance algae blooms have been observed to occur routinely in the Upstream Snake River segment and the upstream sections of Brownlee Reservoir. Site-specific chlorophyll *a* and total phosphorus targets (less than 14 ug/L and less than or equal to 0.07 mg/L respectively) were identified by the TMDL. These targets are seasonal in nature and apply from May through September. Attainment of these targets is projected to result in a reduction of roughly 50 percent in algal biomass (as measured by chlorophyll *a*) that in turn will result in improvement in dissolved oxygen concentrations in both the Upstream Snake River and Brownlee Reservoir segments. The TMDL assigns waste load allocations to direct point source dischargers to the Snake River operating mechanical treatment plants to reduce discharge concentrations by 80 percent. Lagoon discharges will assess the feasibility of changing to land application or biological nutrient removal and implementation objectives will be assessed on a case by case basis. Nonpoint source discharges will be required to reduce to the 0.07 mg/L level. Inflowing tributaries have been assigned load allocations to meet the 0.07 mg/L total phosphorus target at their inflow to the Snake River. A load allocation for the addition of 1,125 tons of dissolved oxygen per season has been assigned to Idaho Power Company to offset reduction in assimilative capacity caused by the Hells Canyon Complex impoundments.

Pesticides. The Snake River is listed for pesticides from RM 285 to 272.5 (Oxbow Reservoir). Pesticides of concern are DDT and dieldrin, both of which are banned and no longer in use in the United States. TMDL targets were identified as less than 0.024 ng/L water column concentration DDT, less than 0.83 ng/L water column concentration DDD, less than 0.59 ng/L water column concentration DDE, and less than 0.07 ng/L water column concentration dieldrin. All available samples showed t-DDT fish tissue concentrations that exceeded the EPA screening level; no samples showed dieldrin fish tissue concentrations that exceeded the EPA screening level. All water column samples exhibited levels above the TMDL targets for both DDT and dieldrin. Load allocations for new application of these banned compounds are zero. Load allocations for legacy application and transport of DDT were established at less than 0.31 kg/year for RM 409 to 335 and less than 0.33 kg/year for Brownlee and Oxbow Reservoirs. Load allocations for legacy application and transport of dieldrin were established at less than 0.88 kg/year for RM 409 to 335 and less than 1.0 kg/year for Brownlee and Oxbow Reservoirs. These load allocations represent the sum of allowable point and nonpoint source-related loading. Pesticide targets apply year-round.

pH. The Snake River is listed for pH from RM 409 to 347 and from RM 335 to 285. Analysis has shown that pH 303(d) listings are not indicated given the available data. No exceedences were observed to occur from RM 409 to 335. Less than 1 percent exceedence was observed in the Brownlee Reservoir segment data. Based on these findings, the TMDL recommends that the mainstem Snake River from RM 409 to 347 and from RM 335 to 285 be delisted for pH by the State of Idaho.

Sediment. The Snake River is listed for sediment from RM 409 to 272.5. The TMDL has established targets of no more than 50 mg/L total suspended solids (TSS) as a monthly average and less than or equal to 80 mg/L TSS for no more than 14 days to protect aquatic life uses. Load allocations to meet the TMDL targets have been established for those tributaries and nonpoint sources (drains) that exceed target values at their inflow to the Snake River.

Temperature. The Snake River is listed from RM 409 to 188 for temperature. Elevated summer water temperatures have been measured in both the Upstream Snake River segment near Weiser, Idaho (RM 351), in the Hells Canyon Complex reservoirs, and in the Downstream Snake River segment prior to the construction of the dams. To address salmonid rearing temperature exceedences, point sources discharging directly to the Snake River within the SR-HC TMDL reach have been allocated heat loads corresponding to discharge loads applied to design flows to ensure that the no-measurable-increase requirements will be met. A waste load allocation for future point sources of no-measurable-increase has been identified as part of this TMDL. A gross nonpoint source temperature load allocation has been established at no greater than 0.14 ^{o}C for nonpoint sources in the SR-HC TMDL reach. A gross nonpoint source temperature load allocation has been established at no greater than 0.14 ^{o}C for tributaries in the SR-HC TMDL reach. These allocations apply at the inflow to the Snake River in the SR-HC TMDL reach, during those periods of time that the site-potential temperature in the mainstem Snake River is greater than 17.8 ^{o}C. A temporal shift in water temperatures exiting Hells Canyon Dam is observed during the late fall and winter months; the decline in temperature in the fall is delayed from that observed immediately upstream of the Hells Canyon Complex. While the temporal distribution of this temperature shift is due to the delay in flow caused by water moving through the Hells Canyon Complex, the actual heat load (warmer water) is not. The impoundments are not a heat source. Sources of elevated water temperature include natural, non-quantifiable and anthropogenic sources upstream of the Hells Canyon Complex and similar sources on inflowing tributaries. To address elevated temperatures occurring during salmonid spawning periods below Hells Canyon Dam, a temperature load allocation in the form of a required temperature change at Hells Canyon Dam was identified such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at RM 345, or the maximum weekly maximum temperature target of 13 °C for salmonid spawning, plus no greater than 0.14 ^{o}C.

Total Dissolved Gas. Total dissolved gas, while not a 303(d) listed pollutant, was addressed in the TMDL due to a direct request by members of the Public Advisory Team. Spill at Brownlee and Hells Canyon Dams is the source of elevated total dissolved gas within the lower SR-HC TMDL reach. A load allocation for total dissolved gas has been assigned to the Hells Canyon Complex that applies to each location where spill occurs (i.e. a load allocation of less than 110 percent of saturation applies to Oxbow Reservoir to address the effects of spill from Brownlee Dam, a load allocation of less than 110 percent of saturation applies to Hells Canyon Reservoir to address the effects of spill from Oxbow Dam, and a load allocation of less than 110 percent maximum saturation applies to the Downstream Snake River segment to address the effects of spill from Hells Canyon Dam).

It is recognized that the SR-HC TMDL addresses an extremely complex system that includes a combination of diverse natural, point, and nonpoint pollutant sources. The system has been highly modified from its original condition through the placement and operation of impoundments; surface water diversions and drains; upstream and tributary modifications for hydropower production, irrigation storage, flood control and recreational use; and a variety of other anthropogenic activities. Data is available for some pollutants to determine whether the water quality standards are met, however, for other pollutants there is only limited data that does not conclusively show that the waters are impaired by such pollutants.

This TMDL has therefore adopted a phased approach to implementation that will identify interim, measurable milestones to determine the effectiveness of management measures or other action controls being implemented, and a process for reviewing and revising management approaches to assure effective management measures are implemented. Agencies responsible for the preparation and approval of the SR-HC TMDL (US EPA, ODEQ and IDEQ) recognize that long time-frames (potentially 50 to 70 years) may be required for water all quality standards to be consistently met.

The Implementation Plan submitted contains two separate, state-specific plans: the State of Oregon General Water Quality Management Plan and the State of Idaho General Implementation Plan. Together, these documents represent the general water quality management plan (implementation plan) for the SR-HC TMDL. In addition to the implementation plan submitted for the mainstem SR-HC TMDL reach, tributary plans will also be prepared as part of tributary TMDL processes. These plans will be prepared according to the appropriate state-specific schedules under which they are identified. It is also expected that information will continue to be collected to fill existing data gaps and allow a more accurate determination of the status of designated beneficial uses within the SR-HC TMDL reach and the influence of pollutants delivered to and processed by the system.

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Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters (33 USC § 1251.101). States and tribes, pursuant to section 303 of the CWA are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list of impaired waters, currently every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants causing impairment, set at a level to achieve water quality standards. This document addresses the water bodies in the Snake River – Hells Canyon (SR-HC) Subbasin that have been placed on what is known as the "303(d) list."

This subbasin assessment and SR-HC TMDL analysis is a joint effort between the Idaho Department of Environmental Quality (IDEQ) and the Oregon Department of Environmental Quality (ODEQ), with participation by the US Environmental Protection Agency (US EPA) and local stakeholders.

What is a TMDL?

A TMDL is the amount of a particular pollutant that a specific stream, lake, river or other waterbody can tolerate without violating state water quality standards.

In this framework, a TMDL can be best described as a watershed or basin-wide budget for pollutant loading to a waterbody. A TMDL, in actuality, is a planning document. The "allowable budget" is first determined by scientific study of a stream to determine the amount of pollutants that can be assimilated without causing the stream to exceed the water quality standards set to protect the stream's designated beneficial uses (e.g., fishing, domestic water supply, etc.). This amount of pollutant loading is known as the *loading capacity*. It is established taking into account seasonal variations, natural and background loading, and a margin of safety. Once the loading capacity is determined, sources of the pollutants are considered. Both *point* and *nonpoint sources* must be included (US EPA, 1991b).

POINT SOURCES

Point sources of pollution are defined as discreet conveyances (e.g. pipes) that discharge directly into waterbodies, such as discharges associated with wastewater treatment plants. A point source is simply described as a discrete discharge of pollutants as through a pipe or similar conveyance.

NONPOINT SOURCES

Nonpoint sources, such as farms, lawns, or construction sites contribute pollution diffusely through run-off. Examples are sheet flow from pastures and runoff from forest logging. Nonpoint sources may include (but are not limited to), run-off (urban, agricultural, forestry, etc.), leaking underground storage tanks, unconfined aquifers, septic systems, farms, lawns, construction sites, stream channel alteration, and damage to a riparian area.

Once all the sources are accounted for, the pollutants are then allocated or budgeted among the sources in a manner that will describe the total maximum pollutant load that can be discharged into the river without causing the water quality standards to be exceeded. Ultimately the responsibility for improving water quality lies on the shoulders of everyone who lives, works or recreates in a watershed that drains into an impaired waterbody.

LOAD ALLOCATIONS

Load allocations are simply the amounts of pollutants that can be discharged from each source or category and still ensure that the total pollutant load does not exceed the loading capacity. The TMDL does not specify how the dischargers must attain their particular load allocation. The TMDL will not set best management practices for a discharger or otherwise tell the discharger how to meet their goal; it merely sets their goal.

Nonpoint sources are grouped into a "load allocation" (LA) and point sources are grouped into a "wasteload allocation" (WLA). By federal regulation, the total load capacity "budget" must also include a "*margin of safety*" (MOS). The "MOS" accounts for uncertainty in the loading calculation. The MOS may not be the same for different waterbodies due to differences in the availability and strength of data used in the calculations. The margin of safety cannot be "traded".
All together,

Loading Capacity = **TMDL** = **WLAs** + **LAs** + **Margin of Safety**.

The (point source) waste load allocation is implemented through an existing regulatory program under the federal Clean Water Act (CWA) called the National Pollutant Discharge Elimination System (NPDES) permit program. These permits set effluent quality limitations and require implementation of best available technologies that may include specific best management practices already established by the US EPA through regulation. Provided that a viable trading framework is in place, pollutant trading is allowed between, or within, the load allocation and the wasteload allocation categories.

In most cases, pollution load data already exists for most permitted point sources through the NPDES permitting process. Similar data are seldom available for nonpoint sources. Therefore, the TMDL process must develop similar load calculations for nonpoint sources of pollution, and for natural sources of pollution. In many circumstances, nonpoint source contributions will be broken down into additional categories, such as agriculture, development, forestry, or mining. Because it is difficult to identify specific nonpoint sources of pollution, it is unlikely that data will be collected on individual nonpoint sources (or landowners) along a waterbody. Instead, most TMDLs focus on estimating the cumulative or combined contribution of all nonpoint sources along a waterbody.

TMDLs generally consist of three major sections:

1) subbasin assessment,
2) loading analysis, and
3) water quality management or implementation plan(s).

SUBBASIN ASSESSMENT

A subbasin assessment describes the affected area, the water quality concerns and status of beneficial uses of individual water bodies, nature and location of pollution sources, and a summary of past and ongoing pollution control activities.

LOADING ANALYSIS

Loading analysis provides the estimate of a waterbody's pollutant load capacity, a margin of safety, and allocations of load to pollutant sources defined as the TMDL. Allocations are required for each permitted point sources and categories of non-point sources whose sum will meet the load capacity with load to spare as a margin of safety. Minor non-point sources may receive a lumped allocation. Generally a loading analysis is required for each pollutant of concern. But it is recognized that some listed pollutants are really water quality problems that are the result of other pollutants. For example, habitat affected by sediment or dissolved oxygen affected by nutrients causing nuisance aquatic growths. In these cases one listed stressor may be addressed by the loading reduction of another.

A complete loading analysis lays out a general pollution control strategy and an expected time frame in which water quality standards will be met. Long recovery periods (greater than five years) are expected for TMDLs dealing with non-point sediment or temperature sources. Interim water quality targets are recommended in these instances. Along with the load reductions, these targets set the sideboards in which specific actions are scheduled in the subsequent implementation plan.

WATER QUALITY MANAGEMENT OR IMPLEMENTATION PLAN

The implementation plan is guided by the TMDL and provides details of actions needed to achieve load allocations, a schedule of those actions, and follow up monitoring to document progress or provide other desired data. Implementation plans specify the local actions that lead to the goal of full support of designated beneficial uses. Important elements of these plans are:

- Implementation actions based on the load allocations identified in the TMDL
- An estimated time by which water quality standards are expected to be met, including interim goals or milestones as deemed appropriate
- A schedule specifying, what, where, and when actions to reduce loads are to take place
- Identification of who will be responsible for undertaking each planned action
- A plan specifying how accomplishments of actions will be tracked
- A monitoring plan to refine the TMDL and/or document attainment of water quality standards

To fulfil the requirements of the State of Oregon TMDL process, an implementation plan will be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, a general implementation plan is being submitted with the SR-HC TMDL and other, more specific plans will be prepared and submitted according to the appropriate IDEQ or ODEQ schedule and procedure. Together, these documents will represent the general water quality management plan (implementation plan) for the SR-HC TMDL.

Snake River - Hells Canyon TMDL General Information

This TMDL has been developed to comply with Idaho and Oregon's TMDL schedule. This assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the SR-HC Subbasin located in southwestern Idaho and eastern Oregon.

The first part of SR-HC TMDL, the subbasin assessment, is an important first step leading to the TMDL. The starting point for this assessment was Idaho's and Oregon's current 303(d) lists of water quality limited water bodies. Seven Idaho segments and four Oregon segments (corresponding to the same stretch of the Snake River) of the SR-HC Subbasin were identified on this list. The subbasin assessment portion of this document examines the current status of 303(d) listed waters, and defines the extent of impairment and causes of water quality limitation throughout the subbasin. The loading analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards.

PUBLIC PARTICIPATION

Throughout the SR-HC TMDL process, local experience and participation have been and will continue to be invaluable in the identification of water-quality issues and reduction strategies appropriate on a local scale. During the initial stages of the SR-HC TMDL process, a structured public involvement program was established that included both local stakeholders and technical, agency personnel. This program was established so members of the local communities could provide direction and leadership in developing and implementing this plan. The public committee created is known as the SR-HC Public Advisory Team (PAT). The SR-HC PAT provides an opportunity for concerned citizens, representing a number of stakeholder groups, to see the SR-HC TMDL process through from start to finish.

Categories for stakeholder representation were identified by IDEQ and ODEQ according to state-specific protocols. Nominations for potential seatholders in each of these interest categories were solicited from the general public through letters to local governments, organizations, stakeholder groups, individuals, and watershed councils in both Oregon and Idaho. Generally, one representative from each state was selected from the nominations received to represent each area of interest. An alphabetical listing of the final stakeholder seats within the SR-HC PAT follows:

- Hydropower Interests
- Idaho Agricultural Interests
- Idaho Environmental Interests
- Idaho Local Government Interests
- Idaho Municipal Interests
- Idaho Public at Large
- Idaho Sporting/Recreational Interests
- Idaho Timber/Forestry Interests
- Industrial Interests
- Oregon Agricultural Interests
- Oregon Environmental Interests
- Oregon Local Government Interests

- Oregon Municipal Interests
- Oregon Public at Large
- Oregon Sporting/Recreational Interests
- Oregon Timber/Forestry Interests
- Other Idaho Interests
- Other Oregon Interests
- Tribal Interests – Nez Perce
- Tribal Interests – Shoshone/Paiute

The SR-HC PAT functions as an advisory body to the DEQs on SR-HC TMDL and implementation matters within the DEQ responsibilities outlined above. SR-HC PAT members help to identify contributing pollutant sources, advise the DEQs in arriving at equitable pollutant reduction allocations, and recommend specific actions needed to effectively control sources of pollution. Additionally, SR-HC PAT seatholders represent a critical mechanism in disseminating information to their respective interest groups, and relaying concerns and advice from these interest groups to the DEQs.

At the initial meetings of the SR-HC PAT, it was determined that due to the large geographical area of the SR-HC TMDL reach and the associated watershed, and the fact that the interests represented by separate SR-HC PAT seatholders may be divergent in their consideration of, and position on, some issues, the SR-HC PAT would not operate under a consensus-based process. The seatholders and the interagency team members (ODEQ and IDEQ) decided that there should be an opportunity for the submission (formally or informally) to the public record of opinions different from that of the SR-HC PAT in general, or to the approach, philosophy or methodology used by the DEQs in the formulation of the SR-HC TMDL.

In accordance with this decision, an informal record of differences in opinion on issues discussed is available to the public in the minutes from SR-HC PAT meetings, and in the listing of informal comments by SR-HC PAT members on initial drafts of the SR-HC Subbasin Assessment (and other sections of the SR-HC TMDL document as they become available) compiled by the DEQs. This information is available on request from the Cascade Satellite Office of IDEQ, PO Box 247, Cascade, ID 83611; and from the Pendleton Office of ODEQ, 700 SE Emigrant, Pendleton, OR 97801.

Subbasin at a Glance

The scope of the SR-HC TMDL extends from where the Snake River intersects the Oregon/Idaho border near Adrian, Oregon (Snake River mile (RM) 409) to immediately upstream of the inflow of the Salmon River (RM 188) (Hydrologic Unit Codes (HUCs) 17050115, 17050201 and 17060101, and a small corner of 17050103). This includes the Hells Canyon Complex reservoirs: Brownlee, Oxbow and Hells Canyon. Figure A shows the geographical scope of this TMDL.

Because of the extensive scope of this TMDL (RM 409 to 188), the overall SR-HC TMDL reach has been divided into smaller subsections or segments based on similar hydrology, pollutant delivery and processing mechanisms, and operational, management or implementation strategies.

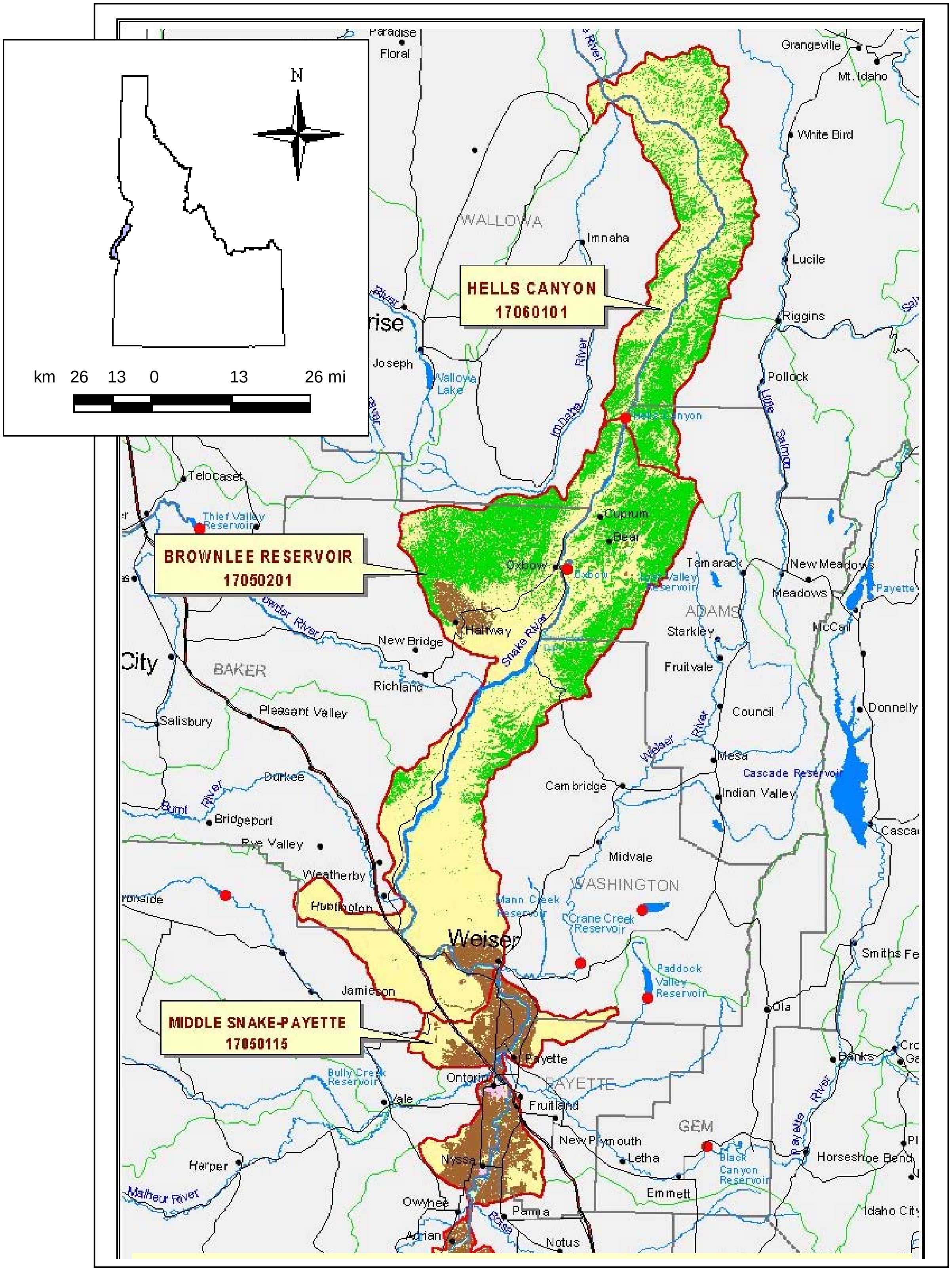

Figure A. Geographical scope of the Snake River – Hells Canyon TMDL

The five segments are:

- Upstream Snake River (RM 409 to 335, 74 miles total)
- Brownlee Reservoir (RM 335 to 285, 50 miles total)
- Oxbow Reservoir (RM 285 to 272.5, 12.5 miles total)
- Hells Canyon Reservoir (RM 272.5 to 247, 25.5 miles total)
- Downstream Snake River (RM 247 to 188, 59 miles total)

Figure B shows the separate segments as identified within the SR-HC TMDL reach.

The Upstream Snake River segment (RM 409 to 335) includes the riverine section of the Snake River upstream of the reservoir impoundments. It extends from where the river intersects the Oregon/Idaho border near Adrian, Oregon (RM 409), downstream to Farewell Bend (RM 335). All of the major tributary inflows to the SR-HC TMDL reach (with the exception of the Burnt and Powder rivers) enter the mainstem river within this segment. The vast majority of agricultural and urban/suburban land use occurs within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. Flow within this segment is primarily driven by snowmelt and seasonal precipitation events, upstream and tributary impoundments, and irrigation diversions and returns. The 303(d) listed pollutants in this segment include bacteria, dissolved oxygen, mercury, nutrients, pH, sediment and temperature (1998 303(d) list).

The Brownlee Reservoir segment (RM 335 to 285) includes Brownlee Reservoir from Farewell Bend through the Brownlee Dam. While Brownlee Reservoir contains three fairly distinct hydrological regions: the riverine zone near the tailwaters (roughly RM 335 to 315), the transition zone (roughly RM 315 to 305), and the lacustrine zone (RM 305 to 285); water management and water quality concerns are well correlated with the reservoir boundaries. Total reservoir volume is 1,420,000 acre-feet. Flow into Brownlee Reservoir is made up of the outflow of the Upstream Snake River segment (RM 409 to 335), and the Burnt and Powder rivers that flow into Brownlee Reservoir at RM 327.5 and RM 296 respectively. However the inflow of these two tributaries is relatively minor when compared with the inflow from the Upstream Snake River segment, representing less than 2% of the combined total. Flow and residence time within the reservoir are controlled by the outflow through Brownlee Dam. Average residence time is 34 days, however, with consideration of the additional internal processes of stratification, depth of withdrawal, flood control requirements and management for power generation, the residence time in different parts of the reservoir can vary considerably. Listed pollutants in this segment include dissolved oxygen, mercury, nutrients, pH, sediment and temperature (1998 303(d) list).

The Oxbow Reservoir segment (RM 285 to 272.5) includes Oxbow Reservoir from the outflow of Brownlee Reservoir below Brownlee Dam to Oxbow Dam. The reservoir is much smaller than Brownlee Reservoir and has an average retention time of only 1.4 days. Flow into Oxbow Reservoir is almost exclusively the outflow of Brownlee Reservoir. Wildhorse River, which flows directly into the reservoir near the Brownlee Dam, constitutes less than 1% of the total inflow. Total reservoir volume is 57,500 acre-feet. Flow and residence time within the reservoir are controlled by the releases from Brownlee Dam and the releases from Oxbow Dam. Oxbow Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in

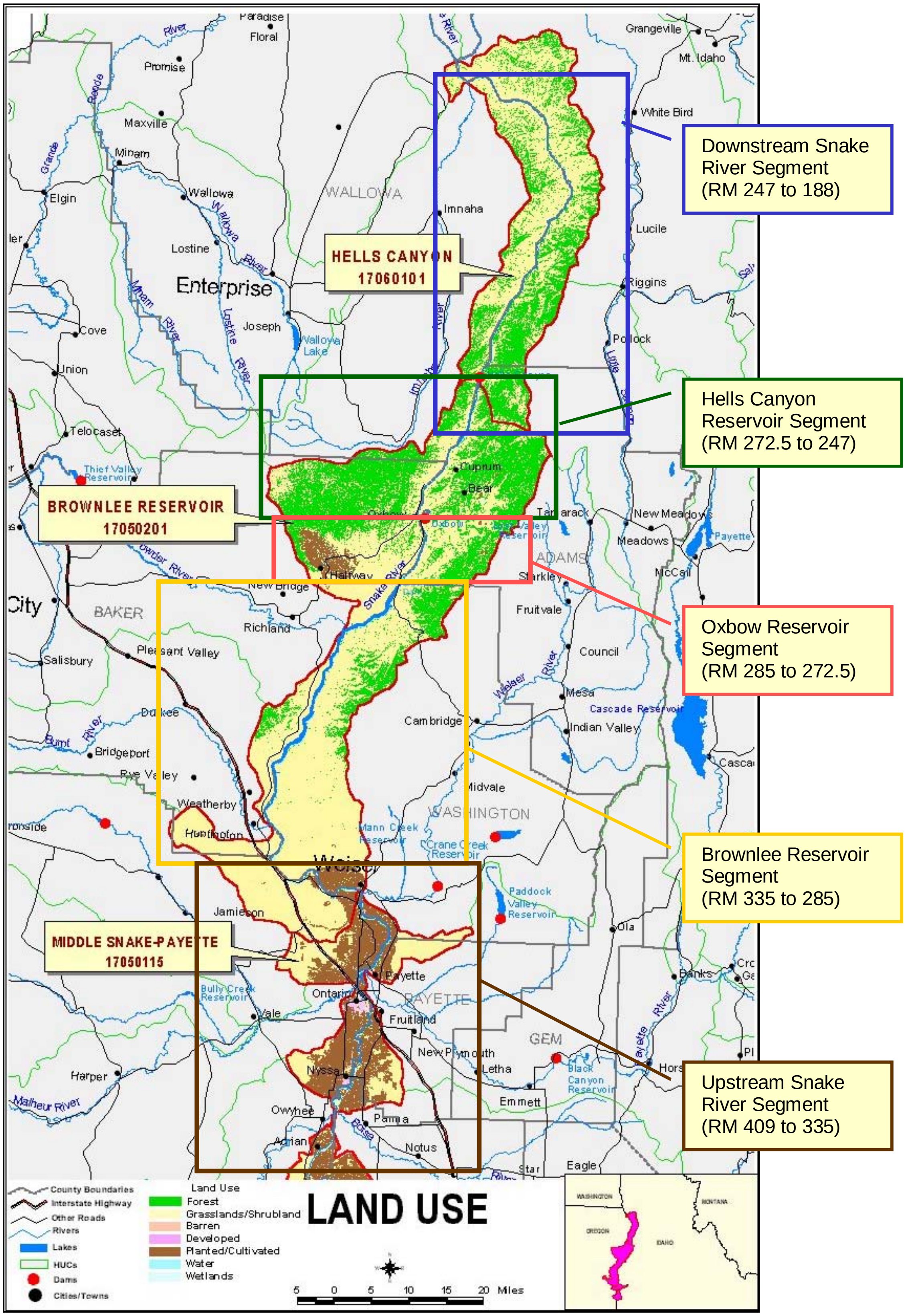

Figure B. Snake River – Hells Canyon TMDL segments.

this segment are well correlated with water quality upstream in Brownlee Reservoir. Listed pollutants in this segment include mercury, nutrients, pesticides, sediment and temperature.

The Hells Canyon Reservoir segment (RM 272.5 to 247) includes Hells Canyon Reservoir from the outflow of Oxbow Reservoir below Oxbow Dam to Hells Canyon Dam. This segment is also fairly small and fast flowing with a total volume of 170,000 acre-feet and has an average retention time of 4 days. Flow into Hells Canyon Reservoir is almost exclusively the outflow of Oxbow Dam. Pine Creek, which flows directly into the reservoir near the Oxbow Dam, constitutes less than 1% of the total inflow. The releases from Oxbow Reservoir and the releases from Hells Canyon Dam control flow and residence times within the reservoir. Hells Canyon Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with water quality upstream in Brownlee and Oxbow Reservoirs. Listed pollutants in this segment include mercury and temperature (1998 303(d) list).

The Downstream Snake River segment (RM 247 to 188) includes the Snake River from below Hells Canyon Dam to immediately upstream of the Salmon River inflow. This segment is a rapid flowing, narrow river characterized by steep canyon walls and stretches of white water. The flow and volume of this segment are almost completely driven by the outflow of the Hells Canyon Complex reservoirs, and support substantial recreational uses year round. Listed pollutants in this segment include mercury and temperature (1998 303(d) list).

PARAMETERS (POLLUTANTS) OF CONCERN AND DESIGNATED BENEFICIAL USES

As this TMDL is a bi-state effort, the final document must meet the needs of both Oregon and Idaho. In order to accomplish this, all designated uses and listed pollutants from both states must be addressed by the TMDL. Therefore, the SR-HC TMDL addresses all listed pollutants from both Idaho's 303(d) list and Oregon's 303(d) list. These designated beneficial uses and the parameters of concern are listed in Tables A-1 and A-2.

KEY INDICATORS OF IMPAIRMENT

Designated beneficial use impairment and target exceedences have been identified to the extent possible given the available data set. Table B lists the pollutants from the 303(d) lists of Idaho and Oregon and the key indicators of impairment associated with each pollutant. Both quantitative (measured data) and qualitative (observations of system characteristics) methods were used in the evaluation of designated use support. Information on the occurrence of impairment indicators is included in Table B on a segment-specific basis. The information listed in Table B represents the current level of understanding of beneficial use impairment and system dynamics within the SR-HC TMDL reach. The phased implementation approach and iterative nature of the TMDL process will allow further refinement of the identified designated use impairment as additional data are collected and understanding of the system dynamics improves.

POLLUTANT SOURCES

Many, varied sources of pollutant loading have been identified within the SR-HC Subbasin. In some cases sources can contribute directly to exceedences of water quality targets (as in the case of excessive nutrient loading causing nuisance algae blooms. In other cases, pollutant sources

Table A-1. Idaho segment specific listing information for the Snake River - Hells Canyon TMDL reach.

Segment	Idaho 303(d) Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 409 to 396.4 Upstream Snake River (OR/ID border to Boise River Inflow)	(downstream from ID border) bacteria, dissolved oxygen, nutrients, pH, sediment	(downstream from ID border) cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 396.4 to 351.6 Upstream Snake River (Boise River Inflow to Weiser River Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 351.6 to 347 Upstream Snake River (Weiser River Inflow to Scott Creek Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	dissolved oxygen, mercury, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 285 to 272.5 Oxbow Reservoir	nutrients, sediment, pesticides	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 272.5 to 247 Hells Canyon Reservoir	not listed	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 247 to 188 Downstream Snake River (Hells Canyon Dam to Salmon River Inflow)	temperature	cold water aquatic life salmonid spawning primary contact recreation domestic water supply special resource water

Table A-2. Oregon segment specific listing information for the Snake River - Hells Canyon TMDL reach.

Segment	Oregon 303(d) Listed Pollutants	Oregon Designated Beneficial Uses
Snake River: RM 409 to 395 Upstream Snake River (Owyhee Basin)	mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics

Segment	Oregon 303(d) Listed Pollutants	Oregon Designated Beneficial Uses
Snake River: RM 395 to 335 Upstream Snake River to Farewell Bend (Malheur Basin)	mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower
Snake River: RM 260 to 188 Lower half of Hells Canyon Reservoir Downstream Snake River (Grande Ronde Basin)	mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning (downstream) resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics anadromous fish passage commercial navigation and transport

Table B. Key indicators of impairment specific to listed pollutants for the Snake River - Hells Canyon TMDL.

Parameter	Indication of Impairment
Bacteria	Site-specific data showing concentrations greater than 126 *E coli* organisms per 100 mL as a 30 day log mean with a minimum of 5 samples OR samples greater than 406 *E coli* organisms per 100 mL. In the absence of site-specific data, key indicators of bacteria problems include illness in primary contact recreation users. • No segments of the SR-HC TMDL reach were found to exhibit these conditions.
Dissolved Oxygen (DO)	Site-specific data showing concentrations less than 6.5 mg/L water column where cool water aquatic life/salmonid rearing is the designated use for the State of Oregon or cold water aquatic life is the designated use for the State of Idaho. Less than 8 mg/L water column DO where cold water aquatic life is the designated use for the State of Oregon, less than 11 mg/L water column DO or intergravel DO lower than 8 mg/L when and where salmonid spawning is a designated use for either state. In the absence of site-specific dissolved oxygen data, key indicators of dissolved oxygen problems include fish kills, anaerobic sediments and lack of support for aquatic life uses. • The portions of the Snake River upstream of RM 409 were shown to exhibit dissolved oxygen concentrations below those required to support salmonid spawning and incubation. Water quality and substrate conditions in the

Parameter	Indication of Impairment
	Upstream Snake River segment (RM 409 to 335) parallel conditions upstream where dissolved oxygen violations were observed. • The Brownlee Reservoir segment (RM 335 to 285) was shown to exhibit dissolved oxygen target exceedences.
Mercury (Hg)	Site-specific data showing concentrations greater than 0.012 ug/L water column concentration total mercury and/or greater than 0.35 mg/kg methylmercury in fish tissue, and fish tissue advisories based on consumption concerns. • Fish in the Upstream Snake River segment (RM 409 to 335) were shown to exhibit exceedences of the fish tissue targets • Fish in the Brownlee Reservoir segment (RM 335 to 285) were shown to exhibit exceedences of the fish tissue targets
Nutrients Nuisance Algae	Key indicators of nutrient problems include excessive algae growth and associated dissolved oxygen and pH problems. For the State of Oregon, exceedence of 15 ug/L chlorophyll *a* (a surrogate for algae mass) indicates that there is potentially a problem with excessive nutrient loading. Chlorophyll *a* concentrations greater than 15 ug/L trigger an evaluation to determine the level of impairment. This TMDL represents that evaluation for the SR-HC TMDL reach. • Excessive algae blooms are observed to occur in the Upstream Snake River segment (RM 409 to 335) (see dissolved oxygen) • Excessive algae blooms are observed to occur in the upstream sections of Brownlee Reservoir (see dissolved oxygen)
Pesticides	Site-specific data showing water column concentrations of greater than 0.024 ng/L DDT, 0.83 ng/L DDD, 0.59 ng/L DDE, and/or 0.07 ng/L Dieldrin. • Fish in the Upstream Snake River segment (RM 409 to 335) were shown to exhibit exceedences of the fish tissue action levels. A very small data set shows water column target exceedences. Sediment concentrations are at levels of concern. • Fish in the Brownlee Reservoir segment (RM 335 to 285) were shown to exhibit exceedences of the fish tissue targets. Sediment concentrations are at levels of concern.
pH	Site-specific data showing pH measurements less than 7 and/or greater than 9 pH units In the absence of site-specific pH data, key indicators of pH problems include fish kills and lack of support for aquatic life uses. • No segments of the SR-HC TMDL reach were found to exhibit these conditions.
Sediment (Total Suspended Solids (TSS))	Site-specific data showing concentrations greater than 80 mg TSS/L for acute events lasting more than 14 days, and/or greater than 50 mg TSS/L monthly average In the absence of site-specific data, key indicators of sediment problems include lack or degradation of spawning habitat, population decline, feeding problems, gill and scale problems and reduced growth rates. • Duration data are not available to make a direct assessment of target exceedence. Habitat concerns exist in the Upstream Snake River and upstream Brownlee Reservoir segments. • The primary concern associated with sediment in this TMDL is as a transport mechanism for mercury, pesticides and nutrients. Sediment acts as an indicator of transport and delivery potential within the system.
Temperature	Cold water Aquatic Life/Salmonid Rearing: Site-specific data showing water temperatures with greater than a 0.14 ^{o}C increase

Parameter	Indication of Impairment
	from anthropogenic sources when the site potential is greater than 17.8 ^{o}C Salmonid Spawning: A maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. Applicable to RM 247 to 188 only, from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish. Or site-specific data showing water temperatures with greater than a 0.14 ^{o}C increase from anthropogenic sources when aquatic species listed under the Endangered Species Act are present and a temperature increase would impair the biological integrity of the Threatened and Endangered population. In the absence of site-specific data, key indicators of temperature problems include fish kills, lack or loss of habitat, unsuccessful spawning and reduced growth rates. • Exceedences of the temperature target for cold water aquatic life and salmonid rearing occur to some degree during June, July, August and September throughout the SR-HC TMDL reach. • These exceedences were determined to be primarily due to natural and non-quantifiable conditions. Exceedences were observed historically in the Upstream Snake River segment (RM 409 to 335) and in the reservoir segments before the impoundments were in place. • Exceedences of the temperature target for salmonid spawning occur to some degree during mid-October in the Downstream Snake River segment (RM 247 to 188).
Total Dissolved Gas (TDG)	Site-specific data showing concentrations greater than 110% total dissolved gas saturation In the absence of site-specific data, key indicators of total dissolved gas problems include gas bubble disease in fish. • Exceedences of the total dissolved gas target are observed to occur in Oxbow, Hells Canyon reservoirs and in the Downstream Snake River segment during periods of spill.

can contribute indirectly to water quality target exceedences (as in the case of sediment transporting mercury within the subbasin, or algae growth leading to dissolved oxygen sags). To the extent possible, pollutant sources have been identified within the SR-HC Subbasin, however, some sources may not have been identified and, with the collection of additional data, some sources currently identified may be found to contribute less of a load than assessed. The sources listed in Table C represent the current level of understanding of pollutant loading, transport and delivery to the SR-HC TMDL reach. The phased implementation approach and iterative nature of the TMDL process will allow further refinement of the identified sources as our understanding of the system improves.

Key Findings

The SR-HC TMDL reach is a very complex system exhibiting varying hydrology, pollutant processing and transport characteristics, and anthropogenic influences. In many cases the data

Table C. Pollutant sources within the Snake River - Hells Canyon TMDL reach.

Parameter	Pollutant Source
Bacteria	No segments of the SR-HC TMDL reach were found to exceed the targets. While there may be sources of bacteria in the subbasin, they are not currently observed to be contributing to designated use impairment in the SR-HC TMDL reach.
Dissolved Oxygen (DO)	• Point sources discharging phosphorus into the Upstream Snake River segment (RM 409 to 335), including municipal, stormwater and industrial discharges • Nonpoint sources including agriculture, stormwater, and natural loading • Tributary inflows to the SR-HC TMDL reach • Reduced assimilative capacity due to impoundments
Mercury (Hg)	• Point source discharges may be sources of mercury; no measured loading is available. Point sources include municipal, stormwater and industrial discharges • Major nonpoint sources include legacy mining and natural loading. Minor nonpoint sources include legacy seed treatments, landfills, domestic sludge, air deposition, cement plants and coal fired power plants • Tributary inflows to the SR-HC TMDL reach • Existing system loading
Nutrients Nuisance Algae	• Point sources discharging phosphorus into the Upstream Snake River segment (RM 409 to 335), including municipal, stormwater and industrial discharges • Nonpoint sources including agriculture, stormwater, and natural loading • Tributary inflows to the SR-HC TMDL reach
Pesticides	• Point source discharges are not considered to be significant sources of loading • Nonpoint sources include legacy pesticide application both within the SR-HC Subbasin and from upstream application • Tributary inflows to the SR-HC TMDL reach • Existing system loading
pH	No segments of the SR-HC TMDL reach were found to exceed the targets for pH.
Sediment (TSS)	• Point source discharges, including municipal, stormwater and industrial discharges, are not considered to be significant sources of loading with the exception of stormwater discharges • Nonpoint sources include erosion from agriculture, recreation and urban/suburban sources as well as natural loading • Tributary inflows to the SR-HC TMDL reach
Temperature	• Dominant source of loading is natural temperature influences • Point source discharges, including municipal, stormwater and industrial discharges, are sources of heating but are currently operating within the no measurable increase margin • Nonpoint sources include flow and temperature influences from agriculture, water management and urban/suburban sources • Tributary inflows to the SR-HC TMDL reach
Total Dissolved Gas (TDG)	• Spill from Brownlee and Hells Canyon Reservoirs

collected to support the SR-HC TMDL effort is sufficient to determine the level of support for designated beneficial uses within the system (i.e. bacteria, nutrients, pH, temperature, total dissolved gas). In some cases, enough data are available to make a preliminary assessment, but additional data are necessary before formal load allocations based on existing loading or designated use support status can be identified (i.e. mercury, pesticides and sediment). The following summary captures the basic findings of this assessment process. All topics are discussed in greater detail within the TMDL document and the attached appendices.

BACTERIA

The SR-HC TMDL reach is listed from RM 409 to 347 for bacteria. Analysis has shown that bacteria 303(d) listings are not indicated given the available data. Designated uses are not impaired due to elevated bacteria levels within any of the listed segments. Available data (1999 and 2000) were collected in an appropriate fashion for evaluation of the 30 day log mean, with a minimum of 5 samples over an appropriate time period collected at most sampling locations. Monitoring occurred during the summer season and correlates well not only with the period of time that conditions in the river would be conducive to bacterial growth, but also to the season of greatest primary contact recreation use. No exceedences were observed. Based on these findings, the SR-HC TMDL process recommends that the mainstem Snake River from RM 409 to 347 be delisted for bacteria by the State of Idaho. The SR-HC TMDL process further recommends that monitoring of bacteria levels (*E. coli*), especially in those areas of the SR-HC TMDL reach where recreational use consistently occurs, continue to be an integral part of the water quality monitoring of the Upstream Snake River and Brownlee Reservoir segments.

MERCURY

The SR-HC TMDL reach is listed from RM 409 to 188 for mercury. To date, data available show that mercury concentrations in the SR-HC reach of the Snake River exceed the fish tissue target established by this TMDL. Water column data are not available to allow an assessment of the use support status of aquatic life uses due to mercury concentrations within the SR-HC system.

All fish tissue data available in this reach were positive for mercury. A summary of these data show that the Oregon and Idaho levels of concern were exceeded by 80% (0.35 mg/kg) and 52% (0.5 mg/kg) respectively. Both states have acted to issue fish consumption advisories based on these exceedences. Primary sources of mercury within the SR-HC TMDL reach are legacy mining and natural loading. Both are associated with geological deposits of mercury within the Owyhee and Weiser watersheds. Based on these findings, and on the concerns associated with consumption of fish by both waterfowl and wildlife within the SR-HC TMDL reach, a TMDL is considered necessary.

Due to the fact that essentially no water column data are available to this effort, a TMDL cannot be established at this time for mercury in the SR-HC TMDL reach. Therefore, IDEQ and ODEQ have determined it is in the public interest to reschedule the mercury TMDL for the SR-HC TMDL reach. IDEQ has rescheduled completion of the mercury TMDL to 2006 in order to gather additional data to better determine the sources and extent of mercury contamination. This schedule change has been approved by US EPA. ODEQ's schedule for the mercury TMDL coincides with this date. The state of Oregon is developing capability to model site-specific bioaccumulation factors. Also, Oregon's mercury TMDL is not due until 2006. This schedule change will allow a better use of these capabilities and the opportunity to collect additional data. Both Idaho and Oregon have interim measures in place to deal with mercury contamination such as sediment controls and fish consumption advisories as described in Section 3.1. It is the opinion of the DEQs that this schedule change will not present an adverse impact to the SR-HC TMDL reach.

NUTRIENTS, NUISANCE ALGAE AND DISSOLVED OXYGEN

The SR-HC TMDL reach is listed from RM 409 to 272.5 for nutrients. Available data show excessive total phosphorus concentrations in the Upstream Snake River segment (RM 409 to 335) of the SR-HC reach. Nuisance algae blooms have been observed to occur routinely in the Upstream Snake River segment and the upstream sections of Brownlee Reservoir. It is evident from data analysis that the distribution of chlorophyll *a* and total phosphorus concentrations observed in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach are elevated when compared to those observed in the Snake River system as a whole. This elevation cannot be wholly attributable to natural sources.

A comparison of conditions in the Upstream Snake River segment (RM 409 to 335) to conditions observed in the Snake River as a whole was used to identify site-specific chlorophyll *a* and total phosphorus targets (less than 14 ug/L and less than or equal to 0.07 mg/L respectively) for the SR-HC TMDL reach. These targets are seasonal in nature and apply from May through September. The 0.07 mg/L total phosphorus target represents a substantial reduction in the current average total phosphorus concentration in the SR-HC TMDL reach. A total phosphorus concentration of 0.07 mg/L correlates to an average chlorophyll *a* concentration of approximately 14 ug/L, which is within the range defined as appropriate for protection of designated aquatic life, domestic water supply and aesthetic/recreational beneficial uses. The reduction in total phosphorus observed in meeting the target concentration also represents a reduction of roughly 50 % in algal biomass (as measured by chlorophyll *a*). The calculated reduction in organic loading is projected to result in an improvement in dissolved oxygen levels in both the Upstream Snake River and Brownlee Reservoir segments.

The 14 ug/L chlorophyll *a* and 0.07 mg/L total phosphorus targets were developed to meet water quality criteria in the Upstream Snake River segment (RM 409 to 335). To identify the change in conditions in Brownlee Reservoir resulting from attainment of these targets in the Upstream Snake River segment, water quality in the reservoir was modeled using all inflowing waters at 0.07 mg/L of total phosphorus. The model output showed dissolved oxygen improvements in the epilimnion sufficient to meet the 6.5 mg/L criteria during the summer months. Dissolved oxygen levels concentrations in the metalimnion also showed improvement, although the projected improvements did not meet water quality targets. Modeling of long-term effects of attaining the targets project that substantial improvements in the hypolimnion will be realized over time.

Load allocations assigned to the inflowing tributaries are based on inflow concentrations meeting the 0.07 mg/L total phosphorus target. Direct point source dischargers to the Snake River operating mechanical treatment plants will be required to reduce discharge concentrations by 80%. Lagoon discharges will assess the feasibility of changing to land application or biological nutrient removal and implementation objectives will be assessed on a case by case basis. Nonpoint source discharges will be required to reduce to the 0.07 mg/L level. As modeling showed that the presence of Brownlee Reservoir acts to reduce the assimilative capacity of the river, additional dissolved oxygen required to offset this reduction in assimilative capacity will be the responsibility of Idaho Power Company and has been identified as a load allocation of 1,125 tons of dissolved oxygen per season.

PESTICIDES

The SR-HC TMDL reach is listed for pesticides from RM 285 to 272.5 (Oxbow Reservoir). Pesticides of concern to this TMDL are DDT and dieldrin, both of which are banned and no longer in use in the United States. Available pesticide data identified total DDT (t-DDT) and dieldrin concentrations in fish tissues throughout the Snake River and several major tributaries in Idaho.

The data show that concentrations of both t-DDT and cyclodiene compounds (dieldrin) increased with distance downstream. Reservoir concentrations (mean = 1,261 ug/kg fish tissue) were somewhat higher overall than tributary concentrations (mean = 990 ug/kg fish tissue), but the trend was evident in both types of surface waters. The reservoir samples exhibited greater variation than the riverine samples. Of the pesticides identified in the SR-HC TMDL reach, all samples showed t-DDT fish tissue concentrations that exceeded the EPA screening level; no samples showed dieldrin fish tissue concentrations that exceeded the EPA screening level. All water column samples (four data points for each compound) exhibited levels above the SR-HC TMDL targets for both DDT and dieldrin.

The available dieldrin data show that fish tissue concentrations were relatively similar throughout the Upstream Snake River segment (RM 409 to 335), increasing slightly within the Brownlee Reservoir samples. A comparison of mean values from the Upstream Snake River segment (riverine mean = 32.4 ug/kg fish tissue) with the Brownlee Reservoir segment (RM 335 to 285) (lacustrine mean = 45 ug/kg fish tissue) shows a relatively moderate difference. The Brownlee Reservoir samples showed much greater variation than the Upstream Snake River samples. In the small data set available for dieldrin, over 73% of the fish tissue data points (n = 16) showed concentrations of dieldrin that were above the detection limits.

Load allocations for new application of these pesticides are all zero as they are banned compounds. Due to the lack of data to accurately characterize pesticide loading to the Oxbow Reservoir segment (RM 285 to 272.5), and the diffuse and widespread legacy nature of pesticide loading to the Snake River, load allocations for legacy application and transport of DDT and dieldrin were assigned on a general basis for the Upstream Snake River segment (RM 409 to 335). These load allocations represent the sum of point and nonpoint source-related loading. Insufficient data are available to further differentiate pollutant sources within the segment. Pesticide targets apply year-round.

pH

The SR-HC TMDL reach is listed for pH from RM 409 to 347 and from RM 335 to 285. Analysis has shown that pH 303(d) listings are not supported by the available data. No exceedences were observed to occur in the data available for the Upstream Snake River segment (RM 409 to 335). Less than 1% exceedence was observed in the Brownlee Reservoir segment (RM 335 to 285). Data were collected over the course of several years and represent a variety of flow and water quality conditions. Based on these findings, the SR-HC TMDL process recommends that the mainstem Snake River from RM 409 to 347 and from RM 335 to 285 be delisted for pH by the State of Idaho. The SR-HC TMDL process further recommends that monitoring of pH continue to be an integral part of the water quality monitoring of the Upstream Snake River and Brownlee Reservoir segments.

Sediment

The SR-HC TMDL reach is listed for sediment from RM 409 to 272.5. No duration data are available to assess the extent of impairment or support in these reaches. Targets of no more than 50 mg/L total suspended solids (TSS) as a monthly average and less than or equal to 80 mg/L TSS for no more than 14 days have been set in a conservative fashion so that aquatic life uses will be protected in the listed segments. These targets closely match those identified by IDEQ for the Lower Boise River (1998) and Mid-Snake River TMDLs (1997) so management of the Snake River system is consistent with previous approaches.

Sediment loading within the SR-HC TMDL reach is also of concern because of the attached pollutant loads (mercury, pesticides and nutrients) that the sediment carries. In the SR-HC TMDL, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants. The available data show that over 95% of the sediment loading into the SR-HC TMDL reach originates in the Upstream Snake River segment (RM 409 to 335). Sources of unmeasured load may include nonpoint source runoff from anthropogenic sources, precipitation events, unidentified small tributaries and drains. Sediment targets apply year round.

TEMPERATURE

The SR-HC TMDL reach is listed from RM 409 to 188 for temperature. Elevated summer water temperatures have been measured in both the Upstream Snake River segment near Weiser, Idaho (RM 351), in the Hells Canyon Complex reservoirs, and in the Downstream Snake River segment prior to the construction of the dams. Summertime water temperatures routinely exceed 24 ^{o}C in both the current and the historic data. Temperature loading calculations within the SR-HC TMDL reach have shown that natural sources and non-quantifiable sources were the dominant cause of temperature exceedences. (Non-quantifiable influences include the effects of upstream and tributary impoundments, water withdrawals, channel straightening and diking and removal of streamside vegetation.) Calculated natural and non-quantifiable background temperature influences to the mainstem Snake River within the SR-HC TMDL reach equal over 90% of the increase in water temperature for the critical months of June, July, August and September. It is well recognized that in hot, arid climates such as that in which the SR-HC TMDL reach is located, natural atmospheric heat sources will have a noticeable influence on water temperatures.

To address salmonid rearing temperature concerns the following point and nonpoint source load allocations have been identified. Point sources discharging directly to the Snake River within the SR-HC TMDL reach have been allocated heat loads corresponding to discharge loads applied to design flows to ensure that no measurable increase requirements will not be exceeded. A waste load allocation for future point sources of no measurable increase has been identified as part of this TMDL.

A gross nonpoint source temperature load allocation has been established at no greater than 0.14 ^{o}C for nonpoint sources in the SR-HC TMDL reach. (This applies primarily to agricultural and stormwater drains and similar inflows.) This allocation applies at discharge to the Snake River in the SR-HC TMDL reach, during those periods of time that the site-potential temperature in the mainstem Snake River is greater than 17.8 ^{o}C. It is projected that implementation associated with total phosphorus and total suspended solids reductions will result in reduced inflow temperatures in the smaller drains and tributaries to the mainstem Snake River as many of the approved methods for the reduction of total phosphorus and suspended solids are based on streambank revegetation and similar methodologies that will increase shading.

A gross nonpoint source temperature load allocation has been established at no greater than 0.14 ^{o}C for tributaries in the SR-HC TMDL reach. This is equal to the sum of the waste load allocation and the load allocation for anthropogenic tributary sources. This allocation applies at the inflow to the Snake River in the SR-HC TMDL reach, during those periods of time that the site-potential temperature in the mainstem Snake River is greater than 17.8 ^{o}C. Anthropogenic temperature influence assessments, similar to those conducted for the Lower Boise River and the SR-HC TMDL reach will be completed as part of the tributary TMDL processes. If anthropogenic sources within the drainage are observed to exceed the no measurable increase value for the tributary inflow, load allocations will be identified through the tributary TMDL process.

A temporal shift in water temperatures exiting Hells Canyon Dam is observed during the late fall and winter months; the decline in temperatures in the fall is delayed from that observed immediately upstream of the Hells Canyon Complex. While the temporal distribution of this temperature shift is due to the delay in flow caused by water moving through the Hells Canyon Complex, the actual heat load (warmer water) is not. The impoundments are not a heat source. Sources of elevated water temperature include natural, non-quantifiable and anthropogenic sources upstream of the Hells Canyon Complex and similar sources on inflowing tributaries. Because peak summer temperatures are several degrees cooler due to withdrawals from below the reservoir surface, and modeling has demonstrated that releases from Hells Canyon Dam would meet cold water aquatic life/salmonid rearing water temperature targets if waters inflowing to the reservoirs met cold water aquatic life/salmonid rearing targets, it is concluded that the Hells Canyon Complex reservoirs are not contributing to temperature exceedences specific to the cold water aquatic life/salmonid rearing designated use

However, water temperature modeling also shows that even if the inflowing water temperature met water quality targets for salmonid spawning at the onset of salmonid spawning (October 23 for fall chinook), the water exiting the Hells Canyon Complex would not meet the salmonid spawning criteria (although by only a small margin) because of the temporal shift created by the Hells Canyon Complex. It is, therefore, concluded that the responsibility for exceeding the salmonid spawning criteria is specific to the presence and operation of the Hells Canyon Complex.

To address violations of the water quality criteria for salmonid spawning temperatures, a thermal site-potential for water downstream of Hells Canyon Dam was established as the water temperature at RM 345 (approximately 10 miles upstream of Farewell Bend) using data from 1991 to 2001. A temperature load allocation in the form of a required temperature change at Hells Canyon Dam was identified as a change in water temperature such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at RM 345, or the maximum weekly maximum temperature target of 13 °C for salmonid spawning, plus the allowable temperature change defined as no greater than 0.14 ^{o}C. The entire load for the Downstream Snake River segment (RM 247 to 188) is allocated to the Hells Canyon Complex of dams owned and operated by IPCo. Specific compliance parameters for meeting this load allocation will be defined as part of the 401 Certification process.

TOTAL DISSOLVED GAS

Elevated total dissolved gas levels are the result of releasing water over spillways of dams. Gas supersaturation is caused when air becomes dissolved in water while spilling over a dam into the depth of a plunge pool. High hydrostatic pressure causes the air to be driven into solution, resulting in supersaturation. Spill at Brownlee and Hells Canyon Dams is the source of elevated total dissolved gas in the SR-HC reach. At this time, voluntary spill does not occur within the Hells Canyon Complex. Spill at dams occurs only involuntarily, usually as a result of flood control constraints. The magnitude of the exceedence (to some extent) and the total distance downstream of the dam where water was observed to exceed the less than 110% standard are observed to be directly related to the volume of the spill. Observed ranges of total dissolved gas loading to the Oxbow Reservoir, Hells Canyon Reservoir and Downstream Snake River segments are between 114% to 128% for spill from Brownlee Dam and 108% to 136% for spill from Hells Canyon Dam.

As spill over Brownlee and Hells Canyon Dams is the source of elevated total dissolved gas in the SR-HC TMDL reach, the entire load allocation is assigned to the Hells Canyon Complex. This load allocation applies to each location where spill occurs (i.e. a load allocation of less than 110% maximum saturation applies to the tailwaters of Oxbow Reservoir during spill from Brownlee Dam, and a load allocation of less than 110% maximum saturation applies to the Downstream Snake River segment during spill from Hells Canyon Dam).

Water Quality Targets

Because the Snake River from RM 409 to 188 is an interstate water body with the state boundary line described as the centerline of the river, water quality standards and particularly water quality criteria for both Oregon and Idaho must be attained. Because the state line between Oregon and Idaho is in the middle of the mainstem Snake River, the waters of both states are mixed mid-river. Therefore waters from both sides must meet the criteria of both states in the mainstem. This is accomplished by determining which standards are the most stringent and applying those criteria as targets for this TMDL.

Due to the use of different methodology for each state, it is not immediately obvious which standards represent the most stringent values. A direct calculation of stringency was therefore undertaken for standards for which numeric criteria had been established. In the case of those pollutants where numeric criteria were not available, reasonable state and federal guidelines and guidance documents have been applied in correlation with the current understanding of the system and the physical constraints imposed by naturally occurring conditions. The resulting water quality targets for the SR-HC TMDL are listed in Table D.

TMDL Summaries

TMDLs have been written for nutrients/dissolved oxygen, pesticides, sediment, temperature and total dissolved gas. The following pages represent a summary of the information specific to each of the TMDLs written for the SR-HC TMDL reach.

Table D. Water quality targets specific to the Snake River - Hells Canyon TMDL.

Parameter	Selected Target	Where Applied
Bacteria	Less than 126 *E coli* organisms per 100 mL as a 30 day log mean with a minimum of 5 samples AND no sample greater than 406 *E coli* organisms per 100 mL	Full SR-HC TMDL reach (RM 409 to 188), year-round
Dissolved Oxygen (DO) • Cold water aquatic life and salmonid rearing	8 mg/L water column dissolved oxygen as an absolute minimum, OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 8 mg/L) dissolved oxygen levels shall not be less than 90%; unless adequate, i.e. continuous monitoring, data are collected to allow assessment of the multiple criteria section in the standards.	Downstream Snake River Segment (RM 247 to 188), year-round
• Salmonid spawning, when and where it occurs	11 mg/L water column dissolved oxygen as an absolute minimum OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95%; with intergravel dissolved oxygen not lower than 8 mg/L, unless adequate, i.e. continuous monitoring, data are collected to allow assessment of the multiple criteria section in the standards. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188), October 23 to April 15
• Cool water aquatic life	6.5 mg/L water column as an absolute minimum, unless adequate, i.e. continuous monitoring, data are collected to allow assessment of the multiple criteria section in the standards.	Full SR-HC TMDL reach (RM 409 to 188), year-round
Mercury (Hg)	Less than 0.012 ug/L water column concentration (total) Less than 0.35 mg/kg in fish tissue	Full SR-HC TMDL reach (RM 409 to 188), year-round
Nuisance Algae	14 ug/L mean growing season limit (nuisance threshold of 30 ug/L with exceedence threshold of no greater than 25%)	Full SR-HC TMDL reach (RM 409 to 188), May through September
Nutrients	Less than or equal to 0.07 mg/L total phosphorus	Full SR-HC TMDL reach (RM 409 to 188), May through September
Pesticides	Less than 0.024 ng/L water column concentration DDT Less than 0.83 ng/L water column concentration DDD Less than 0.59 ng/L water column concentration DDE Less than 0.07 ng/L water column concentration Dieldrin	Oxbow Reservoir Segment (RM 285 to 272.5) and upstream waters, year-round
pH	7 to 9 pH units	Full SR-HC TMDL reach (RM 409 to 188), year-round
Sediment (Turbidity)	Less than or equal to 80 mg TSS/L for acute events lasting no more than 14 days, and less than or equal to 50 mg TSS/L monthly average	Full SR-HC TMDL reach (RM 409 to 188), year-round
Temperature • Cold water aquatic life and salmonid rearing	17.8 ^oC (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^oC. If and when the site potential is greater than 17.8 ^oC, the target is no more than a 0.14 ^oC increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population	Full SR-HC TMDL reach (RM 409 to 188), year-round

Parameter	Selected Target	Where Applied
• Salmonid spawning, when and where it occurs for specific species	then the target is no greater than 0.14 ^oC increase from anthropogenic sources. A maximum weekly maximum temperature of 13 ^oC (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^oC. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^oC, the target is no more than a 0.14 ^oC increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^oC increase from anthropogenic sources. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188), October 23 to April 15
Total Dissolved Gases	Less than 110%	Oxbow Reservoir to the Salmon River Inflow (RM 285 to 188), year-round

TMDL summaries are not included for the bacteria and the pH listings for the Upstream Snake River and Brownlee Reservoir segments as data show that targets are being met and both are recommended for delisting by the State of Idaho. No final TMDL could be prepared for mercury due to a lack of water column data. This TMDL has been postponed to 2006. Data will be collected during the intervening time period and a full assessment completed by 2006. TMDL summaries for all other listed pollutants follow.

NUTRIENTS, NUISANCE ALGAE, DISSOLVED OXYGEN (DO)

Pollutant of Concern:	*Nutrients, Nuisance Algae, Dissolved Oxygen*
Segments Listed: (See Tables A-1 and B-1 for specific stream segments)	Idaho: Upstream Snake River, Brownlee Reservoir, Oxbow Reservoir Oregon: None
Uses Affected:	Aesthetics, Recreation, Resident Fish and Aquatic Life At Risk: Domestic Water Supply
Known Sources:	Point source discharges including municipal, stormwater and industrial discharges Nonpoint sources including agriculture, stormwater and natural loading Tributary inflows to the SR-HC TMDL reach Reduced assimilative capacity due to impoundments
Indications of Impairment:	Excessive algae growth occurring in the Upstream Snake River segment (RM 409 to 335), excessive algae growth in the upstream sections of Brownlee Reservoir and associated dissolved oxygen problems.
Target(s): (see Table 2.2.2 for further detail)	A minimum of 6.5 mg/L dissolved oxygen for listed segments upstream of Hells Canyon Dam, minimum of 8 mg/L dissolved oxygen downstream. No greater than 14 ug/L mean growing season chlorophyll *a* limit (nuisance threshold of 30 ug/L). A maximum of 0.07 mg/L total phosphorus instream.
Critical Conditions:	Dissolved oxygen requires year round application of the target Chlorophyll *a* and total phosphorus target attainment critical May through September.
Capacity: (total phosphorus, May through September)	Upstream Snake River: 2,735 kg/day Brownlee Reservoir: 2,829 kg/day Oxbow Reservoir: 2,839 kg/day
Loading: (total phosphorus, May through September)	Point Sources: 516 kg/day at design flow Nonpoint Sources: Upstream Snake River: 5,899 kg/day Brownlee Reservoir: 3,288 kg/day (calculated at Brownlee Dam) Oxbow Reservoir: 2,918 kg/day (calculated at Oxbow Dam)
TMDL:	Written for all listed segments based on the 14 ug/L mean growing season chlorophyll *a* and 0.07 mg/L total phosphorus targets.
Waste Load Allocations: (total phosphorus, May through September)	All mechanical plants discharging directly to the Snake River within the SR-HC TMDL reach will attain 80% reduction in total phosphorus loading. Lagoon system waste load allocations are set at existing design-flow loading.
Load Allocations*: (*values were determined for an average water year and include natural loading. Target is no greater than 0.07 mg/L total phosphorus instream.) (total phosphorus, May through September)	Snake River inflow: 1,379 kg/day Owyhee River inflow: 71 kg/day Boise River inflow: 242 kg/day Malheur River inflow: 58 kg/day Payette River inflow: 469 kg/day Weiser River inflow: 136 kg/day Drains: 91 kg/day Ungaged: 137 kg/day (including stormwater and overland agricultural runoff) Total Upstream Snake River (nonpoint sources): 2,735 kg/day Brownlee Reservoir: 2,829 kg/day Burnt River: 21 kg/day Powder River: 33 kg/day Oxbow Reservoir: 2,839 kg/day

Pollutant of Concern:	***Nutrients, Nuisance Algae, Dissolved Oxygen***
	Dissolved oxygen load allocation of 1,125 tons seasonally, specific to the transition zone and metalimnion of Brownlee Reservoir to offset reduction in assimilative capacity.
Margin of Safety:	Explicit 13% based on sampling and analytical error, and conservative assumptions
Implementation Time Frame:	Point source implementation within time frames identified by NPDES permit schedules. Nonpoint source implementation to begin with completion of site-specific implementation plans (18 months after approval of TMDL) and to proceed with all deliberate speed. Draft interim goals at 0.01 mg/L total phosphorus decrease in mainstem waters every 10 years Schedule specifics will be determined as part of the implementation planning process. The potential for long-term time frames (up to 70 years) for full system potential to be realized. Implementation of the dissolved oxygen load allocation to Brownlee Reservoir will be timed similar to the nonpoint source implementation schedule. If direct oxygenation is selected as the implementation mechanism, addition will be timed for those periods of low dissolved oxygen and correlated with reservoir monitoring to allow the most effective use of injected dissolved oxygen to the reservoir.
Monitoring Needs:	Point source monitoring of discharge concentrations to track progress, nonpoint/agency monitoring of mainstem concentrations to track progress.

More detail on the general points in the TMDL summary can be found in the loading analysis discussion in Section 3.0 and in the discussion of load allocations in Section 4.0.

PESTICIDES

Pollutant of Concern:	***Pesticides (DDT and Dieldrin, and degradation products)***
Segments Listed: (See Tables A-1 and B-1 for specific stream segments)	Idaho: Oxbow Reservoir Oregon: None
Uses Affected:	Fishing Additional data necessary to evaluate support status of cold water aquatic life/salmonid rearing, resident fish and aquatic life, wildlife and hunting
Known Sources:	Point source discharges are not considered to be significant sources of loading. Nonpoint sources include legacy pesticide application both within the SR-HC Subbasin and drainage area upstream, tributary inflows to the SR-HC TMDL reach and existing system loading from legacy application.
Indications of Impairment:	Fish tissue exceedences of DDT action levels (US EPA) and water column exceedences of SR-HC TMDL DDT and dieldrin targets.
Target(s): (see Table 2.2.2 for further detail)	Less than 0.024 ng/L water column concentration DDT Less than 0.83 ng/L water column concentration DDD Less than 0.59 ng/L water column concentration DDE Less than 0.07 ng/L water column concentration Dieldrin
Critical Conditions:	Year round
Capacity:	Upstream Snake River: 0.34 kg/year (t-DDT), 0.98 kg/year (dieldrin) Brownlee Reservoir: 0.37 kg/year (t-DDT), 1.1 kg/year (dieldrin) Oxbow Reservoir: 0.37 kg/year (t-DDT), 1.1 kg/year (dieldrin)
Loading:	Upstream Snake River: 42 grams/year (t-DDT), 28 kg/year (dieldrin) (Based on an extremely small data set)
TMDL:	Written for upstream and listed segment based on the water-column targets identified for DDT and dieldrin
Load Allocations:	Zero load allocation for new application. Bulk load allocation to point and nonpoint sources set at load capacity less 10% margin of safety.
Margin of Safety:	Explicit, 10%
Implementation Time Frame:	Concurrent with nonpoint source implementation as identified by sediment and nutrient TMDLs.
Monitoring Needs:	Nonpoint/agency monitoring of mainstem concentrations to determine loading, continued fish tissue monitoring to determine trends and progress monitoring.

More detail on the general points in the TMDL summary can be found in the loading analysis discussion in Section 3.0 and in the discussion of load allocations in Section 4.0.

SEDIMENT

Pollutant of Concern:	***Sediment***
Segments Listed: (See Tables A-1 and B-1 for specific stream segments)	Idaho: Upstream Snake River, Brownlee Reservoir, Oxbow Reservoir Oregon: None
Uses Affected:	Aesthetics, Recreation, Resident Fish and Aquatic Life, Fishing Duration data necessary to determine aquatic life use support status
Known Sources:	Point source discharges including municipal and industrial discharges. Nonpoint sources including agriculture, stormwater and natural loading, and tributary inflows to the SR-HC TMDL reach.
Indications of Impairment:	Lack or degradation of habitat, population decline. (See mercury, nutrient, and pesticide discussions for attached pollutant concerns.)
Target(s): (see Table 2.2.2 for further detail)	Less than or equal to 80 mg/L total suspended solids (TSS) for acute events lasting less than 14 days, and less than or equal to 50 mg TSS/L monthly average.
Critical Conditions:	Year round
Capacity: (TSS)	Upstream Snake River: 1,265,630 kg/day Brownlee Reservoir: 1,290,200 kg/day Oxbow Reservoir: 1,305,682 kg/day
Loading:	Point Sources: Design flow = 722 kg/day Nonpoint Sources: Upstream Snake River: 1,483,691 kg/day Brownlee Reservoir: loading cannot be calculated due to reservoir sink effect Oxbow Reservoir: loading cannot be calculated due to reservoir sink effect
TMDL:	Written for all listed segments based on the SR-HC TMDL TSS targets as protective for aquatic life and as indicators of changes in transport and delivery of attached pollutants.
Waste Load Allocations:	NPDES permits set at current limits for point source discharges.
Load Allocations and Threshold Values*: (* Threshold values are based on anti-degradation requirements established at currently measured loads)	Snake River inflow: 677,785 kg/day (threshold value) Owyhee River inflow: 48,007 kg/day Boise River inflow: 130,466 (threshold value) Malheur River inflow: 42,062 kg/day Payette River inflow: 137,887 kg/day (threshold value) Weiser River inflow: 53,617 kg/day (threshold value) Drains: 57,628 kg/day Ungaged: 118,178 kg/day, (including stormwater and overland agricultural runoff) Total Upstream Snake River (nonpoint sources): 1,265,630 kg/day Burnt River: 9,713 kg/day Powder River: 14,857 kg/day (threshold value)
Margin of Safety:	Explicit, 10%
Implementation Time Frame:	Nonpoint source implementation to begin concurrent with nutrient reduction measures. No additional implementation measures are expected based on sediment alone. If fully implemented, nutrient reduction measures should act to reduce sediment sufficient to meet load allocations. Schedule specifics will be determined as part of the implementation planning process. The potential for long-term time frames (up to 70 years) for full system potential to be realized.

Pollutant of Concern:	***Sediment***
Monitoring Needs:	Nonpoint/agency monitoring of duration-based concentrations in mainstem, and progress monitoring.

More detail on the general points in the TMDL summary can be found in the loading analysis discussion in Section 3.0 and in the discussion of load allocations in Section 4.0.

TEMPERATURE

Pollutant of Concern:	***Temperature***
Segments Listed: (See Tables A-1 and B-1 for specific stream segments)	Idaho: Downstream Snake River Oregon: Upstream Snake River, Brownlee Reservoir, Oxbow Reservoir, Hells Canyon Reservoir, Downstream Snake River
Uses Affected:	Cold Water Aquatic Life/Salmonid Rearing, Salmonid Spawning* (*below Hells Canyon Dam)
Known Sources:	Dominant source of loading is natural and non-quantifiable temperature influences. Non-quantifiable influences including the effects of upstream and tributary impoundments, water withdrawals, channel straightening and diking and removal of streamside vegetation. Point source discharges, including municipal, stormwater and industrial discharges, are sources of heating but are currently operating within the no measurable increase margin. Nonpoint sources include flow and temperature influences from agriculture, water management, geothermal (natural and urban/suburban sources, and tributary inflows to the SR-HC TMDL reach.
Indications of Impairment:	Exceedences of the temperature target for cool and cold water aquatic life and salmonid rearing occurring during June, July, August and September throughout the SR-HC TMDL reach. Exceedences were observed historically in the Upstream Snake River segment (RM 409 to 335) and in the reservoir segments before the impoundments were in place. Exceedences of the temperature target for salmonid spawning occurring during mid-October for fall chinook in the Downstream Snake River segment.
Target(s): (see Table 2.2.2 for further detail)	<u>Cold water Aquatic Life/Salmonid Rearing</u>: Less than 0.14 ^{o}C increase from anthropogenic sources when the site potential is greater than 17.8 ^{o}C <u>Salmonid Spawning</u>: A maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. Applicable to RM 247 to 188 only, from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish. Less than a 0.14 ^{o}C increase from anthropogenic sources when aquatic species listed under the Endangered Species Act are present and a temperature increase would impair the biological integrity of the Threatened and Endangered population. *Please see Table D for greater detail.*
Critical Conditions:	June through September for cold water aquatic life/salmonid rearing October 23rd through April 15th for salmonid spawning (below Hells Canyon Dam).
Capacity:	No measurable increase (defined as 0.14 ^{o}C for this TMDL) Upstream Snake River: less than 0.14 ^{o}C cumulative loading Brownlee Reservoir: less than 0.14 ^{o}C cumulative loading Oxbow Reservoir: less than 0.14 ^{o}C cumulative loading Hells Canyon Reservoir: less than 0.14 ^{o}C cumulative loading

Pollutant of Concern:	***Temperature***
	Downstream Snake River: less than 0.14 ^{o}C cumulative loading
Anthropogenic Loading:	Cold water aquatic life/salmonid rearing: Upstream Snake River: less than 0.05 ^{o}C cumulative loading Brownlee Reservoir: less than 0.013 ^{o}C cumulative loading Oxbow Reservoir: less than 0.013 ^{o}C cumulative loading Hells Canyon Reservoir: less than 0.008 ^{o}C cumulative loading Downstream Snake River: less than 0.005 ^{o}C cumulative loading Salmonid Spawning: Temporal shift at the outlet of Hells Canyon Dam. Water leaving the dam is warmer in the fall than upstream water temperatures and cooler in the spring than upstream water temperatures. Some of this temporal shift occurs during the spawning period for fall chinook (starting October 23). Exceedences of the salmonid spawning temperature occur from October 23 thorough 06 November immediately below the Hells Canyon Dam.
TMDL:	Written for all listed segments
Waste Load Allocations:	Cold water aquatic life/salmonid rearing: Current discharge loads applied to design flows to ensure that no measurable increase will not be exceeded Salmonid Spawning: not applicable
Load Allocations:	Cold water aquatic life/salmonid rearing: Anthropogenic nonpoint source loading less than 0.14 ^{o}C, Temperature assessments on a tributary drainage basis. Salmonid Spawning: Idaho Power Company ΔT resulting in water temperatures at the discharge of Hells Canyon Dam of no more than 0.14 ^{o}C above those observed at RM 345 or water temperatures less than 13 ^{o}C (daily maximum) at the discharge of Hells Canyon Dam, October 23rd through 15 April.
Margin of Safety:	Point Sources: Explicit MOS of 10% Nonpoint Sources: Implicit, as defined by criteria application in target.
Implementation Time Frame:	Point source implementation within time frames identified by NPDES permit schedules. Nonpoint source actions for nutrient/sediment reduction should include those practices that can result in localized temperature improvements such as revegetation of streambanks and efficient water usage. Implementation will follow nutrient/sediment implementation schedule. Tributary assessments of anthropogenic temperature influences as defined by tributary TMDL schedules.
Monitoring Needs:	Point source monitoring of discharge temperatures as part of routine reports, tributary monitoring to assess anthropogenic temperature influences, and progress monitoring.

More detail on the general points in the TMDL summary can be found in the loading analysis discussion in Section 3.0 and in the discussion of load allocations in Section 4.0.

TOTAL DISSOLVED GAS (TDG)

Pollutant of Concern:	***Total Dissolved Gas***
Segments Listed: (See Tables A-1 and B-1 for specific stream segments)	Idaho: None Oregon: None Addressed through request from Public Advisory Team members
Uses Affected:	Resident Fish and Aquatic Life, Cold Water Aquatic Life/Salmonid Rearing
Known Sources:	Spill from Brownlee and Hells Canyon Reservoirs
Indications of Impairment:	Greater than 110% of total dissolved gas saturation Gas bubble disease in fish Exceedences of the total dissolved gas target are observed to occur in Oxbow, Hells Canyon reservoirs and in the Downstream Snake River segment during periods of spill.
Target(s):	Less than 110% of saturation (see Table 2.2.2 for further detail)
Critical Conditions:	Year round
Capacity:	Less than 110% of saturation
Loading:	Oxbow and Hells Canyon Reservoir segments: 114% to 128% saturation during spill from Brownlee Dam. Downstream Snake River segment: 108% to 136% saturation during spill from Hells Canyon Dam.
TMDL:	Written for the Oxbow Reservoir, Hells Canyon Reservoir and Downstream Snake River segments.
Waste Load Allocations:	No point source loading for total dissolved gas.
Load Allocations:	Less than 110% of saturation at the edge of the aerated zone below Brownlee Dam, Oxbow Dam and Hells Canyon Dam.
Margin of Safety:	Implicit, using conservative criteria established for protection of designated aquatic life uses.
Implementation Time Frame:	Appropriate to engineering and design/operation studies to identify mechanisms to reduce saturation. Commensurate with correlated FERC and 401 Certification process requirements.
Monitoring Needs:	Monitoring of discharge total dissolved gas concentrations as part of routine progress monitoring.

More detail on the general points in the TMDL summary can be found in the loading analysis discussion in Section 3.0 and in the discussion of load allocations in Section 4.0.

Reasonable Assurance

All identified point sources discharging to the Snake River within the SR-HC TMDL reach are permitted facilities administered by the US EPA (Idaho facilities) or the State of Oregon (Oregon facilities). Wasteload (WLAs) reductions can be precipitated by modification of the NPDES permit. However, the load reductions needed to achieve desired water quality and restore full support of designated beneficial uses in the SR-HC TMDL reach will not be achieved in entirety by upgrades of the point sources.

For watersheds that have a combination of point and nonpoint sources where pollution reduction goals can only be achieved by including some nonpoint source reduction, a reasonable assurance that reductions will be met must be incorporated into the TMDL. The load reductions for the SR-HC TMDL will rely on nonpoint source reductions to meet the load allocations to achieve desired water quality and to restore designated beneficial uses. To ensure that nonpoint source reduction mechanisms are operating effectively, and to give some quantitative indication of the reduction efficiency for in-place BMPs, monitoring will be conducted. The monitoring will not be carried out on a site-specific basis but rather as a suite of indicator analyses monitored at the inflow and outflow of the segments within the SR-HC TMDL reach and at other appropriate locations such as the inflow of tributaries.

The states have responsibility under Section 401 of the CWA to provide water-quality certification. Under this authority, the states review projects to determine applicability to local water-quality issues. The State of Idaho and State of Oregon water-quality standards refer to other programs whose mission is to control nonpoint pollution sources. Some of these programs and responsible agencies are listed in Table E.

Table E. State regulatory authority for nonpoint pollution sources.

Citation	Idaho responsible agency	Oregon responsible agency
Rules governing forest practices	Idaho Department of Lands	Oregon Department of Forestry
Rules governing solid waste management	Idaho Department of Environmental Quality / Health Districts	Oregon Department of Environmental Quality
Rules governing subsurface and individual sewage disposal systems	Idaho Department of Environmental Quality / Health Districts	Oregon Department of Environmental Quality
Rules and standards for stream channel alteration	Idaho Department of Water Resources	Oregon Division of State Lands
Rules governing exploration and surface mining operations	Idaho Department of Lands	Oregon Department of Geology and Mineral Industries
Rules governing placer and dredge mining	Idaho Department of Lands	Oregon Division of State Lands
Rules governing dairy waste	Idaho Department of Agriculture	Oregon Department of Agriculture

If instream monitoring indicates an increasing pollutant concentration trend (not directly attributable to environmental conditions) or a violation of standards despite use of approved

BMPs or knowledgeable and reasonable efforts, then BMPs for the nonpoint sources 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 "feedback loop" in which BMPs or other efforts are periodically monitored and modified if necessary to ensure protection of beneficial uses. With continued instream monitoring, the TMDL will initiate the feedback loop process and will evaluate the success of BMP implementation and its effectiveness in controlling nonpoint source pollution.

If a nonpoint pollutant(s) is determined to be impacting beneficial uses and the activity already has in-place referenced BMPs, or knowledgeable and reasonable practices, the state may request the BMPs be evaluated and/or modified to determine appropriate actions. If evaluations and/or modifications do not occur, injunctive relief may be requested (IDAPA 16.01.02350.2, ii (1); OAR 46EB.025 and 46EB.050).

It is expected that a voluntary approach will be able to achieve load allocations needed. Public involvement along with the commitment of the agricultural community have demonstrated a willingness to implement BMPs and protect water quality. In the past, cost-share programs have provided the agricultural community technical assistance, information and education, and the cost share incentives to implement BMPs. The continued funding of these projects will be critical for the load allocations to be achieved in the SR-HC TMDL.

Water Quality Management Plan and General Implementation Plan

To fulfil the requirements of the State of Oregon TMDL process, a Water Quality Management Plan or Implementation Plan must be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, a general plan will be submitted with the SR-HC TMDL.

A general document is being submitted to fulfill the requirements of the TMDL process. However, substantial differences in state procedure and policy for implementation of TMDLs exist between Oregon and Idaho. Therefore, this document contains two separate, state-specific plans: the State of Oregon General Water Quality Management plan, and the State of Idaho General Implementation Plan. Together, these documents represent the general water quality management plan (implementation plan) for the SR-HC TMDL. More detailed, site-specific implementation plans will be prepared within 18 months of the approval of the SR-HC TMDL.

Conclusions

There is a substantial amount of data available to this effort. While some parameters will require additional monitoring in order to complete the TMDL process, this robust database has made an initial assessment of system needs and designated use requirements possible. The following, general conclusions are the result of the assessment and TMDL process:

- Bacteria and pH listings were not found to be supported by the data and have been recommended for delisting.

- Mercury concentrations were observed to be in excess of the SR-HC TMDL fish tissue targets in over 85% of the data and fish tissue consumption advisories remain in place, but no final TMDL could be prepared due to a lack of water column data. This TMDL has been postponed to 2006. Data will be collected during the intervening time period and a full assessment completed by 2006.

- The assessment of water quality conditions within the SR-HC TMDL reach identified designated beneficial use impairment from excessive nutrient loading in the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir (RM 335 to 285) segments.

- While little data were available for pesticides within the SR-HC TMDL reach, and no data were available for the listed segment (Oxbow Reservoir), the data available indicate that pesticide transport within the SR-HC TMDL reach should be minimized. Implementation of concurrent pollutant reductions for total phosphorus is projected to result in reductions in pesticide transport and delivery within the SR-HC TMDL reach.

- Similarly, the influence of sediment, listed as a pollutant in the Upstream Snake River, Brownlee and Oxbow Reservoir segments, on aquatic life uses could not be fully assessed due to lack of duration data. However, excessive concentrations of sediment were identified based on monthly averages from some tributary and drain inflows. Additionally, sediment was identified as a transport mechanism for mercury, pesticides and nutrients within the SR-HC TMDL reach.

- Atmospheric and non-quantifiable influences were identified as the primary source of temperature exceedences and an in-depth evaluation of cold water refugia in the reservoirs demonstrated the critical nature of such habitat to the arid SR-HC TMDL reach.

- Total dissolved gas was identified as a pollutant of concern by SR-HC PAT members and an assessment of exceedences and impairment was completed. Exceedences of the total dissolved gas target were observed to be the result of spill over Brownlee and Hells Canyon Dams. Load allocations to meet the water quality targets were assigned to the Brownlee and Hells Canyon Dams.

As demonstrated by the size and diversity of the issues addressed in this document, the SR-HC TMDL reach is a highly complex system and will no doubt yield unexpected results as implementation and further data collection proceeds. The challenges encountered in determining designated beneficial use support and system impairment are an outgrowth of this complexity and will require additional assessment and revisitation as our understanding of the system evolves. Additionally, due to the complexity encountered and the enormous geographic scope of this effort, an extended time period for implementation and system response will be required. Generally, TMDL processes are expected to be completed within ten to 15 years of approval, this system, with its sequential tributary TMDL processes, wide diversity of land use and staggering size will not doubt require several decades to respond completely to implementation projects and changes in management.

Because of the complex nature and the extended time frame required, it is absolutely critical that the SR-HC TMDL remain a truly iterative process whereby our improved understanding of the system can be re-applied to the initial targets and goals as time passes, and that these targets and goals can be updated to better reflect system needs and appropriate management.

Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Section 1.0 General Information

Snake River near Nyssa, Oregon circa 1939, Photo by Dr. Lyle Stanford

1.0 General Information

1.0.1 Total Maximum Daily Loads (TMDLs)

The SR-HC TMDL is one of many currently planned or in progress in the states of Oregon and Idaho. The TMDL process is described in §303(d) of the CWA (40 CFR 130.7), the rules implementing §303(d), and Oregon and Idaho Code (OAR Chapter 340, ORS Chapter 468 and Idaho §39-3611, respectively). The following sections offer answers to some of the questions commonly asked about the TMDL process. The information has been collected from a number of state and federal sources. References are cited with specific information in the following sections.

1.0.1.1 WHAT IS A TMDL?

A Total Maximum Daily Load (TMDL) is the amount of an identified pollutant that a specific stream, lake, river or other waterbody can 'accommodate' without violating state water quality standards.

TMDLs are watershed-based plans for restoration of designated beneficial uses in water quality limited waterbodies. These plans must identify the causes of designated beneficial use impairment and estimate reductions in pollutant loads necessary to meet water quality standards and restore impaired designated beneficial uses within a specified time.

Briefly, the TMDL process involves evaluating the available data from 303(d) listed waterbodies to determine point and nonpoint source pollution loads and using the data to set maximum allowable loads from each of these sources. Loads are the quantity of pollution contributed to a stream by a single source (i.e., a wastewater treatment plant) or by a group of sources (i.e., all developments or agricultural fields along a stream).

In this framework, a TMDL can be best described as a watershed or basin-wide budget for pollutant loading to a watercourse. A TMDL, in actuality, is a planning document. The "allowable budget" is first determined by scientific study of a stream to determine the amount of pollutants that can be assimilated without causing the stream to exceed the water quality standards set to protect the stream's designated beneficial uses (e.g., fishing, domestic water supply, etc.). This amount of pollutant loading is known as the *loading capacity*. It is established taking into account seasonal variations, natural and background loading, and a margin of safety. Once the loading capacity is determined, sources of the pollutants are considered. Both *point* and *nonpoint sources* must be included.

Point Sources.

Point sources of pollution, such as wastewater treatment plants, typically involve pipes that convey discharges directly into streams. A point source is simply described as a discrete discharge of pollutants as through a pipe or similar conveyance. A technical definition exists in federal regulation at 40 CFR 122.2.

Nonpoint Sources.
Nonpoint sources, such as farms, lawns, or construction sites contribute pollution diffusely through run-off. Examples are sheet flow from pastures and runoff from forest logging. Nonpoint sources may include (but are not limited to), run-off (urban, agricultural, forestry, etc.), leaking underground storage tanks, unconfined aquifers, septic systems, farms, lawns, construction sites, stream channel alteration, and damage to a riparian area.

Once all the sources are accounted for, the pollutants are then allocated or budgeted among the sources in a manner which will describe the maximum amount of each pollutant (the total maximum load) that can be discharged into a waterbody without causing water quality standards to be exceeded. The load allocations distributed among the sources indicate the maximum amount of a pollutant that can be discharged, or the reduction in pollutant loading required of both point and nonpoint sources. Ultimately the responsibility for improving water quality lies on the shoulders of everyone who lives works or recreates in a watershed that drains into an impaired waterbody.

Load Allocations.
Load allocations are simply the amounts of pollutants that can be discharged from each source or land use category and still ensure that the total pollutant load does not exceed the loading capacity. The TMDL does not specify how the dischargers must attain their particular load allocation. The TMDL will not set best management practices for a discharger or otherwise tell the discharger how to meet their goal; it merely sets their goal.

Nonpoint sources are grouped into a *load allocation* (LA) and point sources are grouped into a *wasteload allocation* (WLA). By federal regulation, the total load capacity "budget" must also include a *margin of safety* (MOS). The MOS accounts for uncertainty in the loading calculation. The MOS may not be the same for different waterbodies due to differences in the availability and strength of data used in the calculations. All together,

Loading capacity = **TMDL = WLAs + LAs + Margin of Safety**

The (point source) WLA is implemented through an existing regulatory program under the federal Clean Water Act (CWA) called the National Pollutant Discharge Elimination System (NPDES) permit program (CWA Section 402). These permits set effluent quality limitations and require implementation of best available technologies that may include specific best management practices already established by the US EPA through regulation. Provided that a viable trading framework is in place, pollutant trading is allowed between, or within, the load allocation and the wasteload allocation categories. The MOS cannot be traded.

In most cases, pollution load data already exists for most permitted point sources through the NPDES permitting process. Similar data is seldom available for nonpoint sources. Therefore, the TMDL process must develop load calculations for nonpoint sources of pollution and for natural sources of pollution. In many circumstances, nonpoint source contributions will be broken down into additional categories such as agriculture, development, forestry, or mining.

Because it is difficult to identify specific nonpoint sources of pollution, it is unlikely that data will be collected on individual nonpoint sources (or landowners) along a waterbody. Instead, most TMDLs focus on estimating the cumulative or combined contribution of all nonpoint sources along a waterbody.

1.0.1.2 WHY SHOULD TMDLS BE WRITTEN?

TMDLs are focused primarily on developing accurate estimates of the contribution of nonpoint sources to total pollution loads in streams. In Oregon and Idaho, as in many other states, the process of identifying streams for TMDL development, developing the proper methods to calculate loads from all pollution sources, and implementing programs to reduce loads in order to meet water-quality goals is just beginning. Although it is expected that this entire process could take 10 to 15 years to complete for all waterbodies requiring a TMDL, some will be completed much more quickly and others may take much longer, depending on the cause of impairment and whether or not the waterbody attains water-quality standards.

Over the past 25 years, pollution control under the CWA has focused on point sources of pollution through the NPDES permitting process. While water quality has improved in many instances, the goals of the CWA have not been met in a number of streams. Data from the US EPA suggest that nonpoint sources are now the largest source of pollution in streams and lakes (U.S. EPA, 1998).

TMDLs are expected to help identify and more fully understand specific links between sources and aggregate pollution loads in streams. The US EPA expects that the data collected as part of this process will help target local, state, and federal efforts on improving water quality enough to meet regulatory standards.

1.0.1.3 WHO IS RESPONSIBLE FOR WRITING TMDLS?

The federal CWA provides that the States have the first right to establish TMDLs. In Oregon and Idaho, the bulk of the TMDL work is done by each state's Department of Environmental Quality and submitted to the US EPA. However, if the States do not set TMDLs to US EPA's satisfaction, then US EPA is required to do so (CWA Section 303(d)).

Both federal and state statutes require the opportunity for public participation in the TMDL process. This participation may include any permittee (point sources), affected landowners (nonpoint sources), regulatory or management agencies, local governments, public interest groups, and concerned citizens. Watershed associations, or similar local organizations, are encouraged to foster communication, planning, and consensus among those concerned.

1.0.1.4 ARE THERE SPECIFIC ELEMENTS THAT A TMDL SHOULD INCLUDE?

According to the IDEQ document <u>Guidance for the Preparation of Total Maximum Daily Loads</u> (1999a), TMDLs generally consist of three major sections:

1) subbasin assessment,
2) loading analysis, and
3) implementation plan(s).

Subbasin Assessment.
Subbasin assessments are problem assessments conducted at the geographic scale of 4th field hydrologic units (cataloging units of the USGS), also referred to as subbasins. A subbasin assessment describes the affected area, the water quality concerns and status of designated beneficial uses of individual water bodies, nature and location of pollution sources, and a summary of past and ongoing pollution control activities. The SR-HC TMDL has chosen the approach of subbasin assessments as a way to package adjacent waters and gain economy of scale in preparation of documents.

Loading Analysis.
A loading analysis provides an estimate of a waterbody's pollutant load capacity, a margin of safety, and allocations of load to pollutant sources defined as the TMDL in EPA regulations (40 CFR 130.2). Allocations are required for each permitted point source and categories of nonpoint sources whose sum will meet the load capacity with load to spare as a margin of safety. Minor nonpoint sources may receive a lumped allocation.

Generally, a loading analysis is required for each pollutant of concern. But it is recognized that some listed pollutants are really water quality problems that are the result of other pollutants. For example, habitat affected by sediment or dissolved oxygen affected by nutrients causing nuisance aquatic growths. In these cases one listed stressor may be addressed by the loading analysis of another.

While it is intended that loading analyses be a quantitative assessment of pollutant loads, federal regulations allow that '*loads may be expressed as mass per unit time, toxicity, or other appropriate measures'* (40 CFR 130.2(I), emphasis added). In many cases, less data will be available than may be considered optimal for loading analysis. This cannot delay TMDL development. Federal regulations also acknowledge that *'load allocations are best estimates of the loading, which may vary from reasonably accurate estimates to gross allotments'* (40 CFR 130.2(g) emphasis added). Load allocations are for nonpoint sources.

A complete loading analysis lays out a general pollution control strategy and an expected time frame in which water quality standards will be met. For narrative criteria, e.g. sediment and nutrients, the measure of attainment of water quality standards is full support of designated beneficial uses. Long recovery periods (greater than five years) are expected for TMDLs dealing with nonpoint sediment or temperature sources. Interim water quality targets are recommended in these instances. Along with the load reductions, these targets set the sideboards in which specific actions are scheduled in the subsequent implementation plan.

Implementation Plan.
The implementation plan is guided by the TMDL and provides details of actions needed to achieve load allocations, a schedule of those actions, and follow up monitoring to document progress or provide other desired data. Implementation plans specify local actions that will lead to the goal of full support of designated beneficial uses. Important elements of these plans are:

- Implementation actions based on the load allocations identified in the TMDL
- An estimated time by which water quality standards are expected to be met,

including interim goals or milestones as deemed appropriate

- A schedule specifying, what, where, and when actions to reduce loads are to take place
- Identification of who will be responsible for undertaking each planned action
- A plan specifying how accomplishments of actions will be tracked
- A monitoring plan to refine the TMDL and/or document attainment of water quality standards

There may be more than one implementation plan to cover different water quality limited waterbodies within a subbasin, as in the case of the SR-HC TMDL. This TMDL has been prepared as a bi-state process between Idaho and Oregon. To fulfil the requirements of the State of Oregon TMDL process, an implementation plan must be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, a general implementation plan is being submitted with the SR-HC TMDL and other, more detailed plans will be prepared and submitted according to the appropriate IDEQ or ODEQ schedule and procedure. Together, these documents will represent the general water quality management plan (implementation plan) for the SR-HC TMDL.

1.0.1.5 SNAKE RIVER - HELLS CANYON TMDL GENERAL PROCESS INFORMATION

The water quality of the SR-HC TMDL reach has been identified as impaired as specified under §303(d) of the CWA. As required by §303(d) of the federal CWA, the states of Oregon and Idaho must identify state waters not achieving water quality standards in spite of application of technology-based controls in NPDES permits and others for point sources (40 CFR 130.7). Such waterbodies are known as water quality limited segments (WQLSs). Once a waterbody is identified as a WQLS, the states of Oregon and Idaho are then required under the 40 CFR 130.7 and Oregon and Idaho Code (Oregon's Administrative Rules (OAR) Chapter 340, and Oregon's Revised Statutes (ORS) Chapter 468 and Idaho §39-3601 *et seq.* respectively*)* to develop a TMDL for each of the pollutants listed as impairing the stream. If the states of Oregon and Idaho default on their obligation to develop management plans, or TMDLs, to achieve water quality standards, then the US EPA is required to develop TMDLs.

The SR-HC TMDL is a plan formulated to restore good water quality conditions in the SR-HC TMDL reach through reduction of pollutant concentrations to levels that satisfy water quality standards. The plan will focus on pollutant reduction in the watershed and will be implemented in phases. In a phased TMDL much is yet unknown and the initial loading analysis may be inexact with a large margin of safety to account for uncertainty. The initial phase focuses on what is known. Interim load reductions move toward the eventual goal (by targeting more obvious source problems in the implementation plan). Essential to this approach is inclusion, in the final implementation plans, of a plan to gather the data needed to refine load estimates and their allocation. The phased implementation approach is utilized because of the complexity of the system; lack of data for some listed pollutants; uncertainty associated with the positive benefits from projects already operating within the SR-HC TMDL reach and in upstream and tributary watersheds; uncertainty associated with actual pollutant loading from various sources (natural, point and nonpoint sources); and in recognition that achieving water quality standards will most likely require a significant amount of time, during which the understanding of pollutant loads, their effect and control will expand and improve.

Calculating the exact pollutant load for nonpoint source pollutants is difficult and often dependent on weather conditions. Therefore, a TMDL with phased implementation is necessary that identifies interim milestones for load allocations, with further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality in the SR-HC TMDL reach.

The SR-HC TMDL complies with state and federal requirements. Substantial funding and personnel time have been committed to this process by federal agencies (including US EPA, US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), US Bureau of Reclamation (USBR), US Forest Service (USFS), US Geological Survey (USGS), US Department of Agriculture (USDA), tribal entities (Nez Perce and Shoshone-Paiute), the states of Oregon and Idaho (including ODEQ, Oregon Department of Fish and Wildlife (ODFW), Oregon Water Resources Department (OWRD), Oregon Department of Agricultural (ODA), IDEQ, Idaho Department of Fish and Game (IDFG), Idaho Department of Health and Welfare (IDHW), Idaho Department of Agriculture (IDA), and numerous other entities (including local industries, municipalities, soil and water conservation districts (SWCDs), watershed councils, irrigation districts and companies and private citizens) to collect and evaluate data, and to develop, review and implement this TMDL. Local citizens and industries throughout the watershed have been instrumental in developing this TMDL. A key component of this TMDL is the implementation of pollutant management plans adopted at the local level.

1.0.1.6 THE PHASED APPROACH

The SR-HC TMDL is a phased or iterative TMDL. Under this approach (defined in US EPA's Guidance for Water Quality-Based Decisions: The TMDL Process (US EPA, 1991c)), the TMDL has established load and waste load allocations calculated with margins of safety to meet water quality standards. The allocations are based on estimates that use available data and information, but monitoring for collection of new data is required. The phased approach provides for further pollution reduction without waiting for new data collection and analysis. The margin of safety developed for the TMDL under the phased approach reflects the adequacy of data and the degree of uncertainty about the relationship between load allocations and receiving water quality.

The TMDL, under the phased approach, includes (1) WLAs that confirm existing limits or would lead to new limits for point sources and (2) LAs that confirm existing controls or include implementing new controls for nonpoint sources. This TMDL requires additional data to be collected to determine if the load reductions required by the TMDL lead to attainment of water quality standards. Data collection may also be required to more accurately determine assimilative capacities and pollution allocations.

In addition to the allocations for point and nonpoint sources, the phased approach of this TMDL will establish the schedule or timetable for the installation and evaluation of point and nonpoint source control measures, data collection, the assessment for water quality standards attainment, and, if needed, additional predictive modeling. The scheduling with this approach will be developed to coordinate all the various activities (permitting, monitoring, modeling, etc.) and involve all appropriate local authorities and State and Federal agencies. The schedule for the installation and implementation of control measures and their subsequent evaluations will include descriptions of the types of controls, the expected pollutant reductions, and the time frame within which water quality standards will be met and controls re-evaluated. This information will be developed as part of the site-specific implementation plans to be completed within 18 months following the approval of this TMDL by US EPA.

As no monitoring program currently exists for the majority of this TMDL reach, and as additional assessments are needed for both pollutants and implementation progress, it will be necessary for the States to design and implement a monitoring plan. The objectives of the monitoring program should include assessment of water quality standards attainment, verification of pollution source allocations, calibration or modification of selected models, calculation of dilutions and pollutant mass balances, and evaluation of point and nonpoint source control effectiveness. In their monitoring programs, the States should include a description of data collection methodologies and quality assurance/quality control procedures, a review of current discharge monitoring reports, and be integrated with volunteer and cooperative monitoring programs where possible. If properly designed and implemented, the monitoring program will result in a sufficient database for assessment of water quality standard attainment and additional predictive modeling if necessary. This plan will be developed as part of the site-specific implementation plans to be completed within 18 months following the approval of this TMDL by US EPA.

1.0.1.7 State Water Quality Standards

The water quality standards specific to the SR-HC TMDL process were set by the respective states through a public process that includes public participation and hearings. Federal law requires the states to review the standards at least once every three years. Standards adopted by the states ultimately must be approved by the US EPA (Clean Water Act Section 303). If the US EPA does not approve the standards adopted by the states then they may either refer them back to the states or promulgate their own standards for the states.

1.0.2 Clean Water Act Overview and Statutory History

The Federal Water Pollution Control Act is the primary federal legislation that protects surface waters such as lakes and rivers. This legislation, originally enacted in 1948, was further expanded and enhanced in 1972; in the 1977 amendments it became known as the “Clean Water Act”. Since 1972, the CWA has undergone many changes, amendments and additions. The Act currently in place today contains much that the original 1972 version did not. It has been and continues to be subject to change as new information and a more complete understanding of the natural system and our impacts (both positive and negative) are identified. A short history of the CWA is presented in the following paragraphs. A more thorough discussion of the CWA can be found in *The Clean Water Act: An Owners Manual* (Elder et. al., 1999).

The main purpose of the CWA is the improvement and protection of water quality through restoration and maintenance of the physical, chemical and biological integrity of the nation's waterways. The CWA provides a mechanism whereby the status of the nation’s waters can be evaluated, beneficial uses for specific water bodies designated and water quality criteria established to protect those designated beneficial uses.

Initial attempts to control pollution of the nation's waterways occurred in the late 19th century (Refuse Act of 1899). The first comprehensive water quality legislation was the Water Pollution Control Act (WPCA) of 1948, which was adopted after four decades of debate over the role of the federal government in addressing water quality issues. The WPCA resulted in a statutory framework that included shared State and Federal program development responsibilities, limited Federal enforcement authority, and limited financial assistance. These concepts were continued in the Federal Water Pollution Control Act (FWPCA) of 1956 and in the Water Quality Act of 1965.

The 1972 amendments to the FWPCA (commonly know as the CWA), established a broader federal role through the establishment of a water quality standards program, a national discharge permitting system for municipal and industrial sources, technology-based effluent standards, and Federal grants for municipal wastewater treatment facilities. Section 303 of the 1972 FWPCA established the statutory basis for the current water quality standards program, TMDLs, and standards implementation for point and nonpoint sources.

1.0.2.1 REGULATORY HISTORY

The Clean Water Act (1972 FWPCA) saw major revisions in 1977 and 1987, with the 1987 revisions being most significant. US EPA first published regulations for water quality standards in 1975 (40 CFR 130.17, 40 FR 55334, November 28, 1975) as part of the water quality management regulations mandated in section 303(e) of the CWA. The 1978 regulation required "appropriate" water quality criteria to support designated uses and did not address toxic pollutants.

The original regulation was revised on November 8, 1983 (40 CFR 131) and is a more comprehensive regulation that addresses legal and programmatic concerns and public, political, and agency concerns that toxic pollutants were not being effectively controlled.

The 1987 revisions to the CWA included phasing out of the grants program for municipal wastewater treatment facilities and adoption of a new toxic pollutant control approach (e.g. required adoption of numeric toxic criteria and NPDES permit limitations for toxic pollutants).

1.0.2.2 ADDITIONAL CLEAN WATER ACT INFORMATION

Under the recently revised federal regulations (US EPA, 2000b), section 303(d) of the CWA each state is required to submit a list to the US EPA identifying waters throughout the state that are not achieving state water quality standards in spite of the application of technology-based controls in NPDES permits (40 CFR 130.7(b)(1)). These recently revised (but as yet unapproved) rules require that the first list must be submitted in 2002, and that an updated list be submitted every five (5) years after that. Current rules require that an updated 303(d) list be submitted every two (2) years. The waters identified on the 303(d) list are known as water quality limited waters. They are those waters that do not meet water quality standards and therefore still require a TMDL in spite of the application of technology-based controls in NPDES permits. IDEQ and ODEQ are directed by state statute (see Idaho Code 39-3601 *et seq*., and

OAR Chapter 340, and ORS Chapter 468) to develop TMDLs for these waters. Once developed, TMDLs are submitted to the US EPA for approval.

This document is being written under the guidance of current federal TMDL rules. The newly revised federal rules (US EPA, 2000b) may become effective after the submission date of this TMDL document. However these new rules allow states to choose between the application of the former TMDL rules and the new TMDL rules for some TMDLs (Section 130.37, section II-W on pages 43635-43636; US EPA, 2000b). The states of Oregon and Idaho have selected to write the SR-HC TMDL under the former TMDL rules, therefore, the structure and content of this document reflect a combination of those state (Oregon and Idaho) and federal requirements in place at the beginning of this TMDL effort (November 1999) (Appendix A).

1.0.3 Federal and State Water Quality Laws

The federal Water Pollution Control Act of 1972, as amended (33 U.S.C. §§ 1251 through 1371), commonly known as the CWA, comprehensively addresses water quality and pollution controls through the establishment of state and federal regulatory roles and responsibilities. The states' roles under the CWA include the development and enforcement of water quality standards, the control of nonpoint source activities to achieve attainment of water quality goals, the identification of WQLSs, and the development of TMDLs. The state agencies principally responsible for the development, implementation, and enforcement of Oregon and Idaho water quality standards and fulfilling Oregon's and Idaho's obligations under the CWA are ODEQ and IDEQ. (See generally Oregon Code OAR Chapter 340, ORS Chapter 468 and Idaho Code §§ 39-105 and 39-3601 *et seq.).*

The federal government's roles under the CWA include regulating the discharge of pollutants from point sources by establishing technology-based controls in point source (NPDES) permits. This responsibility has been delegated to the states in some instances (including Oregon). The federal government, through the US EPA, also oversees state obligations under the CWA, by approving state water quality standards, state WQLS lists, and state and interstate TMDLs.

1.0.3.1 State of Idaho TMDL Background and Water Quality Legislation

In 1993, two Idaho environmental organizations filed a citizen suit authorized under the CWA in federal district court in Seattle against the US EPA. This suit alleged that: (1) the US EPA violated §303(d) of the CWA in approving Idaho's 1992 WQLS list because the list did not identify all impaired state waters; and, (2) the US EPA should develop TMDLs for all Idaho WQLSs since Idaho had not developed TMDLs in a timely fashion in the past.

While the lawsuit was pending, Idaho submitted its 1994 WQLS list to the US EPA for approval. The list included 62 waterbodies. However, in April 1994 the court found that the submission of Idaho's prior WQLS list was "underinclusive" and ordered the US EPA to publish a new list. The US EPA published a final WQLS list for Idaho in October 1994, which included 962 waterbodies. Most of the 962 waterbodies have not been scientifically monitored to determine compliance with water quality standards. In May 1995, the court ordered the US EPA to establish a reasonable and complete schedule with the State of Idaho to develop TMDLs on all WQLSs because the court was concerned about the pace of TMDL development in Idaho (1997).

The issues raised in the §303(d) lawsuit highlighted the need to: (1) develop a comprehensive statewide process to monitor water quality on all state waters; and, (2) develop TMDLs on those waterbodies that were not achieving water quality standards.

In 1995, the Idaho legislature passed Idaho Code §39-3601 *et seq.* regarding the administration of water quality laws in the State of Idaho. Idaho Code §39-3601 *et seq.* requires IDEQ to monitor all waterbodies throughout the state to determine compliance with water quality standards. On those waterbodies not complying with water quality standards, IDEQ is then required to develop TMDLs on a priority basis to ensure attainment of water quality standards. A critical component of Idaho's water quality legislation is the establishment of citizen advisory groups that advise IDEQ on the development of TMDLs and other pollution control strategies on WQLSs.

As required by order of the court, in May 1996, the State of Idaho and the US EPA submitted a schedule to the court for short-term and long-term development of TMDLs. The schedule anticipated that all 962 WQLSs would be monitored by 1997, and thereafter TMDLs would be developed on those waterbodies which monitoring indicates do not comply with state water quality standards. On those waterbodies where monitoring has previously determined non-attainment of water quality standards, such as the SR-HC TMDL reach, the state has committed to the development of TMDLs on a short-term basis. Thus, on the SR-HC TMDL reach, the state has committed to the development of a TMDL to be submitted to the US EPA on completion.

1.0.3.2 State of Oregon TMDL Background and Water Quality Legislation

The State of Oregon has been involved in a legal process regarding TMDLs similar to that described above for the State of Idaho. Following a lawsuit filed by Northwest Environmental Defense Center (NEDC) against the US EPA based on US EPA's failure to ensure ODEQ's development of TMDLs, a Consent Order was entered into in 1987 between US EPA and NEDC. The Consent Order committed ODEQ to complete TMDLs on several specific waterbodies, and to complete a specific percent of TMDLs per year given the number of waterbodies identified as impaired at that time. In 1994, an additional lawsuit was filed by Northwest Environmental Advocates (NWEA) regarding the adequacy of the 303(d) list, followed in 1996 by another lawsuit against US EPA for not forcing ODEQ to complete TMDLs on a faster schedule. The Oregon Plan TMDL schedule was agreed to by US EPA in a Memorandum of Agreement signed by ODEQ and US EPA on February 1, 2000.

On February 7, 2000, the Sierra Club and Jack Churchill re-initiated court action against US EPA seeking to enforce the 1987 Consent Decree. The plaintiffs asked the court to establish an extremely aggressive six-month TMDL completion schedule for Oregon. On July 26, 2000 District Judge Michael R. Hogan ruled on the two important TMDL cases before him. In that ruling, the Court denied the motion of several parties (Sierra Club *et al.*) to intervene in the Churchill Case, which sought to enforce the original 1987 Consent Decree by compelling US EPA to finish all the TMDLs in six months. The Court also denied plaintiff Churchill's motion to enforce the 1987 Consent Decree and granted US EPA's motion to modify the 1987 Consent Decree. The Court approved the settlement of the lawsuit against US EPA brought by environmental groups and granted US EPA's motion to enter (approve) the proposed Consent

Decree (NWEA, NEDC, US EPA proposal). It also ordered the 1987 Consent Decree to be modified to conform to the new Consent Decree.

The new Consent Decree basically endorses Oregon's plan to complete TMDLs on a 10 year schedule (the Oregon Plan schedule), with the last TMDLs to be completed by Oregon by the end of 2007.

1.0.4 Enforcement Authorities

The IDEQ's regulatory and enforcement authorities are set forth in the Idaho Environmental Health and Protection Act (1972), as amended (Idaho Code §39-101 *et seq.*), Idaho Code §39-3601 *et seq.*, and §350 of the *Idaho Water Quality Standards and Wastewater Treatment Requirements*. The ODEQ's regulatory and enforcement authorities are set forth in the Oregon administrative rules, Chapter 340, and ORS Chapter 468. The DEQs will rely on existing authorities to achieve the goals and objectives of the SR-HC TMDL. The goals and objectives of this TMDL will be used by the DEQs as guidelines to document compliance with state water quality standards with consideration for the physical reality of the existing system and compliance with other applicable laws. Attainment of water quality standards including restoration of designated beneficial uses for the SR-HC TMDL reach will require a significant, long-term, coordinated effort from all pollutant sources throughout the watershed.

A letter of agreement signed by the DEQs of both Oregon and Idaho states that the SR-HC TMDL will be a joint effort by both states to be submitted to US EPA on completion. In this letter both states also agree to coordinate activities to assure that all parties are meeting their goals, reconcile differences in water quality objectives and standards, develop a scientifically based plan for pollutant reduction, provide the opportunity for public input to the TMDL process, and provide for meeting all state and federal requirements pertaining to water quality.

For point source discharges of pollutants subject to NPDES permits, the DEQs will ensure achievement of water quality goals established in the SR-HC TMDL through water quality certifications provided in Section 401 of the CWA. However, point sources represent only a minor source of listed pollutants. Water quality standards attainment and full support of designated beneficial uses within the SR-HC TMDL reach will only be possible with joint reductions from both point and nonpoint sources.

For nonpoint sources, a feedback loop will be used to achieve water quality goals. If monitoring indicates a violation of standards despite use of approved best management practices (BMPs) or knowledgeable and reasonable efforts, then BMPs for the nonpoint source activity must be modified by the appropriate agency to ensure protection of designated beneficial uses (Idaho Water Quality Standards and Wastewater Treatment Requirements, § 350.02.b.ii). This process is known as the feedback loop in which BMPs and other efforts are periodically monitored and modified if necessary to ensure protection of designated beneficial uses.

Currently, for agricultural activities in the State of Idaho there are no enforceable BMPs. Therefore, agricultural activities must use knowledgeable and reasonable efforts to achieve water quality standards. The DEQs encourage the use of recommended BMPs developed by the

Natural Resource Conservation Service (NRCS), which when selected for a specific site can become an approved BMP. The DEQs, in cooperation with other agencies, will participate in efforts to evaluate the effectiveness of site specific BMPs and other restoration projects in reducing pollutant loading. If the BMPs prove ineffective they will be modified to ensure effectiveness of existing and future efforts. Modifications to forestry BMPs required by the Forest Practices Act (FPA) will be subject to state rule-making requirements.

In the event that BMPs for nonpoint sources are not implemented adequately using a voluntary approach, the DEQs will use existing regulatory authorities to seek water quality improvements. Adequate implementation requires that enough reduction measures be installed and that they be properly maintained. In general, the DEQs will incorporate pollution prevention into enforcement actions, since pollution prevention is the ultimate goal for protecting human health and the environment. In addition, the DEQs will work closely with the SR-HC public advisory team, resource agencies, and affected parties to review existing authorities and determine if additional regulatory requirements are necessary to achieve the goals of the SR-HC TMDL.

1.0.5 Public Involvement

Throughout the SR-HC TMDL process, local experience and participation have been and will continue to be an important resource in the identification of water-quality issues and reduction strategies appropriate on a local scale. Because of the impact of the TMDL process on the local community and the dependence of any implementation plan on local participation; public involvement is viewed as critical for the entire TMDL process. During the initial stages of the SR-HC TMDL process, a structured public involvement program was established that included both local stakeholders and technical/agency personnel. This program was established so members of the local communities could provide direction and leadership in developing and implementing this plan. The public committee created is known as the SR-HC Public Advisory Team (PAT). The SR-HC PAT provides an opportunity for a group of concerned citizens, representing a number of stakeholder groups, to see the SR-HC TMDL process through from start to finish. The SR-HC PAT, though advisory in nature, has the potential to shape the final outcome of the SR-HC TMDL. Interested citizens not involved directly through the SR-HC PAT can get involved in the SR-HC TMDL process through attendance at public comment and informational meetings, and are invited to attend SR-HC PAT meetings.

1.0.5.1 FORMATION OF THE PUBLIC ADVISORY TEAM

At the beginning of the SR-HC TMDL process, the DEQs from Oregon and Idaho collectively identified general categories of significant stakeholder interests within the SR-HC TMDL reach and watershed areas.

Within the State of Idaho, these interest categories were approved by the South West Basin Advisory Group (BAG) as outlined in Idaho Code 39-3614, 3615. Within the State of Oregon, these interest categories were approved by ODEQ as outlined by Oregon protocol at the time. Nominations for potential seat holders in each of these interest categories were solicited from the general public through letters to local governments, organizations, stakeholder groups, individuals, and watershed councils in both Oregon and Idaho. Generally, one representative from each state was selected from the nominations received to represent each area of interest. In the case of industry and hydropower, only a single nomination was received by both states. Therefore, a single SR-HC PAT representative was nominated for each of these seats. In the case of tribal interests, it was recognized that tribal lands and concerns do not necessarily correspond to state boundaries. Nominations were therefore solicited from all tribal entities potentially affected by this TMDL process. Two nominations were received from Tribal entities; both nominations were selected as Tribal Interest seat holders. An alphabetical listing of the final stakeholder seats within the SR-HC PAT follows:

- Hydropower Interests
- Idaho Agricultural Interests
- Idaho Environmental Interests
- Idaho Local Government Interests
- Idaho Municipal Interests
- Idaho Public at Large
- Idaho Sporting or Recreational Interests
- Idaho Timber/Forestry Interests
- Industrial Interests
- Oregon Agricultural Interests
- Oregon Environmental Interests
- Oregon Local Government Interests
- Oregon Municipal Interests
- Oregon Public at Large
- Oregon Sporting or Recreational Interests
- Oregon Timber/Forestry Interests
- Other Idaho Interests
- Other Oregon Interests
- Tribal Interests – Nez Perce
- Tribal Interests – Shoshone/Paiute

Within the State of Idaho, seat holders for each of the Idaho interest categories were approved by the BAG and the Boise Regional Office of IDEQ as required by Idaho Code 39-3615. The SR-HC PAT functions as the watershed advisory group (WAG) for the State of Idaho for this TMDL process as required by Idaho Code 39-360, 39-3616. The seat holders for each of the Oregon interest categories were approved by the Eastern Regional Office of ODEQ.

A complete list of all SR-HC PAT seat holders and the interest area they represent will be included in Appendix B of the final TMDL document.

1.0.5.2 Role and Responsibilities of the Public Advisory Team

The legal and technical aspects of the SR-HC TMDL are largely the responsibility of the DEQs and experts from other state and federal agencies. It is the responsibility of the DEQs to assess and quantify water quality problems, specify the amount of pollutant reduction necessary in order to meet water quality standards, and to develop pollutant allocations. It is also the responsibility of the DEQs to write the SR-HC TMDL and submit it to the US EPA. It is then the responsibility of the US EPA to approve or disapprove the SR-HC TMDL within 30 days of submission.

The SR-HC PAT functions as an advisory body to the DEQs in developing the SR-HC TMDL and implementation matters within the DEQ responsibilities outlined above. SR-HC PAT members help to identify contributing pollutant sources, advise the DEQs in arriving at equitable pollutant reduction allocations, and recommend specific actions needed to effectively control sources of pollution. As mentioned earlier, the SR-HC TMDL process will affect the local communities and landowners. In addition, the success of the SR-HC TMDL process is dependent on local participation. Public involvement, education and awareness are critical to the TMDL process. SR-HC PAT seat holders are members of local communities that can provide direction and experience in local problems and locally based solutions to the DEQs. Their leadership and experience is invaluable to this process in developing and implementing the TMDL.

Additionally, SR-HC PAT seat holders represent a critical mechanism in disseminating information to their respective interest groups, and relaying concerns and advice from these interest groups to the DEQs. In this manner, SR-HC PAT seat holders work directly with their respective interest groups to provide advice to the DEQs in developing the SR-HC TMDL. After the approval of the SR-HC TMDL, seat holders may potentially also help in identifying funding needs and sources of support for specific projects that may be implemented. They may also assist in the review of implementation project efficiencies and the identification of pollutant reduction trends.

The PAT has been meeting on a monthly basis throughout the process to complete the SR-HC TMDL document. At the initial meeting of the SR-HC PAT, general structure and strategy were discussed. An overall goal of the process discussed was the improvement of water quality in the SR-HC TMDL reach while maintaining the economic and cultural viability of local landowners, citizens, municipalities, tribal entities, and industries. It was determined that due to the large geographical area of the SR-HC TMDL reach and the associated watershed, and the fact that the interests represented by separate SR-HC PAT seat holders may be divergent in their consideration of, and position on, some issues; the SR-HC PAT would not operate under a consensus-based process. The potential for agreement on some issues and disagreement on other issues was acknowledged by SR-HC PAT members at this time.

The seat holders and the interagency team members (ODEQ and IDEQ) decided that there should be an opportunity for the submission (formally or informally) to the public record of opinions different from that of the SR-HC PAT in general, or to the approach, philosophy or methodology used by the DEQs in the formulation of the SR-HC TMDL. In accordance with this decision, an informal record of differences in opinion on issues discussed is available to the public in the minutes from SR-HC PAT meetings, and in the listing of informal comments by SR-HC PAT members on initial drafts of the SR-HC Subbasin Assessment and other sections of the SR-HC TMDL compiled by the DEQs. This information is available on request from the Cascade Satellite Office of IDEQ, PO Box 247, Cascade, ID 83611; and from the Pendleton Office of ODEQ, 700 SE Emigrant, Suite 330, Pendleton, OR 97801.

1.0.5.3 OTHER TECHNICAL, ADVISORY, AND REVIEW OPPORTUNITIES

A less formally structured committee of technical experts from a variety of agency backgrounds is associated with the SR-HC PAT. These technical experts attend SR-HC PAT meetings as their time permits and can be called on to answer specific technical concerns or questions raised. Within the agency and state funding structures currently established, these technical experts may also be responsible for reviewing draft and final versions of the SR-HC TMDL document, implementation plan, and implementation mechanisms to ensure they are consistent with water quality standards, designated beneficial use requirements, and pollutant reduction goals. They may also review the methods and mechanisms used within the SR-HC TMDL process, and proposed implementation projects to ensure that they are scientifically sound and follow scientifically accepted procedures. This group of technical experts includes scientific and engineering representatives from local, state and federal agencies, industry and municipal staff as follows:

- Idaho Soil Conservation Commission
- Idaho Department of Lands
- Idaho Department of Environmental Quality
- Idaho Department of Agriculture
- Idaho Department Fish and Game
- Idaho Department of Water Resources
- Oregon Division of State Lands
- Oregon Department of Environmental Quality
- Oregon Department of Agriculture
- Oregon Department of Fish and Wildlife
- Oregon Department of Water Resources
- National Marine Fisheries Service
- USDI Fish and Wildlife Service
- USDA Natural Resources Conservation Service
- US Environmental Protection Agency
- USDI Bureau of Reclamation
- USDA Forest Service
- US Geological Survey
- US Department of Agriculture
- US Bureau of Land Management
- Local Soil and Water Conservation Districts

1.0.6 Goals and Objectives of the Snake River – Hells Canyon TMDL

The overall goal of the SR-HC TMDL is to improve water quality in the SR-HC TMDL reach by reducing pollution loadings from all appropriate sources to meet water quality standards and restore full support of designated beneficial uses within the SR-HC TMDL reach.

Key objectives of the overall goal of the SR-HC TMDL are:

- To assess the condition of the SR-HC TMDL reach and determine the status of designated beneficial use support.

- To identify the cause of designated beneficial use impairment.
- To establish pollutant targets that are appropriate for the SR-HC TMDL reach and that will result in attainment of water quality standards and support of designated beneficial uses within the reach.
- To identify pollutant-specific critical time periods for the SR-HC TMDL reach.
- To establish load allocation mechanisms that will allow attainment of the water quality targets through (to the extent possible) fair and equitable distribution of the identified pollutant loads, and result in productive implementation without causing undue hardship on any single pollutant source.
- To outline necessary implementation steps to attain the SR-HC TMDL pollutant targets. (This is accomplished in a general fashion in the water quality management plan (Oregon) and implementation plan (Idaho) submitted with this document, and in detail in the implementation plans to be completed within 18 months of US EPA TMDL approval).
- To identify data gaps within the SR-HC TMDL effort.
- To ensure that additional data and information can and will be incorporated into the SR-HC TMDL effort as time goes on.
- To ensure that the improved understanding of the SR-HC system (as provided by additional data) can be incorporated into the TMDL effort through the phased implementation and iterative process of the SR-HC TMDL in such a way that targets and load allocations can be revised (if appropriate) to better meet the needs of the designated beneficial uses of the system.

Implementing these objectives for the SR-HC reach will require a significant effort over the course of many years during which TMDL objectives, assumptions, analysis, progress, and particularly costs and benefits must be periodically reevaluated.

1.0.6.1 Modifying the TMDL When Water Quality Standards or Designated Beneficial Uses Change

Water quality standards consist of designated uses and water quality criteria. One or both of these components of water quality standards may change or be removed from a waterbody, or site specific criteria may be developed to reflect increased understanding of the factors that affect water quality. Changes in water quality standards necessarily affect TMDL objectives, targets and load allocations. An example is the State of Idaho's recent bacteria criteria change from fecal coliform to *E coli* bacteria. During the development of this TMDL, questions from stakeholders regarding the appropriateness of certain designated uses and criteria have been raised and are currently under investigation. The outcome of these investigations will be reviewed by IDEQ and ODEQ and the appropriateness to the SR-HC TMDL process determined. Due to the anticipated long duration of this TMDL, it is foreseeable that water quality standards and/or designated beneficial uses may change in the near or more distant future.

It is therefore appropriate to clarify the existing process for reviewing and modifying (if necessary) the TMDL if water quality standards change. When there has been a change in a designated use or a water quality criteria applicable to a water body for which this TMDL has been developed, the IDEQ and ODEQ shall, in consultation with the applicable BAG or WAG (PAT), evaluate whether the TMDL or implementation plans should be modified to reflect the change in the use or criteria. Changes in the TMDL shall be accomplished pursuant to the requirements of state and federal law, including the requirements for public participation, and be submitted to the US EPA for approval. IDEQ and ODEQ anticipate that needed revisions to the TMDL can be accomplished and be submitted to the US EPA within 120 days from the date that consultation with the BAG or the WAG (PAT) is initiated.

1.0.6.2 Long Term Water Quality-Based Goals

The SR-HC TMDL establishes targets and corresponding load allocations that ODEQ and IDEQ believe are necessary to meet water quality standards and support designated beneficial uses. ODEQ and IDEQ recognize that implementing BMPs to achieve these targets and load allocations may take several years to several decades. These long-term targets and load allocations are based on the analysis of water quality conditions affecting designated uses as presented in Section 2.0 (Subbasin Assessment) and Section 3.0 (Loading Analysis) of this TMDL. Periodic review of long-term targets and load reductions will enable the DEQs and stakeholders to reevaluate and adjust these targets and load allocations in accordance with information, analysis, and experience developed after this TMDL is adopted.

1.0.7 Implementation Considerations

It is recognized that the SR-HC TMDL addresses an extremely complex system that includes a combination of diverse natural, point, and nonpoint pollutant sources. The system has been highly modified from its original condition through the placement and operation of the Hells Canyon Complex hydropower projects; numerous surface water diversions and drains; upstream impoundments operated for hydropower production, irrigation storage, flood control and recreational use; and a variety of other anthropogenic activities. In addition to the altered flows, periodic regional drought conditions, pollutant inputs from upstream sources and the underlying aquifer contribute to the complexity of the system. Data is available for some pollutants to determine whether the water quality standards are met, however, for other pollutants there is only limited data that does not conclusively show that the waters are impaired by such pollutants. For narrative water quality criteria numeric targets were developed as part of this TMDL. Basic water quality modeling was completed to assess maximum loadings that would attain the numeric targets and, therefore, presumably the water quality criteria.

As identified in the IDEQ TMDL Guidance (1999a), "A phased approach is typically needed when nonpoint sources are a large part of the pollutant load, information is limited, or narrative criteria are being interpreted." This TMDL has, therefore, adopted a phased approach that will include additional monitoring and data collection, and periodic review/reassessment of numeric targets and their relationship to the respective water quality criteria. These activities will improve the reliability of the TMDL and provide better assurances that water quality standards will be attained. However, while data gathering, monitoring and modeling occur, the implementation of TMDL control measures will also occur. This TMDL has therefore adopted a phased approach to implementation that will identify interim, measurable milestones to determine the effectiveness of management measures or other action controls being implemented, and a process for reviewing and revising management approaches to assure effective management measures are implemented. Due to the complexity of the SR-HC TMDL reach, the agencies responsible for the preparation and approval of the SR-HC TMDL (US EPA, ODEQ and IDEQ) recognize that long time frames may be required before water all quality standards are met.

It is expected that this phased approach to implementation, where implementation activities are scheduled over a period of time, will result in some sources achieving load allocations prior to other sources. However, the early implementation of some management measures will assure that progress is made toward achieving water quality standards in accordance with the schedule established by the TMDL.

The implementation of the SR-HC TMDL will consist of and support practices and policies that will further sustainable and responsible land use and development. Regional cooperation in developing long-term environmental, economic, and community sustainability plans will be of critical importance to this effort. The site specific implementation plans that follow the completion of the SR-HC TMDL will focus on strategies that promote sustainable options. The implementation of soil, water, and energy conservation programs, which also provide water quality benefits, will be emphasized. Waste minimization, pollution prevention, and waste recycling programs are central to the success of the SR-HC TMDL.

To fulfill the requirements of the State of Oregon TMDL process, an implementation plan must be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, a general plan is being submitted with the SR-HC TMDL and other, more specific implementation plans will be prepared and submitted according to the appropriate IDEQ or ODEQ procedure and schedule requirements. Moreover, through the phased TMDL/adaptive management approach, the implementation plans may be revised as information, data, experience, or other aspects of the TMDL become available to determine the effectiveness of implementation strategies.

The purpose of this water quality management plan is to act as a general outline for implementation of the SR-HC TMDL. However, substantial differences in state procedure and policy for implementation of TMDLs exist between Oregon and Idaho. Therefore, the Plan submitted contains two separate, state-specific plans:

- The State of Oregon General Water Quality Management Plan (Section 6.1) and
- The State of Idaho General Implementation Plan (Section 6.2).

Together, these documents represent the general water quality management plan (implementation plan) for the SR-HC TMDL.

In addition to the implementation plan submitted for the mainstem SR-HC TMDL reach, tributary plans will also be prepared as part of tributary TMDL processes. These plans will be prepared according to the appropriate state-specific schedules under which they are identified. Implementation plans for the tributaries may also reflect the phased approach. The load allocations for tributaries identified by the SR-HC TMDL process, and the management measures identified for sources on the tributaries specific to the load allocations from the SR-HC TMDL will be reviewed and modified (if necessary) as additional data and information becomes available on the relationship between tributary water quality and attainment of water quality standards in other SR-HC TMDL reaches and the relative effectiveness of management measures on other SR-HC TMDL reaches.

It is also expected that information will continue to be collected to fill existing data gaps and allow a more accurate determination of the status of designated beneficial uses within the SR-HC TMDL reach and the influence of pollutants delivered to and processed by the system. In recently formulated guidance on TMDLs, US EPA recognized that additional information regarding the actual performance of management measures may lead to questions concerning the appropriateness of certain water quality standards. If the evidence shows that management measures are not effective in attaining the water quality standards, the States and authorized Tribes may choose to initiate use attainability analyses to determine the appropriate uses for SR-HC TMDL reaches and, possibly, revise those uses on the basis of the information gathered during the implementation phase of the TMDL (US EPA, 2000b).

Tributary inflows to the SR-HC TMDL reach have been treated as discrete, nonpoint sources for the purposes of loading analysis and allocation within this TMDL. Existing or future tributary TMDL processes will distribute load allocations in the form of load allocations and/or waste load allocations within their watersheds. Gross load allocations have been assigned to each inflowing tributary for this TMDL. It should be kept in mind that while inflowing loads to the SR-HC TMDL reach represent nonpoint sources to the mainstem Snake River, actual tributary loading is composed of both point and nonpoint discharges within the respective tributaries. In some tributary watersheds, point source discharges from municipalities or industries combine with nonpoint discharges from agriculture and rural stormwater in the river channel as flow moves downstream. All of these will be represented as nonpoint source loading to the Snake River for the purposes of the SR-HC TMDL.

1.0.7.1 MONITORING PLAN

A monitoring plan will be developed and implemented within 18 months after EPA approval of this TMDL to measure SR-HC water quality conditions, track progress in attaining TMDL objectives, and fill data gaps as part of the site-specific implementation plans to support the SR-HC TMDL. The plan will be developed in consultation with the PAT and other appropriate stakeholders. The DEQs anticipate participation by EPA, the USGS, and other federal and state agencies. The monitoring plan is expected to include instream monitoring of the SR-HC reach, tributary inflows, point sources, and nonpoint source discharges to which loads are allocated by this TMDL.

1.0.7.2 PHASED APPROACH FOR IMPLEMENTATION

The fundamental elements of the phased approach are: (1) a process for modifying TMDL objectives, targets and load allocations when water quality standards change; (2) long-term, scientifically justified, water quality-based goals; (3) interim attainable water quality goals based on implementation of feasible control strategies and an equitable distribution of load reduction; (4) pollutant trading which enables stakeholders to commit limited financial resources to implement the most cost-effective control strategies within watershed(s) of the SR-HC reach; (5) monitoring to periodically review and determine progress in attaining TMDL objectives; and (6) periodic review and modification of these goals, cost-benefit analysis, and progress in achieving them through a clearly articulated and scheduled phased approach. This approach is discussed in more detail in following sections of this document and in the implementation plan (Section 6.2).

1.0.7.3 Periodic Review

The TMDL and Water Quality Management/Implementation Plan objectives will undergo periodic review as part of the phased approach. A general, interim review of data collected and associated TMDL objectives will be undertaken on a five-year interval. A more detailed review of data collected, water quality trends observed, and associated TMDL objectives will be undertaken on a 20-year interval. An associated review of costs and benefits of implementing feasible control strategies should also be undertaken to aid in the identification of future implementation objectives. It is recognized that these reviews are dependent on availability of funding, however, every effort will be made to observe these review objectives.

1.0.8 Adaptive Management

The goal of the Clean Water Act and associated administrative rules for Oregon and Idaho is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where nonpoint sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

TMDLs are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met and designated beneficial uses are supported. ODEQ and IDEQ recognize that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and some other analytical techniques are simplifications of these complex processes and, while they are useful in interpreting data and in predicting trends in water quality, they are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

For the purposes of the SR-HC TMDL, a general Water Quality Management Plan (Implementation Plan) will be written and submitted to EPA as part of the TMDL document. Following this submission, in accordance with approved state schedules and protocols, specific implementation plans will be prepared for pollutant sources in Oregon and Idaho. If specific implementation plans are available at the completion of the TMDL, they will be referenced in the general Water Quality Management Plan. Appropriate agencies and/or entities as designated by the states will assist in the development and oversight of the specific plans. These specific implementation plans will be designed to reduce pollutant loads to meet the TMDLs established for listed pollutants.

For point sources, it is the initial expectation that sources will meet their specific waste load allocations in five years or sooner if feasible. During this time frame, each source will prepare a facilities plan (the point source version of an implementation plan) that will investigate alternatives for meeting allocations. If the facilities plan documents that achieving waste load allocations within the five-year time frame is not feasible, the source may request an extension.

The request may be considered by the Director, but, in the case of Oregon, may also be referred to the Oregon Environmental Quality Commission.

For nonpoint sources, ODEQ and IDEQ also expect that implementation plans be implemented as soon as practicable. ODEQ and IDEQ recognize, however, that it may take some period of time, from several years to several decades, to fully develop and implement effective management practices. ODEQ and IDEQ also recognize that it may take additional time after implementation has been accomplished before the management practices identified in the general Water Quality Management Plan or specific implementation plans become fully effective in reducing and controlling pollution. In addition, ODEQ and IDEQ recognize that technology for controlling nonpoint source pollution is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. The adaptive management process for implementation provides the flexibility necessary to identify and evaluate management practices and, accordingly, modify implementation plans to reflect revised or new management practices. It is possible that after application of all reasonable best management practices, some TMDLs or their associated targets and surrogates cannot be achieved as originally established. Nevertheless, it is the expectation of both ODEQ and IDEQ that nonpoint sources make a good faith effort to achieving their respective load allocations in the shortest practicable time.

Both ODEQ and IDEQ recognize that expedited implementation of TMDLs will be socially and economically challenging. Further, there is a desire to minimize economic impacts as much as possible consistent with protecting water quality and designated beneficial uses.

ODEQ and IDEQ further recognize that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated targets and surrogates. Such events could be, but are not limited to floods, fire, insect infestations, and drought.

For some pollutants in the SR-HC TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDLs. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. It is the expectation, however, that the general Water Quality Management Plan and the associated specific implementation plans will address how human activities will be managed to achieve the water quality targets and surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, the specific implementation plans should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that comply with TMDL load allocations and pollutant surrogates such as system potential vegetation.

If a nonpoint source that is covered by the TMDLs complies with its finalized implementation plan or applicable forest practice rules, it will be considered in compliance with the TMDL.

ODEQ and IDEQ intend to regularly review progress of this general Water Quality Management Plan and the associated specific implementation plans to achieve TMDLs. If and when ODEQ and IDEQ determine the general Water Quality Management Plan and the associated specific implementation plans have been fully implemented, that all feasible management practices have reached maximum expected effectiveness, and a TMDL or its interim targets have not been achieved, the DEQs shall reopen the TMDL and adjust it or its interim targets and the associated water quality standard(s) as necessary.

The implementation of TMDLs and the associated plans is enforceable under the applicable provisions of the water quality standards for point and nonpoint sources by ODEQ, IDEQ, and other state agencies and local governments in both Oregon and Idaho. However, it is envisioned that sufficient initiative exists on the part of local stakeholders to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers to overcome impediments to progress through education, technical support or enforcement. Also, ODEQ and IDEQ will assist stakeholders in seeking grant funds and support stakeholder's requests for grants from federal, state and private agencies (as appropriate), to fund data collection and evaluation efforts, and implementation testing or evaluation of point source and nonpoint source controls. Enforcement may be necessary in instances of insufficient action towards progress. This could occur first through direct intervention from state or local land management agencies, and secondarily through ODEQ or IDEQ. The latter may be based on departmental orders to implement management goals leading to water quality standards.

If a source is not given a load allocation, it does not necessarily mean that the source is prohibited from discharging any wastes. A source may be permitted to discharge by ODEQ or IDEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when site temperature is achieved. Alternatively, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source may be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

Subject to available resources, ODEQ and IDEQ intend to review the progress of the TMDLs, general Water Quality Management Plan and the associated specific implementation plans, on a five-year basis. In conducting this review, ODEQ and IDEQ will evaluate progress towards achieving the TMDLs (and water quality standards) and the success of implementing the general Water Quality Management Plan and associated specific implementation plans.

ODEQ and IDEQ expect that designated agencies in each state will also monitor and document their progress in implementing the provisions of the specific implementation plans for those pollutant sources for which they are responsible. This information will be provided to ODEQ and IDEQ respectively for use in reviewing the TMDL. ODEQ and IDEQ expect that designated agencies will identify benchmarks for the attainment of TMDL targets and surrogates as part of the specific implementation plans being developed. As implementation of the general Water Quality Management Plan and the associated specific implementation plans proceeds, these established benchmarks will be used to measure progress toward the goals outlined in the SR-HC TMDL.

Where implementation of the specific implementation plans or effectiveness of management techniques are found to be inadequate, ODEQ and IDEQ expect designated agencies to revise the components of their implementation plan to address these deficiencies.

ODEQ and IDEQ will review aspects of the TMDL including water quality targets, loading analysis, and management measures. It is expected that the results of this review and any proposed changes will be discussed to the extent possible with both the SR-HC PAT and appropriate stakeholder groups.

If ODEQ and IDEQ, in consultation with the designated agencies, conclude that all feasible steps have been taken to meet the TMDL and its associated targets and surrogates, and that the TMDL, or the associated targets and surrogates are not practicable, the TMDL may be reopened and revised as appropriate. ODEQ and IDEQ would also consider reopening the TMDL should new information become available indicating that the TMDL or its associated targets and/or surrogates should be modified.

1.0.9 Pollutant Trading

As stated by Dr. Clinton Shock of the Malheur Experiment Station: “The future lies in the direction of the best attainable function and use in the environment in view of the physical constraints and multiple use needs. Every cost and benefit interacts with others. Site specific capabilities need to be determined, so that we are effectively working towards economically and environmentally realistic long term improvements (2001).” This is a primary goal of the TMDL process. While the interpretation and application of water quality standards from either Oregon or Idaho cannot address cost effectiveness (cost of attainment can be addressed in the establishment of standards, but not the application of existing standards), the implementation mechanisms utilized can recognize this issue.

One valuable tool to meet water quality goals in an efficient manner is pollutant trading. Pollutant trading is a market-based, business-like way to help solve water quality problems by focusing on cost-effective, watershed-level solutions to problems caused by discharges of pollution. Pollutant trading is most practical when pollution sources face substantially different pollution reduction costs. Typically, a party facing relatively high pollution reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction. This compensation, in many cases, may actually provide the other party with enough funds to meet or exceed their own load allocation under a TMDL in addition to the trade. The result is overall lowered pollution discharges with the most cost-effective pollution reductions attainable.

An important aspect of pollutant trading is that it is voluntary. Parties trade only if both are better off as a result of the trade. Pollutant trading does not create any new regulatory obligations because trading systems are designed to fit within existing regulatory frameworks.

Trading allows pollutant sources to decide how to best reduce discharges. A successful pollutant trading program will create flexibility that allows common sense selection of pollutant reduction methods based on financial merit, while ensuring water quality goals are met.

Currently, a policy framework is available for pollutant trading. A demonstration project was initiated in November 1997 in the Lower Boise River watershed. The Idaho DEQ, in cooperation with the US EPA and interested stakeholders representing municipalities, industry, agriculture, and environmental interests have developed a proposed trading system for the Lower Boise watershed. The first phase of this process focused on developing an administrative framework for the dynamic trading of pollutant loading to the river system, and identified the following important conclusions:

- Trading could offer municipalities flexible, cost-effective options for managing increased flows and loads associated with growth, and provide nonpoint sources with the financial resources to help them achieve reductions needed to meet TMDL goals.
- Costs for nutrient reductions range widely among sources, providing the financial basis (or conditions) to produce economic benefits. Incremental costs for phosphorus reductions at wastewater treatment plants range from $5 to more than $200/lb, whereas agricultural management practices hold the potential to reduce phosphorus loads for $5 to $50/lb.
- Stakeholders favor an approach in which regulatory agencies set the critical parameters for trading (e.g., tradable pollutants, and pollutant reductions required to meet water quality standards), while the day-to-day trade administration is handled by a nonprofit association of stakeholders, rather than by a government agency.

The second phase focused on development of two model trades and detailed development of the TMDL, permit, trade tracking, and nonpoint source credit mechanisms necessary to support dynamic trading that results in environmentally equivalent outcomes. Key features of the proposed trading system include:

- Trades that follow permit requirements and the adoption of trading rules that do not require up-front agency review or approval;
- Wasteload allocations and pollutant limits that are adjusted in the NPDES process by the creation and registration of valid credits in a trade tracking database;
- A BMP list that specifies how to create and quantify either measured or calculated nonpoint source credits, including monitoring and maintenance requirements; and
- Ratios calculated from watershed data and applied to the trade transaction that ensure environmentally equivalent reductions.

The Lower Boise River trading framework should be modified for the SR-HC TMDL process. This could be accomplished within the first five-year phase of the implementation of the SR-HC TMDL. Pollutant trades that could occur under a SR-HC TMDL trading program, either in the SR-HC watershed or on any of the tributaries to the SR-HC watershed, include:

- Point Source-to-Point Source trades (e.g. between municipalities or other NPDES permitted sources);
- Point Source-to-Nonpoint Source trades (e.g. between a municipality or other permitted source and a nonpoint source such as a watershed-based application of BMPs to agricultural lands);

- Nonpoint Source-to-Nonpoint Source trades (e.g. between a watershed-based agricultural BMP implementation project and the Idaho Power Company, purchasing pollutant trading credits under their load allocation for Brownlee Reservoir).

Modification and adoption of a framework specific to the SR-HC TMDL process would provide the administrative process under which dynamic pollutant trading could occur in the watershed and its tributaries, ensuring that the most cost-effective pollution controls are used in the TMDL implementation process. The SR-HC TMDL PAT would be the most logical committee to oversee and lead this effort, preferably within the first five-year phase of TMDL implementation. The US EPA, IDEQ and ODEQ will actively support the ultimate adoption of a trading framework to allow both point and nonpoint sources to participate in pollutant trading within the SR-HC TMDL watershed.

Until a point source-nonpoint source trading framework is in place, IDEQ and ODEQ recommend that point sources with allocations expand their facilities planning efforts to consider means and costs of reducing their loads further than necessary to meet allocations. Sources could then market their additional load reductions to others under the existing point source to point source trading framework and, if their load reductions were cheaper to achieve, sell them. IDEQ and ODEQ are willing to adjust allocations after the TMDL is established provided the parties involved have enforceable contracts, permits, or other instruments to ensure that effluent trades can and will be implemented.

IDEQ and ODEQ will further support the construction (or modification) of a trading framework to allow nonpoint sources to participate in pollutant trading within the SR-HC TMDL watershed.

IDEQ is currently (2002 to 2003) funding an effort to identify key issues and trading potential in the SR-HC TMDL reach. A similar effort of more general nature is being undertaken by ODEQ with the support of US EPA.

Among the significant issues which need to be addressed are the potential water quality impacts from trading between tributary inflows to the Snake and between stretches of the main stem of the Snake; mechanisms which will ensure the 0.07 mg/L instream target will be attained while trades are employed; protection of water quality on the local scale; and the environmental and economic feasibility of trading within each tributary watershed.

If trading between tributaries and the mainstem is contemplated, a mechanism will need to be developed which will ensure that the total loadings discharged into each tributary will not exceed their allocation set by the SR-HC TMDL at the inflow point. In addition, if trading is to occur prior to a TMDL distributing the tributary allocation among the various sources in that watershed, US EPA recommends the involved parties refer to the US EPA "Proposed Water Quality Trading Policy Statement" for additional guidance. This draft policy requires a net reduction of the pollutant such that a direct water quality benefit may be obtained.

If nonpoint source to nonpoint source pollution trades are contemplated, mechanisms will need to be developed to hold the buyer or seller accountable for the validity of the credit's underlying reduction and to ensure that credit purchases can be tracked. These mechanisms would have to provide the same type of assurances required of point sources in the Lower Boise River trading framework.

Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Section 2.0 Subbasin Assessment

2.0 Subbasin Assessment

2.0.1 Introduction and General Information

This document represents the subbasin assessment and preliminary problem statement for the Snake River - Hells Canyon (SR-HC) Total Maximum Daily Load (TMDL). The SR-HC TMDL is a joint effort between the Idaho Department of Environmental Quality (IDEQ) and the Oregon Department of Environmental Quality (ODEQ), with participation by the US Environmental Protection Agency (US EPA) and local stakeholders.

The overall goal of the SR-HC TMDL is to improve water quality in the SR-HC TMDL reach by reducing pollution loadings from all appropriate sources to attain water quality standards and restore full support of designated beneficial uses within the SR-HC TMDL reach.

The scope of this TMDL extends from where the Snake River intersects the Oregon/Idaho border at Snake River mile (RM) 409 near Adrian, Oregon and Homedale, Idaho, to immediately upstream of the inflow of the Salmon River (RM 188) including Hydrologic Units (HUCs) 17050115, 17050201 and 17060101, and a small corner of 17050103. Figure 2.0.1 is a map of the geographic area within the scope of the SR-HC TMDL. The scope includes free-flowing sections of the river and the Hells Canyon Complex reservoirs: Brownlee, Oxbow and Hells Canyon. For the purposes of this document, the SR-HC TMDL reach has been divided into five segments: the Upstream Snake River segment (RM 409 to 335); the Brownlee Reservoir segment (RM 335 to 285); the Oxbow Reservoir segment (RM 285 to 272.5); the Hells Canyon Reservoir segment (RM 272.5 to 247); and the Downstream Snake River segment (RM 247 to 188).

Two major geographical descriptions will be used in this document: the SR-HC TMDL reach and the SR-HC watershed. The SR-HC TMDL reach is defined as the specific HUCs designated above (17050115, 17050201 and 17060101, and a small corner of 17050103) which contain the Snake River from RM 409 to RM 188 and comprise approximately 2,500 square miles of land immediately adjacent to the river. The scope of the SR-HC TMDL includes the area contained within the SR-HC TMDL reach.

The SR-HC watershed encompasses the SR-HC TMDL reach **and** the drainage areas of all tributaries inflowing to the SR-HC TMDL reach. It is a large and complex area, extending some 73,000 square miles. Because the SR-HC watershed is the source of inflowing tributaries, it is therefore potentially the source of tributary-based pollutant loads to the SR-HC TMDL reach. A discussion of the SR-HC watershed is included where appropriate in this document as it provides a necessary framework for the evaluation of water quality parameters, pollutant loading, and potential benefits from implementation measures identified by upstream TMDLs and water-quality processes.

This document (subbasin assessment, loading analyses, load allocations, implementation plans and associated appendices) constitutes the SR-HC TMDL. The SR-HC TMDL provides an assessment of the current water quality status in the reach; identifies probable causes of designated beneficial use impairment within the waterbody; identifies water quality targets and

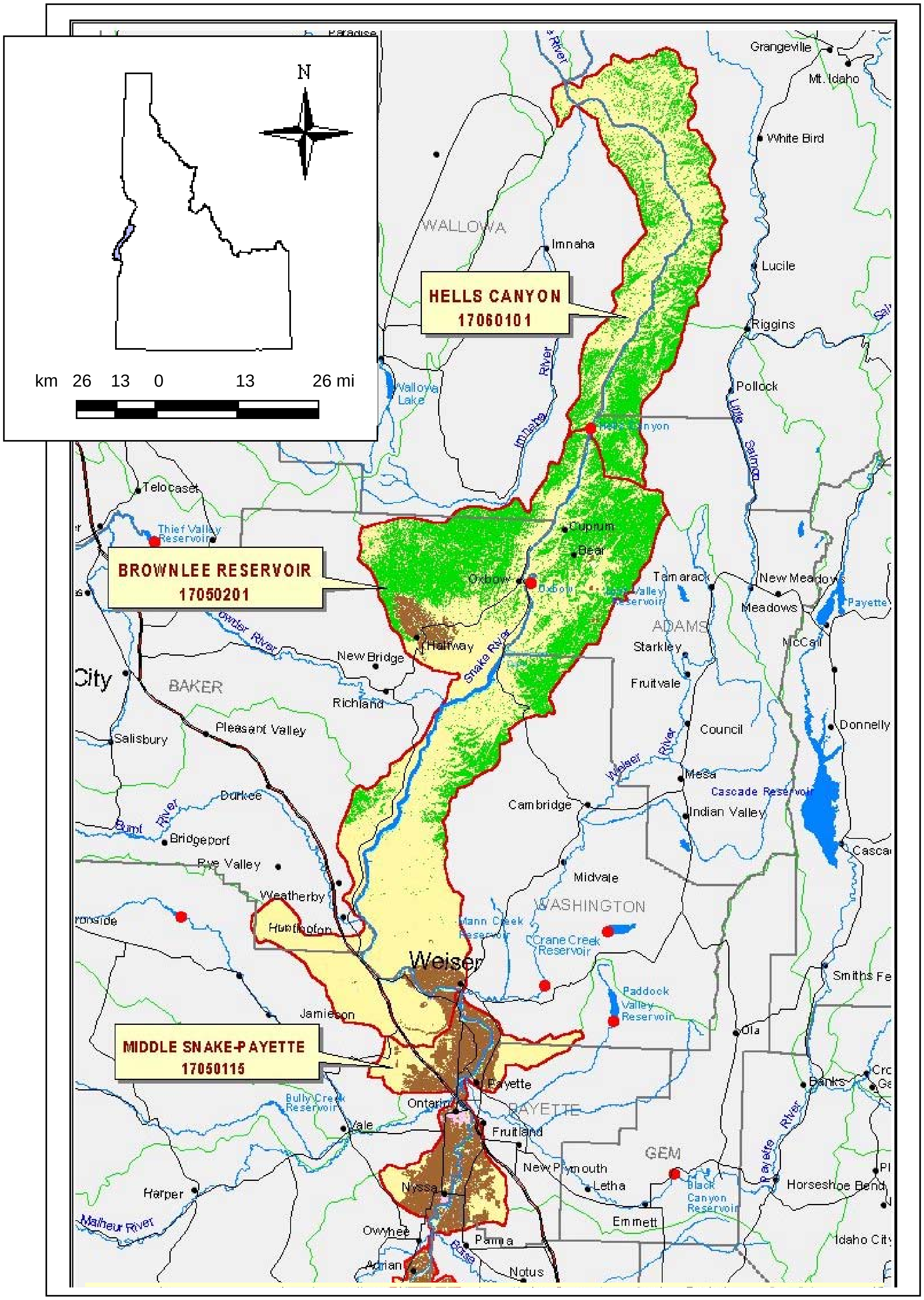

Figure 2.0.1 Geographical scope of the Snake River – Hells Canyon TMDL.

pollutant load reductions that will result in full support of designated beneficial uses; allocates pollutant loads to identified sources within the SR-HC TMDL reach and identifies the general structure for implementing the measures necessary to meet water quality targets as outlined by the TMDL.

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2.1 Characterization of the Watershed

The Snake River Basin includes areas of Idaho, Nevada, Oregon, Utah, Washington and Wyoming. The Snake River is the 10th longest river system in the United States, extending over 1000 miles from its headwaters in Yellowstone National Park, Wyoming, to its confluence with the Columbia River near Pasco, Washington (see Figure 2.1.1). Over its length, the river falls nearly 7,000 feet in elevation. It passes through some of the richest farmland, and the deepest canyons in North America. The Snake River is the major tributary to the Columbia River system. It drains about 87 percent of the State of Idaho (roughly 73,000 square miles); approximately 17 percent of the State of Oregon (about 16,900 square miles) and over 18 percent of the State of Washington (approximately 19,600 square miles). The Snake River flows nearly 760 miles through southern and southwestern Idaho, with about 270 miles of this segment acting as the border between Oregon and Idaho. Near the town of Lewiston, the Snake River leaves Idaho (having left Oregon upstream near China Garden Creek), traveling the remainder of its length westward across Washington to its confluence with the Columbia River.

2.1.1 Physical and Biological Characteristics - Historical and Current

As outlined above, the scope of this document encompasses a very large and diverse geographical area (Figure 2.0.1). Conditions within this system vary ecologically, geologically and hydrologically between upstream and downstream segments. Ecological variations within the river system are evident in the changes in climate, vegetation, animal populations and fisheries throughout the listed segments. Geologic variations such as changes in elevation, soil, rock type, landforms and relative impact of naturally occurring erosive processes are observed upstream to downstream. Equally evident are the hydrologic variations that occur with distance traveled from the fast-flowing upstream section of the river, through the slower-flowing, more lacustrine (lake-like) reservoir systems, to the rapid, white-water sections downstream of Hells Canyon Dam. In addition to changes in flow and velocity, hydrologic variations include differences in relative ground and surface-water inflows and channel morphology throughout the listed segments. Variations in water quality and quantity also occur over time. Temporal variations cover a wide range of factors including historical vs. current land use and river management conditions, changes induced by differences in flow and precipitation in a wet year vs. a dry year, and seasonal variations. Each of these categories is explored in greater detail in the following sections.

2.1.1.1 ECOLOGY

Climate

The climate of the SR-HC TMDL reach of the Snake River is hot and dry in the summer and cold and dry in the winter. Precipitation is bi-modal with intense, short duration summer storms and milder, longer duration winter storms. Much of the water in this reach is derived from snowmelt runoff from high elevations and upstream reaches of the mainstem Snake River and the inflowing tributaries. Only minor differences in precipitation and temperature occur from the upstream to downstream segments of the SR-HC TMDL reach. However, major differences in precipitation and temperature occur within the tributary watersheds that feed into this reach of the Snake River.

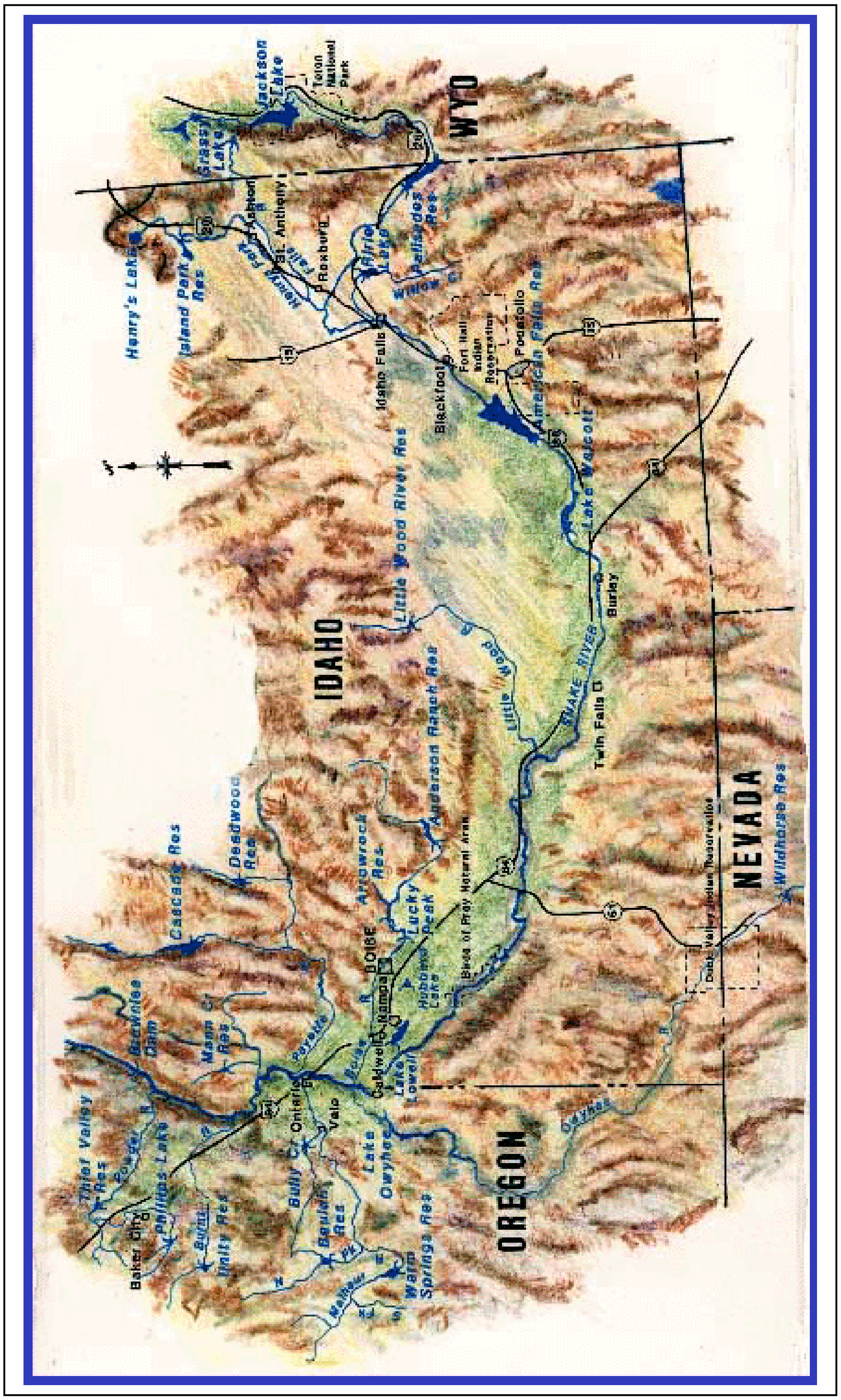

Figure 2.1.1 Snake River Basin Area, including portions of Oregon, Idaho, Nevada and Wyoming.

As shown in Figure 2.1.2, precipitation measured from 1961 to 1990 averaged approximately 11.3 inches per year at Weiser, Idaho (located within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach). The maximum recorded annual precipitation in this area during this time frame was 16.3 inches (1970). During the same period of record, precipitation in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach (measured near Lewiston, Idaho) averaged 12.4 inches annually. The maximum precipitation recorded in this downstream area during this period was 15.4 inches (1971). The total difference in average precipitation levels observed upstream to downstream is 1.1 inches (8.9%) over the period of record.

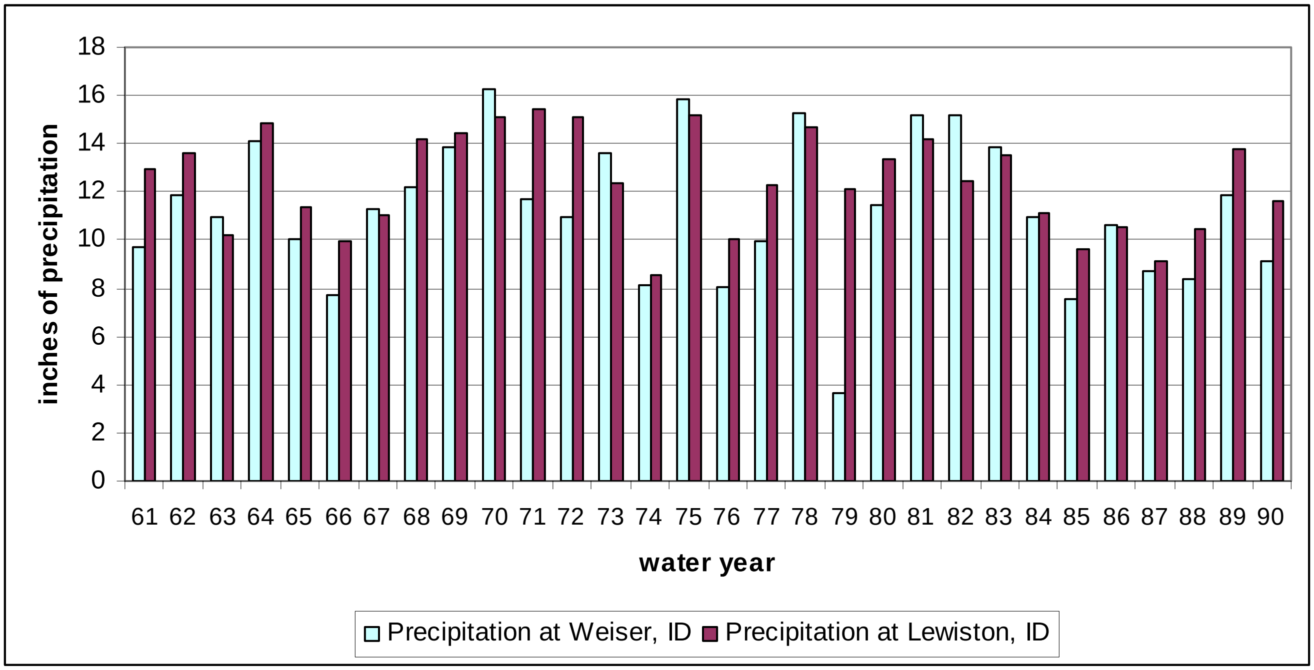

Figure 2.1.2 Mean precipitation in inches for two sites in the area of the Snake River - Hells Canyon TMDL (Weiser, ID at RM 351 and Lewiston, ID at RM 139, downstream of the TMDL reach).

As shown in Figure 2.1.3 (SNOTEL, 2000), summer high air temperatures averaged 23.8 ^{o}C (74.9 ^{o}F) in the Upstream Snake River segment (RM 409 to 335), with a daily maximum air temperature average of 32.7 ^{o}C (90.9 ^{o}F) from 1961 to 1990. Over the same period of record, summer high air temperatures averaged 23.4 ^{o}C (74.1 ^{o}F) in the Downstream Snake River segment (RM 247 to 188), with a daily maximum air temperature average of 31.7 ^{o}C (89.0 ^{o}F). Winter low air temperatures during the same time period averaged -2.3 ^{o}C (27.8 ^{o}F) in the Upstream Snake River segment (daily minimum air temperature average of -6.3 ^{o}C (20.7 ^{o}F)) and 0.9 ^{o}C (33.6 ^{o}F) in the Downstream Snake River segment (daily minimum air temperature average of -2.5 ^{o}C (27.6 ^{o}F)). The average air temperature difference upstream to downstream was 1.2 ^{o}C (2.1 ^{o}F) (ranging from 3.2 ^{o}C (5.8 ^{o}F) in January down to 0.36 ^{o}C (0.65 ^{o}F) difference in August) for daily average air temperatures; 1.3 ^{o}C (2.3 ^{o}F) (ranging from 2.6 ^{o}C (4.7 ^{o}F) in June down to 0.2 ^{o}C (0.4 ^{o}F) difference in November) for daily maximum averages; and 1.9 ^{o}C (3.4 ^{o}F) (ranging from 6.9 ^{o}C (3.8 ^{o}F) in January down to 0.1 ^{o}C (0.2 ^{o}F) difference in May) for daily minimum averages.

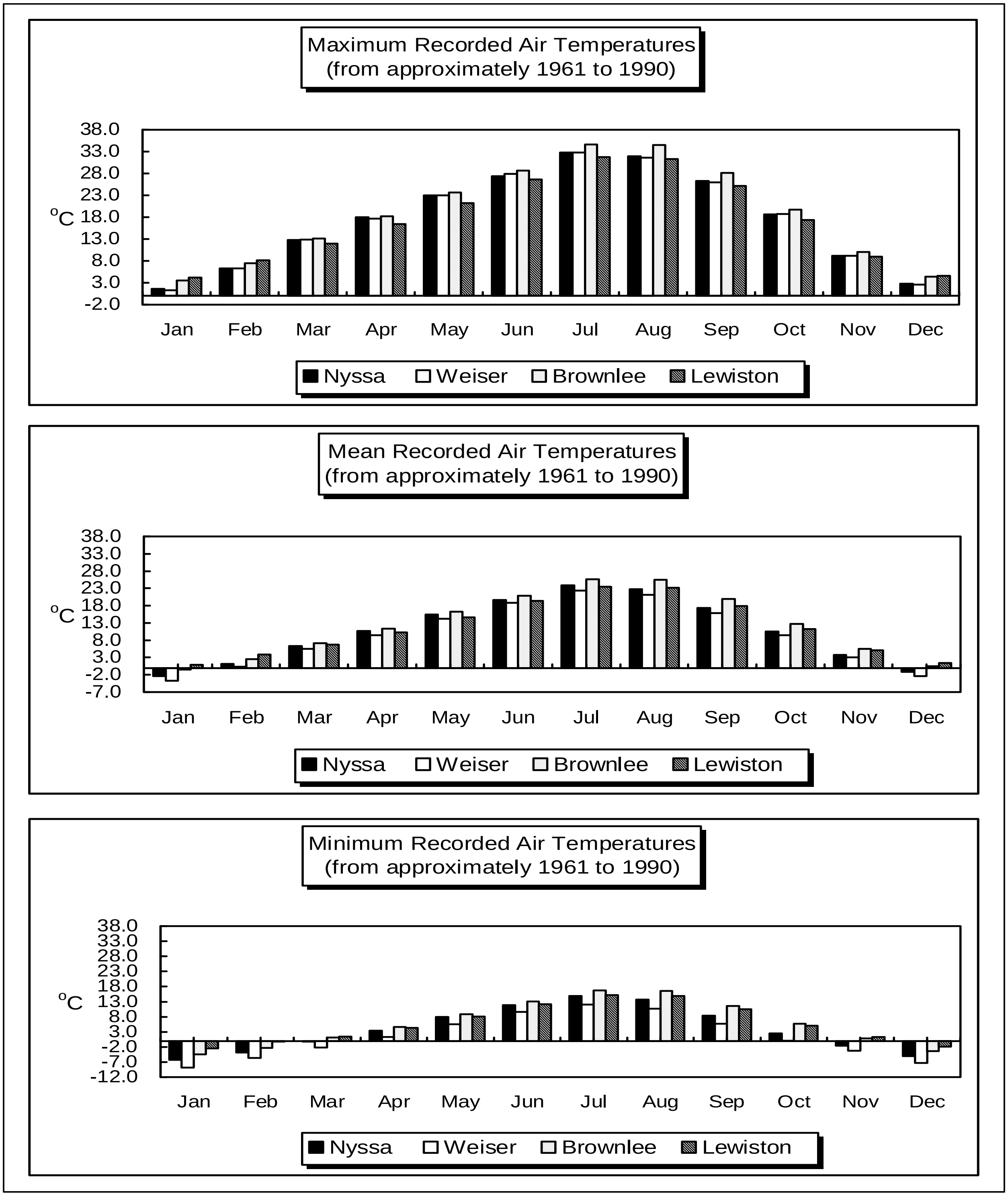

Figure 2.1.3 Air temperatures observed at four locations in the Snake River – Hells Canyon area between 1961 and 1990 (Nyssa at RM 385, Weiser at RM 351, Brownlee at RM 285 and Lewiston, downstream of the TMDL reach, at RM 139).

Photo 2.1.0. Ice accumulation on the bank of the Snake River near Ontario, Oregon (near RM 369) circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

Flora and Fauna

The flora of the SR-HC TMDL reach of the Snake River is dominated by shrubland vegetation communities (approximately 42.7% of the total area) with a narrow strip of riparian vegetation (0.1% of the total area) along the river and reservoirs. Approximately 2.2 percent of the area is non-vegetated (water or barren slopes and cliffs) and about 10.4 percent is used for agricultural purposes (crops and grazing). Grassland areas make up the majority of the remaining land area (15.9% total). Upland vegetation communities are primarily grasslands, shrublands and shrub-savanna assemblages. Riparian vegetation is primarily scrub-shrub wetlands and shore and bottom-land communities. Nearly 71 percent of the total area is either shrub or forested land. See Figure 2.1.4 (USGS, 2000a).

There is a large diversity of fauna that inhabits these vegetation communities. Large game animals include (among others) black bear, antelope, mule and white tail deer, elk, bighorn sheep, mountain lions and mountain goats. In addition there are a number of smaller mammals including coyote, mink, otter, badger, red fox, and beaver.

A wide variety of birds use the upland vegetation including western meadow larks, valley and mountain quail, western kingbirds, lark sparrows, mourning doves, Brewer's blackbirds, lazuli buntings, spotted towhees, brownheaded cowbirds, Bullock's orioles, black billed magpies, chukars and rock wrens. The riparian vegetation is also used by many species including lazuli buntings, spotted towhees, blackcapped chickadees, yellow breasted chats, cedar waxwings, warbling vireos, blackheaded grosbeaks, black billed magpies, song sparrows, western tanagers and red-eyed vireos. The river and reservoirs provide food for a number of other birds including great blue herons, bald eagles, and a variety of geese, ducks and gulls (IMNH, 2002, Audubon, 1997).

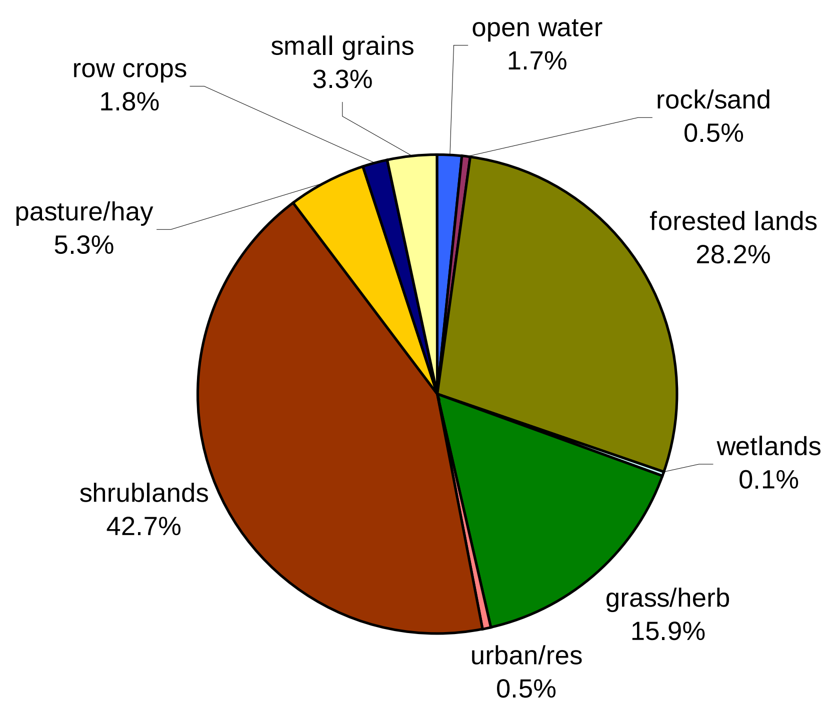

Figure 2.1.4 Relative percent land cover in the Snake River – Hells Canyon TMDL reach.

This reach also provides habitat for many reptile and amphibian species and a large variety of invertebrates. Amphibians in this reach of the Snake River include spadefoot, western and Woodhouse's toads; longtoed salamanders; Pacific tree, spotted and tailed frogs; and bullfrogs (IMNH, 2002, Audubon, 1979). Bullfrogs are an exotic (introduced) species in this area and have caused problems and decline in native populations. Reptiles in this reach include painted turtles, collared lizards, horned lizards, leopard lizards, sagebrush lizards, fence lizards, side-blotched lizards, whiptails, boas, racers, night snakes, gopher snakes, longnose snakes, ground snakes, garter snakes, and rattlesnakes (IMNH, 2002, Audubon, 1979). Invertebrates in this reach include the Idaho springsnail (*Pyrgulopsis idahoensis,* formerly *Fontelicella idahoensis*), identified in the region between RM 422 and 393 and between RM 372 and 366; and the Bliss Rapids snail (*Taylorconcha serpenticola*), identified in the region between RM 228 and 225 and in several areas of the Snake River upstream of the SR-HC TMDL reach. Both of these snail species are listed as threatened under the Federal Endangered Species Act (ESA).

Fisheries

The free-flowing segments of the Snake River and the reservoirs within the SR-HC TMDL reach are home to several native and non-native fish. The native fish that use the river and reservoirs include bull trout and redband trout, northern pike minnow, large-scale and bridgelip suckers, mountain whitefish and white sturgeon. Adult bull trout use the river and reservoirs in and below Hells Canyon Reservoir and its tributaries (RM 272.5 and downstream), with the documented use of Hells Canyon Reservoir being extremely limited. Bull trout are present in the Powder River Basin above Thief Valley and Mason Dams. These populations are not expected to utilize the SR-HC TMDL reach of the Snake River (personal communication, Jeff Zakel, ODFW, 2002). Bull trout are listed as threatened under the ESA. Non-native fish present in the SR-HC TMDL reach include large and small mouth bass, yellow perch, blue gill, black and white crappies, four species of catfish and common carp as well as hatchery rainbow trout. The river and its tributaries below Hells Canyon Dam also provide habitat for the Snake River fall and spring/summer chinook as well as steelhead, all of which are listed as threatened under the ESA. Historically the Snake River also provided passage and habitat for coho salmon. This evolutionarily significant unit (ESU) was declared extinct in 1986.

2.1.1.2 GEOLOGY

The Snake River drains parts of two major geological landforms within the Columbia Intermontaine province: the eastern half of the Central Mountains, and the north central part of the High Lava Plains, principally the Malheur-Owyhee Upland. Hells Canyon, the portion of the

Photo 2.1.1. Arial view of Hells Canyon area, pre-construction of the Hells Canyon Complex of dams, circa 1939 to 1940. Photo from the collection of Dr. Lyle M. Stanford.

reach below Hells Canyon Dam, drains out of the Central Mountains that include the Blue, Wallowa and Seven Devils mountain ranges. These mountains are a complex group of folded and faulted uplifts that reach elevations of 6,000 to 10,000 feet. Hells Canyon is 8,000 feet deep at its deepest and averages 5,500 feet in depth for 50 miles of its length.

The canyon walls include rocks from the Permian period through the Cretaceous period that were folded and faulted, and then intruded by granitic batholiths. These were eroded and then covered by a number of basaltic lava flows during the Miocene epoch. The area then was raised and the canyons cut by the eroding activity of the rivers. Most of the exposed rocks in Hells Canyon are the dark-colored Miocene basalts of the Columbia River basalt group (Orr *et al.*, 1992).

Near Brownlee Dam the Cuddy Mountain fault intersects the Snake River (Mann, 1989). This fault is still active and several small earthquakes have been detected in the vicinity of the fault. At the oxbow where Oxbow Dam is located there is evidence that the ancient Snake River broke through a divide and captured a south flowing river during the Pleistocene epoch. From this point upstream, past the end of the SR-HC TMDL reach, the Snake River drains mainly the Malheur-Owyhee Upland which is considered either to be part of the High Lava Plains (Rosenfeld, 1993) or part of the Basin and Range landforms (Orr *et al.*, 1992). This is an area underlain by Cenozoic lava flows that have subsequently been covered by thick ash and alluvial deposits.

The area upstream of the SR-HC TMDL reach is geologically rich in phosphorus. A 1974 inventory of the nations waters (US EPA, 1974a) found that the mountains along the southeastern border of the Snake River, which form its headwaters, contain some of the world's richest phosphate deposits.

2.1.1.3 SOILS

Most of the soils in the SR-HC TMDL reach of the Snake River fall into one of two soil orders: Mollisols or Aridisols (Jones, 1993). Mollisols are well-developed soils with organic-rich surface horizons and that are rich in basic cations such as calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^{+}) and sodium (Na^{+}). Xerolls are the most common suborder of the Mollisol soils within this reach. These soils develop in moist winter/dry summer climates, and are continually dry for long periods of time. These soils dominate the steppe and shrub-steppe vegetation areas in the reach. Aridisols are soils that occur in dry areas. These soils tend to be low in organic matter and are typically light in color. The two most common Aridisols in this reach are those with accumulations of calcium carbonate and other salts (Orthids) and those that are distinguished by the accumulation of clay in the subsurface horizons (Argids). The latter are typical to the Snake River plain at the upstream end of the SR-HC TMDL reach.

The Bonneville Flood, a catastrophic flood event that occurred approximately 14,500 years ago as the result of the failure of one of the natural dams at Red Rock Pass of Pleistocene Lake Bonneville, deposited fine-grained silty soils over much of the region. Pleistocene Lake Bonneville covered most of Utah and parts of Idaho. During the flood event, approximately 25 million cubic feet of water per second moved down what is now the Snake River Canyon. The floodwaters eroded the canyon to over 500 feet deep and a mile wide in some places. The results of this erosion are visible today in the large bar complexes, fine-grained, easily re-suspended slack water deposits, scoured and eroded basalt and scabland topography in the SR-HC TMDL reach (Link *et al.*, 1999).

2.1.1.4 HYDROLOGY

Surface Water

Flows.

The Snake River is a highly regulated river, with the first dams constructed nearly a century ago, primarily to provide irrigation water supply. Available estimates indicate that nearly half the annual discharge of the Snake River is stored and diverted for irrigation upstream of the Hells Canyon Complex of dams (usable storage capacity above Hells Canyon is ~10 million acre-feet, average annual runoff at Weiser, ID of 13.25 million acre-feet). With such a highly regulated system it is difficult to determine what are natural conditions, or precisely how altered are current conditions from natural.

Because of the extensive flow regulation within the Snake River system, late summer and early fall flows into the Hells Canyon Complex are typically greater than they were before flow regulation began. While no flow data exists prior to the beginning of diversion for irrigation within the Snake River system, the period prior to completion of American Falls Dam in 1926 is one of relatively unregulated flow. By 1956, with completion of Palisades and Lucky Peak Dams, all major storage above the City of Weiser, Idaho was completed. Snake River flow at Weiser for these two time periods is compared in Table 2.1.0.

Table 2.1.0 Comparison of historical (1911 to 1926) and recent mean Snake River flow at Weiser, Idaho.

Mean cfs	June	July	Aug	Sep	Oct
1911 to 1926	36,155	14,138	7,691	8,947	13,925
1956 to 2001	23,692	11,626	10,779	12,970	14,962
%Diff	-34%	-18%	+40%	+45%	+7%

Though there are many dams on the Snake River, most of them on the river itself are what are known as “run of the river” impoundments, and do not store much water. Major storage reservoirs include Palisades Reservoir, American Falls Reservoir, Lake Walcott, and Brownlee Reservoir. The first three are several hundred miles upstream of the SR-HC TMDL reach. Furthermore they are above Milner Dam (RM 639), where practically all water is diverted for irrigation from July through September, often longer. Below Milner Dam the Snake River is replenished by springs and extensive surface water return flows, rapidly gaining volume, and averaging 15,700 cfs at Weiser, Idaho (RM 351), 16 miles upstream of Brownlee Reservoir.

As evidenced by the information above, flows in the SR-HC TMDL reach are heavily influenced by water resource development and management within the reach and upstream in the Snake River and in the tributaries. This development provides irrigation water supplies for more than 3.5 million acres of irrigated lands upstream of Brownlee Dam. The average annual flow of the Snake River at Brownlee Dam is about 14 million acre-feet. The USBR (1997) estimates that between 14.5 and 16.5 million acre-feet of water are diverted from streams and between 3.5 and 7.5 million acre-feet are pumped from ground water in the basin upstream of Brownlee Dam. About 8.5 million acre-feet is estimated to return to the rivers or aquifers for a total annual consumptive use from surface diversions of between 6 and 8 million acre-feet (USBR, 1998). However there are minimum flows (3,300 cubic feet per second (cfs) at the Murphy gage, and 4,750 cfs at the Weiser gage) adopted for the SR-HC TMDL reach by the Idaho legislature (Idaho State Water Plan, 1996).

Due to differences in tributary inflows, diversions and interactions with underlying aquifers, the average annual flow of the Snake River varies widely by location and year. It is therefore important to specify a period of record when discussing surface hydrology in this basin. In the following sections, different periods of record are used depending on the available information, however each period is appropriately identified when it is used. Data available from the USGS gauge near the Weiser River inflow in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach reflect most of the water management upstream of Brownlee Reservoir, including tributaries, reservoirs, ground-water discharge and irrigation return flows to the mainstem Snake River.

For the period of record 1911 – 1999, Snake River flow data at Weiser, Idaho show an average seasonal variation from 9,829 cfs in August (low) to 28,690 cfs in May (high) (Brennan *et al.* 1999). In contrast, average flow data from the USGS gauge immediately below Hells Canyon Dam (period of record 1966 – 1999) show 11,560 cfs in August (low) to 30,950 cfs in April (high). These data suggest a slight increase in base summer flows, likely attributable to tributary inflows, leaving the Hells Canyon Complex reservoirs as compared to that entering Brownlee Reservoir at Farewell Bend. Also, the peak flows below Hells Canyon Dam are shifted slightly earlier in the spring (April) than peak flows at the Weiser Gage (May). While the magnitude of the peak flow from Hells Canyon Dam is higher than the peak flow at Weiser, this can also be attributed to tributary inflows between the two monitoring locations. Comparisons of the two locations for the same period of record show similar results. The average outflow of the Snake River at Hells Canyon Dam is about 14 million acre-feet per year, which closely matches the average annual inflow at Brownlee Dam.

Major tributaries to the SR-HC TMDL reach are the upstream Snake River mainstem flowing into the reach at RM 409, the Owyhee River (RM 396.7), the Boise River (RM 396.4), the Malheur River (RM 368.5), the Payette River (RM 365.6), the Weiser River (RM 351.6), the Burnt River (RM 327.5), the Powder River (RM 296), and the Imnaha River (RM 191.6).

Flows within the Snake River system are strongly seasonal. The majority of in-river flow is a result of snowmelt and runoff from those areas of the watershed where precipitation falls mostly as snow, although ground water does represent a substantial source in some areas. Snowmelt-driven flow regimes commonly result in low flows during the fall and winter months and high flows during the spring and early summer months. The total volume and timing of surface runoff is highly variable from year to year. In the upstream drainage areas of the major tributaries to the SR-HC TMDL reach, ground-water discharge to streams is generally fairly constant throughout the year, but varies somewhat from year to year depending on the relative level of annual precipitation and the duration and timing of snowmelt.

Annual discharge is also highly variable. During the 1928 to 1996 hydrologic period, the annual discharge of the Snake River at the Weiser gauge varied from a high of 24.5 to a low of 6.4

million acre-feet (1971 and 1934 respectively). The annual flow of the Snake River near Weiser was greater than 19 million acre-feet 10 percent of the time and greater than 8.1 million acre-feet 90 percent of the time (USBR, 1998) for this period of record.

Table 2.1.1 Range of flows in the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Inflow[1]	Gauge Location	Mean Annual Flow (cfs)	Average Summer Flow[2] (cfs)	Low Flow (cfs)	USGS Gauge #	Comments[3]
Mainstem Snake River	Murphy, Idaho, upstream of RM 409	9,577	8,529	4,370 (06/1992)	13172500	
Owyhee River (RM 396.7)	None (Closest gauge is near Rome, Oregon)	436	438	56 (08/1992)	13181000	*Inflow value calculated by USBR (2001) because gauge is above Owyhee Reservoir
Boise River (RM 396.4)	Near Parma, Idaho	1,349	1,496	82 (04/1987)	13213000	
Malheur River (RM 368.5)	Near Vale, Oregon	382	357	11 (09/1994)	13233300	*Inflow value calculated by USBR (2001) because gauge is well upstream of mouth
Payette River (RM 365.6)	Near Payette, Idaho	2,693	2,903	127 (08/1991)	13251000	A one-time flow of 32,000 cfs was recorded during a rain-on-snow event in Jan. 1997
Weiser River (RM 351.6)	Near Weiser, Idaho	1,100	840	34 (10/1988)	13266000	A one-time flow of 31,000 cfs was recorded during a rain-on-snow event in Jan. 1997
Mainstem Snake River	Near Weiser, Idaho RM 351.6	15,714	14,526	4,460 (06/1992)	13269000	A one-time flow of 82,000 cfs was recorded during a rain-on-snow event in Jan. 1997

[1] River miles in this column refer to the Snake River Mile (RM) at the inflow of the named tributary.
[2] Summer season is defined as May through September
[3] This precipitation event produced singular, extreme high flows that were well outside of the general range observed over the period of record (1980 to 1999).
* USBR calculated flows from 1991 to 1992 and 1997 to 1998 were used to calculate the average flows at the inflow to the SR-HC TMDL reach (USBR, 2001).

The operation of the reservoir system for flood control and for flow regulation is also a significant factor in the shaping of mainstem flow patterns. The Hells Canyon Complex reservoirs are operated primarily for hydropower. In addition, they are currently operated to control and store runoff (Brownlee Reservoir only, under US Army Corps of Engineers direction), to accommodate spawning and migration of anadromous fish (below Hells Canyon Dam only), to support navigation (below Hells Canyon Dam only) and to support recreation. It should be noted that these various functions of the complex can be contradictory, which sometimes leads to fulfilling one mission at the expense of another. Tributary reservoir systems are operated, for the most part, to control and store runoff and to release storage during the irrigation season. These operational constraints on both the tributary and mainstem systems overlie the natural runoff pattern and alter natural streamflow patterns.

Impoundments.
Mainstem flow within the SR-HC TMDL reach is heavily controlled by dams and other water-control structures on both the mainstem (upstream) and inflowing tributaries. It is estimated that less than 20 percent of the total inflow from the Snake River watershed reaches the mainstem river without first passing through a reservoir or other flow-control structure (USBR, 1998). This high level of management affects both the magnitude and timing of flow variations within the mainstem Snake River. Current high flows are usually not as high as those recorded in the early 1900s and in some areas average low flows are not generally as low as those recorded prior to the placement of impoundments. Although the average volume of water flowing through the river system on an annual basis may not have changed substantially over time, the water volume now tends to be more evenly distributed over the year. Increased spring flows still occur, but are spread out over longer intervals and tend to peak at flow values lower than those recorded historically (USBR, 1998; USGS, 1999). In addition to the stabilization in flow from upstream impoundments, the calculated consumptive use of legal, state-authorized agricultural diversions within the SR-HC TMDL reach equates to approximately 35 percent reduction in flow (average).

The upstream impoundments themselves also have an observable effect on pollutant transport within the basin. Pollutants associated with increased flow volumes and high velocities (i.e. sediment, mercury and pesticides) are not distributed as randomly as they would be in a more free-flowing system. Instead, they tend to accumulate behind structures such as dams and diversions. While this reduces the overall concentration of such pollutants downstream, it localizes the pollutant mass and can lead to significant pollutant releases if water-management practices in the impoundments result in substantial drawdowns. It can also lead to conditions where designated beneficial uses are negatively affected by a reduction in a given constituent such as sediment. Sediment tends to accumulate behind structures and in their reservoirs, resulting in less than optimal spawning habitat due to cobble-embeddedness (too much fine sediment upstream) in flowing river systems with redd-spawning fish species. Cobble embeddedness is generally not a major issue with reservoir spawning fish since they typically are broadcast or nest spawners rather than redd-spawners. Reservoir spawning fish generally do not deposit eggs in the substrate. Hydraulic conditions in low velocity areas (such as reservoirs) are not conductive to intergravel egg survival. In-reservoir sediment deposition can lead to reduced availability of gravel-sized particulates downstream that may in turn reduce available spawning habitat for downstream fish species.

Dams and related structures can also result in changes in flow velocity and timing that can affect designated beneficial use support through changes in the transport and processing of nutrients and algae. Reduced velocities can lead to conditions where excessive incoming nutrient and organic loads, delivered to an impoundment, result in nuisance algal growth and dissolved oxygen depletion. These blooms, in combination with delivered organic loading can lead to increased oxygen demand in the lower layers of the reservoir system. Reduced dissolved oxygen concentrations created by the elevated oxygen demand can, in turn, lead to a reduction in suitable aquatic habitat, fish kills, and increased nutrient and toxics release at the sediment/water interface. In this manner, impoundments can act to increase the sensitivity of the river system to incoming nutrients and algal loading (also described as a reduction in assimilative capacity).

Additional potential effects of impoundments on pollutant fate and transportation include increased opportunity for methylation of mercury, increased surface water temperatures due to increased surface area and decreased flow rates, cooling effects on impounded volumes, opportunities for the creation/release of ammonia, hydrogen sulfide, metals and phosphorus from bottom sediments, and thermal stratification leading to anoxia/hypoxia below the thermocline. Not all of these occur in all reservoir systems, and not all occur at the same rate or intensity. The influences of the reservoir systems within the SR-HC TMDL reach are discussed in more detail in the following sections and in the pollutant-specific loading analyses.

While many of the above processes can result in reduced water quality, impoundments can also act to improve some aspects of water quality in downstream segments. Reservoirs often act as a sink for both sediment and nutrients, reducing delivered loads downstream, and can reduce summer water temperatures through deep-water releases. However environmental management for preventing pollution before it enters the waterways rather than depending on instream treatment is preferred by the US EPA, IDEQ and ODEQ.

Ground Water

Significant amounts of ground water (about 250 million acre-feet in the top 500 feet of substrate) are found in the Snake River Plain Aquifer system (SRPA), one of the largest ground-water systems in the United States (USBR, 1998). The western portion of the SRPA underlies the SR-HC TMDL reach between RM 409 and roughly RM 340). This section of the SRPA covers about 4,800 square miles and is composed primarily of sedimentary deposits of silt, clay, sand and gravel with basalt interflows. Aquifers in the drainage areas tributary to the Snake River provide ground water for use within the individual drainage areas. These also provide varying amounts of recharge to the SRPA, in the form of subsurface ground-water inflow, (USBR, 1998).

While shallow ground water (subsurface recharge) in the SR-HC watershed is more easily influenced by agricultural and stormwater pollutants, deep ground water in the SR-HC watershed is commonly of high quality, suitable for drinking, agriculture, and industrial uses. Deep ground-water quality is often better than that required to meet national drinking water standards. However, while there are exceptions in some cases where concerted efforts have been made to prevent or reverse negative impacts (Shock *et al.,* 2001), general ground-water quality trends in the SR-HC watershed indicate an increasing occurrence of nitrate contamination in areas of intense ground-water usage (ODEQ, 2000b; NRCS, 2000; IDEQ, 1985, 1986, and 1988a).

Contamination from both point and nonpoint source activities has occurred, however, it is generally localized, ranging from a few acres up to several square miles. The most common point sources of ground-water contamination are above- and below-ground petroleum storage, leaks and accidental spills of industrial chemicals, and land application of wastewater.

Nonpoint sources of ground-water contamination are difficult to identify and assess due to limited monitoring data. Potential nonpoint sources include agriculture, septic systems and urban runoff. Shallow ground water (subsurface recharge) has also been found to contain high concentrations of phosphorus (USDA and USGS monitoring). Agricultural chemicals can reach ground water in significant quantities under conditions of high soil permeability, chemical mobility, and inappropriate water application practices. While high nitrate levels in some areas have been observed, the limited data available for agricultural pesticides in ground water has not shown levels that pose a public health threat. Septic systems can impact ground water when the water table is shallow, soil conditions are inappropriate or system density is excessive. Little site-specific data is available on septic-based effects on ground water in this area. Impacts from infiltration of urban runoff in this area are also poorly investigated. With appropriate placement, management and control programs in place, these nonpoint source effects can be minimized or removed in many cases (USBR, 1998; NRCS, 2000; IDEQ, 1988a).

Within the Snake River Basin, surface and ground-water systems are interconnected. Changes in ground-water recharge or discharge have been observed to affect surface water flows (IDEQ, 1988a). Similarly, infiltrating water from irrigation systems and stream flows represent a significant portion of the ground-water budget (USBR, 2001). At many places in the basin, the Snake River channel is above the regional water table and instead of the aquifer discharging to the river, the river recharges the underlying aquifer (USBR, 1998). In low-water years, pumping and diversions can remove more water from the Snake River than is contributed by some of the inflowing tributaries. Irrigation recharge during periods of low tributary input represents a significant source of in-river flow (as much as 52 percent (IDWR and ODWR, water supply data)).

2.1.1.5 Temporal Variations

Many changes have occurred in the Snake River Basin over the course of historic time. While a detailed assessment of these changes would require extensive volumes of text and is therefore impossible to include within the scope of this document; the following sections attempt to capture these changes and their effects on the SR-HC system in a general sense. Separate discussions of changes in pollutant loading over time, or violations of water quality standards are included in those sections specific to pollutant assessment and loading.

2.1.1.6 Subwatershed and Tributary Characteristics

Over 95 percent of the average total mainstem flow in the Snake River system within the SR-HC TMDL reach is from direct tributary inputs. The tributary inflows to the SR-HC TMDL reach include the Snake River upstream of the SR-HC TMDL reach (inflowing at RM 409). Tributary flows can be ranked according to relative average annual inflow as follows: the upstream Snake River (55.8 %), the Payette River (15.7 %), the Boise River (7.9 %), the Weiser River (6.4 %), the Owyhee River (2.5 %), the Malheur River (2.2 %), the Powder River (1.4 %) and the Burnt

River (0.5 %). These inflowing tributaries routinely exhibit highly variable annual flows (Table 2.1.1). Ungaged flows make up approximately 7.5 percent of the total flow volume.

2.1.2 Cultural Characteristics

2.1.2.1 Land Use and Ownership - Historical and Current

Tribal Use

The majority of the SR-HC TMDL reach is located within most of the Nez Perce Tribe's ceded territory as documented by the Indian Claims Commissions in Docket No. 175. In the Treaty of 1855, the Nez Perce Tribe retained numerous rights that extend into the ceded territory and beyond. These include the right to take fish at all usual and accustomed places, the right to gather roots and berries, the right to hunt on all open and unclaimed lands and the right to pasture horses and livestock. These rights have been upheld by federal courts and have given the Tribe co-management authority in some areas.

The Snake River and Hells Canyon are of vital importance to the Nez Perce Tribe. This area has been utilized by the Tribe since time immemorial for salmon, sturgeon and lamprey fishing, the gathering of ceremonial, medicinal and food plants, hunting, and spiritual and ceremonial use. These uses continue today. The economic, social, and spiritual health of the Tribe is in part derived from a healthy Snake River ecosystem.

Agriculture and Grazing

Agriculture in the Snake River Basin surrounding the SR-HC TMDL reach includes both irrigated and non-irrigated uses; the latter includes crop production, animal feeding operations (AFOs) and open range grazing. No quantitative information is available on the level of irrigated agriculture in the Snake River Basin preceding the arrival of white settlers.

With the advent of white settlement in the region, irrigation practices became widespread and intensive. During this period (mid 1800s to the early 1970s), impoundment and diversion of the Snake River and tributary waters increased significantly. From early settlement to the late 1960s and 1970s, the predominant irrigation practices included furrow, sub-flood and flood irrigation techniques. In the first two cases, water is diverted from a larger surface water supply (creek, canal, ditch, etc.) and allowed to move laterally down a secondary ditch or furrow, saturating the adjacent soil. In flood irrigation, water is allowed to move across the top of the soil in a sheet and saturation occurs from the surface downward. During the 1960s and 70s, sprinkler systems were constructed in many areas of the Snake River Basin, allowing lands that were previously not irrigated due to elevation or location to be brought under irrigation. Furrow, flood and sub-flood, sprinkle and drip irrigation methods continue to be used in many areas of the basin.

Irrigated agriculture accounts for over 95 percent of all out-of-stream water diversions and ground-water pumping in the Snake River basin. Of the 3.5 million acres of irrigated land upstream of Brownlee Dam, about 2 million acres are supplied by surface water, mostly by gravity diversions (USBR, 1998).

An estimated 14.5 to 16.5 million acre-feet of surface water are annually diverted and conveyed by more than 3,000 miles of canals and laterals to irrigated fields (IWRB, 1996; USBR, 1997).

Of this amount, gravity diversions from the Snake River (mainstem) total about 9.5 million acre-feet, while gravity diversions from tributaries are about 6 million acre-feet and pumpage from the mainstem and tributaries is about 1 million acre-feet. In addition, another 3.5 to 7.5 million acre-feet of ground water, mostly from the upper Snake River basin, is supplied annually to agricultural lands. Total out-of-stream diversions and ground-water pumpage averages about 20.5 million acre-feet per year. Most of the diverted water returns to the stream or aquifer; consumptive use of surface diversions is calculated at between 6 and 8 million acre-feet (USBR, 1997 and 1998; Idaho State Water Plan, 1996).

Over 95 percent of ground-water withdrawals in the Snake River basin are used for irrigation. Ground water pumping represents between 19 and 30 percent of the total agricultural water requirements depending on the water year and local seasonal variations. Under average conditions, ground-water pumping accounts for approximately 25 percent of the total agricultural requirements. Ground water is also used to meet virtually all domestic, public supply, and industrial requirements in the Snake River Basin (USBR, 1998).

The increase in agricultural land use that has occurred in the SR-HC TMDL reach since early settlement has resulted in increased pressures on surface and ground-water quality. In some areas of the drainage, nitrate and phosphate levels in ground water have increased with the application and improper handling of agricultural fertilizers. In addition agricultural pesticides have been detected in ground water in some areas of the drainage (NRCS, 2000; IDEQ, 2000c; Hedley *et al.*, 1995; US EPA, 1986a; ODEQ, 2000b). Recently however, a concerted effort has been undertaken in many areas of the drainage to reduce the negative impacts of past practices and restore water quality. Many cropping and grazing practices have been, and are being improved specifically with water quality in mind (IDEQ, 1998a; IDEQ, 1999b and 1999c; Malheur Co., 1978, 1981, 2000; MRBLAC, 2000; MOWC, 1999). Riparian restoration and grazing and irrigation management improvements are being applied on a voluntary basis in many areas. While these projects cannot promise instant improvements in water quality, over time concerted efforts are showing positive results.

Mining

The SR-HC TMDL reach of the Snake River has been the site of a number of mining activities, mostly for gold, silver and mercury ores. Gold was mined in the Central Mountain landform particularly in the Blue, Seven Devils and Wallowa Mountains but also along the banks of the Snake River itself. Gold, silver, uranium, bentonite (volcanic ash) and mercury were mined in the Owyhee uplands and Malheur County. Silver City, Idaho, (Photo 2.1.2) located in the Jordan valley area of the Owyhee River watershed, was the site of a major historic silver mining operation. Much of the mercury used for amalgamation of the mined silver and gold was mined just outside the Owyhee watershed (Idaho) in the Opalite mining district near the McDermitt caldera in southeastern Oregon. Most of the mines have not been operational since the 1950s or 1960s but there are occasional, usually small, mining activities currently in place. Mercury deposits have also been identified in the Weiser River drainage (IDEQ, 1985), although mining activities in this drainage were more limited in scope.

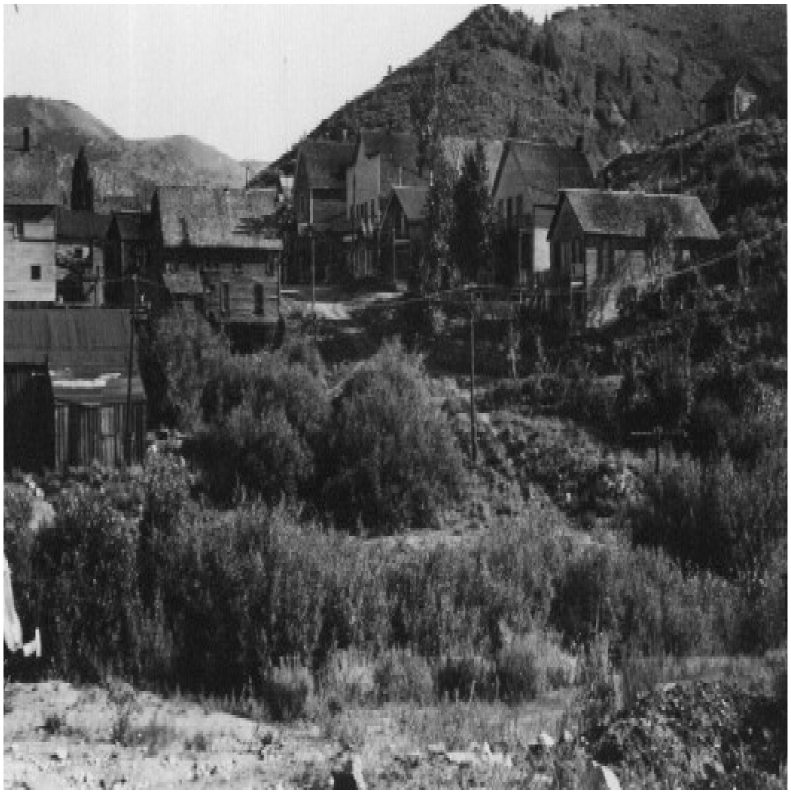

Photo 2.1.2. Historic mining town of Silver City, located in Owyhee County, Idaho, circa 1938. Photo from the collection of Dr. Lyle M. Stanford.

Historically, dredge mining occurred on many sections of the Boise River, a tributary to the Snake River. Some lode and other forms of placer mining also occurred. Most of the historic mining in this drainage occurred on the Middle and South Fork of the Boise River and its tributaries near Atlanta and Idaho City (Middle Fork Boise River), and the Featherville-Rocky Bar area (South Fork Boise River). Currently, the largest mining district within this drainage is the Atlanta district. Historic production is estimated at 400,000 ounces of gold. Other old mines in the area include an antimony mine near Swanholm Peak (Middle Fork Boise River), and some small gold and silver base-metal mines in tributaries to the Boise River. Recreational mining also occurs in this area with small suction dredges. Operators are regulated by permits and rules issued by the Idaho Department of Water Resources (IDWR).

Urbanization

Both Oregon and Idaho have been predominantly rural from their initial settlement until the fairly recent past (~1960). Original territory and later state economies were based on agriculture (both livestock and irrigated croplands), timber and mining. Over the last 30 years, significant population increases have occurred. Although the majority of population growth has been centered primarily between the municipalities of Boise, Idaho and Ontario, Oregon, many areas within the scope of this TMDL and its tributary drainages have experienced a noticeable shift from agricultural-based land use to more urban/suburban land use. This trend is occurring to a greater degree in southwestern Idaho than in southeastern Oregon. As with the expansion of agricultural land use discussed earlier, increasing urbanization of the SR-HC TMDL reach has also resulted in increased pressures on environmental quality.

Urban/suburban runoff from impervious surfaces and roadways, lawn-based fertilizers and pesticides, poorly treated effluent from failing or improperly functioning septic and sewer systems, and many other factors have negatively affected both ground and surface-water quality (IDEQ, 1998a, 2000c; Arnold and Gibbons, 1996; Chandler, 1994). Significant efforts have been undertaken on the part of both municipalities and rural subdivisions to improve both air and water quality. In particular, advancements in wastewater treatment and stormwater treatment have resulted in reductions in loading to surface water systems over the past two decades.

Recreation

Recreation within the SR-HC TMDL reach historically included many of the same opportunities available today although at a much lower intensity and potential for negative impacts on water quality. Accounts detailing recreational boating, fishing, hunting, swimming and camping are

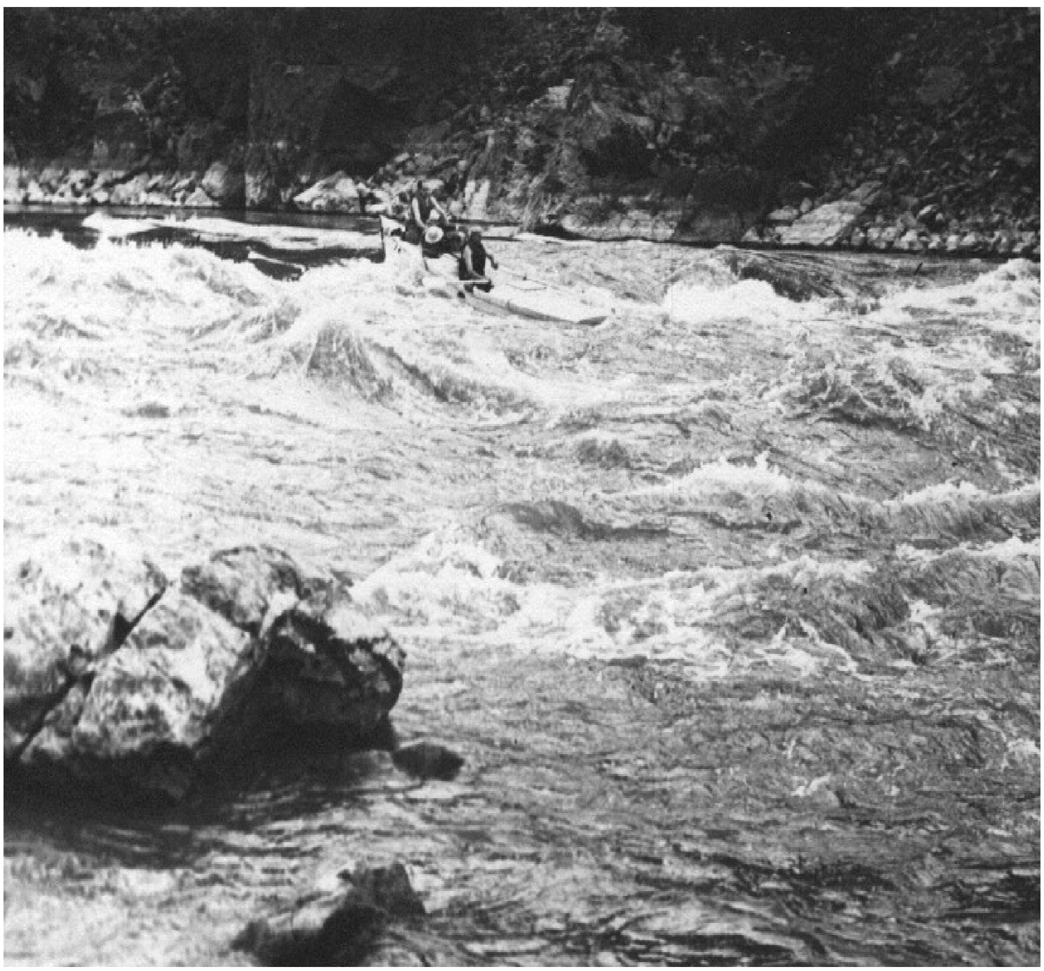

Photo 2.1.3. Running Steamboat Rapids in a rigid craft, circa 1939 to 1940. Front boatman is identified as Horace Parker. Photo from the collection of Dr. Lyle M. Stanford.

plentiful from the time of the first recorded contact with the area by both native peoples and the white settlers who came later. Early recreational use was limited by accessibility and flow in some areas, but continued to grow as the local population increased.

Construction of improved access roadways and the construction and operation of the Hells Canyon Complex reservoirs have changed both the level and type of recreational use in the area. Use intensity has increased dramatically and motorized craft have replaced other more primitive forms of boating to a large degree. Currently the SR-HC TMDL reach contains many locally, state-wide and nationally recognized recreation opportunities including the Hells Canyon National Recreation Area, national forests, state and local parks, specially designated recreation areas, wildlife refuges and trophy fisheries. This wide variety of recreation opportunities available to visitors and area residents adds to both the quality of life and the local economy.

Most, if not all, of these recreational opportunities are directly dependent on water quality in one form or another (i.e. salmon fisheries require water quality adequate for cold water aquatic life while bass fisheries require water quality adequate for warm water aquatic life). Activities such as fishing, swimming and boating depend on the attainment of water quality standards for safety in contact recreation and for adequate habitat for aquatic life. Somewhat less obvious is the link between recreational activities such as hunting, hiking or camping and water quality. However, wildlife habitat, and forest and riparian area health can be directly affected by water quality. Water also provides an aesthetic component to many land-based activities that do not require a body of water but are generally enhanced by association with water (USBR, 1998). Operational and flow management conditions can also have a significant effect on recreational uses. Both direct usage and local economies may be affected to a noticeable degree by water quality and water quantity management practices. Some recreational opportunities are described in more detail below.

Boating.

Boating is one of the most popular water-dependent recreation activities in the SR-HC TMDL reach. The type of boating activities varies with the type of water in each segment of the reach. Boating use is significant in both the riverine (upstream and downstream of the reservoirs) and the reservoir sections of the SR-HC TMDL reach. Overall boating use (upstream, downstream and in-reservoir) has increased with the completion of the Hells Canyon Complex reservoir system. The reservoirs provide numerous flat-water recreation opportunities that include water-skiing, cruising and fishing. These activities are normally enjoyed early in the recreation season when reservoirs are full. Reservoir drawdown and low river flows in the late recreation season often limit these activities due to decreased boat access resulting from low water levels. If drawdown and low river flows occur during the peak recreation season, these activities may be curtailed depending on the magnitude and duration of the drawdowns (USBR, 1998). Non-motorized boating, such as sailing and canoeing are also popular in the SR-HC TMDL reach, but represent a smaller percentage of overall boating activity on reservoirs than motorized boating. In contrast, kayaking, canoeing, and scenic and white-water rafting are the most popular boating activities on the free-flowing Snake River below Hells Canyon Dam and on tributary streams. However, motorized boating does occur in some tributary reaches.

Fishing.
Fishing is also a popular recreation activity on the river system and provides an important boost to local economies. Fishing activity peaks in early summer after the spring runoff and remains high through October. A high percentage of summer fishing on reservoirs is boat fishing, but there are also opportunities for shoreline fishing (USBR, 1998). Game fish species present in the SR-HC TMDL reach include bass, catfish, crappie, white sturgeon, salmon, steelhead, and rainbow trout. Fishing on the reservoirs can be affected directly due to the boat access issues cited above or indirectly due to the effects of reservoir levels on reservoir fish populations by fluctuating reservoir levels. The critical time for nesting by such resident fish as small mouth bass and crappie is from May 1 to June 30. Drawdowns and refilling during or near spawning periods for resident warm water fish in reservoirs can cause lowered spawning success rates. Fluctuating water levels decrease the amount of suitable spawning, early emergence and early rearing habitat for resident fish.

Wildlife and Hunting.
As with fishing, hunting and viewing wildlife is a popular recreational activity in the SR-HC TMDL reach. Important wildlife that are hunted or trapped in the area include bear, coyote, otters, mink, deer, Rocky Mountain wild sheep, mountain lions, elk and a multitude of birds. There are established hunting seasons for a number of these animals as well as for various types of waterfowl and upland birds in the fall and winter months.

Swimming.
Swimming is another popular recreational activity throughout the SR-HC TMDL reach. Swimming activities are usually linked with other recreational use activities such as boating, camping or hiking; and as such, have increased with the increase in recreational use observed following completion of the Hells Canyon Complex reservoir system. Most swimming use occurs during the summer and fall months. Because of its close correlation with other recreational activities, swimming use is also affected by the water quality of the SR-HC TMDL reach, and by flood control and storage operation of the reservoir system.

Camping.
Camping use varies by reservoir and river reach. Many campers choose their destination based on proximity to other recreation activities, particularly boating and fishing. The reservoirs and rivers in the SR-HC system are important destination recreation sites for overnight visitors who travel to the sites to camp and participate in a variety of water-related activities (USBR, 1998). There are a number of camp sites available along the mainstem Snake River, ranging from well-groomed camp grounds equipped with modern facilities maintained by Idaho Power Company (IPCo) along the reservoirs to primitive camp sites used by white water boaters below the Hells Canyon Dam.

2.1.2.2 History and Economics

The economies within the SR-HC TMDL reach are strongly dependent on the Snake River in several ways. Water is a scarce commodity in the area and helps to fuel local business and industry through agriculture, recreation and hydropower generation. The economy of the Snake River Basin is fueled in large part by agriculture. Together with food processing, agriculture represents 23 percent of Idaho’s Gross State Product (IDC, 1999). Agriculture in the Snake

River Basin is heavily dependent on irrigation. Sources of irrigation water include surface water diverted from the Snake River and inflowing tributaries, and ground-water pumping. Agricultural water use is seasonal, correlating strongly with the summer growing season reflecting local temperature and precipitation variations. While still providing the primary economy of the basin, agriculture is slowly being replaced by urban/suburban encroachment and industrial land uses.

In the early 1900's, over 90 percent of Idaho's population was rural, by the 1950's rural population dropped to about 50 percent of the total, in 1998 this figure had dropped to 36 percent. Over the last 10 years the number of farms and farm acres have decreased in the State of Idaho, down by nearly 20 percent between 1969 and 1997. The number of individuals listing their primary occupation as farmer on the 1997 Census of Agriculture decreased by 17.2 percent between 1987 and 1997 (IDC, 1999) alone. As the local population increases, recreational usage of the SR-HC system has also increased. Recreation now represents a significant contribution to the economy in populated areas of southwestern Idaho and the Hells Canyon National Recreation Area (NRA), while in some rural counties recreation-induced costs actually represent a drain on the local economies. Most recreational use within the watershed occurs during the summer season, but some level of recreational use occurs year round. Most recreational use in the SR-HC TMDL reach is dependent on water quality (swimming, boating, whitewater recreation) and aquatic habitat (fishing).

In addition to the increased use of surface water for recreation purposes, the growing population in the region has also resulted in increased electrical power demand. While hydropower plants are expensive to construct, they can represent a more environmentally friendly and relatively economical alternative to more expensive mechanisms of power production such as coal-fired facilities. However, there is recent evidence and analysis to show that the environmental, social, and cultural costs of large hydropower systems may be much higher than for other types of power generation (World Commission on Dams, 2000). One of the externalized costs associated with the Hells Canyon Complex is that in order to operate effectively, there must be a manipulation of naturally occurring flows. This manipulation can present challenges to water quality and aquatic habitat, e.g. the migration of anadromous fish species. With the West Coast currently experiencing substantial power shortages, operation of hydroelectric facilities is viewed by many as equally important to the local economy as agriculture or recreational water uses.

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2.2 Water Quality

2.2.1 Water Quality Standards and Criteria

Water quality standards under the Clean Water Act consist of three main components: designated beneficial uses, water quality criteria that are established to protect designated beneficial uses, and antidegradation policies and procedures. Water quality criteria can be either numeric limits for individual pollutants and conditions, or narrative descriptions of desired conditions. Table 2.2.1 summarizes the Oregon and Idaho water quality criteria and lists specific citations where the full code language can be found. Because of the bi-state nature of the SR-HC TMDL, and the fact that the Snake River from RM 409 to RM 188 is an interstate water body with the state boundary line described as the centerline of the river, water quality standards and particularly water quality criteria for both Oregon and Idaho must be attained. Because the state line between Oregon and Idaho is in the middle of the mainstem Snake River, the waters of both states are mixed mid-river. Therefore waters from both sides must meet the criteria of both states in the mainstem.

The CWA regulations require that state water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters. There is a precedent set by the Dioxin TMDL for the Columbia to use the more stringent standards of a bi-state system. In addition, in the Coeur d'Alene TMDL, WLAs were set to ensure that downstream water-quality criteria would be met. The US Supreme Court ruling in Arkansas v. Oklahoma provided that US EPA has the authority to require discharges from NPDES permitted facilities to comply with downstream state standards.

Due to the fact that the states of Oregon and Idaho use different methodologies to determine what constitutes a violation of water quality standards and to calculate whether or not a violation of state standards has occurred, it is not immediately obvious which state's standards represent the most stringent values. A direct calculation of stringency was therefore undertaken for standards for which numeric criteria had been established. In the case of those pollutants where numeric criteria were not available, reasonable state and federal guidelines and guidance documents have been applied in correlation with the current understanding of the system and the physical constraints imposed by naturally occurring conditions. A copy of the stringency analysis generated is attached in Appendix C. The resulting water quality targets for the SR-HC TMDL are listed in Table 2.2.2.

Please note, the identification of stringency and the use of Oregon or Idaho State standards determined to be the more stringent as a basis for the identification of water quality targets for the SR-HC TMDL should not be interpreted as applying Idaho State standards to Oregon waters or v/v per se. Rather, this mechanism is being used to ensure that both states' standards will be met at the border (mid-river) where the two states' waters meet.

Table 2.2.1 Idaho and Oregon water quality standards and criteria summary

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Bacteria	Less than 126 *E. coli* organisms/100 mL as a 30 day log mean with a minimum of 5 samples **AND** no sample greater than 406 *E. coli* organisms/100 mL	251.01.a & b	Less than 126 *E. coli* organisms/100 mL as a 30 day log mean with a minimum of 5 samples **AND** no sample greater than 406 *E. coli* organisms/100 mL	340-41-725, 765, 805, 845 (2) (e)(A)
Dissolved Oxygen (DO)				
Cold Water Aquatic Life	Greater than 6.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth **Site-specific criteria**: a minimum of 6.5 mg/L water column dissolved oxygen from the Idaho/Oregon border to Hells Canyon Dam. (approved by the Idaho Legislature 20 March 2004, subject to US EPA action)	250.02.a 285.Snake River, Subsections 140.13, HUC 17050115, unit SW1; and 140.19, HUC 17050201, units SW1 - SW4	8.0 mg dissolved oxygen/L **OR** (where conditions of barometric pressure, altitude, and temperature preclude attainment of 8 mg/L) dissolved oxygen levels shall not be less than 90% saturation as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	340-41-725, 765, 805, 845 (2) (a) (D)
Cool Water Aquatic Life	N/A		6.5 mg/L as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	340-41-725, 765, 805, 845 (2) (a) (E)
Salmonid Spawning	Water column dissolved oxygen of not less than 6.0 mg/L or 90% of saturation whichever is greater.	250.02.e.2.a	Water column dissolved oxygen of not less than 11.0 mg/L OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95% of saturation (if adequate data exists a water column criteria of 9 mg/L if the intergravel dissolved oxygen is greater than 8 mg/L)	340-41-725, 765, 805, 845 (2) (a) (A)
	Intergravel dissolved oxygen of not less than 5 mg/L (1 day min) **AND** not less than 6.0 mg/L (7 day avg. mean) during spawning and incubation period for species inhabiting the waters	250.02.e.1	Intergravel dissolved oxygen of not less than 6 mg/L	340-41-725, 765, 805, 845 (2) (a)(B)

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Salmonid Rearing	N/A		N/A	
Seasonal Cold	Greater than 6.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth, applicable during the time period from the summer solstice to the autumnal equinox	250.03.a.i-iii	N/A	
Warm Water Aquatic Life	Greater than 5.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth	250.04.a	5.5 mg/L as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards	340-41-725, 765, 805, 845 (2) (a) (F)
Mercury	Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. Toxic substance criteria is set forth in CWA 40 CFR 131.36 (b)(1) (National Toxics Rule (NTR)). 0.012 ug/L water column concentration aquatic life chronic criterion	210	Toxic substances will not be introduced above natural background levels in the waters of the state which may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare (2.4 mg/L for acute aquatic exposure and 0.012 mg/L for chronic aquatic exposure)	340-41-725, 765, 805, 845 (2) (p)(A)
	0.14 ug/L water column concentration for ingestion of fish and drinking water	210 and National Toxics Rule (CWA 40 CFR 131.36 (b)(1)	Less than 0.144 ug/L water column concentration for ingestion of fish and drinking water	340-41-725, 765, 805, 845 (2)(p)(B) which references Table 20
	1.0 mg/kg total mercury (NTR), less than 0.5 mg methylmercury /kg in fish tissue (wet weight) for human consumption	210 and National Toxics Rule (CWA 40 CFR 131.36 (b)(1)) Idaho Dept. of Environ. Health and Safety	Less than 0.35 mg Hg/kg in fish tissue	340-41-725, 765, 805, 845 (2) (p)(A) as interpreted by the Oregon Health Division

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Nuisance Algae	Surface waters shall be free from floating, suspended or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that impair designated beneficial uses and be free from oxygen-demanding materials in concentrations that would result in an anaerobic water condition.	200.05 & 07	A threshold level of less than 0.015 mg chlorophyll *a*/L which when exceeded should trigger a Department determination of impairment of a designated use. (This TMDL represents that determination and contains site-specific targets for protection and support of the designated uses)	340-41-150 (1)(b) and 340-41-725, 765, 805, 845 (2)(h-l),
Nutrients	Surface waters shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.	200.06	Addressed by watershed if chlorophyll *a* action levels are not met or there is evidence through dissolved oxygen or pH problems that a designated use is being impaired.	
Pesticides	Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. Toxic substance criteria is set forth in CWA 40 CFR 131.36 (b)(1) (National Toxics Rule).		Toxic substances shall not be introduced above natural background levels at levels that may be harmful, may change to harmful forms, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect designated beneficial uses.	340-41-725, 765, 805, 845 (2)(p)(A-D); Table 20 criteria
DDT	Less than 0.00059 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	Less than 0.000024 ug/L water column concentration for ingestion of fish and drinking water	Table 20 criteria
DDD	Less than 0.00083 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	N/A	
DDE	Less than 0.00059 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	N/A	
Dieldrin	Less than 0.00014 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	Less than 0.000071 ug/L water column concentration for ingestion of fish and drinking water	Table 20 criteria

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
pH	6.5 to 9.0 standard units	250.01.a	7.0 to 9.0 standard units. From RM 260 to 409 reservoirs impounded prior to 1996 are exempt from this criterion if the pH numeric criteria would not have been exceeded without the impoundment and all practicable measures have been taken to bring the pH into compliance with the criteria.	340-41-725, 765, 805, 845 (2)(d)
Temperature				
Cold Water Aquatic Life	Water temperatures of 22 °C or less with a maximum daily average of no greater than 19 °C	250.02.b	N/A	
Salmonid Spawning (criteria are specific to those spawning periods designated as appropriate for the specific species present)	Water temperatures of 13 °C or less with a maximum daily average no greater than 9 °C **Site-specific criteria:** A maximum weekly maximum temperature of 13 °C to protect fall chinook spawning and incubation applies from October 23rd through April 15th in the Snake River from Hell's Canyon Dam to the Salmon River. (Temporary rule, effective by action of the IDEQ board 11-14-03, pending approval by Idaho Legislature 2005, subject to US EPA action)	250.02.e.ii 286.Snake River, Subsection 130.01, HUC 17060101, Unit S1 to S3.	12.8 °C or less as a 7-day moving average of the daily maximum temperature	340-41-725, 765, 805, 845 (2)(b)(A &B)
Salmonid Rearing	N/A		17.8 °C or less as a 7-day moving average of the daily maximum temperature	340-41-725, 765, 805, 845 (2)(b)(A &B)
Seasonal Cold	Water temperatures of 26 °C or less as a daily maximum with a daily average of no greater than 23 °C, applicable during the time period from the summer solstice to the autumnal equinox	250.03.b	N/A	
Warm Water Aquatic Life	Water temperatures of 33 °C or less with a maximum daily average not greater than 29 °C	250.04.b	N/A	

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Turbidity (Sediment)	Less than 50 NTU above background for any given sample **OR** Less than 25 NTU for more than ten consecutive days (below any applicable mixing zone set by the IDEQ) applies to waters designated for cold water aquatic life	250.02.d	Less than a 10% cumulative increase in natural stream turbidities	340-41-725, 765, 805, 845 (2)(c)
Sediment	Sediment shall not exceed quantities specified in general surface water quality criteria (IDAPA 58.01.02.250 or 252), or, in the absence of specific sediment criteria, quantities that impair designated beneficial uses.	200.08		
Total Dissolved Gases	Less than 110%, with the authority to specify the applicability of this standard with respect to excess stream flow conditions.	250.01.b 300.01.a	Less than 110%, except when stream flow exceeds the ten-year, seven-day average flood flow	340-41-725, 765, 805, 845 (2)(n)

Table 2.2.2 Water quality targets specific to the Snake River - Hells Canyon TMDL.

Parameter	Selected Target	Where Applied
Bacteria	Less than 126 *E coli* organisms per 100 ml as a 30 day log mean with a minimum of 5 samples AND no sample greater than 406 *E coli* organisms per 100 ml	Full SR-HC TMDL reach (RM 409 to 188)
Dissolved Oxygen (DO) • Cold water aquatic life and salmonid rearing	8 mg/L water column dissolved oxygen as an absolute minimum, OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 8 mg/L) dissolved oxygen levels shall not be less than 90%; unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	Downstream Snake River Segment (RM 247 to 188)
• Salmonid spawning, when and where it occurs	11 mg/L water column dissolved oxygen as an absolute minimum OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95%; with intergravel dissolved oxygen not lower than 8 mg/L, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188) October 23 to April 15
• Cool water aquatic life	6.5 mg/L water column as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	Full SR-HC TMDL reach (RM 409 to 188)
Mercury (Hg)	Less than 0.012 ug/L water column concentration (total) Less than 0.35 mg/kg in fish tissue	Full SR-HC TMDL reach (RM 409 to 188)
Nuisance Algae	14 ug/L mean growing season limit (nuisance threshold of 30 ug/L with exceedence threshold of no greater than 25%)	Full SR-HC TMDL reach (RM 409 to 188)
Nutrients	Less than or equal to 0.07 mg/L total phosphorus	Full SR-HC TMDL reach (RM 409 to 188) May through September
Pesticides	Less than 0.024 ng/L water column concentration DDT Less than 0.83 ng/L water column concentration DDD Less than 0.59 ng/L water column concentration DDE Less than 0.07 ng/L water column concentration Dieldrin	Oxbow Reservoir Segment (RM 285 to 272.5) and upstream waters
pH	7 to 9 pH units	Full SR-HC TMDL reach (RM 409 to 188)
Sediment (Turbidity)	Less than or equal to 80 mg TSS/L for acute events lasting no more than 14 days, and less than or equal to 50 mg TSS/L monthly average	Full SR-HC TMDL reach (RM 409 to 188)

Parameter	Selected Target	Where Applied
Temperature • Cold water aquatic life and salmonid rearing	17.8 °C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 °C. If and when the site potential is greater than 17.8 °C, the target is no more than a 0.14 °C increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 °C increase from anthropogenic sources.	Full SR-HC TMDL reach (RM 409 to 188)
• Salmonid spawning, when and where it occurs for specific species	A maximum weekly maximum temperature of 13 °C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 °C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 °C, the target is no more than a 0.14 °C increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 °C increase from anthropogenic sources. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188) October 23 to April 15
Total Dissolved Gases	Less than 110%, except when stream flow exceeds the ten-year, seven-day average flood flow	Oxbow Reservoir to the Salmon River Inflow (RM 285 to 188)

These targets were established through an evaluation of the stringency of Oregon and Idaho State standards. The methodology and results of this evaluation are described in complete detail in Appendix C.

2.2.2 Overview of Designated Beneficial Uses

Designated surface water beneficial use classifications are intended to protect the various uses of each state's surface water. The specific designated beneficial uses for the SR-HC TMDL reach differ slightly between the two states but the basic concepts are consistent. The various designated beneficial uses can be grouped into five categories: **aquatic life**, **recreation**, **water supply**, **wildlife habitat** and **aesthetics**.

2.2.2.1 General Information

Within Idaho, IDEQ designates beneficial uses for selected waterbodies as outlined in IDAPA 58.01.02.140. Undesignated waterbodies are presumed to support cold water aquatic life and primary or secondary contact recreation unless IDEQ determines that other uses are appropriate. Within Oregon, ODEQ designates beneficial uses for selected waterbodies by basin as outlined in OAR 340-41. Under the Clean Water Act, any uses that existed or were presumed to exist in a waterbody on or after November 28, 1975 are required to be protected as existing uses. The designation of existing uses for protection generally applies to segments where beneficial uses are not formally designated. All of the existing uses in the SR-HC TMDL reach are listed as designated beneficial uses by the states of Oregon and/or Idaho (Table 2.2.3 a and b).

Table 2.2.3 a Idaho segment-specific listings for the Snake River - Hells Canyon TMDL reach.

Segment	Idaho 303(d) Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 409 to 396.4 Upstream Snake River (OR/ID border to Boise River Inflow)	(downstream from ID border) bacteria, dissolved oxygen, nutrients, pH, sediment	(downstream from ID border) cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 396.4 to 351.6 Upstream Snake River (Boise River Inflow to Weiser River Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 351.6 to 347 Upstream Snake River (Weiser River Inflow to Scott Creek Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	dissolved oxygen, mercury, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 285 to 272.5 Oxbow Reservoir	nutrients, sediment, pesticides,	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 272.5 to 247 Hells Canyon Reservoir	not listed	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 247 to 188 Downstream Snake River (Hells Canyon Dam to Salmon River Inflow)	temperature	cold water aquatic life salmonid spawning primary contact recreation domestic water supply special resource water

*The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning.

Table 2.2.3 b Oregon segment-specific listings for the Snake River - Hells Canyon TMDL reach.

Segment	Oregon 303(d) Listed Pollutants	Oregon Designated Beneficial Uses
Snake River: RM 409 to 395 Upstream Snake River (Owyhee Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 395 to 335 Upstream Snake River to Farewell Bend (Malheur Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower
Snake River: RM 260 to 188 Lower half of Hells Canyon Reservoir Downstream Snake River (Grande Ronde Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (downstream) resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics anadromous fish passage commercial navigation and transport

* The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality criteria apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific criteria for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

2.2.2.2 DESCRIPTIONS OF DESIGNATED USES

Aquatic life

Aquatic life classifications are for waterbodies that are suitable or are intended to be made suitable for protection and maintenance of viable aquatic life communities of aquatic organisms and populations of significant aquatic species. Aquatic life uses include the following official Oregon and/or Idaho designated beneficial uses:

- cold water aquatic life
- salmonid rearing and spawning

- resident fish and aquatic life (including warm and cool water designations where applicable)
- anadromous fish passage

Cold Water Aquatic Life (RM 409 to 188).
Waters designated for cold water aquatic life use within the SR-HC TMDL reach are required to exhibit appropriate levels of dissolved oxygen, temperature, pH, ammonia and turbidity for cold water aquatic life support.

Salmonid Rearing and Spawning.
Waters designated for salmonid spawning and rearing within the SR-HC TMDL reach are required to exhibit appropriate levels of water column dissolved oxygen, intergravel dissolved oxygen, temperature, pH, ammonia, toxics, and turbidity for full support of fish during the spawning, incubation and rearing periods for those salmonid species inhabiting the designated waters.

The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. General time periods identified for spawning and incubation of the salmonid species that occur in these waters are listed below.

Where specific local information is available on actual spawning and incubation periods, this information has been used. The spawning and incubation times referenced in this document are based on site-specific data, laboratory data, and/or literature references as available. If additional site-specific data on spawning and incubation times or water temperatures become available following the submission and approval of this TMDL, these data will be evaluated in the context of the iterative TMDL process. If it is determined that the additional data are appropriate to this TMDL, the time frames and/or temperatures identified for spawning and incubation will be updated as necessary to reflect the expanded data set and improved understanding of the SR-HC TMDL reach and related habitat and use-support needs.

Tributary Spawners:	
Chinook salmon	August 01 to April 01 (spring)
Chinook salmon	August 15 to June 15 (summer)
Rainbow/Steelhead	March 01 to July 15*
Redband trout	March 01 to July 15
Upper Tributary Spawners:	
Bull Trout	September 01 to April 01
Mainstem Spawners:	
Chinook salmon (fall)	October 23 to April 15*
Mountain Whitefish	November 01 to March 30*

* represents spawning times identified by IDFG and ODFW as specific to the SR-HC TMDL reach.

The entire SR-HC TMDL reach (from RM 409 to RM 188) is listed for temperature on the state 303(d) lists. The water quality standards and guidance values identified for temperature in the

SR-HC TMDL are numeric criteria specific to the designated beneficial uses of *cold water aquatic life* and *salmonid spawning and rearing*.

The entire SR-HC TMDL reach (from RM 409 to RM 188) has been designated for cold water aquatic life by the State of Idaho. This same reach has been designated for salmonid spawning and rearing by the State of Oregon. Within the beneficial use designation of salmonid spawning and rearing, the State of Oregon can differentiate between those areas where salmonid spawning occurs and those areas where salmonid rearing occurs separately within a watershed. The water quality targets applied to these areas are then determined by this localized designation of use with salmonid rearing targets applied to those areas designated for salmonid rearing and salmonid spawning targets applied to those areas designated for salmonid rearing.

Specific designation of the salmonid spawning and salmonid rearing beneficial uses are as in the SR-HC TMDL reach follows:

<u>Salmonid Spawning (RM 247 to 188).</u>
The states of Oregon and Idaho have designated the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach for salmonid spawning. The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. As the mainstem Snake River between RM 247 and 188 is an interstate waterway, the more stringent of the two states' standards identified has been identified as the salmonid spawning target for this TMDL (Table 2.2.2).

The State of Idaho and the State of Oregon have designated some of the tributaries to the SR-HC TMDL reach for salmonid spawning based on the available data and the current level of understanding of fish species present. Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Salmonid spawning is not observed to occur in the Upstream Snake River segment (RM 409 to 335) or the reservoir segments (RM 335 to 247). Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will be determined by each State outside the scope of this TMDL.

This localized designation of salmonid spawning areas is integral to the approach outlined in the initial sections of this document regarding the open acknowledgement by this TMDL effort that there are distinct spatial and temporal use patterns within the specific segments designated for specific beneficial uses within the SR-HC TMDL reach. Targets have been set to recognize those spatial/temporal use patterns that exist, as well as the needed connectivity within the mosaic of designated beneficial uses (including critical habitat for sensitive species) throughout the waterbody; and to provide for full support of existing uses and the restoration of impaired designated uses within that mosaic. In setting specific salmonid rearing and salmonid spawning designations, the SR-HC TMDL also recognizes that this ecosystem is comprised of a variety of aquatic environments that include lentic (still water), lotic (moving water) and transition areas, each with their own characteristic attributes, habitat types and beneficial uses. In this way the proposed approach will result in a TMDL that is achievable, that will meet criteria, and that will support designated beneficial uses without imposing inappropriate and unreachable water quality targets and implementation expectations.

The State of Idaho designation of salmonid spawning as a beneficial use for Brownlee Reservoir, Oxbow Reservoir and Hells Canyon Reservoir has been formally removed by state legislative action finalized on March 30, 2001. For the purposes of this TMDL, the current use designations identified by the states will be applied.

Salmonid Rearing (RM 409 to 188).

The State of Oregon has designated the mainstem Snake River in the SR-HC TMDL reach for salmonid rearing (the State of Idaho equivalent to salmonid rearing is cold water aquatic life). The State of Idaho has designated the entire reach for cold water aquatic life. The salmonid rearing/cold water aquatic life beneficial use designation, and the accompanying water quality targets apply to the mainstem Snake River within the SR-HC TMDL reach. As the mainstem SR-HC TMDL reach of the Snake River is an interstate waterway, the more stringent of the two states' standards identified has been identified as the salmonid rearing/cold water aquatic life target for this TMDL (Table 2.2.2).

Resident Fish and Aquatic Life (RM 409 to 188).

Waters designated for resident fish and aquatic life within the SR-HC TMDL reach are required to exhibit appropriate levels of water column dissolved oxygen, temperature, pH, ammonia and turbidity for full support of fish during the spawning, incubation and rearing periods for those resident species inhabiting the designated waters. In addition to water quality, water level fluctuations can affect fish spawning success. The critical time for nesting by such resident fish as small mouth bass and crappie is from May 1 to June 30. Fluctuating water levels can decrease the amount of suitable spawning, early emergence and early rearing habitat for resident fish.

Anadromous Fish Passage (RM 260 to 188).

It should be noted that although anadromous fish passage is a designated beneficial use above Hells Canyon Dam (RM 247) by the State of Oregon, the only fish passage at Hells Canyon Dam is provided via a trapping system at the dam for collection of anadromous fish for hatchery stocks and upstream "put and take" fisheries. Anadromous Fish Passage is usually intended for passage of both hatchery and wild stock and this is not the case at Hells Canyon Dam. This barrier to fish passage was in place when this beneficial use was designated for the mainstem of the Snake River within the Grande Ronde basin. It seems likely that the designated beneficial use was meant to be applicable only up to the dam and an administrative oversight left it in place up to RM 260. On the other hand, the original Federal Energy Regulatory Commission (FERC) license for the Hells Canyon Dam included anadromous fish passage. So anadromous fish passage could be interpreted as an existing use in 1975. This issue needs to be clarified through an Oregon administrative review of the designated uses for this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

The variety of aquatic life that occurs in the SR-HC TMDL reach poses some unique challenges to this TMDL. The most sensitive beneficial uses, often salmonid spawning and rearing, must be protected. There are areas in the SR-HC TMDL reach where salmonid spawning would be quite limited spatially and temporally. For instance, salmonids (with the exception of mountain whitefish (Northcote and Ennis, 1994)) are redd spawners that spawn in areas with moving water and a gravel substrate (Scott and Crossman, 1973). Therefore, salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning. Therefore, while it is critical to protect spawning habitat in the tributaries, it is not assumed to occur in the mainstem channel of the Upstream Snake River (RM 409 to 335) and reservoir segments (RM 335 to 247).

In addition, the resident (non-salmonid) fish make up the dominant community in the reservoirs as these species are most suited to the physical conditions that are present in reservoir and lake systems, and naturally inhabit reservoirs and lakes. The salmonids that use these reservoirs are rainbow trout and mountain whitefish. Therefore, it is important to protect the water quality and habitat of the resident fish in the reservoir and free-flowing areas, as well as maintaining sufficient quality where appropriate in the reservoirs for the limited salmonid populations. As a result of the complexity of the aquatic life in the SR-HC TMDL reach, this TMDL depends on spatial and temporal analysis of needs of the dominant fish communities in establishing targets and loads while maintaining sufficient areas of appropriate water quality to protect the non-dominant species.

Recreation

Recreation classifications are for waterbodies that are suitable or are intended to be made suitable for primary and secondary contact recreation; this includes fishing for consumption. Water or primary contact recreation refers to prolonged and intimate human contact with water where ingestion is likely to occur, such as swimming, water skiing and skin diving. Secondary contact recreation refers to uses where intimate human contact and ingestion of water is expected to occur to a lesser degree such as fishing, boating and wading. Recreation uses include the following official Oregon and/or Idaho designated beneficial uses:

- water contact recreation (including primary contact recreation)
- fishing
- boating

Water Contact Recreation (RM 409 to 188).

The SR-HC TMDL reach is designated for both primary contact recreation and water contact recreation. These classifications are for waterbodies that are suitable or intended to be made suitable for prolonged and intimate human contact with water where ingestion is likely to occur, such as swimming, water skiing and skin diving. Therefore, designated waters are required to meet surface water quality criteria specific for bacteria and nuisance algal growth.

Fishing (RM 409 to 188).

Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of fishing as contained in the general surface water quality criteria of Oregon and Idaho. In addition to meeting the criteria described above for the protection of fish, these waters must also meet criteria for both states regarding nuisance algal growth and toxic materials that may affect such uses as fishing for human consumption.

Boating (RM 409 to 188).
Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of boating particularly those for bacteria and nuisance algal growth.

Water Supply
Water supply classifications are for waterbodies that are suitable or are intended to be made suitable for agriculture, domestic and industrial uses. Industrial water supply includes hydropower uses where designated. Water supply uses include the following official Oregon and/or Idaho designated beneficial uses:

- public/private domestic water supply
- agricultural water supply (including irrigation water and livestock watering)
- industrial water supply
- hydropower generation
- commercial navigation and transportation

Public/Private Domestic Water Supply (RM 409 to 188).
Waters designated for domestic water supply within the SR-HC TMDL reach are required to meet general surface water quality standards for toxic materials and turbidity. These waters, while not required to meet drinking water standards in-stream, must be of sufficient quality that it is possible for them to meet drinking water standards with conventional treatment measures.

Agricultural Water Supply (RM 409 to 188).
Waters designated as agricultural water supply (including irrigation water and livestock watering) within the SR-HC TMDL reach are required to be suitable for the irrigation of crops or as drinking water for livestock. Waters designated for agricultural water supply are required to meet general surface water quality criteria for toxic materials. These waters are also required to meet narrative criteria related to sediment and excessive nutrients.

Industrial Water Supply (RM 409 to 188).
Waters designated as industrial water supply are required to be suitable for industrial uses. Waters designated for industrial water supply within the SR-HC TMDL reach are required to meet general surface water quality criteria.

Hydropower Generation (RM 335 to 260).
No hydropower facilities are located in the Upstream (RM 409 to RM 335) or Downstream (RM 247 below Hells Canyon Dam to RM 188) Snake River segments of the SR-HC TMDL reach (see Section 2.3 for a more detailed discussion of these segments) but the flows into the SR-HC TMDL reach are regulated by upstream and tributary hydropower and irrigation developments. Brownlee, Oxbow, and Hells Canyon Dams are located within the SR-HC TMDL reach and are operated for hydropower generation. These three facilities are collectively referred to as the Hells Canyon Complex (HCC).

Brownlee Reservoir was constructed primarily for power production although it is also operated for flood control purposes through direction from the US Army Corps of Engineers. The reservoir is also currently operated with consideration for anadromous fish protection and passage in the downstream reaches of the Snake and Columbia rivers under consultation with NMFS. Brownlee Reservoir provides the flows from the Hells Canyon Complex for fish protection and passage. Brownlee Dam was completed in 1958, with a nameplate generating capacity of 585.4 megawatts (MW). (Nameplate capacity is the capacity of a facility based on output at maximum efficiency.)

Oxbow Reservoir was constructed and is currently operated for power production. Oxbow Dam was completed in 1961 with a nameplate generating capacity of 190 MW.

Hells Canyon Reservoir was constructed and is currently operated for power production. Hells Canyon Dam was completed in 1969 with a nameplate generating capacity of 391.5 MW. It should be noted that although hydropower generation is a designated beneficial use extending from Farewell Bend (RM 335) to midway through the Hells Canyon Reservoir above Hells Canyon Dam (RM 260) by the State of Oregon, it is recognized that hydropower generation occurs at the Hells Canyon Dam (RM 247). The dam was in place and operating when this beneficial use was designated for the mainstem of the Snake River. Thus hydropower at Hells Canyon Dam was an existing use in 1975. Therefore the designated beneficial use of hydropower was most probably meant to be applicable downstream to the dam but not beyond. This is the interpretation that will be used in this document; however, this is an issue that should be resolved by an administrative review of the Oregon designated uses in this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

Many factors can affect the operation of hydropower facilities. Changes in operation efficiency, reservoir release flow and reservoir water surface elevation can affect the amount of energy produced. The energy production of run-of-the-river hydropower facilities (like the HCC) can change if the stream flows change. Inflowing tributaries to the SR-HC TMDL reach can therefore affect hydropower generation within the mainstem reservoirs. Operation of these facilities can in turn affect water levels and flow characteristics downstream and can impact hydropower generation at downstream facilities. Changes in diversions to irrigation canals can also affect generation at hydropower facilities located downstream. Water quality of water flowing into a hydropower reservoir can also substantially affect the operation and efficiency of power production. If inflowing water is degraded, operational alterations, physical modifications, or in-reservoir water quality improvements may be required so that project discharges and water within the reservoir are not substandard. These requirements can significantly affect the ability of the project to operate efficiently and meet power needs. TMDLs are required for waters that do not meet state standards. Operation of hydropower facilities under the FERC licensing process must provide consideration for both power generation and the environment. Additionally, one of the primary influences on the operation of hydropower facilities is consumer and system demand. Consumer demand can influence flow from hour to hour during any day.

The operation of hydroelectric power generation facilities within the Pacific Northwest is accomplished through a grid of private, non-federal public and federal transmission lines. Electricity is transferred throughout this grid system to those locations where it is needed regardless of ownership of power lines and generating facilities. Because of the interconnection of the power grid, any large change anywhere in the system may be felt throughout the system (USBR, 1998).

Commercial Navigation and Transportation (RM 260 to 188).
It should be noted that although commercial navigation and transportation is a designated beneficial use above Hells Canyon Dam by the State of Oregon, commercial navigation and transportation through the dam is not possible as there are not any shipping locks at the dam. In addition, this designation only goes halfway up Hells Canyon Reservoir (RM 260) but no further, suggesting it is not meant for small chartered commercial craft. However, this barrier to navigation and transportation was in place when this beneficial use was designated for the mainstem of the Snake River within the Grande Ronde basin. Therefore, the designated beneficial use was most probably meant to be applicable up to the dam but not beyond. This is the interpretation that will be used in this document. However this is an issue that should be resolved by an administrative review of the Oregon designated uses in this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

Wildlife habitat
Wildlife habitat waters are those which are suitable or are intended to be made suitable for wildlife habitat and hunting and are represented by the official Oregon designated beneficial use of:

- wildlife and hunting

Wildlife and Hunting (RM 409 to 188).
This designated beneficial use is applied to water bodies utilized by various non-game wildlife species in addition to game species and hunters. Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of wildlife habitat as contained in the general surface water quality criteria of Oregon and Idaho.

Aesthetics
Aesthetics are designated as a beneficial use for special resource waters or for aesthetic enjoyment of a waterway. Special resource waters are those waters protected due to unique or outstanding characteristics or where intensive protection of the water quality is necessary to maintain an existing but jeopardized designated beneficial use. Aesthetic uses include the following official Oregon and/or Idaho designated beneficial uses:

- aesthetics
- special resource waters

Aesthetics (RM 409 to 188).
This use includes those waters within the SR-HC TMDL reach protected due to unique or outstanding aesthetics characteristics or where intensive protection of the water quality is necessary to maintain aesthetic enjoyment.

Special Resource Waters (RM 409 to 188).
This use includes those waters within the SR-HC TMDL reach protected due to unique or outstanding characteristics or where intensive protection of the water quality is necessary to maintain an existing but jeopardized designated beneficial use.

2.2.2.3 Threatened and Endangered Species

The SR-HC TMDL reach provides habitat for the Idaho spring snail (identified in the region between RM 422 and 393 and between RM 372 and 340) and the Bliss Rapids snail (identified in the region between RM 228 and 225 and in several areas of the Snake River upstream of the SR-HC TMDL reach). Both of these snail species are listed as threatened under the Federal ESA, both are listed as requiring cold, clear, well oxygenated water for full support.

Adult bull trout, known to utilize the reservoir segments (RM 335 to 247), are listed as threatened under the ESA. The SR-HC TMDL reach and some inflowing tributaries below Hells Canyon Dam (RM 247) also provide habitat for the Snake River fall and spring/summer chinook as well as steelhead, all of which are listed as threatened under the ESA. In addition, pacific lamprey are rumored to inhabit the river below Hells Canyon Dam, however, no sampling effort has identified them in any quantity, and no available published reports refer to their presence currently.

Idaho Springsnail (*Pyrgulopsis idahoensis,* formerly *Fontelicella idahoensis* (Frest and Johannes, 2001))
Status: Endangered (57 FR 59257, December 14, 1992)
Distribution: Random locations at sites near CJ Strike Reservoir, Upstream to Bancroft Springs. Recent population studies have identified Idaho Springsnails in the mainstem Snake River from RM 422 to 393 and from RM 372 to 340 (IPCo, 2001a).
Habitat requirements: Free flowing, clear, cold water environments
Reasons for status: Loss of habitat due to alteration of natural flows and declining water quality.
Solutions: Prevention of further Snake River diversions, improved water quality and natural flow corridors.
Information provided by: US Fish and Wildlife Service

Bliss Rapids snail (*Taylorconcha serpenticola*)
Status: Threatened (57 FR 59257, December 14, 1992)
Distribution: Random locations at sites between Salmon Falls and King Hill. Recent population studies have identified Bliss Rapids snails in the mainstem Snake River below Hells Canyon Dam from RM 229 to 225 (IPCo, 2001a).
Habitat requirements: Gravel and boulders of swift currents, usually just below canyon segments in the river, in rapids or in boulder bars just below rapids. Free flowing, clear, cold water environments.
Reasons for status: Loss of habitat due to alteration of natural flows and declining water quality.
Solutions: Prevention of further Snake River diversions, improved water quality and natural flow corridors.
Information provided by: US Fish and Wildlife Service

Bull Trout (*Salvelinus confluentus*)
Status: Threatened (Conterminous US, 64 FR 58910, November 1, 1999)
Distribution: Adult Bull trout identified in the Hells Canyon Reservoir and Downstream Snake River segments of the SR-HC TMDL reach (mainstem Snake River from RM 272.5 to RM 188). Bull trout have been identified to spawn in the upper reaches of some tributaries to the SR-HC

TMDL reach. Spawning is not identified to occur in the mainstem Snake River within the TMDL reach.
Habitat requirements: Free flowing, cold-water environments
Reasons for status: Loss of habitat, degraded habitat, declining water quality, increased sedimentation in spawning gravels, higher stream temperatures, blocked migratory corridors and introduction of competing, non-native fish species.
Solutions: Restricted fishing, prohibited non-native species introduction, protection of habitat, public education for proper identification.
Information provided by: US Fish and Wildlife Service and Idaho Department of Environmental Quality

Fall Chinook (*Oncorhynchus tshawytscha*)
Status: Threatened (58 FR 49880, September 23, 1993, Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold water environments with appropriate spawning gravels.
Reasons for status: Habitat loss and degradation, declining water quality, mistaken angler harvest, impoundments (low seaward migration survival) and blocked migratory routes.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest and improved water quality.
Information provided by: National Marine Fisheries Service

Spring and Summer Chinook (*Oncorhynchus tshawytscha*)
Status: Threatened (58 FR 49880, September 23, 1993, Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold water environments with appropriate spawning gravels.
Reasons for status: Habitat loss and degradation, declining water quality, mistaken angler harvest, impoundments (low seaward migration survival) and blocked migratory routes.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest and improved water quality.
Information provided by: National Marine Fisheries Service

Steelhead (*Oncorhynchus mykiss*)
Status: Threatened (63 FR 32997, June 17, 1998; Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold-water environments
Reasons for status: Loss of habitat, degraded habitat, declining water quality, increased sedimentation in spawning gravels, higher stream temperatures, blocked migratory corridors and overfishing.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest, restoration of natural flows and improved water quality.
Information provided by: National Marine Fisheries Service

<u>Bald Eagle</u> (*Haliaeetus leucocephalus*)
Status: Threatened (60 FR 36010, July 12, 1995; Proposal to delist, 64 FR 36453, July 6, 1999)
Distribution: Throughout the SR-HC TMDL reach, RM 409 to 188.
Habitat requirements: Bald eagles use snags, trees with exposed limbs and lateral branches, for perching and nesting. Forage is predominantly fish and small birds.
Reasons for status: Lack of adequate perch trees, recreational and urban encroachment on nesting and forage territories, poor water quality, low reproductive success and direct bird mortality due to DDT, lead poisoning due to feeding on waterfowl containing lead shot.
Solutions: Ban on DDT in 1972, phasing out of lead shot, protection of nesting areas, wintering areas and food sources.
Information provided by: US Fish and Wildlife Service and Idaho Department of Fish and Game

2.2.2.4 Other Use Refinement Processes

An effort is currently in progress within the Lower Snake River Basin to assess the existing beneficial use designations for applicability and attainability. This effort has been undertaken by stakeholders of both the Lower Boise River TMDL and the SR-HC TMDL processes. These stakeholders and their technical advisors are conducting an in-depth study of the current use designations, the actual uses existing today, and the attainability of current use designations. Initial discussions of the potential outcomes of the current use refinement effort follow closely with the findings and recommendations of the SR-HC TMDL.

The information produced by this and any other similar efforts will be evaluated within the context of the SR-HC TMDL process. The data collected and the conclusions drawn will be reviewed by the DEQs. If changes to the current designated beneficial uses are determined to be appropriate, state-specific processes will be initiated to make changes to the use designations. Changes to the SR-HC TMDL, if appropriate, will be made. As these use refinement studies will most likely not be completed until after the submission of the SR-HC TMDL, changes (if appropriate) will be incorporated during the phased implementation process.

2.2.3 Water Quality Limited Waters

Under section 303(d) of the CWA, waters that do not meet water quality standards even with the implementation of technology-based effluent limits (40 CFR 130.7(b)) are listed as water quality limited waters. These waters are required to have a TMDL developed to bring them back into compliance with water quality standards. The mainstem Snake River, from where the river intersects the Oregon/Idaho border at RM 409 downstream to immediately above the inflow of the Salmon River at RM 188 has been identified as water quality limited, due to violations of water quality standards for both Oregon and Idaho. Tables 2.2.3 a and b give a complete listing of all designated beneficial uses and pollutant listings for each segment within the scope of the TMDL for the two states. A further discussion of the designated beneficial uses, pollutant listings, available data and evidence of non-compliance with standards is contained in the following sections on each segment of the SR-HC TMDL reach (Section 2.3). To delineate between current and previous data collection efforts the terms *historical data* and *current data* are used. For the purposes of this document, historical data is defined as data collected prior to 1975. Current data is defined as data collected during or after 1975.

2.2.4 General Water Quality Concerns for the Snake River - Hells Canyon TMDL Reach

Some common water quality issues occur in more than one segment of the SR-HC TMDL reach. The following sections will outline these general issues by pollutant parameter. More detailed and individually relevant discussions will be offered under the discussion of each individual segment (Section 2.3). Those pollutants that only appear in a single segment are presented in the section for that individual segment. Discussion of general concerns below and in the segment specific sections that follow is not meant to indicate that all potential effects discussed in these sections occur within the SR-HC TMDL reach. Rather, it is intended as a general overview of potential effects from the pollutants listed for this system. A range of potential effects from relatively minor to more severe are discussed for most pollutants. This is intended as general information only and is not intended to imply that the full range of possible effects is currently occurring, or has ever occurred within the SR-HC TMDL reach.

2.2.4.1 Dissolved Oxygen

General Concerns

Dissolved oxygen (DO) is important to the health and viability of fish and other aquatic life. High concentrations of dissolved oxygen (from 6 to 8 mg/L or greater) are beneficial to aquatic life. Low dissolved oxygen (concentrations below 5 mg/L) can result in stress to aquatic species, lower resistance to environmental stressors and even death at very low levels (less than 2 mg/L). Intergravel dissolved oxygen levels of 5 to 6 mg/L or more are needed to support salmonid spawning and water column dissolved oxygen needs to be 6 to 11 mg/L or more during spawning and at locations where spawning is designated to occur within the SR-HC TMDL reach.

In addition to the above direct effects on aquatic life, low dissolved oxygen concentrations can lead to changes in water and sediment chemistry that can influence the concentration and mobility of nutrients and toxins, e.g. phosphorus, ammonia and mercury, in the water column. Low dissolved oxygen at the sediment-water interface can result in substantial releases of adsorbed phosphorus to the water column, which in turn can lead to increased algal growth and further decrease the dissolved oxygen concentration in a waterbody. Anoxic conditions, combined with available organic matter can also result in higher rates of methyl-mercury production. Methyl-mercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds. Finally, increased water column ammonia concentrations can result from the chemical changes caused by anoxic conditions. Elevated ammonia levels can represent a significant threat to the health of aquatic life forms, and, at extreme concentrations, can result in death.

Water Quality Targets

In order to meet the water quality criteria of both states, a target of 6.5 mg/L water column dissolved oxygen has been established by this TMDL as an absolute minimum to ensure full support of cool water and cold water aquatic life. This target applies to the Snake River between RM 409 and 335, Brownlee Reservoir (RM 335 to 285), and Oxbow Reservoir (RM 285 to 272.5) as the designated uses for both states reflect cool and cold water aquatic life as the most sensitive overall population. Because of the dominance of cool water fish in the reservoirs (Brownlee and Oxbow) and in the Upstream Snake River (RM 409 to RM 335) (ODFW, 2001), the cool water aquatic life dissolved oxygen standard for the State of Oregon (6.5 mg dissolved oxygen/L) was used as the basis for the dissolved oxygen target for interstate waters in these segments of the SR-HC TMDL. Both the cool water and the cold water dissolved oxygen standards for the State of Oregon were determined to be more stringent than the cold water standard for the State of Idaho. Therefore, it was determined that basing the SR-HC TMDL dissolved oxygen target on the Oregon water quality criteria for cold water aquatic life would result in a dissolved oxygen target that was more conservative than necessary for these interstate segments of the Snake River based on the dominant fish populations. As a result, where cool water aquatic life are the dominant community rather than cold water aquatic life, an absolute minimum target is 6.5 mg dissolved oxygen/L, while 8.0 mg dissolved oxygen/L is the absolute minimum where cold water aquatic life are the dominant community (Downstream Snake River segment (RM 247 to 188)). These targets are based on dissolved oxygen concentrations in the critical aquatic environment. Most natural, unpolluted waters will have sufficient dissolved oxygen to meet these targets.

Salmonid spawning has been designated to occur in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL. The dissolved oxygen target for salmonid spawning is 11 mg/L water column dissolved oxygen as an absolute minimum OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95 percent saturation; with intergravel dissolved oxygen not lower than 8 mg/L, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated dissolved oxygen targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round. The salmonid spawning beneficial use designation and the associated dissolved oxygen targets apply to the mainstem Snake River in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL between October 23 and April 15.

Common Sources

Low dissolved oxygen is often the result of high nutrient, organic or algal loading to a surface water system. Nutrients lead to algal growth, which in turn consumes oxygen from the water column during periods when respiration is the dominant process. In addition, in slow moving streams, and in lakes and reservoirs, when algae die and settle to the bottom of the water body, aerobic decomposition of the dead algae and other detritus (non-living organic material) can also deplete the oxygen supply in the overlying water and sediment. In systems where suspended solids are primarily organic in origin, low dissolved oxygen levels may be correlated with sediment inputs as well.

Dissolved oxygen concentrations are also reduced by pollutants that require oxygen in oxidation processes. Biochemical oxygen demand (BOD) is a measure of the dissolved oxygen required to oxidize material (usually organic) whether it is naturally occurring, the result of increased natural material, or contained in municipal, agricultural, or industrial wastes. Parts of the SR-HC TMDL reach carry a substantial load of such organic material. This organic load is delivered by the inflowing Snake River above the TMDL reach, by the inflowing tributaries, and by organic matter production within the reach. Some of this organic material is algae and some is detritus. Both of these organic matter components produce a certain amount of BOD.

2.2.4.2 MERCURY

The SR-HC TMDL reach is listed as water quality limited due to human fish consumption advisories for mercury issued by both Oregon and Idaho (Appendix D). Elevated levels of mercury in fish tissues have been observed in both the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir (RM 335 to 285) segments of the SR-HC TMDL reach (Rinella *et al.*, 1994; Clark and Maret, 1998). In addition, data have shown a similar problem in the Owyhee basin (Rinella *et al.*, 1994; Craft *et al.*, 2000). Because of the fish consumption advisories in place, the designated beneficial use of fishing for both Oregon and Idaho is not fully supported.

General Concerns

The presence of mercury in surface waters can be a water quality concern, especially when present in readily mobile and easily accumulated forms such as methylated mercury. In rare cases, when concentrations are extremely high, mercury can result directly in the death of aquatic biota. More commonly, bioaccumulation and concentration affect designated beneficial uses (fishing and wildlife habitat) by building up concentrations within the food chain to levels where consumers (human or other predators) can be adversely affected.

Water Quality Targets

Bioaccumulation of mercury to dangerous levels in fish tissues is the basis for the current human fish consumption advisories within the SR-HC TMDL reach, issued by the states of Oregon and Idaho (Appendix D). Mercury concentrations of concern to the direct health of aquatic life are identified in the US EPA toxics rule and ODEQ Table 20, as cited in Table 2.2.1 of this document. In order to meet the water quality criteria of both states, a target of less than 0.012 ug/L total recoverable water column mercury has been established by this TMDL process as an absolute maximum to support the designated beneficial use of fishing and domestic water supply. It should be noted that this water column target is only one of the factors that determine fish tissue mercury levels. It is the fish tissue mercury levels that determine the necessity for a fish consumption advisory and therefore the lack of full support of fishing as a designated use. In addition, US EPA (2001a, 2001b, 2001c) has recently issued guidance on mercury criteria based on fish tissue levels. The fish tissue mercury concentration identified by this guidance as protective for human health is 0.3 mg/kg wet weight.

The fishing and salmonid rearing/cold water aquatic life beneficial use designation and the associated mercury targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round.

Common Sources

The primary sources of mercury in the SR-HC TMDL reach are air deposition, legacy mining activities and natural geologic materials. Historical agricultural chemicals, industrial and municipal source inputs of mercury are generally considered to be relatively minor within this reach compared to the air deposition, legacy mining and natural geologic inputs. The SR-HC TMDL reach has been the site of a number of mining activities mostly for gold, silver and mercury ores. Gold was mined in the Central Mountain landform particularly in the Blue, Seven Devils and Wallowa Mountains but also along the banks of the Snake River itself. Gold, silver, uranium, bentonite (volcanic ash) and mercury were mined in the Owyhee uplands and Malheur

County. Silver City, Idaho, located in the Jordan valley area of the Owyhee River watershed, was the site of a major silver mining operation. Mercury was used to amalgamate gold and silver at mining sites throughout the region, and is still present in mining tailings and around old mining sites. Much of the mercury used locally for amalgamation of silver and gold was mined just outside the Owyhee watershed (Idaho) in the Opalite mining district near the McDermitt caldera in southeastern Oregon. Most of the mines have not been in routine operation since the 1950s or 1960s but there are occasional, usually small, mining activities currently in place.

2.2.4.3 Nutrients

General Concerns

General concerns associated with excessive nutrient concentrations include both direct and indirect effects. Direct effects are nuisance algae and periphyton growth. Indirect effects include low dissolved oxygen, increased methylmercury production, elevated pH, cyanotoxins from cyanobacteria (blue-green algae) production, trihalomethane production in drinking water systems, and maintenance issues associated with domestic water supplies.

Nuisance aquatic growth, both algae (phytoplankton or water column algae, and periphyton or attached algae) and rooted plants (macrophytes), can adversely affect both aquatic life and recreational water uses. Algal blooms occur where nutrient concentrations (nitrogen and phosphorus) are sufficient to support growth. Available nutrient concentrations, flow-rates, velocities, water temperatures and penetration of sunlight in the water column are all factors that influence algae (and macrophyte) growth. When conditions are appropriate and nutrient concentrations exceed the quantities needed to support algal growth, excessive blooms may develop. Commonly, these blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, cyanobacteria (blue-green algae) often produce toxins that can result in skin irritation to swimmers, and illness or even death in organisms ingesting the water. Two canine deaths due to ingestion of blue-green algal toxins were confirmed (November, 2000) and several others suspected (Fall 1999) below the Minidoka Dam along the Snake River between Rupert and Burley, Idaho (Eyre, 2001). In Cascade Reservoir, located upstream in the Payette River drainage, 23 cattle died from ingestion of cyanotoxins in 1993. Several types of cyanobacteria (blue-green algae) produce cyanotoxins. Most commonly, hepatotoxins (which can affect liver and kidney function) and/or neurotoxins (which can affect central nervous system functions) are produced. While not every bloom produces such toxins, increased levels of growth (greater biomass) are more likely to produce higher concentrations of these compounds.

The US EPA identifies nutrient enrichment as a serious health problem in the context of drinking water supplies. Trihalomethanes are carcinogenic compounds that can be produced when water containing organic compounds is chlorinated or brominated as part of the treatment and disinfection processes in drinking water facilities. The organic compounds commonly associated with trihalomethane formation processes are humic substances, algal metabolites and algal decomposition products (US EPA, 2000d). According to references in the recent US EPA nutrient guidance document for surface waters, the density of algae and the level of eutrophication in the raw water supply have been correlated with the production of trihalomethanes (US EPA, 2000d).

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water supplies, and can produce intense coloration of both the water and shorelines. In extreme cases algal blooms can also result in impairment of agricultural water supplies due to toxicity. Waterbodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. Algae is not always damaging to water quality, however. The extent of the effect is dependent on both the type(s) of algae present and the size, extent and timing of the bloom. In many systems algae provide a critical food source for many aquatic insects, which in turn serve as food for fish.

In addition to the direct effects of excessive algal growth, when algae die, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, dissolved oxygen concentrations near the bottom can be substantially depleted by a large algal bloom. Low dissolved oxygen in these areas can lead to decreased fish habitat and even fish kills if there are not other areas of water with sufficient dissolved oxygen available where the fish can take refuge. Both living and dead (decomposing) algae also can affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low dissolved oxygen levels caused by decomposing organic matter can lead to changes in water chemistry and release of sorbed phosphorus to the water column at the water/sediment interface. These same conditions are conducive to methylmercury production in areas where inorganic mercury is present in the system.

Both nitrogen and phosphorus represent nutrients that can contribute to eutrophication. Either nutrient may be the limiting factor for algal growth depending on algal species. Cyanobacteria (blue-green algae) can dominate in nitrogen-limited systems as they are able to fix nitrogen from the atmosphere (at the air/water interface) and from the water column. In systems where cyanobacteria (blue-green algae) are the dominant population, nitrogen is not a limiting agent based on this ability to fix nitrogen. Therefore, these organisms can grow where low nitrogen concentrations may inhibit the growth of other algal species (Sharpley *et al.*, 1995 and 1984; Tiessen, 1995; IDEQ, 1993b). The dominant algal types observed in the SR-HC system are cyanobacteria (blue-green algae), also known as cyanobacteria, and diatoms, depending on the specific location and season (IPCo, 1998a and 1999d).

Phosphorus can be measured in a variety of ways. The most common forms of phosphorus monitored in the SR-HC TMDL reach are total phosphorus (TP), which includes all phosphorus (dissolved and particulate-bound) in a sample; and ortho-phosphate (OP), which includes highly soluble, oxidized phosphorus. Because of its solubility, ortho-phosphate is commonly more available for biological uptake and leads more rapidly to algal growth than total phosphorus. The relative amount of each form measured can provide information on the potential for algal growth within the system. If a high percentage of the total phosphorus is present as soluble ortho-phosphate, it is more likely that rapid algal growth will occur than if the majority of the total phosphorus was mineral phosphorus incorporated in sediment, provided other conditions such as light and temperature were adequate. Due to phosphorus cycling (conversion between forms) it is important to consider total phosphorus concentrations in the evaluation of nutrient loading.

Excess nutrient loading can be a water quality problem due to the direct effect of high phosphorus concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on dissolved oxygen and pH within aquatic systems. As total phosphorus includes both dissolved and particulate-bound phosphorus, it represents the phosphorus that is currently available for growth as well as that which has the potential to become available over time. Therefore, the reduction of total phosphorus inputs to the system can act as a mechanism for water quality improvements particularly in surface-water systems dominated by cyanobacteria (blue-green algae) which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in the following water quality parameters: nutrients (phosphorus), nuisance algae, dissolved oxygen and pH.

Consideration of flow is important in the evaluation of nutrient and phytoplankton, periphyton, and rooted macrophyte concentrations. In a riverine system, flow transports phytoplankton and nutrients from upstream to downstream in an advective or dispersive transport mode. In other words, the riverine system is a dynamic system in which nutrients are being continually cycled as the water moves downstream. The flow regimen is important in determining the result of this combination of component concentrations. High flows can flush dissolved constituents like nutrients downstream replacing them with the concentrations in the high flows. High flows can also scour periphyton and rooted macrophytes, reducing their concentrations considerably. Finally, high flows can scour sediments causing movement of the sediment downstream and increasing nutrient concentrations at the same time by releasing nutrients tied up in the sediments prior to scouring (Armstrong, 2001).

High total phosphorus concentrations can result in increased algal growth rate and increased productivity up to the saturation point. Increased total phosphorus loading can result in increased algal production and increased algal biomass. The increased algal biomass production and transport results in increased biological oxygen demand (BOD) and decreased dissolved oxygen levels. The reservoir systems in the Snake River, particularly those in the Hells Canyon Complex, modify the river's flow regimen to the extent that the water's residence time in a particular stretch of the river is increased, and the greater the increase the greater the affect on water quality. (Residence time within the Hells Canyon Complex averages approximately 34 days for Brownlee Reservoir, 1.4 days for Oxbow Reservoir and 4 days for Hells Canyon Reservoir, 39.4 days total.) Such an increase residence time is caused by an increase in water volume behind the impoundment due to widening and deepening of the channel. In addition, the deeper the channel the greater the opportunity for thermal (density) stratification. The kinds of physical, chemical, and biological processes that can take place in such systems as Brownlee Reservoir under lower flow conditions are described by IPCo (1999d). However, their description does not represent the changes that occur under higher flow conditions in which the reservoir becomes more riverine in nature (Armstrong, 2001).

A separate consideration is the difference between algae concentrations and the rate of algal growth. Algal concentrations are a function of the availability of nutrients on a continuing basis, the availability of adequate light, and the presence of flows (velocities) that will permit continued growth without losses due to flushing (of phytoplankton), sloughing (of attached algae or periphyton), or mechanical breakage and scouring (of rooted macrophytes). In quiescent systems like lakes, algal concentrations are dependent on nutrient availability, and only if nutrient concentrations have been depleted by algal uptake does the growth rate approach zero, and phytoplankton begin to die. In streams and rivers, the nutrients also cycle between the water, sediment, living organisms, and detritus (nutrient spiraling as it is called), but high velocities generally occur often enough to scour attached and rooted vegetation and to keep concentrations of aquatic vegetation low. Under low velocities, however, attached and rooted vegetation may increase to noticeable levels. As long as nutrients continue to be available and flows are inadequate to cause losses of algae mass, the algae will continue to grow and may reach levels that cause algal mats on the bottom or at the surface. This is often the case in shallow lakes or ponds or pools in intermittent streams. However, the presence of algal mats or attached algae does not necessarily indicate an excess of nutrients (Armstrong, 2001).

Water Quality Targets

Nutrient concerns for both Oregon and Idaho are assessed through the interpretation of narrative criteria based on excessive or nuisance aquatic growth. Numeric targets established to support designated beneficial uses within the SR-HC TMDL reach were based on an understanding of nutrient transport and processing within this system, research carried out in systems with similar climate and geology, and the linkage established between inflowing nutrient concentrations, organic growth and decay and water chemistry processes (affecting dissolved oxygen, pH, nutrient desorption, etc). The Mid-Snake River TMDL (IDEQ, 1997c) established a 0.075 mg/L in-stream phosphorus concentration for support of designated beneficial uses in the reach from RM 638.7 to RM 544.7. Similar targets have been identified by the SR-HC TMDL. A total phosphorus target of less than or equal to 0.07 mg/L has been identified as appropriate to reduce nutrient and organic loading and transport, and as a surrogate target to improve dissolved oxygen concentrations within the SR-HC TMDL reach.

In addition, ODEQ has identified a threshold level of 0.015 mg chlorophyll *a*/L as an indication that further assessment is necessary to determine if nutrient concentrations or algal populations are sufficient to impair beneficial uses. Chlorophyll *a* concentrations of greater than 0.015 mg/L, observed to occur for three months, triggers an investigation by ODEQ to determine if designated uses are being impaired in the particular watershed being monitored. This TMDL serves as the ODEQ investigation into impairment due to observed chlorophyll *a* concentrations above the threshold level in the SR-HC TMDL reach. The chlorophyll *a* target for this TMDL was set at 14 ug/L mean growing season limit (nuisance threshold of 30 ug/L with exceedence threshold of no greater than 25 percent) to be protective of designated beneficial uses. This target is also based on an understanding of nutrient transport and processing within this system, research carried out in systems with similar climate and geology, and the linkage established between inflowing nutrient concentrations, organic growth and decay and water chemistry processes (affecting dissolved oxygen, pH, nutrient desorption, etc).

Therefore, the SR-HC TMDL will use a combination of the 14 ug/L chlorophyll *a* mean growing season limit and the 0.07 mg total phosphorus/L to ensure that nutrient concentrations do not result in excessive algae or other aquatic growth, do not preclude the attainment of water quality standards for dissolved oxygen, and pH, and do not result in impairment of the designated beneficial uses for the SR-HR TMDL reach. The derivation of these targets is discussed in detail in Section 3.2.

The aesthetics, agricultural water supply, domestic water supply, recreation, and salmonid rearing/cold water aquatic life beneficial use designations apply year round and the associated nutrient and algae targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) from May through September.

Common Sources

There are many sources and conditions that contribute to phosphorus in the environment. Phosphorus can be present as a constituent of certain rock types (silicious igneous rock) and in the mineral *apatite*. A 1974 inventory of the nations waters (US EPA, 1974a) found that the mountains along the southeastern border of the Snake River, which form its headwaters, contain some of the world's richest phosphate deposits, including the Phosphoria formation which was deposited about 230 million years ago during the Permian period. This deposit, which extends from Idaho into western Wyoming and southwestern Montana, contains the largest known reserves of phosphate rock in the world (Alt and Hyndman, 1989).

The environment itself can also be a factor in the phosphorus levels occurring within a region, as the climate, pH of natural waters and the presence of other substances that may adsorb or release phosphorus (Hedley *et al.*, 1995) can all potentially affect phosphorus levels. However there are also anthropogenic (man-made) nutrient sources. Applied fertilizers in farming or landscaping, the duration and density of livestock grazing, the creation of artificial waterways and water levels through irrigation and water-management practices, and the presence of sewage and septic waste (treated and untreated) in the surface, subsurface and ground water of a region often represent significant contributions to the phosphorus concentration in an area. All of these sources exist to one extent or another in the SR-HC TMDL reach.

Natural sources of nutrients include indigenous wildlife and wildfowl that utilize the watershed. While these populations are relatively stable throughout much of the year, substantial increases in some populations are observed with spring and fall migration patterns. Fluctuations in the levels of pollutant loading in other watersheds in North America, specific to migrating waterfowl have been identified. In some cases this additional loading is especially noticeable as migration effects are directly correlated with surface water and wetland areas within the watershed.

Nitrogen occurs in the environment in a variety of sources and forms. It can be present as a mineral constituent of certain rock types, as a result of the decomposition of plant and other organic material, in rainfall, as a component of agricultural or urban/suburban runoff, and as a constituent in treated or untreated wastewater from industrial, municipal, or septic discharges. The Rock Creek Rural Clean Water Program (Rock Creek, Twin Falls County, Idaho) found that processes involving applied fertilizers and the plowout of alfalfa were major contributors of nitrogen (Clark, 1989). In addition, the air is composed of about 80 percent nitrogen gas. As stated earlier, cyanobacteria (blue-green algae) can use atmospheric nitrogen at the surface-water interface or the nitrogen dissolved in the water as a source of nitrogen to support growth. Therefore in water systems dominated by cyanobacteria (blue-green algae) nitrogen is not often targeted as a factor for reduction to achieve water quality improvements. Reducing watershed-based sources of nitrogen is not usually a successful treatment option in these systems.

Both physical and chemical processes impact the transport and availability of phosphorus in the SR-HC TMDL reach. Physical processes (wind and water movement) dominate in the transport of phosphorus contained within or adsorbed to sediment and particulate. Chemical processes (change in water chemistry such as dissolved oxygen or pH levels) dominate in the transport of dissolved phosphorus to the system, and in the transformation of phosphorus from one form or state (i.e. free or adsorbed) to another, within both the transport pathway and the water column. Both of these processes represent primary sources of phosphorus input to the SR-HC system.

2.2.4.4 pH

General Concerns
pH is an indicator of the acidity or alkalinity of a system as measured by the hydrogen ion activity in the water. A pH value of 7.0 is neutral with values from 0 to 7 being acid and those from 7 to14 being alkaline. Extremely acid or alkaline waters can be problematic. Extreme levels of pH can be directly toxic to aquatic life. Even at less extreme levels either acid or alkaline conditions can cause chemical shifts in a system that result in the release of metallic compounds from sediments in acid conditions or increased ammonia toxicity and release of sorbed phosphorus under alkaline conditions.

Water Quality Targets
In order to meet the water quality criteria of both states, a pH range of 7 to 9 units has been established as a target for this TMDL process to support designated aquatic life beneficial uses within the SR-HC TMDL reach. Because the SR-HC TMDL reach provides habitat for fish (including salmonids) and other aquatic life, it is important that pH levels be in the appropriate range to provide full support for aquatic life. The target range is based on pH in the critical aquatic environment. Most natural, unpolluted waters will have pH ranges that meet this criterion.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated pH targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round.

Common Sources
In the SR-HC TMDL reach, pH could be altered to a small degree or in a localized area by acidic or alkaline industrial or municipal wastes, ammonia production during organic matter decomposition, agricultural runoff, or by excessive algal growth due to the carbon dioxide released during respiration. However, in this reach, pH is also buffered by sodium, calcium, and magnesium salts (carbonates) dissolved and/or eroded from the landscape and delivered as sediment and bedload, so changes, when they occur, are usually small.

2.2.4.5 Sediment

General Concerns
Sediment loads can influence turbidity, nutrient concentrations, the absorption of toxic substances, and bed form characteristics. Sediment distribution through water-based transport is essential in many ecological processes (e.g. fertilization of land through annual flooding), but increased sediment loads, e.g. as a result of an extreme meteorological event (such as heavy rainstorms inducing erosion, sandstorms blowing solids into the sea) or human activities

(removal of vegetation cover, increase of stream velocities through canalization), can have severe negative impacts on an aquatic ecosystem (NRCS, 2001).

Total sediment loading is composed of suspended sediment and bedload sediment. Suspended sediment encompasses that fraction of solid particles small enough to be held suspended in the water column for extended periods of time and at low flow velocities. Bedload sediment consists of large particles that are moved only during high or extreme flow events and moderately sized particles that are small enough to be frequently entrained by moderate flows but large enough to settle out of the water column at lower flow velocities (NRCS, 2001).

Both suspended sediment and bedload can have negative effects on aquatic life. Many fish species are adapted to high suspended sediment levels that occur for short periods of time as such events are common during natural spring runoff. However, longer durations of exposure to high levels of suspended sediment can interfere with feeding behavior, damage gills, reduce available food, reduce growth rates, smother eggs and fry in the substrate, damage habitat and in extreme cases eventually lead to death. Eggs, fry and juveniles are particularly sensitive to suspended sediment, although at high enough concentrations adult fish are affected as well. Since all fish life stages are listed as designated beneficial uses in the SR-HC TMDL reach, the levels of suspended sediment and their potential affect on aquatic life are of concern.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on suspended sediment in streams and estuaries. For rainbow trout, lethal effects, which include reduced growth rate, begin to be observed at concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species. Adverse effects on habitat, especially spawning and rearing habitat, were noted at similar concentrations.

Suspended sediment concentrations are generally reported on a dry weight basis. However, to determine characteristics and sources, suspended sediment dynamics should be assessed (Chapra, 1997). Sediments originating from the drainage basin are primarily inorganic with a low carbon content and higher density (about 2.65), and often increase in the water column during runoff events. Sediments originating instream (from primary production) are organic with a higher carbon content and lower density (less than 1.25), and often increase in association with algal blooms. The concentration of organic sediments (and potentially their affects) can be underestimated because of their lower density. These organic sediments can accentuate problems of low dissolved oxygen since they become part of the material that is decomposed, consuming oxygen from the water column in the process.

The majority of data collected to date in the SR-HC TMDL reach are measurements of total suspended solids (TSS) rather than total suspended sediment (SSC). Turbidity data are also available. Little direct inorganic sediment information is available. Total suspended solids data have been used as a surrogate for the assessment of sediment within this system. More detail on the data available to the evaluation of sediment within the SR-HC TMDL reach and the comparison of TSS and SSC data used for this selection of targets is available in Section 3.5. It should be kept in mind that both TSS and SSC values may include algae and other organic matter that do not directly correlate with inorganic sediment concentrations in the water column.

Bedload sediment can also adversely affect aquatic species. As sand and silt wash downstream, they can cover spawning gravels. This increases cobble embeddedness in the streambed. If it occurs during incubation or while small fry are using the spawning gravels, this sediment covering can reduce intergravel dissolved oxygen (IGDO) levels and smother eggs or juvenile fish. Accumulation of sand and silt on stream bottoms can also directly limit the availability of spawning gravels, thus reducing habitat for salmonid and other bed spawning species. Bedload deposition also acts to fill in pools within the stream channel, thus reducing or eliminating cold water refugia important to cold water aquatic life during periods of high water temperature. Organic suspended sediments can also settle to the bottom and, due to their high carbon content, can lead to low intergravel dissolved oxygen.

Water Quality Targets

Sediment problems for both Oregon and Idaho have been assessed through the interpretation of narrative criteria based on impacts to aquatic life. Numeric targets established to support designated beneficial uses within the SR-HC TMDL reach have been based on an understanding of sediment transport and delivery within this system and research carried out in systems with similar climate and geology. Current guidelines established by other TMDL efforts recommend less than or equal to 80 mg/L concentration for acute events lasting no more than 14 days, and less than or equal to 50 mg/L concentration for acute events lasting less than 60 days. The Lower Boise River TMDL (IDEQ, 1998a) established these concentrations for support of designated beneficial uses in the Lower Boise River drainage. Similar targets have been identified by the SR-HC TMDL. Total suspended solids targets of less than or equal to 80 mg/L concentration for acute events lasting no more than 14 days, and less than or equal to 50 mg/L concentration maximum monthly average have been identified as protective of the salmonid rearing/cold water aquatic life beneficial use designations. Additional information on the identification of these targets is available in Section 3.5.

Sediment loading within the SR-HC TMDL reach is also of concern because of the attached pollutant loads (mercury, pesticides and nutrients) that the sediment carries. In the SR-HC TMDL, sediment (TSS) targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated sediment targets apply to the mainstem Snake River in the SR-HC TMDL reach between RM 409 and 272.5 (Oxbow Dam), year-round.

Common Sources

Common sources of sediment within the SR-HC TMDL reach are predominantly erosion-based as well as from instream biological productivity. Sediment may originate from natural causes such as landslides, forest or brush fires or high flow events; or anthropogenic sources such as erosion from roadways, agricultural lands, urban/suburban stormwater runoff and construction sites. Irrigated agriculture has been identified as a source of sediment in many tributaries to the Snake River both above and within the SR-HC TMDL reach. Sediment loads within the system are highest in the spring when high flow volumes and velocities result from snowmelt in higher elevations. While no quantitative information is available, it is recognized that a substantial amount of sediment can be generated and transported relatively long distances by extreme precipitation events such as the January 1997 rain-on-snow event in the SR-HC watershed. It has been estimated that although they occur only rarely, such events can account for the movement of a greater volume of sediment in a single event than would be expected to occur in an entire water year under average conditions (IDEQ, 1998c; BCC, 1996)

However, sediment inputs to the SR-HC TMDL reach are limited to some degree by the highly controlled nature of the watershed. As stated previously, the number of dams within the Snake River drainage has substantially modified the transport and delivery of sediment within the SR-HC system. The controlled nature of flow management in the upstream Snake River and in most of the major tributaries reduces the amount of sediment delivered to this reach. Sediment transport, and the transport and delivery of sediment-bound pollutants are directly associated with increased flow volumes and high velocities. Within the SR-HC watershed, sediment loads are not distributed as randomly as would be observed in a free-flowing system. Instead, sediment tends to accumulate behind structures such as dams and diversions both within the SR-HC TMDL reach and in the upstream and tributary watersheds. This reduces the overall concentration of such sediment and sediment-bound pollutants downstream. However, this process localizes the sediment and pollutant mass, which can then lead to substantial pollutant re-entrainment if water-management practices of the impoundments are altered substantially. Additionally, sediment deposition areas within the impoundments can be altered (and in turn have the potential to alter water quality through renewed availability of previously sealed sediment layers) through substantial drawdown scenarios such as high water year flood control management in Brownlee Reservoir.

The depositional action of these impoundments can also lead to conditions where designated beneficial uses are negatively impacted by a decrease in certain sediment sizes downstream. For example, reduced availability of small and moderately sized particulates downstream may reduce available spawning habitat for some fish species.

While the above processes can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Often, upstream structures can act as treatment mechanisms to improve water quality downstream, creating a sink for inflowing sediment and reducing delivered loads downstream. However, the agencies prefer to prevent the initial loading of pollutants rather than to depend on such instream retention systems.

2.2.4.6 TEMPERATURE

General Concerns

Temperature is an element of water quality that is key to good fish and aquatic habitat. It is used to determine if water will support warm or cold water aquatic species. High water temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Elevated temperature, as a stressor to adult fish, can result in lower body weight, poor oxygen exchange and reduced reproductive capacity. Extreme high temperatures can result in death if they persist for an extended length of time. Juvenile fish are more sensitive to temperature variations and duration than adult fish, and can experience negative impacts at a lower threshold value than the adults. Acceptable temperature ranges vary for different species of fish, with warm water species being the most tolerant of high water temperatures. The SR-HC TMDL reach contains a wide variety of warm, cool and cold water fishes. The system must therefore be managed to provide appropriate habitat to support designated beneficial uses at those locations and seasons where use occurs for the various species. Criteria have been established for the aquatic life needs of the important cold and warm water species that must be protected. The temperature criteria are usually built around a maximum allowable value that relates to critical life stage requirements. Appendix C contains more detailed information specific to temperature tolerances of fish species found in the SR-HC TMDL reach.

Water Quality Targets

Temperature targets for the SR-HC TMDL were established based on a comparison between the temperature standards for Idaho and Oregon. A detailed description of this methodology is contained in Appendix C.

Temperature targets are based on both Oregon and Idaho temperature standards which include narrative criteria acknowledging that "natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions" (OAR 340-41-120 (11)(c)). To accommodate such systems that naturally exceed the numeric temperature criteria, the Oregon narrative criteria includes the following language. "No measurable surface water temperature increase resulting from [human] activities is allowed in a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 17.8 ^{o}C [7-day average of the daily maximum]" (OAR 340-41-725, 765, 805, and 845 (2)(b)).

The SR-HC TMDL temperature target identified for the protection of salmonid rearing/cold water aquatic life when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: 17.8 ^{o}C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^{o}C. If and when the site potential is greater than 17.8 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources.

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

The SR-HC TMDL temperature target identified for the protection of salmonid spawning when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: a maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources.

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

The temperature target for salmonid spawning is applicable only when and where salmonid spawning has been identified to occur within the SR-HC TMDL reach. This target applies to the Downstream Snake River segment (RM 247 to 188) only, and is specific to those salmonids identified to spawn in this area, namely fall chinook and mountain whitefish.
Temperature targets for salmonid spawning in the SR-HC TMDL apply during critical time periods for salmonid spawning only. These targets apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188). Critical time periods for salmonid spawning in the Downstream Snake River segment of the SR-HC TMDL reach are from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish. The target therefore applies from October 23 through April 15.

As was mentioned in Section 2.2.2.2, salmonid spawning has been designated to occur in specific tributaries to the SR-HC TMDL reach. Salmonid rearing/cold water aquatic life is designated to occur in the mainstem Snake River in the SR-HC TMDL reach. Because the SR-HC TMDL reach provides habitat for fish (including salmonids) and other aquatic life, it is important that the temperature levels be appropriate to support them. These targets are based on temperatures in the critical aquatic environment. They are protective of cold water aquatic species as well as salmonid rearing life stages.

Although there are data that show temperatures that exceed the temperature target in the reach, there is considerable information (data as well as anecdotal) available that indicates there were temperatures over this target historically, even when aquatic species were present in healthy populations (prior to dam construction) (USFWS, 1957, 1958, 1960 and 1968). One explanation for this could be the occurrence of colder water refugia during periods of high stream temperatures in the bulk of the waterway. Such refugia could be present around springs and at the mouth of tributaries to the SR-HC TMDL reach.

An alternative explanation is that there have always been high water temperatures in much of the SR-HC TMDL reach and the lower portions of its tributaries due to high summer air temperatures, high solar radiation, and low summer flows. Native fish species may have adapted to these conditions and are capable of surviving and thriving under temperature conditions with summer water temperatures in excess of those defined by the targets identified in this TMDL either with physiological or migration adaptations. Cold water refugia may have been more extensive than it is today due to anthropogenic effects in tributaries, the upstream Snake River and dam construction. It is assumed that a combination of more extensive cold water refugia and an evolutionary temperature tolerance may have acted to support healthy population levels historically.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated temperature targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round. The salmonid spawning beneficial use designation and the associated temperature targets apply to the mainstem Snake River in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL between October 23 and April 15.

Common Sources
Temperature increases in the SR-HC TMDL reach are potentially the result of a combination of sources. Most probably, the process of natural heat exchange through high air temperatures and direct solar radiation affects on the water surface play a major role in high summer water temperatures. Both the mainstem Snake River and the inflowing tributaries drain basins that experience hot, dry climates (See Figure 2.1.3 for average daily air temperatures in the SR-HC TMDL reach). In addition, native vegetation in all but the headwaters of most drainages is relatively low growing and sparse (providing little shading on major tributaries). These environmental factors play a major role in water temperatures in the SR-HC TMDL reach. Additional temperature influences may stem from industrial and agricultural inputs, diversions and impoundments, straightening and diking of stream channels, loss of riparian vegetation, and other anthropogenic modifications to both the mainstems Snake River and the inflowing tributaries, however, while these inputs may have a substantial effect on localized temperatures, they most likely represent only minor influences on water temperatures in the mainstem Snake River. A more detailed discussion of temperature influences is available in Section 3.6.

2.2.4.7 TOTAL DISSOLVED GAS (TDG)

General Concerns
Elevated total dissolved gas levels (above 110 percent of saturation) are known to have a detrimental effect on aquatic biota. High concentrations of gas in the water can result in *gas bubble trauma* in fish. This condition occurs when air bubbles form in the circulatory systems of salmon and resident fish. Gas bubble trauma results when the sum of the dissolved gas pressures exceeds the compensating pressures of hydrostatic head, blood, tissue, and water surface tension. Signs of gas bubble trauma have been observed in trapped adult fish below Hells Canyon Dam (IPCo, 1999b, 1999f).

Water Quality Targets
Both Oregon and Idaho share the same numeric water quality standard for total dissolved gas (TDG). Oregon State standards require that the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection shall not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood flow (OAR340-41-725, 765, 805, 845 (2)(n)). Idaho State Standards require that the total concentration of dissolved gas shall not exceed 110 percent (110%) of saturation at atmospheric pressure at the point of sample collection (IDAPA 58.01.02.250.01.b). Idaho State Code further states that the Director has the authority to specify the applicability of the gas supersaturation standard with respect to excess stream flow conditions (IDAPA 58.01.02.300.01.a). The target for the SR-HC TMDL reach is therefore established as a total concentration of dissolved gas that shall not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood flow.

Total dissolved gas exceedences have been documented to occur within the SR-HC TMDL reach, however, no segment of the reach is listed for total dissolved gas exceedences by either the State of Oregon or the State of Idaho.

The Hells Canyon Complex is licensed by FERC, and requires 401 Certification from both the State of Oregon and the State of Idaho. These re-licensing processes represent a very broad and capable effort to identify the full extent of total dissolved gas concerns, designated use support needs, and viable treatment options associated with total dissolved gas violations in the Hells

Canyon Complex. In addition, these processes will act in an enforcement capacity to provide reasonable insurance that total dissolved gas improvements by the Hells Canyon Complex will be realized and designated beneficial uses fully supported.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated total dissolved gas target applies to the mainstem Snake River in the SR-HC TMDL reach between RM 285 (Brownlee Dam) and RM 188, year-round.

Common Sources
Elevated total dissolved gas levels are the result of spilling water over spillways of dams. Spill at Brownlee and Hells Canyon Dams is the only source of elevated total dissolved gas in the SR-HC TMDL reach.

2.2.5 Other Regulatory Water Quality Efforts Occurring in the Snake River - Hells Canyon TMDL Reach

Several upstream and tributary TMDLs have been completed, others are currently in process; still others will be initiated in the near future that may affect the water quality in the SR-HC TMDL reach. The current pollutant reductions identified by existing TMDLs have been incorporated in the loading analysis for the SR-HC TMDL to the extent possible. TMDLs currently in progress or scheduled for the near future will build on allocations developed by the SR-HC TMDL.

All of these efforts will, collectively, be evaluated to determine future water quality benefits and long-term trends within the SR-HC TMDL reach. These assessments will be critical to the ongoing SR-HC TMDL process in order to monitor if identified reduction mechanisms are sufficient or if additional reductions may be necessary to meet water quality standards.

Similarly, the FERC re-licensing process for the Hells Canyon Complex is proceeding concurrently with the SR-HC TMDL process. IPCo filed a draft FERC license application in September 2002. This application included proposed protection, mitigation and enhancement (PM&E) measures, some of which address water quality impacts associated with the project. The final license application and PM&E measures will be filed on or before July 31, 2003. In addition, section 401 of the CWA establishes the requirement for State certification of proposed projects or activities that may result in discharge of pollutants to navigable waters. States evaluating a 401 Certification application are authorized to condition any granted certification to assure compliance with appropriate water-quality related requirements of state law. IPCo expects to file a 401 Certification application with the states of Oregon and Idaho on or before July 2003 as a part of its re-licensing obligations.

The SR-HC TMDL process will be completed and the final document submitted to the US EPA prior to the completion of either the FERC or 401 Certification processes. Because mitigation of the environmental impacts of hydropower projects is currently recognized as part of both the FERC and 401 Certification processes, it is expected that both of these processes will build on the recommendations for water quality improvements identified within the SR-HC TMDL and its accompanying implementation plan. In this manner, some of the water quality-based PM&E

measures identified within the FERC license application and similar measures identified within the 401 Certification process are expected to be driven by the requirements for changes in management, maintenance or other appropriate implementation mechanisms identified as the responsibility of the hydropower projects by this TMDL and its accompanying implementation plan.

Implementation of these measures will be evaluated along with the implementation of water quality improvement projects for both point and nonpoint sources. An assessment of the collective effectiveness of all implementation measures will be incorporated into the ongoing TMDL process to accurately assess trends in water quality conditions, and identify those issues that still need to be addressed by identified point and nonpoint sources.

Photo 2.2.0. Water quality monitoring in the mainstem Snake River near Ontario, Oregon (near RM 369) circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

In addition to the processes discussed above, the SR-HC TMDL reach is home to two species of snail (the Idaho Spring Snail and the Bliss Rapids Snail) and several fish species (chinook and sockeye salmon as well as steelhead and bull trout) currently listed under the Endangered Species Act (ESA). Habitat for these species may be affected by water quality conditions within the SR-HC TMDL reach. In setting instream water quality targets and load allocations to meet appropriate state water quality standards, habitat requirements for these species will be evaluated within the SR-HC TMDL process. The SR-HC TMDL process, along with the TMDL-based water quality recommendations carried through into the FERC and 401 Certification processes for this system will address to the extent possible, the water quality needs of endangered species within the system. Every effort will be taken to ensure that the management actions of this TMDL are consistent with the ESA.

2.3 Overview of Segments within the SR-HC TMDL Reach

Because of the extensive scope of this TMDL (RM 409 to RM 188), the SR-HC TMDL reach has been divided into five smaller segments (Figure 2.3.1) on the basis of hydrology, management, listed pollutants and designated beneficial uses.

- The Upstream Snake River segment (RM 409 to 335, 74 miles)
- The Brownlee Reservoir segment (RM 335 to 285, 50 miles)
- The Oxbow Reservoir segment (RM 285 below Brownlee Dam to RM 272.5, 12.5 miles)
- The Hells Canyon Reservoir segment (RM 272.5 below Oxbow Dam to RM 247, 25.5 miles)
- The Downstream Snake River segment (RM 247 below Hells Canyon Dam to RM 188, 59 miles)

The Upstream Snake River segment (RM 409 to 335) includes the riverine section of the Snake River upstream of the reservoir impoundments. It extends from where the river intersects the Oregon/Idaho border (near the town of Adrian, Oregon), downstream to Farewell Bend. All of the major tributary inflows to the SR-HC TMDL reach (with the exception of the Burnt and Powder rivers) enter the mainstem Snake River within this segment. The vast majority of agricultural and urban/suburban landuse occurs within this segment of the SR-HC TMDL reach. Flow within this segment is primarily driven by snowmelt and seasonal precipitation events, upstream and tributary impoundments, and irrigation diversions and returns.

The Brownlee Reservoir segment (RM 335 to 285) includes Brownlee Reservoir from Farewell Bend through Brownlee Dam. Total reservoir volume is 1,420,000 acre-feet. While Brownlee Reservoir contains three fairly distinct hydrological regions: the riverine zone near the tailwaters (roughly RM 335 to RM 315), the transition zone (roughly RM 315 to 305), and the lacustrine zone (RM 305 to 285); water management and water quality concerns are well correlated with the reservoir boundaries. Flow into Brownlee Reservoir is almost exclusively the product of the outflow of the Upstream Snake River segment which becomes the tailwaters of the reservoir at RM 335, and the Burnt and Powder rivers that flow directly into Brownlee Reservoir at RM 327.5 and RM 296 respectively. However the inflow of these two tributaries is relatively minor when compared with the inflow from the Upstream Snake River segment (3.6% combined total). Flow and residence time within the reservoir is controlled by outflows through Brownlee Dam. Average residence time is 34 days, however, with consideration of the additional internal processes of stratification, depth of withdrawal, flood control requirements and management for power generation, the residence time in different parts of the reservoir can vary considerably.

The Oxbow Reservoir segment (RM 285 to 272.5) includes Oxbow Reservoir from the outflow of Brownlee Dam to Oxbow Dam. This segment is much smaller than the Brownlee Reservoir segment (total reservoir volume is 57,500 acre-feet), and has an average retention time of only 1.4 days. Flow into Oxbow Reservoir is made up almost exclusively of the outflow of Brownlee Reservoir. Wildhorse River, which flows directly into Oxbow Reservoir near Brownlee Dam, constitutes less than 1% of the total inflow. Flow and residence times within the Oxbow Reservoir are controlled by water releases from Brownlee Reservoir and Oxbow Dam. Oxbow Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with the reservoir boundaries.

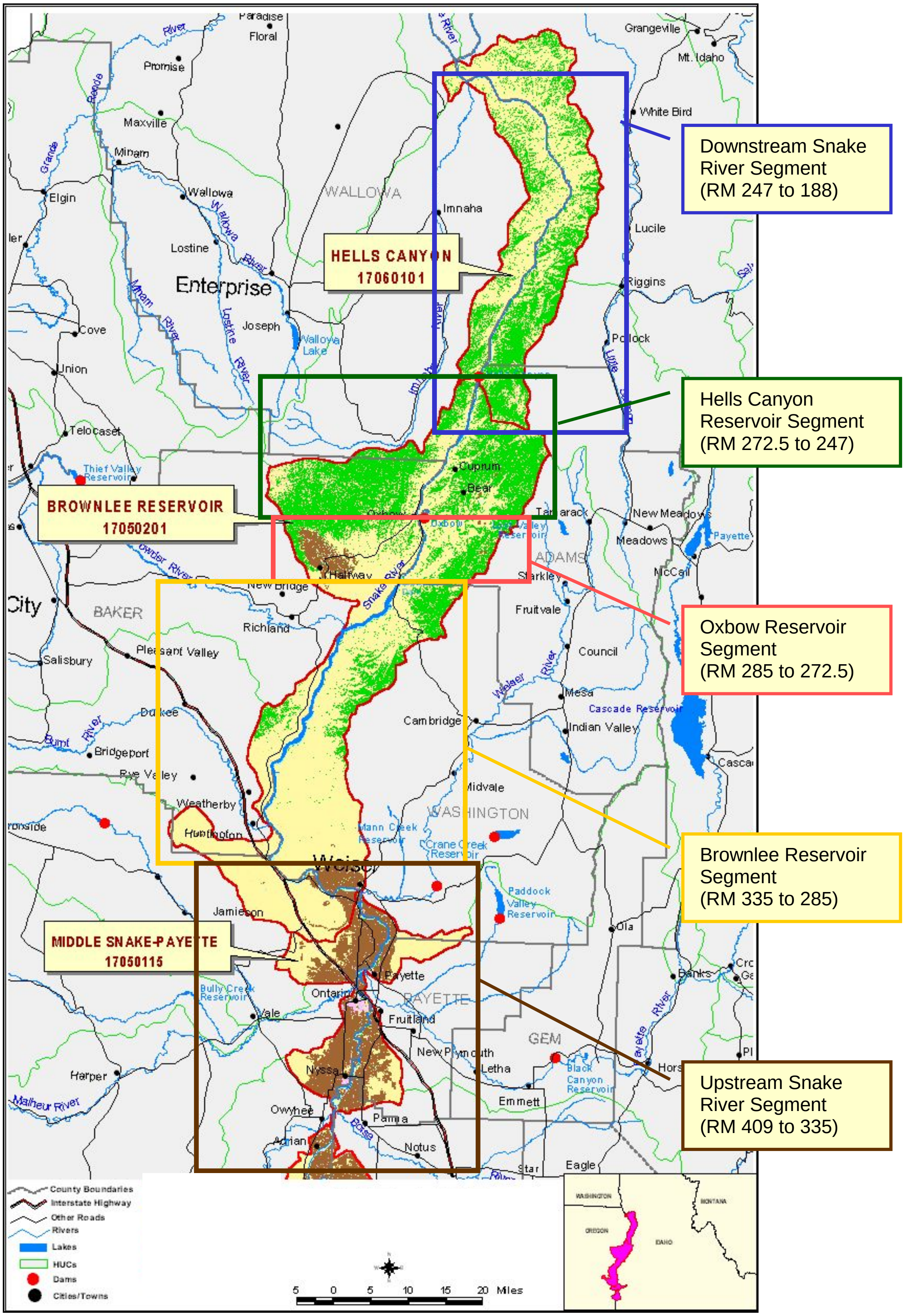

Figure 2.3.1 Snake River – Hells Canyon TMDL Segments.

The Hells Canyon Reservoir segment (RM 272.5 to 247) includes Hells Canyon Reservoir from the outflow of Oxbow Reservoir to Hells Canyon Dam. This segment is also fairly small and fast flowing with a total volume of 170,000 acre-feet and has an average retention time of 4 days. Flow into Hells Canyon Reservoir is made up almost exclusively of the outflow of Oxbow Reservoir. Pine Creek, which flows directly into Hells Canyon Reservoir near Oxbow Dam, constitutes less than 1% of the total inflow. Water releases from Oxbow Reservoir and Hells Canyon Dam control flow and residence times within the reservoir. Hells Canyon Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with the reservoir boundaries.

The Downstream Snake River segment (RM 247 to 188) includes the Snake River from below Hells Canyon Dam to immediately upstream of the Salmon River inflow. This segment is a rapid-flowing, narrow river, characterized by high, steep canyon walls and stretches of white water. The flow and volume of this segment are almost completely driven by the outflow of the Hells Canyon Complex reservoirs, and support significant recreational uses year round.

A more detailed discussion of these segments, designated beneficial uses and pollutant listings, as well as the relationship between water quality data and pertinent SR-HC TMDL water quality targets is presented in Sections 2.3.1 through 2.3.5.

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2.3.1 Upstream Snake River Segment (RM 409 to 335):

The Upstream Snake River segment (RM 409 to 335) includes the riverine section of the Snake River upstream of the Hells Canyon Complex (Figure 2.3.2). It extends from where the river intersects the Oregon/Idaho border (near Adrian, Oregon) downstream to Farewell Bend. All of the major tributary inflows to the SR-HC TMDL reach (with the exception of the Burnt and Powder rivers) enter the mainstem river within this segment. The vast majority of agricultural and urban/suburban land use within the SR-HC TMDL reach occurs within this segment. Flow within this segment is primarily driven by snowmelt and seasonal precipitation events, upstream and tributary impoundments, and irrigation diversions and returns. Because of the significant role flow plays in water quality issues in the SR-HC TMDL reach, a brief discussion of specific flow characteristics has been included below for each of the tributaries into the Upstream Snake River segment (RM 409 to 335).

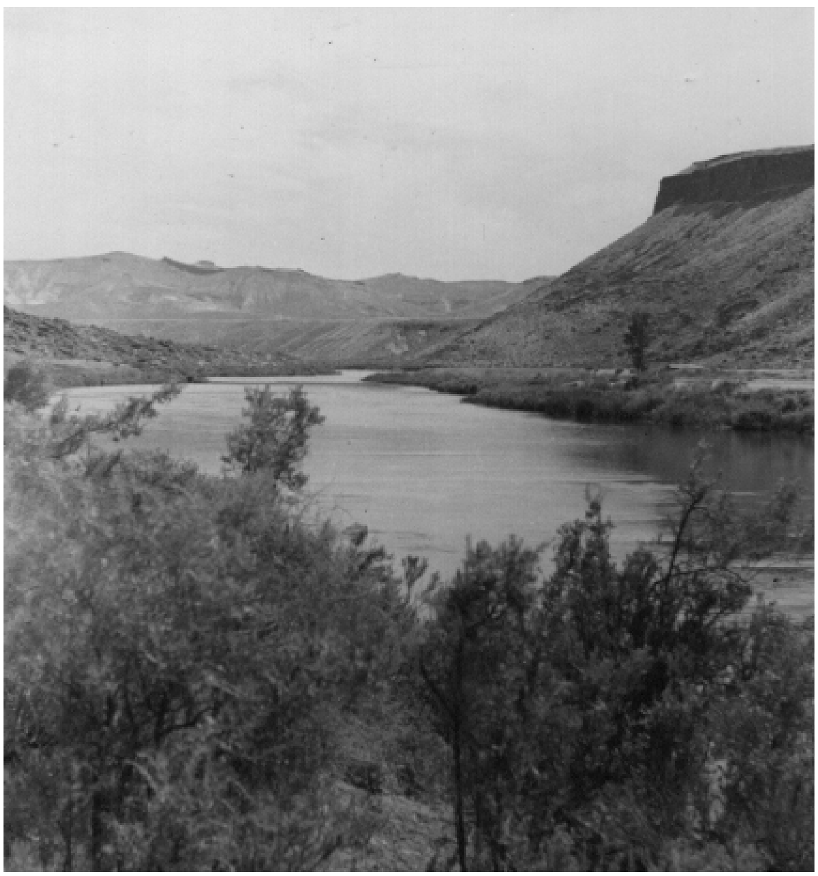

Photo 2.3.1. The mainstem Snake River near Murphy, Idaho (near RM 453.5) circa 1939-40, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

2.3.1.1 INTRODUCTION

The tributary inflows to the SR-HC TMDL reach include the Snake River upstream of the SR-HC TMDL reach (inflowing at RM 409), which contributes approximately 52.7 percent of the

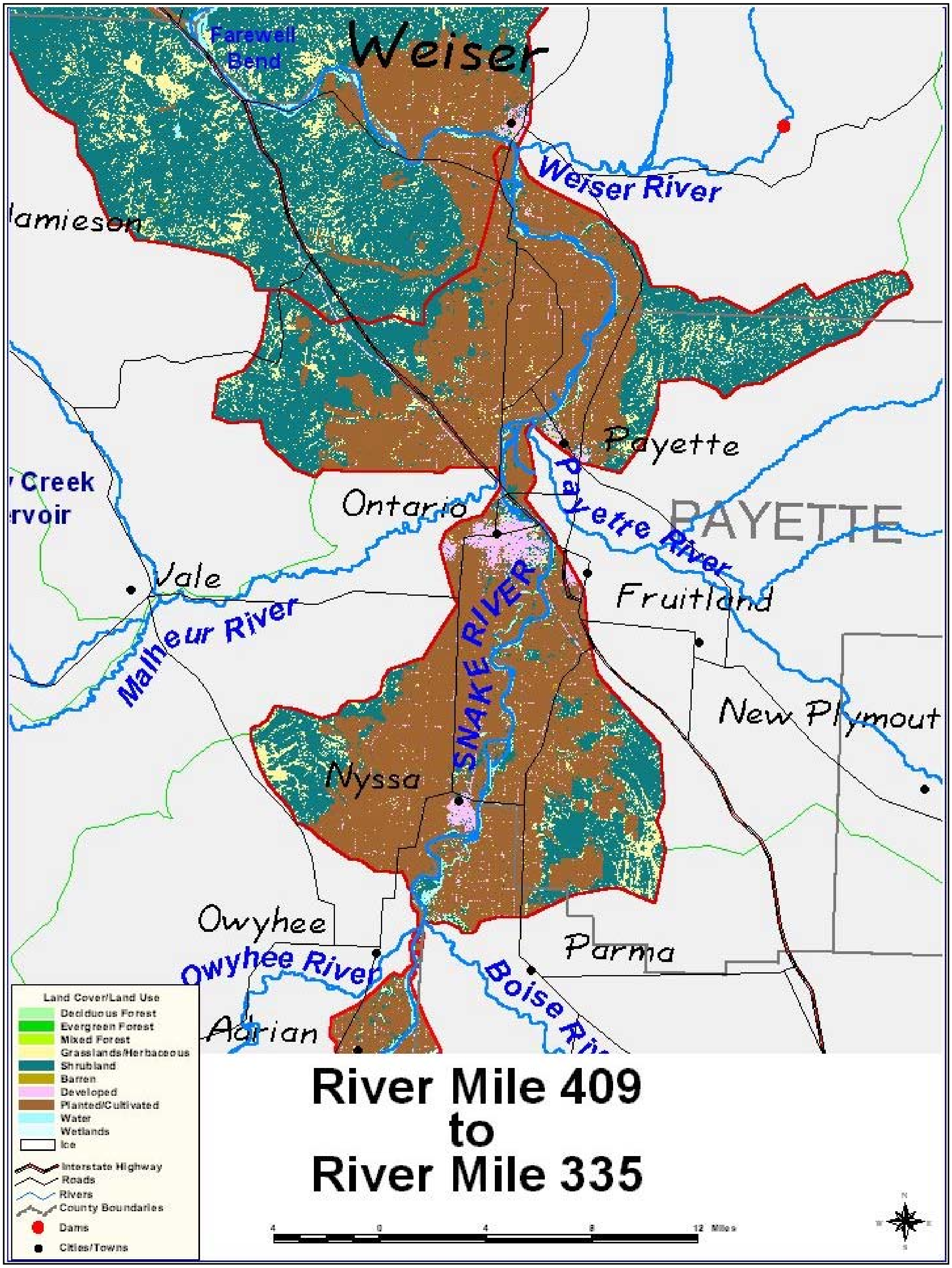

Figure 2.3.2 Upstream Snake River segment of the Snake River – Hells Canyon TMDL.

relative average annual inflow to the SR-HC TMDL reach and drains approximately 42,800 square miles of land in southern Idaho. Segments of the Snake River above the SR-HC TMDL reach are listed for nutrients, pesticides, mercury, temperature and sediment. The Mid-Snake River segment (RM 638.7 to RM 544.7) has an approved TMDL in place and is currently in the implementation process for reductions in phosphorus (IDEQ, 1997c). Using the total inflow to Brownlee Reservoir as calculated from the average annual outflow of 16,191 cfs, the tributary flows can be ranked by relative average annual inflow as follows: the upstream Snake River (52.7 %), the Payette River (17.9 %), the Boise River (9.2 %), the Weiser River (5.2 %), the Owyhee River (2.7 %), the Malheur River (2.2 %), the Powder River (1.2 %) and the Burnt River (0.8 %). These inflowing tributaries routinely exhibit highly variable annual flows (Table 2.1.1). Ungaged flows make up approximately 8.1 percent of the total flow volume.

Due to flood control and storage management upstream, overall flow patterns within the mainstem Snake River as it enters the Upstream Snake River segment (at RM 409) of the SR-HC TMDL reach are less variable than some of the other inflowing tributaries. However, the reach does experience seasonal variation in flow patterns. Flows within the Snake River in this area are commonly higher during spring runoff (usually extending from late February to early June) when mountain snows melt and spring rains increase tributary flows. Irrigation diversions in the major tributaries and dryer summer weather patterns substantially reduce summer and fall flows. These flows are not usually less than 50 percent of those observed during the spring season however. As shown in Figure 2.3.3, mean annual flows vary from an average of 15,000 cfs during spring runoff to an average of 8,000 cfs during the summer season (annual averages compiled from 1980 to 1999 USGS flow data from the gauge near Murphy, Idaho #13290450).

Owyhee River.
The Owyhee River (inflow at RM 396.7) represents 2.7 percent of the relative average annual inflow to the SR-HC TMDL reach and drains approximately 11,160 square miles of land in southeastern Oregon, southwestern Idaho and northern Nevada. Land use is primarily agricultural, with grazing being the predominant practice. Limited areas of irrigated agriculture are present along the river and its tributaries (IDEQ, 1993b).

A TMDL for the lower Owyhee River in Oregon targeting pesticides, mercury, temperature, bacteria and chlorophyll *a* is scheduled for 2006. TMDLs for the Middle, North and South Fork Owyhee River in Idaho targeting temperature have recently been completed and approved by US EPA (IDEQ, 1999c and 2000a).

Flow patterns within the Owyhee drainage are seasonal in nature; increasing during spring runoff (usually extending from late February to early April) when mountain snows melt and spring rains increase secondary tributary flows. Irrigation needs and dryer summer weather patterns substantially reduce summer and fall flows. These flows are often less than 7 percent of those observed during the spring melt.

The operation of the Owyhee Reservoir (1932, 715,000 acre-feet active capacity) and Wildhorse Reservoir on the East Fork Owyhee (in Nevada) reduce total flow variability and localize sedimentation within the reservoir systems. The reservoirs are operated primarily for irrigation storage but also for flood control and recreation. Owyhee Reservoir is also operated for hydropower generation.

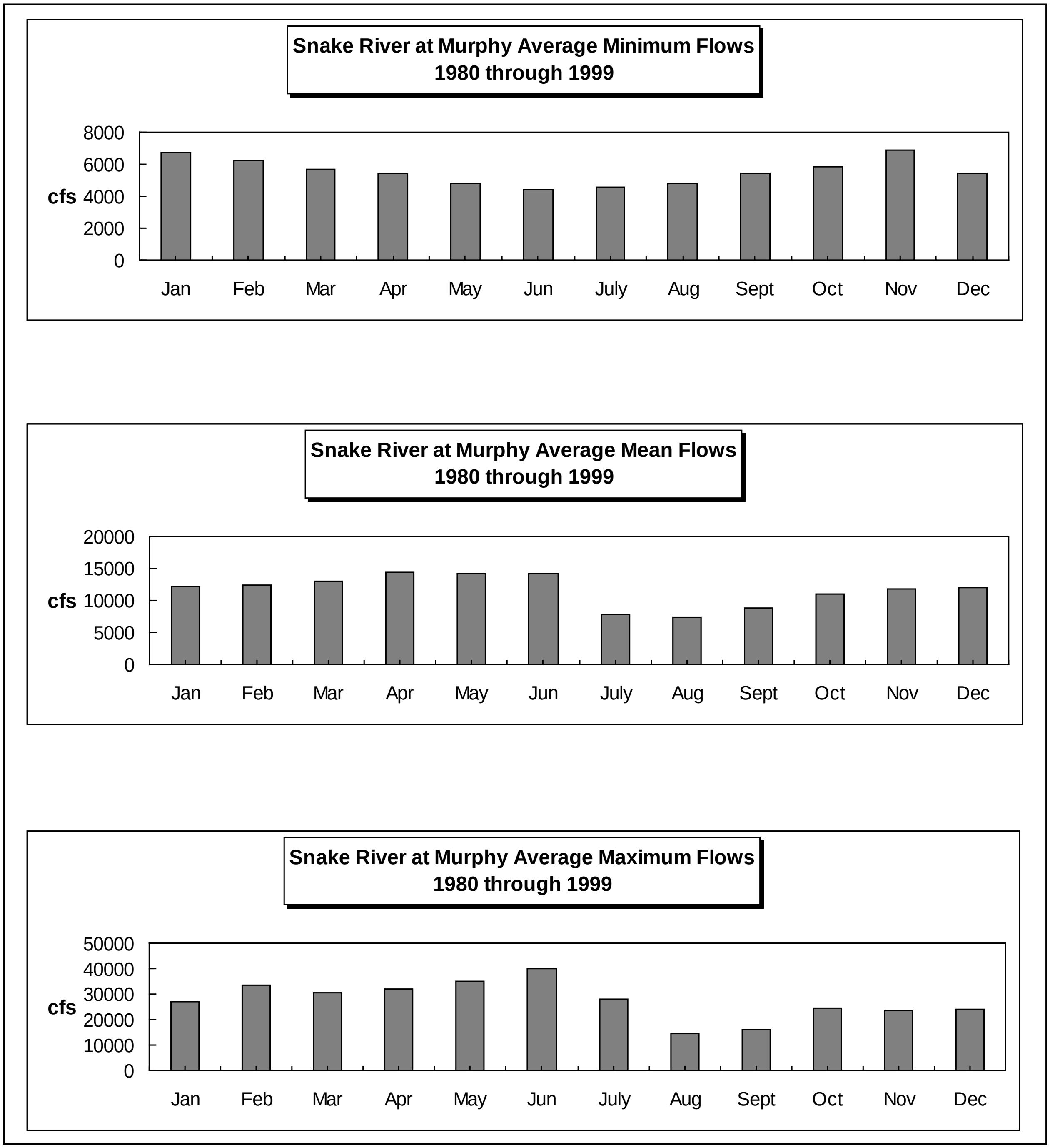

Figure 2.3.3 Minimum, mean and maximum flows observed in the mainstem Snake River (near Murphy, Idaho, RM 453.5).

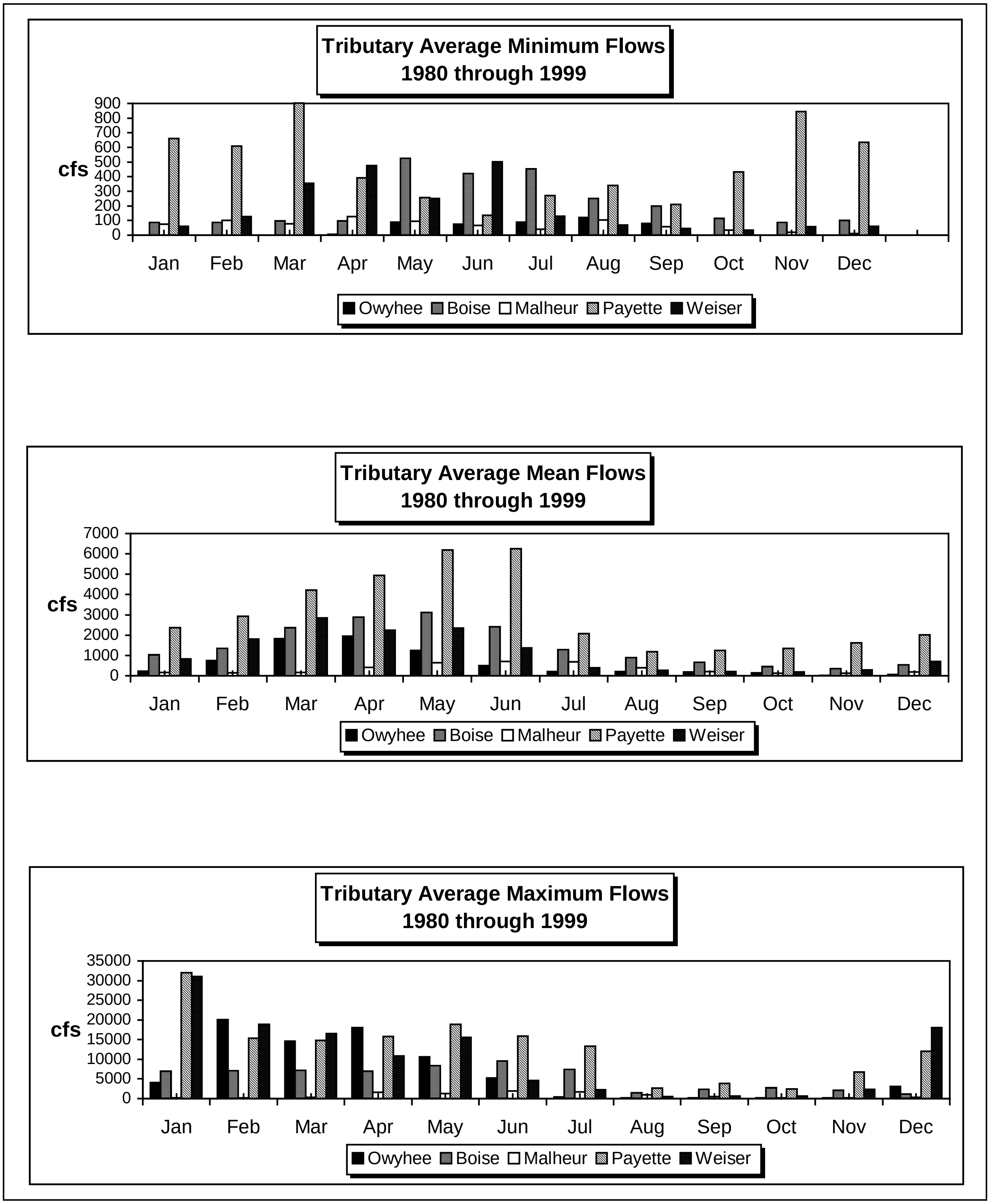

Figure 2.3.4 Minimum, mean and maximum flows for tributaries to the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL reach.

As shown in Figure 2.3.4, average mean flows vary from 2,900 cfs during spring runoff (April) to an average of 140 cfs during the late summer season (September) (annual averages compiled from 1980 to 1999 USGS flow data from the gauge near Rome Oregon, #13181000) and total flows at the mouth as calculated by the USBR (USBR, 2001).

Boise River.

The Boise River (inflow at RM 396.4) contributes approximately 9.2 percent of the relative average annual inflow into the SR-HC TMDL reach and drains 3,970 square miles of land in southwestern Idaho. The Boise River watershed contains two sections, distinct in characteristics and flow. Dams dominate flow in the upper watershed and land use is primarily forestry (public lands), rangeland, recreation and mining activities. The reservoirs in the upper watershed have a substantial influence on the flow patterns in the lower watershed. The lower watershed contains no major impoundments. Land use in the lower Boise River drainage area is predominantly agricultural, but is becoming more urbanized with the recent growth in population in the Boise area. The Boise River drainage contains several major urban areas including the City of Boise, the largest population center in the SR-HC watershed, containing over 32 percent of the total population of the State of Idaho (US Census estimates for 1997).

A TMDL addressing sediment and bacteria issues in the Lower Boise River was approved in 2000 (IDEQ, 1998a). Nutrient reductions in the lower Boise River TMDL were deferred to correlate with the completion of the SR-HC nutrient TMDL. Load and waste load allocations for Lower Boise River nutrient sources specific to downstream impacts will be identified by the Lower Boise River TMDL process.

Flow and velocity within the Boise River drainage are seasonal in nature. High flow volumes and velocities are commonly observed during spring runoff conditions (late February to early April), when warmer temperatures and spring rains result in rapid snowmelt and increased tributary flows. Dry, hot summer conditions, in combination with the fact that significant landmass in the drainage (over 200,000 acres) is under irrigation result in lower summer and fall flows. These flows are often less than 10 percent of those observed during the spring melt. However, while total flow volumes decrease after the spring melt, these irrigation practices act to increase average minimum stream flows in the Lower Boise River throughout May, June, July, August and September. Flows generally taper off through October and November, with annual average minimum flows occurring during the winter months (November through January).

The operation of three impoundments, Lucky Peak Reservoir (1957, 264,400 acre-feet active capacity), Arrowrock Reservoir (1915, 286,600 acre-feet active capacity) and Anderson Ranch Reservoir (1950, 423,200 acre-feet active capacity) act to reduce the total flow variability and localize sedimentation within the reservoir systems. All three reservoirs are operated for flood control and irrigation storage. In addition, Lucky Peak and Arrowrock Reservoirs are operated for hydropower generation. Although recreation and the associated facilities are important to all three reservoirs, only Arrowrock Reservoir is specifically designated as being operated for recreation.

As shown in Figure 2.3.4, mean flows vary from a monthly average mean of 3,100 cfs during spring runoff (May) to a monthly average of 800 cfs during the late summer season (August) (annual flow data compiled from 1974 to 1999 USGS flow data from the gauge located near Parma, Idaho, #13213000). This reach also contains the Sand Hollow Creek drainage.

Malheur River.
The Malheur River (inflow at RM 368.5) contributes approximately 2.2 percent of the relative average annual inflow into the SR-HC TMDL reach and drains 3,900 square miles of land in southeastern Oregon. Land use in the lower Malheur drainage is predominantly agricultural (grazing and row crops), and contains the City of Ontario (IDEQ, 1993b). Flood irrigation is more commonly utilized in the upper Malheur River system than furrow irrigation.

A TMDL targeting bacteria, chlorophyll *a* and pesticides is scheduled for 2003 by the State of Oregon.

Flow within the Malheur River follows seasonal patterns with high flows in the upper watershed during the spring (March to April) due to spring rains and snow melt, however these high spring flows usually do not occur in the lower watershed because of reservoir filling which acts to hold the water in the upper reaches. Low flows occur in the lower reaches during the late summer and fall seasons as a result of agricultural diversion. Low flows usually average less than 40 percent of high spring flows.

The operation of four impoundments, Bully Creek Reservoir (1964, 30,000 acre-feet active capacity), Beulah Reservoir (1935, 59,900 acre-feet active capacity), Warm Springs Reservoir (1919, 191,000 acre-feet active capacity), and Malheur Reservoir (1912, original capacity was 38,000 acre-feet; current capacity is 21,000 acre-feet due to safety restrictions on the upper portion of the dam), act to reduce the total flow variability and localize sedimentation within the reservoir systems. The reservoirs are operated primarily for irrigation storage. Bully Creek Reservoir is also operated for flood control, recreation and fish and wildlife uses.

As shown in Figure 2.3.4, average mean flows in the lower reaches vary from 500 cfs during spring runoff when reservoirs are filling, to an average of 700 cfs during the summer irrigation season (annual averages compiled from 1980 to 1999 USGS flow data from the gauge located near Vale, Oregon, #13233300, approximately 20 miles upstream of the mouth of the river.) Warm (geothermal) springs are prevalent in the Malheur River drainage and may act to influence water temperatures in localized areas.

Payette River.
The Payette River (inflow at RM 365.6) contributes approximately 17.9 percent of the relative average annual inflow to the SR-HC TMDL reach and drains approximately 3,240 square miles of land in southwestern Idaho. Land use in the Payette River drainage is predominantly agricultural and forestry. Forested land is primarily located in the upper portion of the Payette River drainage, with the majority of agricultural and urban areas located in the lower portion of the river basin (IDEQ, 1993b).

A TMDL addressing bacteria in the Lower Payette River was approved in 2000 (IDEQ, 1999b). Nutrient reductions for the Lower Payette River drainage were deferred to correlate with the completion of the SR-HC nutrient TMDL. Load and waste load allocations for the Lower

Payette River nutrients specific to downstream impacts will be identified by the Lower Payette River TMDL process.

Flow and velocity tend to increase during spring runoff, usually occurring between late February and early April, when mountain snows melt and spring rains increase secondary tributary flows. Irrigation needs and dry summer weather patterns significantly reduce summer and fall flows. These flows are often less than 30 percent of those observed during the spring melt.

The operation of Black Canyon Dam (1924, a diversion facility), Deadwood Reservoir (1933, 161,000 acre-feet active capacity) and Cascade Dam (1947, 653,200 acre-feet active capacity), act to reduce the total flow variability and localize sedimentation within the reservoir systems. Black Canyon Reservoir is largely filled with bedload sediment and no longer represents a substantial storage capacity. The reservoirs are operated for irrigation storage and hydropower generation. In addition, Cascade Dam is operated for flood control, and Deadwood and Black Canyon reservoirs are operated for recreation.

As shown in Figure 2.3.4, average mean flows vary from 6,200 cfs during spring runoff to 1,700 cfs during the summer season (annual averages compiled from 1980 to 1999 USGS flow data from the gauge located near Payette, Idaho, #13251000, relatively close to the mouth of the river.)

Weiser River.
The Weiser River (inflow at RM 351.6) represents approximately 5.2 percent of total system flow and drains over 1,455 square miles of land in the southwestern Idaho. Land use is predominantly agricultural with grazing and cropping being the most common practices in the drainage. Forested land is primarily located in the upper portion of the river drainage. The proportion of agricultural and urban use increases near the inflow of the Weiser to the Snake River (IDEQ, 1993b; IDEQ, 1985).

A TMDL addressing bacteria, dissolved oxygen, nutrients, sediment and temperature in the Weiser is scheduled for 2003 by the State of Idaho. Nutrient reductions for the Weiser River TMDL will include nutrient load allocations from the approved SR-HC nutrient TMDL.

Flows within the Weiser River drainage exhibit substantial seasonality with annual high flows commonly occurring during the spring (March to April) due to snow melt and spring rain, and low flows occurring during the late summer and fall seasons as a result of agricultural diversion. Low flows usually average approximately 20 percent of high spring flows. While the only large impoundments in the Weiser River are located high in the drainage, irrigation water management results in significant alteration of historical flows.

As shown in Figure 2.3.4, average mean flows vary from 2,700 cfs during spring runoff to an average of 300 cfs during the fall season (annual averages compiled from 1980 to 1999 USGS flow data from the gauge located near Weiser, Idaho, #13266000, relatively close to the mouth of the river.)

Hydrology within the tributary drainages to the Upstream Snake River segment (RM 409 to 335) is extremely complex. All of the major tributary watersheds contain agricultural lands. Irrigation water use within these drainages is often highly complex in nature. In many cases, water is diverted onto fields and pasturelands, discharged back into the tributary streams through irrigation drains and subsurface flows, and is then re-diverted onto lands downstream. Additionally, water is also diverted from one tributary and then discharged through irrigation drains into a separate watershed entirely. Site or discharge-specific tracking of pollutant loading is therefore equally complex and highly dependent on precipitation and flow levels, as well as seasonal timing and irrigation usage.

Photo 2.3.2. The mainstem Snake River near Weiser, Idaho (near RM 351) circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

It is expected that some reductions in loading in highly enriched nutrient and sediment-laden waters occur as irrigation flows move through tributary systems and are diverted onto fields and pastures with growing vegetation and low velocity water movement. However, in other areas where diverted waters initially contain relatively low concentrations of nutrients and sediment, the potential for enrichment increases as the water moves downstream within the tributary drainage and is repeatedly diverted. These system complexities have been taken into account to the extent possible in the loading assessment, and will be addressed in the implementation plan for the SR-HC TMDL, and in the distribution of load allocations within the tributary drainages.

2.3.1.2 Water Quality Concerns/Status

General Information

The waters of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach are listed as water quality limited for bacteria, dissolved oxygen (RM 409 to 396.4 only), mercury, nutrients, pH, sediment, and temperature as outlined in Table 2.3.1.

A detailed examination of the data available to this assessment has identified two of these pollutants (bacteria and pH), which do not seem to be serious water quality issues in this segment at this time (see detailed discussions below). The rest of the pollutants appear, from the existing data to be limiting the attainment of the designated beneficial use support in this segment. Each of the pollutants and its potential impact on this segment of the SR-HC TMDL reach is described in more detail in the following sections.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.1 summarizes the listed pollutants and designated beneficial uses for the Upstream Snake River segment (RM 409 to 335). A more detailed description of each of the designated beneficial uses is included in the Designated Beneficial Uses section (Section 2.2.2). A more detailed description of the listed pollutants and the assessment process is located in Sections 3.0 through 3.7.

Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

As outlined in Table 2.3.1, salmonid rearing as well as resident fish are included in the designated beneficial uses in this segment. The primary salmonid species in this segment are rainbow trout and mountain white fish. Resident fish include cool and warm water fish such as bass, crappie, and catfish. In addition there is a small population of white sturgeon at the lower end of this segment. A more complete listing of fish species by segment is located in Section 3.6.

Summary and Analysis of Existing Water Quality Data

Bacteria.

The Upstream Snake River segment (RM 409 to RM 335) is listed for bacteria. Additional, more detailed information on bacteria is included in Section 3.4.

<u>General Concerns</u>. Violations of the numeric criteria for bacteria (see Table 2.2.1) in surface waters can result in health risks to individuals using the water for primary contact recreation such

Table 2.3.1 Listing information for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 409 to 396.4 Upstream Snake River (OR/ID border to Boise River Inflow)	(downstream from ID border) bacteria, dissolved oxygen, nutrients, pH, sediment	(downstream from ID border) cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 396.4 to 351.6 Upstream Snake River (Boise River Inflow to Weiser River Inflow)	bacteria, nutrients, pH, sediment	Cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 351.6 to 347 Upstream Snake River (Weiser River Inflow to Scott Creek Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	dissolved oxygen, mercury, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 409 to 395 Upstream Snake River (Owyhee Basin)	mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 395 to 335 Upstream Snake River to Farewell Bend (Malheur Basin)	mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics

* Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning. This use has been removed from RM 347 to 285 (Brownlee Reservoir) by the State of Idaho; however, this change is still subject to action by US EPA.

as swimming, water skiing or skin diving. Such activities carry the risk of ingestion of small quantities of water. This is of particular concern in this area where recreation is a significant use of the waterbody and where recreation frequently involves primary water contact and the risk of ingesting water.

Water Quality Targets. During the majority of time that the monitoring data used in this process was being collected, both Oregon and Idaho bacteria criteria were based on fecal coliform concentrations. Recently, these standards have been updated in both states to reflect advances in understanding health risks associated with pathogen exposure in surface waters. Standards now identify *E. coli* levels in surface waters as a better mechanism for identifying health risks. The criteria of both Oregon and Idaho require waterbodies where primary contact recreation occurs to contain less than 126 *E. coli* organisms/100 mL water (as a geometric mean based on a minimum of five samples, see Table 2.2.1 for details), and an upper limit of less than 406 *E. coli* organisms/100 mL of water in any single sample. In areas where secondary contact recreation occurs the criteria of both Oregon and Idaho require waterbodies to contain less than 126 *E. coli* organisms/100 mL water (as a geometric mean based on a minimum of five samples, see Table 2.2.1 for details), and an upper limit of less than 576 *E. coli* organisms/100 mL of water. Because the criteria are the same for both states, they will be used as the bacteria targets for the SR-HC TMDL. (See Table 2.2.2)

The primary contact recreation beneficial use designation and the associated bacteria targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round.

Common Sources. Common sources of bacteria in surface water include improperly treated sewage and septic systems as well as wastes from warm-blooded animals (domestic animals, humans and wildlife). These may enter the system directly, be carried in through tributary or agricultural inflows, or may be the result of improper disposal of boating or camping wastes.

Natural sources of bacteria (and other pathogens) include indigenous wildlife and wildfowl that utilize the watershed. While these populations are relatively stable throughout much of the year, substantial increases in some populations are observed with spring and fall migration patterns. Fluctuations in the levels of bacteria from waterfowl are especially noticeable as migration effects are directly correlated with surface water and wetland areas within the watershed.

Historical Data. There are no known historical bacteria data available in either an anecdotal or numeric format for this segment of the SR-HC TMDL reach.

Current Data. The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a Water Quality Index (WQI) rating for the Snake River at Weiser, show that bacteria levels in this segment had a “fair” rating both years while the overall station conditions for all evaluated pollutants were judged to be fair in 1986 but poor in 1988. Current data collection allows *E. coli* levels to be evaluated in the Upstream Snake River segment of the SR-HC TMDL reach. Both current (*E. coli* based information) and previous (fecal coliform based) data have been used in the assessment of bacteria criteria violations in the SR-HC TMDL reach. Monitoring dates and sources are shown in Table 2.3.2. Each data set has been evaluated with its appropriate criterion (i.e. fecal coliform data using the previous fecal coliform criteria) as there is currently no approved method for the correlation of fecal coliform and *E. coli* bacteria data.

Segment Status. This listing has been evaluated using available data collected from within this segment from 1978 until present, with available recent data correlated with areas and periods of recreation use. The data show that bacteria counts (*E. coli* and fecal coliform) have not exceeded water quality criteria for primary or secondary contact recreation within the Upstream Snake River segment of the SR-HC TMDL reach over this time period. Table 2.3.3 shows summary bacteria data for the 1999 season (data for 2000 has not been controlled for quality at this time and is therefore not yet available). These data (1999 and 2000) were collected in an appropriate fashion for evaluation of the 30 day log mean, with a minimum of 5 samples over an appropriate time period collected at most sampling locations. The available data represent depth and width integrated sampling of the mainstem channel of the Snake River only. They do not assess violations of bacteria criteria within inflowing tributaries or drains.

Table 2.3.2 Bacteria monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Bacteria Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 1999 to 2000 1978 to 1980	BCPW, 2001 IPCo, 2000a US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 Seasonal sampling 1988 to 1989 1999 to 2000 1978 to 1980	BCPW, 2001 USGS and USBR data IPCo, 2000a US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 1999 to 2000 1978 to 1979	BCPW, 2001 IPCo, 2000a US EPA STORET data, 1998a

Note: Monitoring prior to 1998 is almost exclusively fecal coliform data. Monitoring after 1998 is often both fecal coliform and *E. coli* data or *E. coli* data only.

Table 2.3.3 Summary bacteria data for the 1999 summer season in the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

RM	Number of samples	***E. coli*** **(#/100 mL)**	
		Mean	Maximum
335	3	13	22
340	15	11	53
385	7	18	37
403	8	19	91

These data were collected during the summer season and correlate well not only with the period of time that conditions in the river would be conducive to bacterial growth, but also to the season of greatest primary contact recreation use. Thus, they represent the critical time period for violations within the segment. Based on these data, a recommendation has been made to delist the mainstem Snake River (RM 409 to RM 347, OR/ID border to Scott Creek inflow) for bacteria on the State of Idaho 303(d) list. This proposed delisting will be included as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL. However, monitoring of bacteria levels (*E. coli*) will continue to be an integral part of the water quality monitoring of the Upstream Snake River segment (RM 409 to 335). Additionally, bacteria TMDLs in other (inflowing) tributary watersheds will serve to further improve water quality in the SR-HC TMDL reach.

Dissolved Oxygen.

A portion of the Upstream Snake River segment of the SR-HC TMDL reach is listed as water quality limited due to low dissolved oxygen and the potential for non-support of designated salmonid rearing and cold water aquatic life beneficial uses. The listed stretch extends from RM 409 to RM 396.4. Additional, more detailed information on dissolved oxygen is included in Section 3.2.

General Concerns. See Section 2.2.4.1.

Water Quality Targets. See Section 2.2.4.1 and Table 2.2.2.

Common Sources. See Section 2.2.4.1.

Historical Data. Data collected from 1968 to 1974 by the US EPA in the Upstream Snake River segment (near Weiser, Idaho) and slightly upstream from RM 409 (near Marsing, Idaho) show dissolved oxygen levels that average 10 to 11 mg/L in all available water column samples. No water column dissolved oxygen levels less than the 6.5 mg/L water quality target were observed in the data available. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975), and do not address dissolved oxygen concentrations at the sediment/water interface. Water column data collected near Weiser, Idaho (1969 to 1974) ranged from a high value of 13.6 mg/L (January, 1973) to a low of 8.4 mg/L (July, 1972 and August, 1969).

Current Data. Data collected at RM 385 (near Nyssa, Oregon) at (approximately) monthly frequency during 1975, 1976 and 1977 (US EPA, 1998a) show water column dissolved oxygen levels at mid-day that range from a high of 13.9 mg/L (February, 1977) to a low of 8.6 mg/L (June, 1977). A similar data set collected between 1975 and 1990 at RM 351 (near Weiser, Idaho), show water column dissolved oxygen levels at roughly mid-day that range from 14.2 mg/L (December, 1979) to 6.7 mg/L (June, 1979). The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River at Weiser, show that oxygen in this segment had a "good" rating both years while the overall station conditions for all evaluated pollutants were judged to be "fair" in 1986 but "poor" in 1988.

Water column data collected by IPCo in 1995 at three locations show dissolved oxygen levels that range from 8.8 mg/L in June to 11.8 mg/L in March (near RM 409, Adrian, Oregon); from 7.9 mg/L to 12.7 mg/L both in April (near RM 385, Nyssa, Oregon); and from 7.8 mg/L to 14.1 mg/L both in August (RM 340, near Weiser, Idaho). Preliminary data collected by the Boise City Public Works (BCPW) contractors at eight in-river and tributary locations during the spring, summer and fall of 2000 show no exceedences of the 6.5 mg/L SR-HC TMDL dissolved oxygen target (BCPW, 2001).

As outlined in Table 2.3.4, water column dissolved oxygen levels have been monitored in the Upstream Snake River segment for some time. Currently available inflow data for the SR-HC TMDL reach includes dissolved oxygen monitoring from major tributaries discharging into the SR-HC TMDL reach. Dissolved oxygen concentrations (both mainstem and inflow data) vary seasonally and with variation in annual precipitation. Lower dissolved oxygen levels are most common in late summer, when water levels are low and air temperatures are high (See Figure 2.3.5).

Table 2.3.4 Dissolved oxygen monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Dissolved Oxygen Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 Monthly 1995 to present 1978 to 1980	BCPW, 2001 IPCo, 1999d US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 1978 to 1980	BCPW, 2001 US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 Monthly 1995 to present 1978 to 1979	BCPW, 2001 IPCo, 1999d US EPA STORET data, 1998a

Segment Status. Figure 2.3.5 displays the average seasonal water column dissolved oxygen concentrations for inflowing tributaries and the mainstem Snake River as observed from data collected between 1975 and 2000. Available water column data from the mouths of the tributaries show that most meet the 6.5 mg/L water column dissolved oxygen target for cool and cold water aquatic life year round (BCPW, 2001; IPCo, 2000a, 2000c; USGS, 1999; US EPA, 1998a).

Data collected in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach in 1995, 1996, 1999 and 2000 show no exceedences of the 6.5 mg/L water column dissolved oxygen target for cool and salmonid rearing/cold water aquatic life within this segment. However, a high level of concern in correlation with the aquatic habitat needs of larval sturgeon and other young fish is associated with dissolved oxygen concentrations the sediment/water interface. Initial qualitative evaluation of the dissolved oxygen at the sediment/water interface showed glazed appearance and odor indicative of anaerobic conditions. Available information on dissolved oxygen concentrations at the sediment/water interface immediately upstream of the SR-HC TMDL reach (upstream of RM 409) indicate that dissolved oxygen concentrations are often well below the 6.5 mg/L target value. Substrate conditions are very similar in both reaches of the Snake River. Concerns are generated due to excessive levels of algal growth and slime production leading to an environment conducive to low substrate dissolved oxygen, and increased mercury methylation.

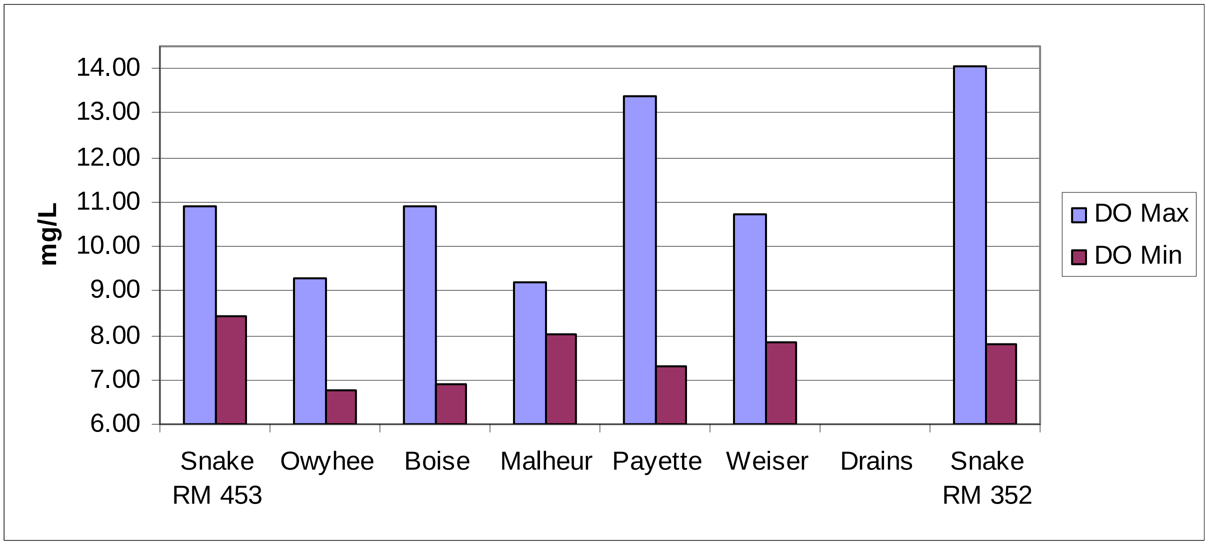

Figure 2.3.5 Mean dissolved oxygen concentrations at tributary and mainstem sites for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL (RM 409 to 335), 1975 through 2000.

While this information alone is not sufficient to adequately assess the level of impairment in this segment of the SR-HC TMDL reach, it does indicate that additional data collection is necessary before a recommendation on delisting can be made. Direct determination of impaired, threatened or full support status of these designated beneficial uses on a site-specific basis will require further study and data collection. A more in-depth discussion of this concern and the available upstream data is available in section 3.2.

Mercury.

The Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach is listed as water quality limited due to a human fish-consumption advisory for mercury from the State of Oregon (Appendix D). Additional, more detailed information on mercury is included in Section 3.1.

General Concerns. See Section 2.2.4.2.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2.

Historical Data. The earliest mercury measurements in this segment date to the early 1970s, post construction of the Hells Canyon Complex as shown in Table 2.3.5. However with changes in sampling and analytical techniques it is difficult if not impossible to correlate the 1970s data with current data.

Current Data. The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River at Weiser, indicate that metal toxicity levels in this segment had a “fair” rating for 1986 and a “good” rating for 1988. The overall station conditions for all evaluated pollutants were judged to be “fair” in 1986 but “poor” in 1988. As outlined in Table 2.3.5, mercury levels have been monitored in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach over an extended period of time. The most recent data collection and analysis occurred in 1997 (Clark and Maret, 1998) and 1999 (IPCo, 2000d). However, the majority of data available are fish tissue and sediment values. Water column data are much more limited. The only water column mercury data available is a single sample from the Upstream Snake River segment at Weiser (~RM 352), collected in 1990, and two samples collected in 2001 immediately upstream of the City of Weiser Wastewater Treatment Plant. The sample collected in 1990 showed a dissolved mercury concentration less than the analytical detection limit (0.1 ug/L) (Rinella *et al.*, 1994). The samples collected in 2001 showed concentrations less than 0.01 ug/L. The analytical detection limit appropriate to the vast majority of the samples analyzed is much higher than the SR-HC TMDL target for total mercury. Therefore, the very limited available data do not provide conclusive evidence on whether or not water column mercury levels in this segment are above the target of 0.012 ug/L identified in this TMDL.

Table 2.3.5 Mercury monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Mercury Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	Jan 1970 July to Sept 1990	Gebhards *et al.*, 1971 (IDFG) Buhler *et al.*, 1971 (OSU) Rinella *et al.*, 1994 (USGS)
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	Jan 1970 July to Sept 1990 Aug 1997	Buhler *et al.*, 1971 (OSU) Rinella *et al.*, 1994 (USGS) Clark and Maret, 1998 (USGS) IPCo, 2000d
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	July to Sept 1990	Rinella *et al.*, 1994 (USGS) IPCo, 2000d

The action level for fish tissue mercury concentrations for the State of Oregon is 0.35 mg/kg. The action level for fish tissue mercury concentrations for the State of Idaho is 0.5 mg/kg (wet weight).

The data collected in 1994 and 1997 indicate that exceedences of the State of Oregon action level may be occurring in individual fish tissue samples. Data collected in 1990 and 1997 (Table 2.3.6) show a decrease in average methylmercury concentration; however, this data set is insufficient to demonstrate a conclusive downward trend for two reasons: 1. Data from 1970 cannot be compared directly due to differences in analytical techniques. 2. The size, age, weight and species sampled differ from data set to data set and are therefore not directly comparable.

Further monitoring is necessary to determine if the lower fish tissue methylmercury concentrations observed in the recent data set collected in the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir (RM 335 to 285) segments of the SR-HC TMDL reach are representative of actual conditions.

Segment Status. While there is no data to show that the water column target established for the SR-HC TMDL is being exceeded, there is sufficient fish tissue mercury data to warrant a fish consumption advisory from the State of Oregon (Appendix D).

Table 2.3.6 Mercury in fish tissue in the Upstream Snake River segment (RM 409 to 335) over the past 30 years. All averages represent data over several species and age classes.

Year	Number of Samples	Mean Mercury Concentration (mg/kg wet weight)
1970	16	0.79
1990	9	0.20
1997	2	0.28

* These values are means. The range is based on the mean measured methylmercury concentration observed for a species, not an individual fish. Therefore, in 1990 some individual fish tissue data exceed the action levels set by both the State of Oregon and the State of Idaho. In 1997, some individual fish tissue data exceed the action level established by the State of Oregon.

The current status review of this segment for mercury contamination is based on fish tissue data. When considering the available fish tissue data, it is apparent that from the 1970s until present, this segment has exhibited fish tissue mercury concentrations that are of concern for human health.

Data show impairment of the designated beneficial use of fishing. Available data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine whether target exceedences are occurring. This information is required in order to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, domestic water supply designated beneficial uses.

Nutrients.

The Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach is listed as water quality limited due to nuisance algal growth and excessive nutrient loading. Both of these factors are of concern because of the effect excessive algal growth can have on dissolved oxygen, pH levels, and formation of trihalomethane compounds (THMs) in drinking water treatment. Additional concerns are associated with the production of cyanotoxins from cyanobacteria (blue-green algae) growth. More detailed information on these concerns is included in Section 3.2.

General Concerns. See Section 2.2.4.3.

Water Quality Targets. See Section 2.2.4.3 and Table 2.2.2.

<u>Common Sources</u>. In addition to the common sources described in Section 2.2.4.3, additional sources of nutrients to the Upstream Snake River segment (RM 409 to 335) may include natural levels of phosphorus from the mountains that rim the southeastern border of the Snake River Basin and anthropogenic releases of phosphorus to the Snake River from mining and smelting of phosphate ores upstream (US EPA, 1974a).

<u>Historical Data.</u> Anecdotal information on nutrient concentrations in the Upstream Snake River segment (RM 409 to 335) indicates that algal growth may also have occurred at noticeable levels before extensive anthropogenic impact to this reach from agricultural practices or urbanization occurred (US EPA, 1974a). The Mid-Snake River Problem Assessment (IDEQ, 1997c) cites the following: The Snake River has historically been a biologically productive system. As early as 1811, before the first anthropogenic discharge entered the river, a "light pea-green color" was observed. While there is no available mechanism to extrapolate this information to algal or nutrient concentrations in the river, one logical interpretation of this statement would be that the coloration noted was due to an accumulation of algal growth in the river system at the time of the 1811 expedition.

Mainstem data collected at (approximately) monthly frequency from 1969 to 1974 by the US EPA in the Upstream Snake River segment (near Weiser, Idaho) show total phosphorus levels that range from 0.54 mg/L (July, 1972) to 0.03 mg/L (March, 1970) with an average concentration value of 0.13 mg/L. This same study showed a range in concentration for dissolved ortho-phosphate from 0.01 mg/L (April, 1972 and June 1971) to 0.1 mg/L (November, 1970 and February and March, 1971). The mean dissolved ortho-phosphate concentration for this study was 0.05 mg/L. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1998a).

Data collected for determination of aqueous phosphorus concentrations (both mainstem and inflow data) vary seasonally and with variation in annual precipitation. Inflow data varies seasonally with changes in agricultural recharge, spring runoff, subsurface contributions, and rate of instream biological processing. Annual variations also result from relative precipitation amounts, frequencies and intensities.

Data collected from 1968 to 1974 by the US EPA in the Upstream Snake River segment (near Weiser, Idaho) and slightly upstream from RM 409 (near Marsing, Idaho) show total phosphorus levels that range from an average of 0.08 mg/L near the inflow of the Boise and Owyhee Rivers to 0.120 mg/L near the Malheur and Payette River inflows. All of the average values available are above the US EPA Gold Book (US EPA, 1986b) targets for waters flowing into a lake or reservoir (0.05 mg/L).

Nitrate/nitrite levels in this segment averaged 0.5 mg/L to 0.75 mg/L near the inflow of the Malheur and Payette Rivers and the Boise and Owyhee Rivers respectively. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

The biology of the Snake River was the subject of a Ph.D. dissertation authored by Lyle Stanford in 1942 (Stanford, 1942). Dr. Stanford's observations and data (collected in 1941 and 1942) show plankton in the un-impounded SR-HC TMDL reach to be dominated by diatoms. Green algae were abundant in backwater areas and oxbow lakes. Some cyanobacteria (blue-greens) were also observed but were not the dominant population even in the summer season.

A study completed approximately 20 years later by IDFG (IDFG, 1961) details the water quality condition of the Snake River between Adrian, Oregon and Weiser, Idaho. General conclusions from the report include:

(1) All inflowing tributaries were observed to carry excessive loading of sediment. Excessive nutrient loading from the tributaries was suspected because of "great algal blooms in most areas".
(2) The Snake River was observed to carry an "exceptionally heavy load of algae in suspension". Dominant algae types were identified as blue greens (*Anabaena*, *Pediastrum*, *Spirogyra*, *Aphanizomenon*, *Staurastrum*, and *Anacystis*).
(3) The river was observed to carry a high organic load, which "appears to exceed by many fold all sources of industrial and domestic wastes in the study area".
(4) Areas of "gross organic pollution" (slimes) were identified to occur in the Snake River on the Oregon side below the City of Ontario.
(5) Fish populations of the Malheur, Weiser and possibly Owyhee rivers were hypothesized to be limited by high turbidity.

<u>Current Data</u>. Data collected at RM 385 (near Nyssa, Oregon) at (approximately) monthly frequency during 1975, 1976, 1977 and 1990 (US EPA, 1998a) show total phosphorus concentrations that range from 0.02 mg/L (January, 1975) to 0.14 mg/L (July, 1976), with a mean total phosphorus concentration of 0.08 mg/L. A similar data set collected between 1975 and 1990 at RM 351 (near Weiser, Idaho), show total phosphorus levels that range from 0.02 mg/L (July 1976) to 0.22 mg/L (March 1984), with a mean total phosphorus concentration of 0.14 mg/L. Dissolved ortho-phosphate values collected from 1981 to 1990 range from 0.01 mg/L (July, 1984 and December, 1989) to 0.1 mg/L (November, 1981 and January, 1982). The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a) list nutrients as a primary pollutant in this segment. WQI ratings for the Snake River at Weiser in these studies show that the trophic status of this segment had a "fair" rating for both years while the overall station conditions are judged to be "fair" in 1986 but "poor" in 1988. These studies found cold water aquatic life and salmonid spawning in this segment to be only partially supported and other beneficial uses to be potentially at risk due in part to the trophic status of this segment.

Currently available inflow data for the Upstream Snake River segment (RM 409 to 335) includes aqueous samples from major tributaries discharging into the SR-HC TMDL reach (Figures 2.3.6 and 2.3.7). The majority of the data are grab samples, but some depth-integrated sampling information is available. Data sources are listed in Tables 2.3.7.

Data collected by IPCo between 1996 to 1999 show an increasing trend in total phosphorus concentrations in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach and distance downstream.

During the critical summer months (June through September) when conditions for algal growth are optimal, concentrations at RM 413 (near where the Snake River enters the SR-HC TMDL reach) average 0.09 mg/L total phosphorus, 0.02 mg/L ortho-phosphate and 22 ug/L chlorophyll *a* (1995 to 1999). At RM 385 (below the Owyhee and Boise river inflows) concentrations average

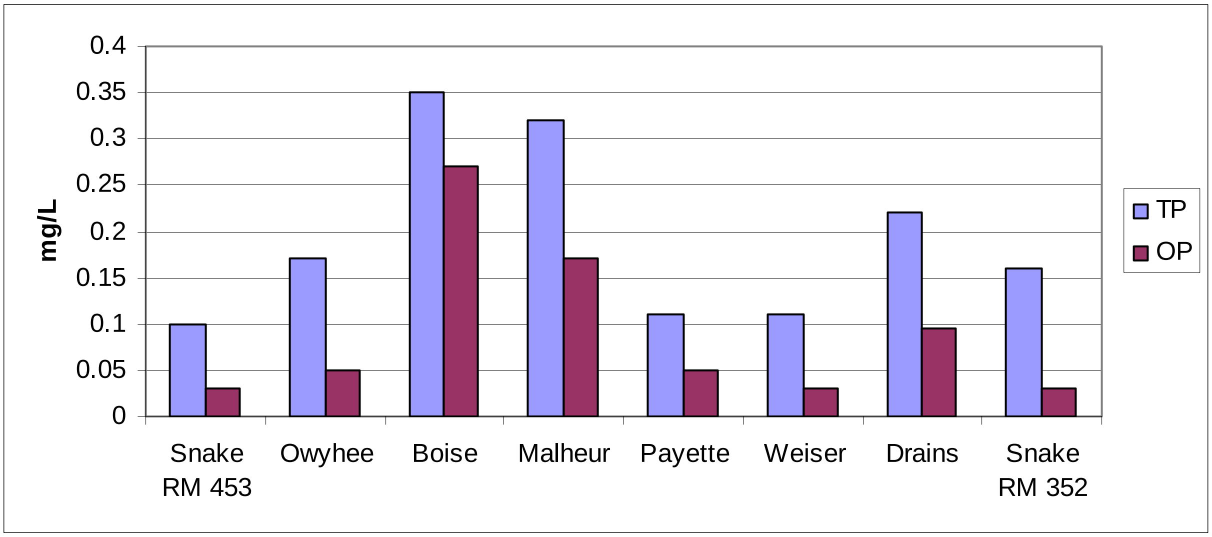

Figure 2.3.6 Median total phosphorus (TP) and ortho-phosphate (OP) concentrations for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL (RM 409 to 335).

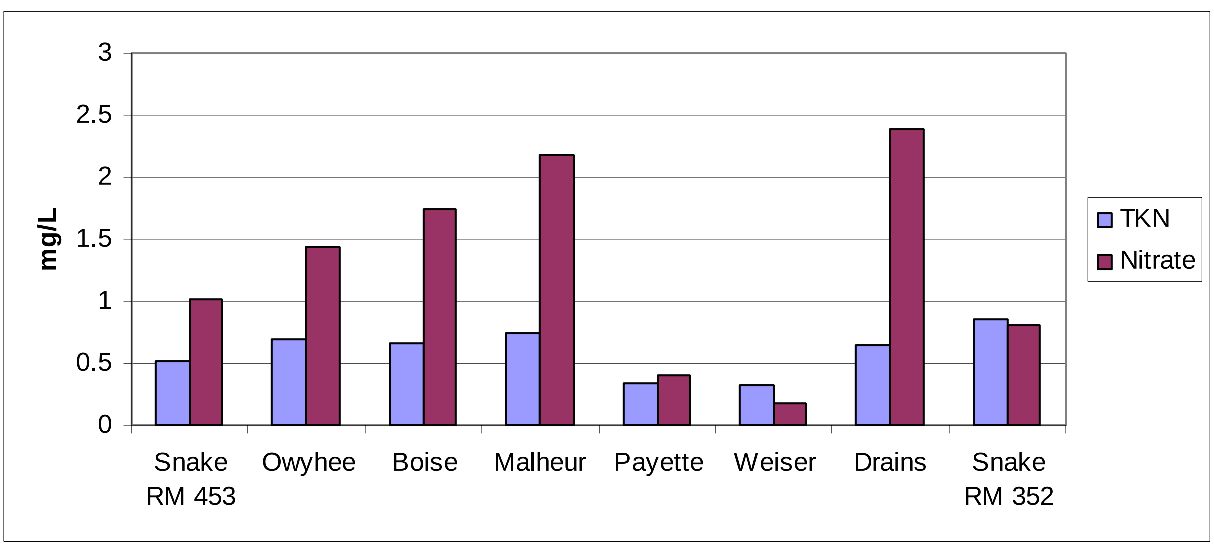

Figure 2.3.7 Median nitrate and total Kjeldahl nitrogen (TKN) concentrations for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL (RM 409 to 335).

0.12 mg/L total phosphorus, 0.02 mg/L ortho-phosphate and 24 ug/L chlorophyll *a* (1995 to 1999). At RM 351 (below the Malheur and Payette river inflows, near the Weiser River inflow) concentrations average 0.13 mg/L total phosphorus, 0.02 mg/L ortho-phosphate and 34 ug/L chlorophyll *a* (1995 to 1999). At RM 340 (near the head of Brownlee Reservoir) concentrations average 0.13 mg/L total phosphorus, 0.02 mg/L ortho-phosphate and 30 ug/L chlorophyll *a* (1995 to 1999). Within this same data set, chlorophyll *a* varied from 3 to 51 ug/L at the Adrian, Oregon site; from 2 to 107 ug/L at the Nyssa, Oregon site; and from 2 to 84 ug/L at the Weiser, Idaho site (Figure 2.3.8). Data sources for chlorophyll *a* are listed in Table 2.3.8.

Table 2.3.7 Nutrient monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Nutrient Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 Monthly 1995 to present Summer 1992 1974 to 1977, 1978 to 80	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 Monthly 1995 to present Summer 1992 1977 to 1980	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 Monthly 1995 to present Summer 1992 1974 to 1975, 1978 to 1979	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a

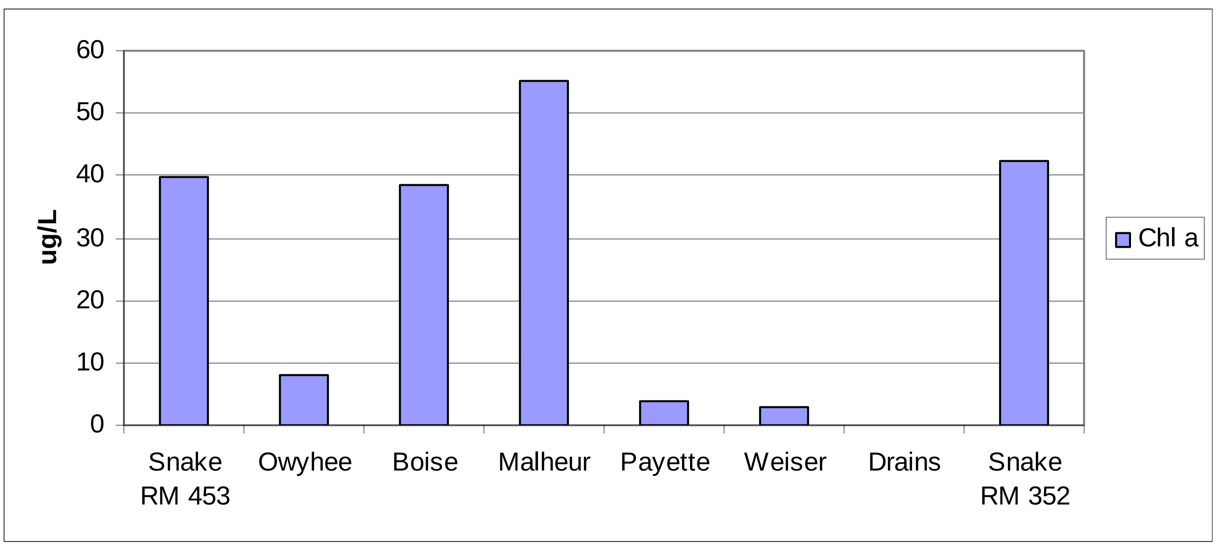

Figure 2.3.8 Mean chlorophyll *a* concentrations for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL.

As discussed in Section 2.2.4.3, there are two major nutrients of concern in surface water systems, phosphorus and nitrogen. However in systems where cyanobacteria (blue-green algae) are routinely a dominant community, phosphorus is the nutrient most likely to be limiting as these organisms can fix nitrogen from the air/water interface. Both cyanobacteria (blue-green algae) and diatoms have been observed as dominant populations in the Upstream Snake River segment (RM 409 to 335) depending on the season, water quality, and water temperature (IDEQ, 1993b; IDFG, 1961).

Table 2.3.8 Chlorophyll *a* (as an index for algae) monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Chlorophyll *a* Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 Monthly 1995 to present Summer 1992 1988 to 1996	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 Monthly 1995 to present Summer 1992 1973 to 1974, 1978 to 1988, 1995	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 Monthly 1995 to present Summer 1992	BCPW, 2001 IPCo, 1998a, 1998b, 2000a IDEQ, 1993b US EPA STORET data, 1998a

Recent monitoring within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach indicates that water quality (as defined by a combination of algal and phosphorus concentrations) tends to degrade with increasing distance downstream.

Because of the relationship between nutrients, algae and dissolved oxygen within a surface waterbody, algal biomass has been monitored through sampling and analysis for chlorophyll *a* and pheophytin (a metabolite of chlorophyll *a*). Data available from both nutrient and algal monitoring has been identified as an important part of the assessment of water quality. Therefore, these data have been included in the monitoring information on algae even though they are not specifically listed as parameters on the 303(d) list.

<u>Segment Status</u>. Monitoring data collected from tributaries inflowing to the Snake River regularly exceed the total phosphorus target for the SR-HC TMDL reach. Available data showed that in a low water year (1992 to 1993), the median total phosphorus concentration in inflowing tributary waters was consistently 0.2 to 0.4 mg/L. Median mainstem Snake River concentrations at the same time were approximately 0.1 mg/L (IDEQ, 1993b; USGS, 1999; US EPA, 1998a). During this same time, ortho-phosphate made up approximately 30 percent of the total phosphorus load in the mainstem Snake River, and averaged 57 percent of the total phosphorus load from the inflowing tributaries. In an average water year the median total phosphorus concentration in inflowing tributary waters ranged from 0.2 to over 0.3 mg/L. Median mainstem Snake River concentrations at the same time ranged from approximately 0.1 to 0.2 mg/L (BCPW, 2001; IPCo, 1998a, 1998b, 2000a; US EPA, 1998a; USGS, 1999). During this same

time, ortho-phosphate made up approximately 30 percent of the total phosphorus load in the mainstem Snake River, and averaged 62 percent of the total phosphorus load from the inflowing tributaries.

In general, median total phosphorus concentrations observed at the mouth of the Boise and the Malheur Rivers are the highest of the inflowing tributaries (0.35 and 0.32 mg/L respectively). Total phosphorus concentrations in the Weiser River (~0.10 mg/L) are the lowest of the inflowing tributaries (BCPW, 2001; IPCo, 1998a, 1998b, 2000a; US EPA, 1998a; USGS, 1999). In general, median ortho-phosphate concentrations observed at the mouth of the Boise and the Malheur rivers are the highest of the inflowing tributaries (0.27 and 0.17 mg/L respectively). Ortho-phosphate concentrations in the Snake (upstream of RM 409) and Weiser rivers are the lowest of the inflowing tributaries to the Upstream Snake River segment (0.03 mg/L) (BCPW, 2001; IPCo, 1998a, 1998b, 2000a; US EPA, 1998a; USGS, 1999). Figure 2.3.6 displays the median total and ortho-phosphate concentrations for inflowing tributaries and the mainstem Snake River as observed from data collected during recent average water years.

In the case of nitrogen loading, available data show that in a low water year (1992 to 1993), the range of median total nitrogen (TN) concentrations in inflowing tributary waters was 0.30 mg/L to 4.9 mg/L. Median mainstem Snake River total nitrogen concentrations at the same time were approximately 0.7 mg/L (BCPW, 2001; IDEQ, 1993b; USGS, 1999; US EPA, 1998a). In an average water year the median nitrate concentration in inflowing tributary waters ranged from 0.17 mg/L to over 2.35 mg/L. Median mainstem Snake River concentrations at the same time ranged from approximately 1.1 mg/L to 1.5 mg/L (BCPW, 2001; IPCo, 1998a, 1998b, 2000a; US EPA, 1998a; USGS, 1999).

In general, median nitrogen concentrations (nitrate and total kjeldahl nitrogen (TKN)) observed at the mouth of the drains and the Malheur River are the highest of the inflowing tributaries (2.39 mg/L and 0.64 mg/L; and ~2.18 mg/L and 0.74 mg/L respectively). Median nitrogen concentrations (nitrate and TKN) in the Weiser and Payette rivers are the lowest of the inflowing tributaries (0.17 mg/L and 0.32 mg/L; and 0.41 mg/L and 0.34 mg/L respectively). Figure 2.3.7 displays median nitrogen concentrations for inflowing tributaries and the mainstem Snake River as observed from data collected during recent average water years.

In addition to the nutrient loads entering the system, algae is both grown in place in the mainstem Snake River and transported into this segment from the inflowing tributaries (Figure 2.3.8). A study completed during a dry water year (IDEQ, 1993b) showed that chlorophyll *a* concentrations ranged from 0.01 mg/L to 0.09 mg/L, with concentrations increasing upstream to downstream. This same study observed that inflowing tributary chlorophyll *a* concentrations were markedly lower than mainstem Snake River concentrations in this segment. More recent monitoring (1994 through 1999) supports this trend, showing chlorophyll *a* levels in the mainstem often measured at five to eight times higher than those in the inflowing tributaries (IPCo, 1998a, 1998b, 1999c, 1999d, 2000a).

Available data and information show impairment of aesthetic and recreational uses due to excessive algal growth and slime production. Available data and information also demonstrate a high level of concern for cold water aquatic life, salmonid rearing, resident fish and aquatic life, fishing, and domestic water supply designated beneficial uses, and endangered species support. Concerns are generated due to excessive levels of algal growth and slime production leading to an environment conducive to low substrate dissolved oxygen (specific to young fish and other aquatic life at the sediment/water interface), increased mercury methylation, and potential for cyanotoxin production. Endangered species concerns center around support for the Idaho Springsnail (present in this segment), that requires free flowing, clear, cold water environments. Determination of impaired, threatened or full support status of these designated beneficial uses will require further study and data collection.

pH.

The Upstream Snake River segment (RM 409 to RM 335) of the SR-HC TMDL reach is listed for pH. Additional, more detailed information on pH is included in Section 3.4.

<u>General Concerns</u>. See Section 2.2.4.4.

<u>Water Quality Targets</u>. See Section 2.2.4.4 and Table 2.2.2.
<u>Common Sources</u>. See Section 2.2.4.4.

<u>Historical Data</u>. Data collected from 1968 to 1974 by the US EPA in the Upstream Snake River segment (RM 409 to 335) show a fairly narrow range of pH values from 7.5 to 9.0 at RM 361 (near Weiser, Idaho) and between 7.7 and 8.5 slightly upstream from RM 409 (near Marsing, Idaho). These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

<u>Current Data</u>. Data collected from 1975 to 1991 by the US EPA in the Upstream Snake River segment also show a fairly narrow range of pH values. Values range from 7.5 to 9.1 at RM 361 (near Weiser, Idaho). Exceedences of the pH target for the SR-HC TMDL (7.0 to 9.0) occurred less than 1 percent of the time. A study over a similar time period but with less frequent sampling slightly upstream from RM 409 (near Marsing, Idaho) showed a range of pH values from 7.5 to 8.9. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River at Weiser, show that pH in this segment had a “good” rating both years while the overall station conditions for all evaluated pollutants were judged to be “fair” in 1986 but “poor” in 1988. As outlined in Table 2.3.9, pH levels have been monitored over a considerable time period in the Upstream Snake River segment of the SR-HC TMDL reach.

Currently available inflow pH data for the SR-HC TMDL reach includes the inflowing tributaries and the mainstem Snake River. Data collected by IPCo during 1995 at three locations in the Upstream Snake River segment of the SR-HC TMDL reach show pH levels that range from 8.2 to 8.9 near RM 409, Adrian, Oregon; from 7.1 to 8.9 near RM 385, Nyssa, Oregon; and from 8.3 to 9.0 at RM 340, near Weiser, Idaho. An evaluation of all available pH data for the Upstream Snake River segment of the SR-HC TMDL reach show less than 1 percent exceedence of the 7.0 to 9.0 pH target.

Table 2.3.9 pH monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach.

Segment	pH Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 1995 1960 to 1996	BCPW, 2001 IPCo data US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 Summer sampling 1988 to 1989 1995 1957 to 1990, 1995	BCPW, 2001 USGS & USBR data IPCo data US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 1995 1974, 1978 to 1979, 1988 to 1989	BCPW, 2001 IPCo data US EPA STORET data, 1998a

<u>Segment Status</u>. The listing of pH as a pollutant impairing designated beneficial uses in the Snake River (RM 409 to 335) has been evaluated using available data collected from within this segment. The data show that exceedence of the SR-HC TMDL pH targets occur less in less than 1 percent of the data (the total number of samples is greater than 300). Figure 2.3.9 shows summary pH for the 1995 to 1999 years. Based on these data, a recommendation has been made to delist the mainstem Snake River (RM 409 to RM 347, OR/ID border to Scott Creek inflow) for pH on the State of Idaho, 303(d) list. This proposed delisting will be included as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL. However, monitoring of pH levels will continue to be an integral part of the water quality monitoring of the mainstem Snake River (RM 409 to RM 335).

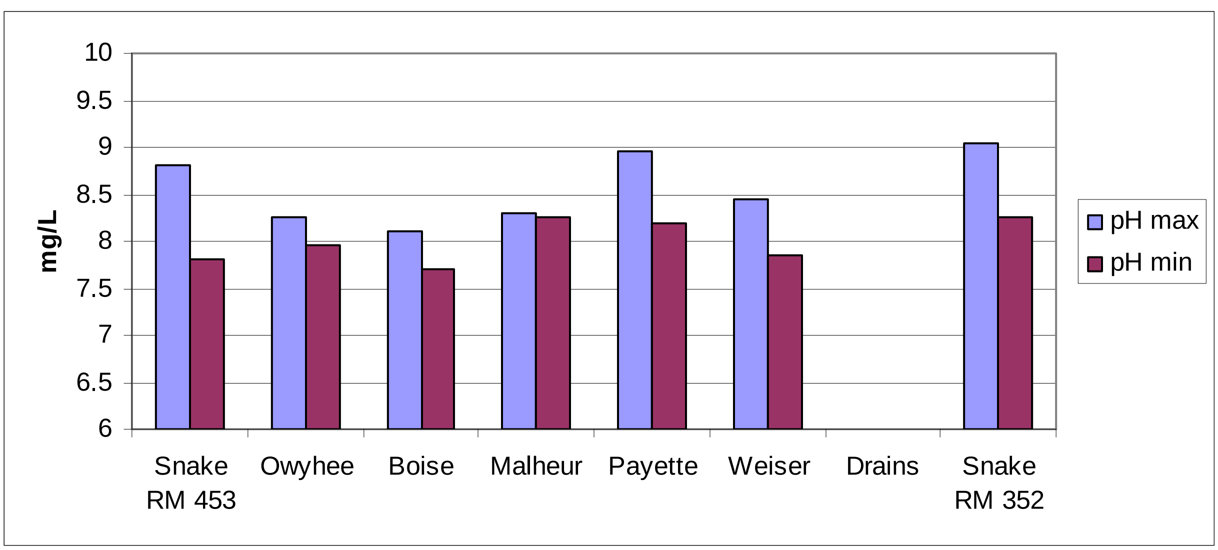

Figure 2.3.9 Measured maximum and minimum pH levels for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL.

Sediment.

The Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach is listed for excessive sediment. Additional, more detailed information on sediment is included in Section 3.5.

General Concerns. See Section 2.2.4.5.

Water Quality Targets. See Section 2.2.4.5 and Table 2.2.2.

Common Sources. See Section 2.2.4.5.

Historical Data. This segment of the SR-HC TMDL reach has historically carried a substantial sediment load particularly during spring runoff (US EPA, 1974a). However there is little quantitative data from earlier periods (particularly prior to the construction of the Hells Canyon Complex).

Current Data. Data collected as part of a US EPA study from 1978 to 1990 at RM 361 near Weiser, Idaho (RM 351.6) show total suspended solids (TSS) data that range from 5 mg/L to 211 mg/L. While these data show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a) list sediment as a primary pollutant in this segment. WQI ratings for the Snake River at Weiser in these studies show that solids in this segment had a “fair” rating for both years while the overall station conditions were judged to be “fair” in 1986 but “poor” in 1988. These studies found cold water aquatic life and salmonid spawning in this segment to be only partially supported and other beneficial uses to be potentially at risk due in part to suspended sediments concentrations. Total suspended sediment data have been collected for the Upstream Snake River segment of the SR-HC TMDL reach as shown in Table 2.3.10.

Table 2.3.10 Total suspended solids (TSS) monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	TSS Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 1995 1965 to 1996	BCPW, 2001 IPCo, 2000a US EPA STORET data, 1998a
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 1995 1960 to 1990, 1995	BCPW, 2001 IPCo, 2000a US EPA STORET data, 1998a
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 1995 1974 to 1975, 1978 to 1979, 1988 to 1989, 1995 to 1997	BCPW, 2001 IPCo, 2000a US EPA STORET data, 1998a

<u>Segment Status</u>. An evaluation of all inflowing and mainstem total suspended sediment data showed that the lowest average concentrations are observed in the Payette (13 mg/L) and Weiser rivers (15 mg/L) and in the mainstem Snake River near Murphy (15 mg/L). The highest average TSS concentrations observed occurred in the Owyhee (50 mg/L) and Malheur rivers (44 mg/L). Figure 2.3.10 displays the average total suspended sediment concentrations for inflowing tributaries and the mainstem Snake River as observed from data collected between 1970 and 1999.

Within the Upstream Snake River segment (RM 409 to 335), the majority of water in the inflowing Snake River is a combination of that released from CJ Strike Dam (RM 494) and Swan Falls Dam (RM 458) and irrigation return flows to the river. The tributaries inflowing to this segment contain numerous reservoirs and other impoundments and diversion structures. Nearly all reservoirs are operated for irrigation storage, and act to reduce overall flow variability within the tributary and mainstem systems. These structures also act as “settling ponds” and localize sedimentation within the reservoir systems. The amount of flow alteration occurring due to irrigation management varies from one tributary to the next. The two tributaries with the least management are the Weiser and Payette Rivers. However, all are substantially altered by impoundments and diversions.

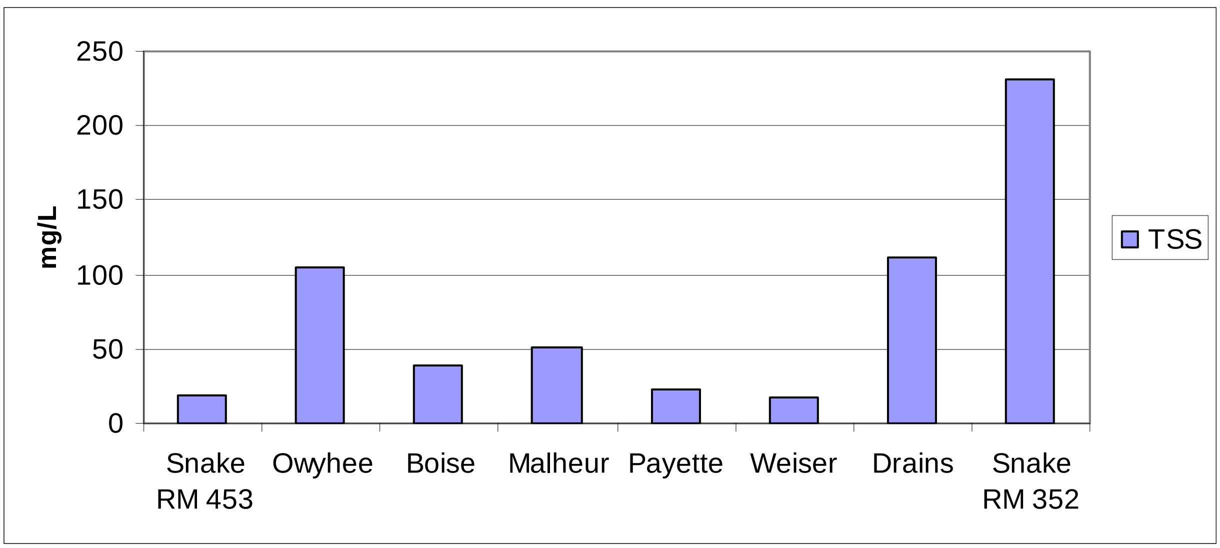

Figure 2.3.10 Mean total suspended solids (TSS) concentrations for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL.

While variability in the tributary systems follows a natural sequence of snow melt (high flows in the early spring) and dry summers (low flows in late July and August), most of the river systems tributary to the Upstream Snake River segment do not currently reflect historical velocities or flow. Sediment transport in the Snake River and its tributaries is complex. For example, flood control and irrigation management may result in slower, lower-flow spring seasons with the peak flows spread over a greater time frame than would be observed in an un-impounded system. In contrast, anthropogenic stream channelization actions may increase flow velocities in segments of the Snake River system. While the reduction in flow velocity due to flood control and diversion may cause less overall erosion of stream banks, dams cause sediment deposition within the reservoir systems; isolation of floodplain areas through stream channelization may increase erosion and limit floodplain deposition of sediments. Primary erosion impacts occur during spring runoff when flow volumes and velocities are greatest. However, while sediment transport still occurs within the river systems, overall sediment delivery to locations downstream of the impoundments is substantially reduced.

Sediment TMDLs are scheduled or completed for the Owyhee River, the Boise River, the Payette River, the Weiser River and many of the smaller tributaries that discharge to major tributaries within the SR-HC system. It is expected that, if successfully implemented, these TMDL efforts will result in improvement of sediment concentrations within these segments.

Available data do not contain duration information and therefore are not sufficient to determine if target exceedences are occurring. This information is needed to determine the support status of cold water aquatic life, salmonid rearing, or residential fish and aquatic life designated beneficial uses. However, sediment data do show elevated total suspended sediment concentrations occurring in a sufficiently consistent manner to be of concern. Therefore, sediment targets are set to be protective of these uses. Additionally, due to the fact that sediment acts as a primary transport mechanism for adsorbed pollutants, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

Temperature.

The Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach is listed for temperature due to violations of the Oregon and Idaho water quality standards, including the numeric and narrative criteria for cold water aquatic life, resident fish and aquatic life, and salmonid rearing. Additional, more detailed information on temperature is included in Section 3.6.

General Concerns. See Section 2.2.4.6.

Water Quality Targets. See Section 2.2.4.6 and Table 2.2.2.

Common Sources. See Section 2.2.4.6.

Historical Data. Available historical temperature data from the Upstream Snake River segment (RM 409 to 335) show single, daily measurements indicate a probable exceedence of the temperature targets for salmonid rearing/cold water aquatic life (see Table 2.2.1). However, the data are not sufficient to assess whether or not the overall temperature targets for either salmonid rearing/cold water aquatic life was being exceeded as there is no way to determine if the data available represent daily maximum temperatures. In addition, there is no historic data that would allow comparisons to a 7-day moving average of the maximum temperatures. These data however, when combined with available air temperature data, indicate that waters in this segment experience substantial warming due to non-anthropogenic sources. Data collected roughly monthly from 1968 to 1974 by the US EPA in the Upstream Snake River segment slightly upstream from RM 409 (near Marsing, Idaho) show water temperatures that range from 12 ^{o}C to 13 ^{o}C near the inflow of the Malheur and Payette Rivers and near the inflow of the

Boise and Owyhee Rivers. A similar study from 1969 to 1974 at RM 361 (near Weiser, Idaho) show temperatures ranging from 2 ^{o}C in December, 1971 (air temperature at –3.5 ^{o}C) to 25.5 ^{o}C in July, 1971 and August, 1973 (air temperature at 38 ^{o}C and 35.5 ^{o}C respectively). Roughly 20 percent of these data show temperatures above 17.8 ^{o}C (all occurring during July or August). Roughly 20 percent of these data also show temperatures above 22 ^{o}C (all occurring during July or August). These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a, 1975, 1999).

Current Data. Data collected by the US EPA in the Upstream Snake River segment at RM 385 (near Nyssa, Oregon) at (approximately) monthly frequency from 1975 to 1991 show temperature levels that range from 1 ^{o}C in December 1975 (air temperature at 0 ^{o}C) to 26 ^{o}C in July 1977 (air temperature at 29 ^{o}C). Roughly 30 percent of these data show temperatures above 17.8 ^{o}C (all occurring during July or August). Roughly 28 percent of these data also show temperatures above 22 ^{o}C (all occurring during July or August). A similar study from 1975 to 1991 at RM 361 (near Weiser, Idaho) show temperatures ranging from 1 ^{o}C in February, 1975, January, 1988 and March 1989 (air temperature at 2.5 ^{o}C, -1.0 ^{o}C and 2.5 ^{o}C respectively) to 27 ^{o}C in July, 1975 (air temperature at 37 ^{o}C).

Table 2.3.11 Water temperature monitoring for the Upstream Snake River segment of the Snake River - Hells Canyon TMDL reach (RM 409 to 335).

Segment	Temperature Monitoring Dates	Source
Snake River: OR/ID border to Boise River Inflow (RM 409 to 396.4)	April to Oct 2000 1995 1967 to 1996 1961 to 1999	BCPW, 2001 IPCo, 1998a, 2000a US EPA STORET data, 1998a WRCC, 2000
Snake River: Boise River Inflow to Weiser River Inflow (RM 396.4 to 351.6)	April to Oct 2000 Summer sampling 1980 to 1992 1995 1957 to 1992, 1995 1961 to 1999	BCPW, 2001 USGS & USBR IPCo, 1998a, 2000a US EPA STORET data, 1998a WRCC, 2000
Snake River: Weiser River Inflow to Farewell Bend (RM 351.6 to 335)	April to Oct 2000 1995 1974 to 1975, 1978 to 1979, 1989	BCPW, 2001 IPCo, 1998a, 2000a US EPA STORET data, 1998a

Roughly 21 percent of these data show temperatures above 17.8 ^{o}C (all occurring during July or August). Approximately 10 percent of these data also show temperatures above 22 ^{o}C (all occurring during July or August). These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a, 1975, 1999). The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River at Weiser, show that temperature levels in this segment had a "fair" rating both years while the overall station conditions for all evaluated pollutants were judged to be "fair" in 1986 and "poor" in 1988. Current water temperature data available for the Upstream Snake River segment (RM 409 to 335) include monitoring of both tributary and mainstem values. Water temperature data for some areas of the drainage extend back to the 1950's, and represent a variety of annual precipitation levels (high and low). Daily maximum, mean and minimum water temperatures are recorded in several areas of the Upstream Snake River segment, but collection frequency and period of record varies.

Concurrent air temperature data for some areas extends back to the 1950's and represents a range of seasonal and annual climate variations. Daily maximum, mean and minimum air temperatures are recorded for the last 10 years for most monitoring stations. Idaho sites include weather stations at Boise, Brownlee Dam, Caldwell, Cambridge, Council, Lewiston, Nampa, Parma, Payette, Riggins and Weiser. Oregon sites include: Adrian, Durkee, Halfway, Huntington, Malheur, Nyssa, Ontario, Owyhee dam, Richland and Vale (SNOTEL, 2000).

Segment Status. As water moves downstream from CJ Strike Dam toward the SR-HC TMDL reach, solar radiation and high air temperatures combine with warmer irrigation return flows entering the Snake River to raise temperatures in the mainstem river channel. Daily maximum and minimum water temperatures show a wider overall range and greater total variance as distance downstream from CJ Strike Dam increases (IPCo, 1998a, 1998b).

As shown in Figure 2.3.11, water temperatures within the mainstem Snake River vary from an average of 4 ^{o}C in the winter months to 24 ^{o}C in the summer, well above the numeric cold water aquatic life target of 17.8 ^{o}C.

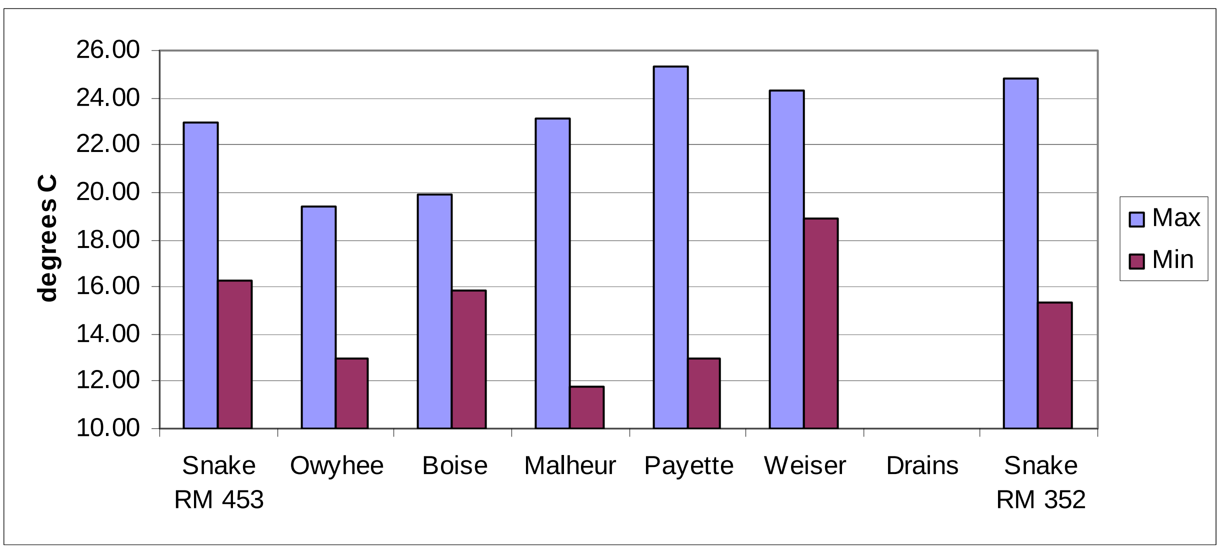

Figure 2.3.11 Mean water temperature values for tributary and mainstem sites within the Upstream Snake River segment of the Snake River - Hells Canyon TMDL (RM 409 to 335).

A temperature TMDL has been written for the Middle, North and South Forks of the Owyhee River, which, if successfully implemented, will result in attainment of State of Idaho water quality temperature standards within these segments (IDEQ, 1999c, 2000a). In this TMDL, temperature increases in the upstream segments of the Owyhee River within the state of Idaho were determined to be the result of natural heat exchange through high air temperatures, solar radiation and heating by rhyolitic outcroppings through which the river passes. Water temperatures in the South Fork Owyhee River at the Nevada/Idaho state line have been determined to exceed Idaho State temperature standards. A TMDL has been written and approved that requires Idaho temperature standards to be met by the State of Nevada at the Nevada/Idaho state line (IDEQ, 1999c).

Temperature is not listed in the lower Owyhee or Malheur rivers by the State of Oregon because salmonid spawning and rearing are not designated beneficial uses in these sections of the two rivers, except in the Owyhee River where they are designated in and above the Owyhee Reservoir. Therefore temperature assessments developed by ODEQ for the lower Owyhee and Malheur will be specific to the needs of the downstream SR-HC TMDL reach. It should be noted however that the hot, dry climate of the watersheds, and the fact that native vegetation in the drainages is relatively low growing and sparse (providing little shading on major tributaries), will play a major role in attainable water temperatures in this drainage. As shown in Figure 2.3.11, water temperatures in the Owyhee River range from an average of 4 ^{o}C in the winter months to 17 ^{o}C in the summer. The water temperatures in the Malheur River are slightly warmer and range from an average of 4 ^{o}C in the winter months to 23 ^{o}C in the summer.

Water temperatures in exceedence of the SR-HC TMDL cold water aquatic life target have been observed within the Boise (measured near Parma), Payette, and Weiser Rivers at their respective confluences with the Snake River during the months of July and August. The Lower Boise River TMDL cites the primary source of high water temperature as climatic influences such as elevated air temperatures (IDEQ, 1998a). The Lower Payette River subbasin assessment (IDEQ, 1999b) found that although water temperatures exceeding the temperature criteria for the support of cold water aquatic life, a cold/cool water fishery was supported in the river. This TMDL cited the inflowing waters from Black Canyon Dam as one cause of elevated water temperature in the Lower Payette River system as these waters already exceeded the state temperature criteria.

It is highly probable that a major source of high water temperature in all tributary drainages is climatic conditions that include hot, dry summers and native vegetation that is low growing and sparse. Other inputs of heat load to these river systems such as irrigation drains and wastewater treatment plants are estimated to contribute only modest percentages of the total temperature increases that occur in the rivers (IDEQ, 1998a). Geothermal sources are also present in some areas of the watershed, especially the Malheur River drainage.

As shown in Figure 2.3.11, water temperatures in the Boise River range from an average of 3 ^{o}C in the winter months to 21 ^{o}C in the summer; in the Payette from an average of 4 ^{o}C in the winter months to 25 ^{o}C in the summer; and in the Weiser from an average of 4 ^{o}C in the winter months to 24 ^{o}C in the summer.

Although there are recorded temperatures that exceed the temperature target in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach, there is considerable information available that indicates that water temperatures exceeded the SR-HC TMDL target historically when aquatic species were present in healthy populations. One explanation for this could be a greater occurrence of colder water refugia during periods of high water temperatures in the mainstem. Such refugia would most probably have been present around springs and at the mouth of tributaries in this segment of the SR-HC TMDL reach.

An alternative explanation is that there have always been historical high water temperatures in much of the SR-HC TMDL reach and the lower portions of its tributaries due to high summer air temperatures, high solar radiation, and low summer flows. Native fish species may have adapted to these conditions and are capable of surviving and thriving under temperature conditions with summer water temperatures in excess of those defined by the targets identified in this TMDL.

Available data show exceedences of temperature criteria throughout the SR-HC TMDL reach during the months of June, July, August and September. Cold water aquatic life and salmonid rearing designated beneficial uses are supported in only a limited fashion in the Upstream Snake River segment (RM 409 to 335). Viable populations of mountain whitefish are present in this river segment, rainbow trout and other salmonids are not. Temperature is not judged to be the primary determining factor in the limited support observed within this segment. Lack of cold water refugia and poor water quality are identified as contributing factors.

2.3.1.3 Data Gaps

See Section 2.4

2.3.1.4 Pollutant Sources

See Section 2.5. Table 2.5.0 contains a listing of all point sources discharging directly to the mainstem Snake River within the SR-HC TMDL reach.

Point Source Pollution

The majority of permitted point sources discharging to the mainstem Snake River in the SR-HC TMDL reach are located in the Upstream Snake River segment (RM 409 to 335). These include treated municipal sewerage discharges, municipal stormwater discharges and industrial discharges (detailed in Section 2.5.2 and Table 2.5.0). Permitted discharges to the inflowing tributaries also occur. These include treated municipal sewerage discharges, municipal stormwater discharges, agricultural (i.e. confined animal feeding operations) and industrial discharges.

Point sources discharging to tributaries will not receive a separate waste load allocation. Bulk load allocations have been identified for the mouths of the tributaries. The identification of load and waste load allocations specific to the tributary loading will be accomplished through the tributary TMDL process in the case of those tributaries that do not yet have a TMDL in place and as part of the TMDL implementation plan process in the case of tributaries where a TMDL is already in place.

Nonpoint Source Pollution

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.

Agricultural land use comprises roughly 25 percent of the total area contained within the SR-HC TMDL reach. Much of this agricultural land, nearly 97 percent, is located in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. Predominant agricultural practices within the drainage of this segment include irrigated and non-irrigated croplands, and irrigated and dryland pasture (grazing). Much of the area is grazed although variations in timing and density of grazed land make exact figures difficult to obtain. The majority of agricultural return flows associated with the SR-HC TMDL reach are also located in the Upstream Snake River segment (RM 409 to 335).

Recreational.

Due to its proximity to populated urban areas and other recreational opportunities within the Hells Canyon Complex, the Upstream Snake River segment (RM 409 to 335) is a major recreational destination site year-round. Water-based recreational activities peak in the summer season with heavy usage observed between Memorial Day weekend and Labor Day weekend, when the river is utilized by boaters, rafters, swimmers, campers, naturalists, hunters and anglers.

Urban/Suburban.

Urban/Suburban land use comprises 0.5 percent of the total direct drainage area of the SR-HC TMDL reach. The majority of urban/suburban land use in the SR-HC TMDL reach is located in the Upstream Snake River segment (RM 409 to 335). Urban/suburban land is present in all tributary and mainstem drainages within the Upstream Snake River segment of the SR-HC TMDL reach. All of the major municipalities within the SR-HC TMDL reach are located in this segment, some discharge directly to the mainstem Snake River, others discharge to inflowing tributaries. All tributary and mainstem drainages in this segment contain septic systems. The highest septic system density in the SR-HC TMDL reach occurs in the Upstream Snake River segment.

Forestry.

Forested land comprises 28.2 percent of the total area contained within the SR-HC TMDL reach. Much of the forested land within the SR-HC TMDL reach is located in the higher elevation portions of the drainage. Silvicultural practices occur or have occurred to some extent within most of this area. However, the majority of water-quality effects from silvicultural practices occur within the drainage areas of tributaries to the SR-HC TMDL reach.

Ground Water.

Many natural springs and ground-water inflows have been identified in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. These inflows occur in all of the tributary drainages and the mainstem Snake River, entering both above and below the water level in many locations. Subsurface recharge to the Snake River system is estimated to be largest in the Upstream Snake River segment due to high irrigation water usage in this area (USBR, 1998). Subsurface recharge from irrigation activities is estimated to dominate over natural ground-water inputs in most areas of this segment.

Background and Natural Contributions.

Natural sources of pollutant loading discussed in section 2.5.3.6 are known to be present in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. While the

Upstream Snake River segment has been substantially altered by the impoundment and diversion of a significant proportion of the upstream drainage, the occurrence of natural sediment transport within this segment is estimated to be greater than in downstream segments due to steep slopes and high elevations in the tributary drainages, and the dominance within the tributary drainages of high velocity, spring runoff flows. The occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) than in the segments located downstream.

2.3.1.5 Pollution Control Efforts

See Section 2.6

Nonpoint Source Efforts

Pollutant reduction projects within the watersheds tributary to the Upstream Snake River segment (RM 409 to 335) have been undertaken by a variety of subwatershed work groups outside of the SR-HC TMDL process. Projects have been identified and prioritized in an effort to reduce generation and transport/delivery of pollutants of concern within the tributary watersheds. While the following is not an exhaustive list, individual projects include the following practices:

- canal/ditch delivery upgrades
- field/ditch erosion control measures
- forest practices act measures/practices
- irrigation management upgrades
- irrigation pumpback systems
- river channel/streambank/shoreline erosion controls and restoration
- sediment pond settling and removal of sediments
- stormwater management and treatment
- surface erosion controls
- water conservation measures
- wetland construction/enhancement

Improved grazing, cropping and water management practices have been combined with approved BMP application in the inflowing tributary watersheds and in the mainstem Snake River drainage upstream of this TMDL (upstream of RM 409). Nutrient management plans are in place or in progress in many areas. Several irrigation districts and canal companies in the tributary drainages have made a commitment to meeting water quality standards in irrigation waters discharged to the Snake River. Specific goals have been set to reduce nitrate contamination of ground-water sources, and to reduce sediment, nutrient and bacteria loading to surface water systems through treatment of in-field and end-of-field discharges, and agricultural drains and outflows. Wetland and other treatment systems have been constructed to reduce nutrient loadings and the associated algal growth and decreased dissolved oxygen. Many others are planned. Grazing management programs have been initiated in the inflowing Snake, Boise, Malheur and Payette river watersheds to reduce the negative effects that can be caused by improper grazing management on riparian zones and restore streambank vegetation in an effort to reduce nutrient and sediment loading from pasture lands. Many of these efforts, especially those employed for nutrient and sediment reductions, often require two to five years after completion before they are able to operate at full efficiency. It should be recognized that current data may not reflect the full extent of the water quality improvements that may be realized through these projects. Data collection and evaluation must therefore be an integral part of the overall TMDL assessment process for water quality improvements within the mainstem and/or tributary systems.

Stormwater management plans are in place or pending in the cities of Boise, Ontario and other municipalities that discharge directly or indirectly to the SR-HC TMDL reach. These plans target specific projects and practices to reduce stormwater-based pollutant loads. In several cases substantial progress has been made and positive trends have been documented in overall loading. Septic and wastewater treatment upgrades have been completed, are in progress, or are planned in many areas of the watershed.

Recreational facilities have been upgraded in several areas of the Upstream Snake River segment (RM 409 to 335). Restroom facilities have been improved in high use campground and boat ramp areas and have been installed in other less-used areas that previously did not offer facilities. Pumpout and dump facilities are provided in areas of high use, and public participation in proper disposal of waste materials has increased.

The management practices outlined in the Forest Practices Act (FPA), enforced in both Oregon and Idaho, actively reduce the impact of logging and other use practices in riparian corridors and similarly sensitive areas. Application of these practices on both public and private forested lands has resulted in reduced sediment, nutrient and other pollutant loads being generated and transported within forested systems. Additionally, these practices act to preserve and enhance riparian areas that act as buffers for stream channels in degraded areas, further reducing the potential for pollutant transport to the SR-HC TMDL reach.

Other TMDL Efforts

A matrix containing the reach covered, pollutants listed; state responsible and scheduled completion date for TMDLs in the general area of the SR-HC TMDL reach is included in Section 7.1.

The Mid-Snake TMDL (IDEQ, 1997c) set an in-river target for total phosphorus at 0.075 mg/L, which equates to a 30 percent reduction in total phosphorus loading in the mainstem Mid-Snake system (RM 638.7 to RM 544.7). The Upper-Snake Rock TMDL (IDEQ, 2000d) addresses the same mainstem Snake River segment (RM 638.7 to RM 544.7) but includes tributaries. This TMDL addresses sediment and bacteria concerns in the mainstem and the inflowing tributaries.

There are TMDLs in-place for the North, South and Middle Fork of the Owyhee River in Idaho (IDEQ, 1999c and 2000a). The North Fork Owyhee TMDL set instream targets for temperature to support cold water aquatic life. Additionally, the TMDL addresses the need to meet Oregon State temperature standards at the Idaho/Oregon state line. The data collected for this TMDL do not show impairment from bacteria within the system. The South Fork Owyhee TMDL determined that if water temperatures met Idaho state standards at the Idaho/Nevada border, designated beneficial uses would be supported. This TMDL therefore, requires the State of Nevada to meet Idaho temperature standards at the Idaho/Nevada state line. The data collected for the South Fork Owyhee TMDL do not show impairment from sediment within the system.

The Middle Fork Owyhee TMDL set instream targets for temperature to support cold water aquatic life. The data collected for this TMDL do not show impairment from sediment within the system.

The Lower Boise River TMDL (IDEQ, 1998a) set instream targets for sediment at 50 mg/L for no more than 60 days, and 80 mg/L for no more than 14 days. Targets for bacteria within the Lower Boise River were set as follows: for primary contact recreation (May 1 to September 30) fecal coliform bacteria colonies may not exceed 500 organisms/100 mL at any time; may not exceed 200 organisms/100 mL in more than 10 percent of the total samples taken over a thirty day period; and may not exceed a geometric mean of 50 organisms/100 mL based on a minimum of five samples taken over a thirty day period. For secondary contact recreation (year-round) fecal coliform bacteria colonies may not exceed 800 organisms/100 mL at any time; may not exceed 400 organisms/100 mL in more than 10 percent of the total samples taken over a thirty day period; and may not exceed a geometric mean of 200 organisms/100 mL based on a minimum of five samples taken over a thirty day period. A no-net-increase of instream phosphorus levels was established pending completion of load allocations for the SR-HC TMDL; at which time a nutrient TMDL will be completed for the Lower Boise River to address nutrient targets and bulk load allocations set for the mouth of the Boise River by the SR-HC TMDL.

The Lower Payette River TMDL (IDEQ, 1999b) set instream targets for bacteria (fecal coliform) at less than 50 colony forming units (cfu) per 100 mL. The nutrient TMDL for the Lower Payette River was deferred pending completion of load allocations for the SR-HC TMDL; at which time a nutrient TMDL will be completed for the Lower Payette River to address nutrient targets and bulk load allocations set for the mouth of the Payette River by the SR-HC TMDL.

Agricultural management plans nearing completion for the Malheur watershed (MRBLAC, 2000; MOWC, 1999) have outlined appropriate best management practices for agricultural land use. Measures for the reduction of nutrient loading are detailed, as are mechanisms to reduce erosion and sediment transport from cropping, grazing and irrigation practices.

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2.3.2 Brownlee Reservoir (RM 335 to 285)

The Brownlee Reservoir segment (RM 335 to 285) includes Brownlee Reservoir from Farewell Bend to Brownlee Dam (Figure 2.3.12). While Brownlee Reservoir contains three fairly distinct hydrological regions: the riverine zone near the tailwaters (roughly RM 335 to RM 325), the transition zone (roughly RM 325 to 305), and the lacustrine zone (RM 305 to 285); water management and water quality concerns are well correlated with the reservoir boundaries. The total reservoir volume is 1,420,000 acre-feet. The Upstream Snake River segment (RM 409 to 335) becomes the headwaters of the reservoir at RM 335. The Burnt and Powder Rivers flow directly into Brownlee Reservoir at RM 327.5 and RM 296 respectively, however, the inflow of these two tributaries is relatively minor (3.6% combined total) when compared with the inflow from the Upstream Snake River segment.

2.3.2.1 INTRODUCTION

Brownlee Reservoir has a total volume of 1,420,000 acre-feet, 975,000 acre-feet of which is available for storage (Table 2.3.12). Brownlee Reservoir at full pool has a surface area of about 14,000 acres, an elevation of 2,077 feet (mean sea level (msl)) and approximately 190 miles of shoreline. It is a long, deep system oriented predominantly in a north-south direction. The inflow to the reservoir is on the south end and the dam is located almost due north, approximately 52 miles downstream. The reservoir is relatively deep and narrow, occupying the canyon carved out by the Snake River. Reservoir depth ranges from approximately 30 feet at the upstream end to approximately 300 feet near the dam (IPCo, 1999d). Flow and residence time within the reservoir are controlled by outflows through Brownlee Dam. Average residence time is 34 days, however, with consideration of the additional internal processes of stratification, depth of withdrawal, flood control requirements and management for power generation, the residence time of water in different parts of the reservoir can vary considerably. Residence times generally decrease as flow increases. In an average year, nominal residence times (based on full-pool volumes) average 66 days. In a dry year (1992, 43.2% of a 30-year average), nominal residence time was nearly double that of an average year (130 days) (IPCo, 1999d).

Table 2.3.12 Physical characteristics of Brownlee Reservoir

Date Closed	1958
Full Pool (feet msl)	2,077
Minimum Pool (feet msl)	1,976
Total Volume (acre-feet)	1,420,000
Surface Area (acres)	14,133
Mean Depth (feet)	100
Length (river miles)	52
Mean Width (feet)	2,242
Shoreline (miles)	193
Average Retention Time (days)	34

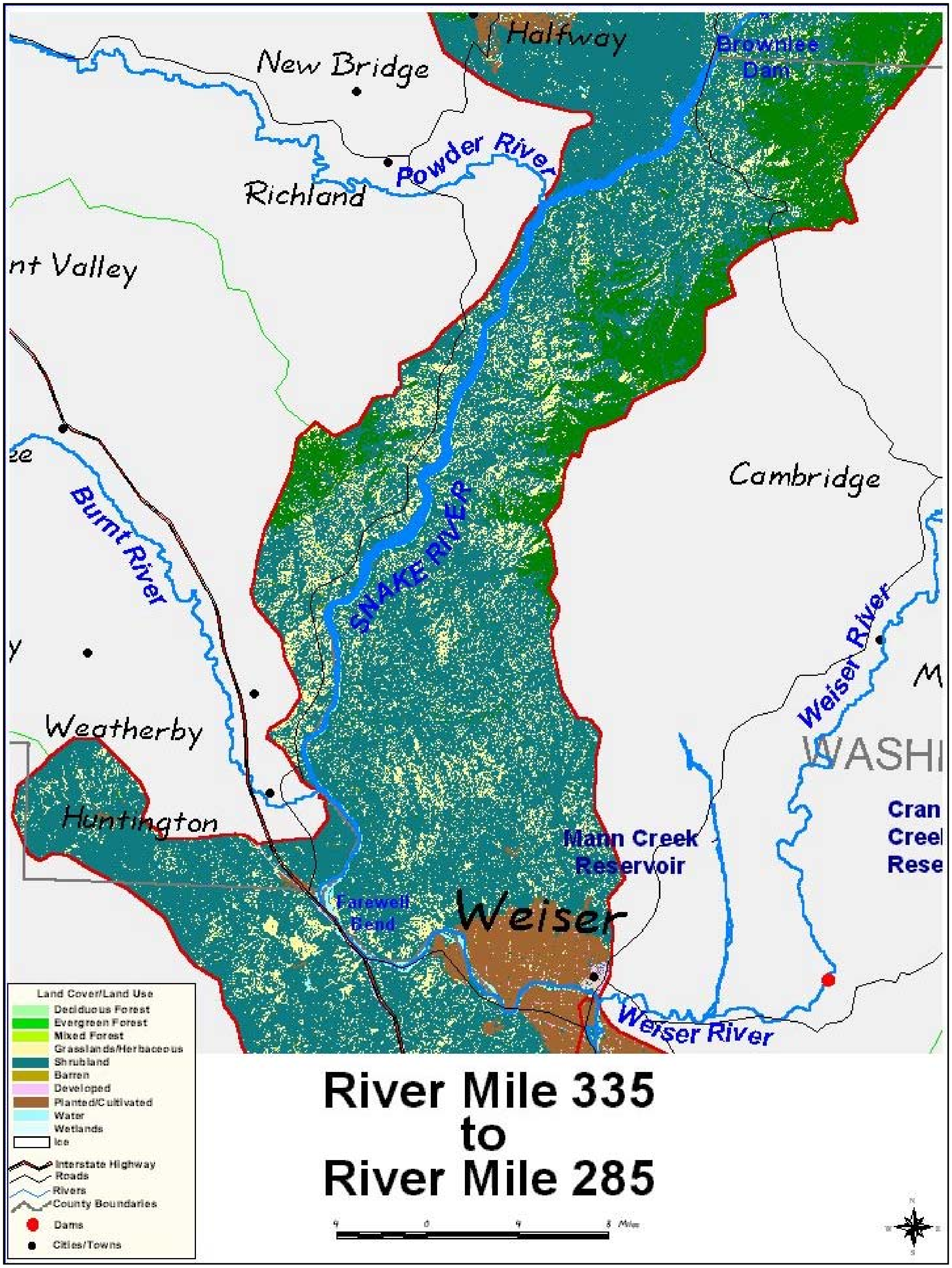


Figure 2.3.12 Brownlee Reservoir segment (RM 335 to 285) of the Snake River – Hells Canyon TMDL reach.

The primary purpose of operation for Brownlee Reservoir is hydropower generation, which generally results in water level fluctuations of less than 10 feet (IPCo, 1999d). However, the reservoir is also operated for flood control under the jurisdiction of the US Army Corps of Engineers (USACOE), and participates in flow augmentation release scenarios designed to help anadromous fish move through the mainstem Snake and Columbia River systems. Reservoir releases in early spring are managed to assist migrating anadromous fish. Reservoir releases in the early fall are managed for downstream salmon spawning. Typical drawdown for flood control averages 40 feet. Maximum drawdown is approximately 100 feet (IPCo, 1999d).

Brownlee Reservoir contains three distinct zones: the riverine zone, the transition zone, and the lacustrine zone. Each zone represents different hydrological and pollutant transport/processing characteristics (Figure 2.3.13). The riverine zone is located in the upstream-most section of the reservoir (RM 340 to 325), and displays the most "river-like" flow characteristics. Water in this

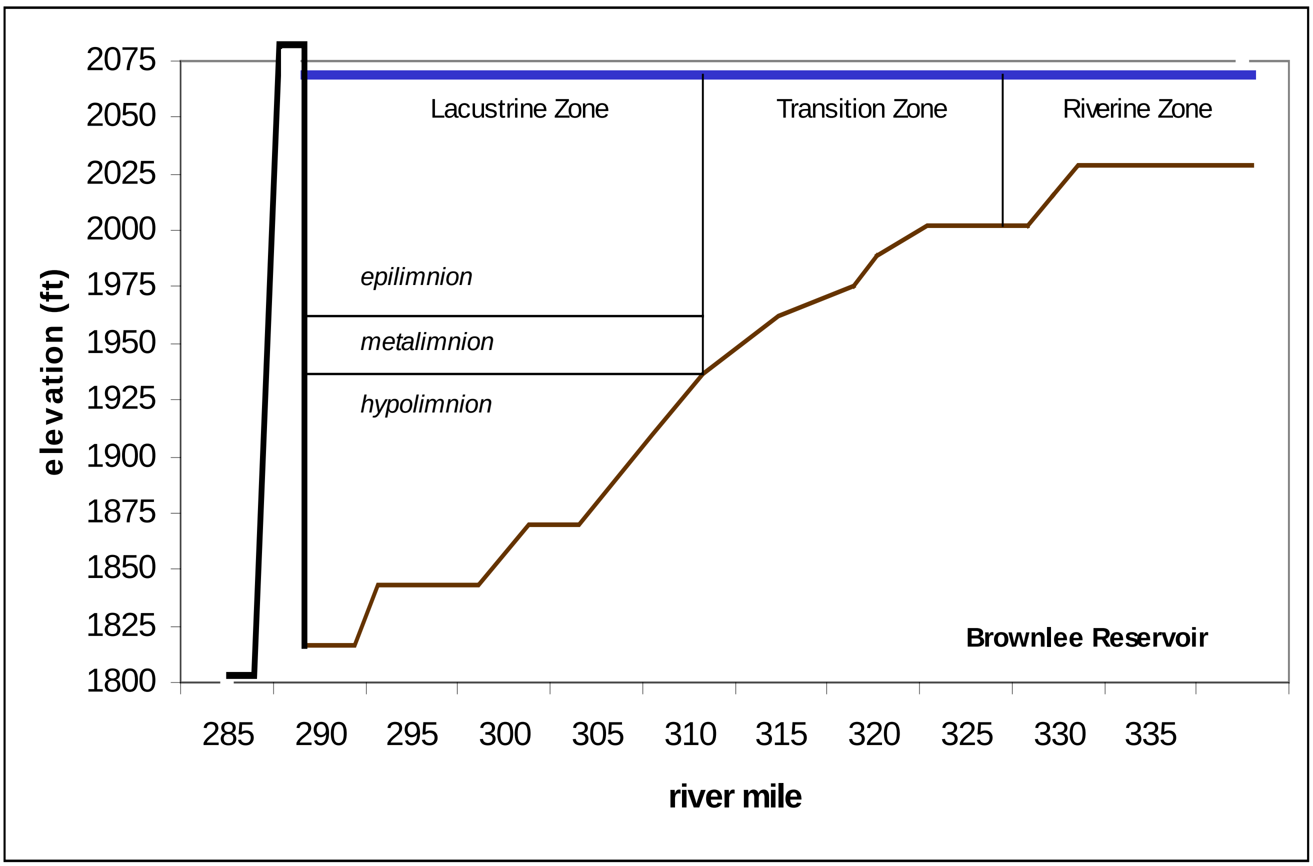


Figure 2.3.13 Location of separate reservoir "zones" within Brownlee Reservoir. (Brownlee Dam is located at river mile 285.)

zone is relatively shallow and exhibits higher velocities than downstream waters within the reservoir. Water quality in this zone is heavily influenced by the water quality of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. During summer months, this zone routinely exhibits high concentrations of nutrients, organic matter and chlorophyll *a*. Wind action within this zone of the reservoir acts to mix inflowing waters, resulting in algae suspension throughout the water column. Productivity in this zone is observed to be high, which in turn increases the dissolved oxygen content of the water during photosynthesis.

The transition zone is located between the riverine and lacustrine zones of the reservoir (RM 325 to 308), and acts as a transition from the more river-like characteristics immediately upstream to the more lake-like characteristics immediately downstream. The transition zone is deeper than the riverine zone and flows are generally slower. As a result, sediment settles out at the upstream end of this zone. Inorganic sediment has accumulated between RM 325 and RM 315 due to this settling action. Algae settles out in this area also, drifting to depths where sunlight cannot penetrate. This settling results in death and decomposition, creating a high potential oxygen demand, and often depleting the dissolved oxygen content in the transition zone waters, especially in low flow years (IPCo, 1999d). In addition to the aquatic life habitat concerns associated with depleted dissolved oxygen levels, this combination of inorganic sediment and organic matter deposition, and anaerobic conditions can lead to the conversion of inorganic or elemental mercury to methylmercury which is much more easily absorbed by aquatic organisms than the elemental or inorganic forms associated with mercury from natural geologic deposits and legacy mining activities upstream.

The lacustrine zone is located between the transition zone and Brownlee Dam (RM 308 to RM 285). When the reservoir is thermally stratified (late spring to early fall), this zone is divided into three layers: the epilimnion, metalimnion and hypolimnion (Figure 2.3.13). Thermal stratification occurs to a greater extent in low and average water years than in high water years as the larger, late spring drawdowns common in high water years act to eliminate a portion of the deeper, colder water (IPCo, 1999d).

The epilimnion extends from surface elevation to approximately 35 m below the surface. This section of the reservoir generally exhibits higher dissolved oxygen concentrations than the metalimnion or hypolimnion during stratification. Dissolved oxygen levels are generally higher at the surface (up to 12 mg/L) and decrease with depth (to 0 mg/L near the metalimnion) (IPCo, 1999d). The epilimnion is the only layer within the lacustrine zone that experiences wind mixing.

The metalimnion extends from approximately 35 m below the surface to 45 m below the surface. The location of the metalimnion is directly associated with the placement of the dam outlet as releases from the penstocks act to pull water across the lacustrine zone. The location of the metalimnion is therefore less variable than would be expected if Brownlee Reservoir were a natural lake. Thermal gradients act to stabilize water within the hypolimnion, resulting in water from the transition zone moving laterally through the metalimnion with little vertical mixing. Dissolved oxygen concentrations are generally lower in the metalimnion than in the epilimnion due to this relative lack of mixing. Temperatures are also generally lower than those observed in the epilimnion.

The hypolimnion extends from 45 m below the surface to depth. During stratification, very low dissolved oxygen concentrations are consistently observed in the hypolimnion, due to oxygen demand from decaying organic matter and sediments. This low dissolved oxygen leads to the release of sediment-bound phosphorus and other constituents. However, the stratification of the reservoir, and the resulting lack of communication with surface waters, acts to isolate released nutrients from the surface waters during the growing season. With mixing, concentrations equilibrate within the reservoir and are discharged downstream with winter and spring flows.

For a more detailed discussion on the effect of impoundments on the SR-HC TMDL reach see Section 2.1.1.4. While most of the processes discussed in Section 2.1.1.4 can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. As observed in the case of the Hells Canyon Complex, Brownlee Reservoir, located in the farthest upstream position, acts as a sink for both sediment and nutrients within the Hells Canyon Complex and downstream river segments. Brownlee Reservoir retains sediment and attached pollutants that might otherwise enter Oxbow and Hells Canyon reservoirs, and downstream reaches. In addition, downstream summer-season temperatures are reduced through deep-water releases from Brownlee Dam. Water is most commonly released at a depth of approximately 30 meters, which is well correlated with the location of the thermocline. It should be noted however, that while the above processes can result in improved water quality, the agencies prefer to prevent the initial pollutant loading into the system rather than to use instream retention systems (ODEQ, 1999).

2.3.2.2 WATER QUALITY CONCERNS/STATUS

General Information

The waters in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach are listed as water quality limited for dissolved oxygen, mercury, nutrients, pH, sediment and temperature.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.13 summarizes the listed pollutants and designated beneficial uses for the Brownlee Reservoir segment (RM 335 to 285). A more detailed description of each of the designated beneficial uses is included in Section 2.2.2. A more detailed description of the listed pollutants and the assessment process is located in Section 3.0 through 3.7.

Salmonid spawning within this drainage basin is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

Cold water aquatic life, salmonid spawning (see above) and rearing, as well as resident fish are designated as beneficial uses in this segment.

The primary salmonid species in this segment are rainbow trout and mountain whitefish. The general spawning periods for these two species are March 01 to July 15 and November 01 to March 30, respectively. Resident fish species include such cool and warm water fish as bass, crappie, and catfish. In addition there is a small population of white sturgeon at the very upper end of this segment. The dominant fish communities in the Brownlee Reservoir segment (RM

335 to 285) are the resident cool and warm water fish. A more complete listing of fish species by segment is located in Section 4.6.

Summary and Analysis of Existing Water Quality Data

Dissolved Oxygen.
The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed as water quality limited due to low dissolved oxygen (DO) and potential for non-support of designated salmonid rearing/cold water aquatic life beneficial uses. Additional, more detailed information on dissolved oxygen is included in Section 3.2.

Table 2.3.13 Listing information for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	Dissolved oxygen, mercury, nutrients, pH, sediment	Cold water aquatic life primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower

* Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

<u>General Concerns</u>. See Section 2.2.4.1.
While there is potential for negative impacts to occur within the hypolimnion of Brownlee Reservoir because of the sediment release processes described in Section 2.2.4.1, the formation of a deep, strong thermocline limits the expression of these effects in Brownlee Reservoir. Instead, the effects of hypolimnetic processes in Brownlee Reservoir would likely be most prevalent in water being released downstream from the Brownlee Dam discharge.

<u>Water Quality Targets</u>. See Section 2.2.4.1 and Table 2.2.2.

<u>Common Sources</u>. See Section 2.2.4.1.
Elevated organic matter loading to Brownlee Reservoir results in low dissolved oxygen levels within the reservoir. Three primary mechanisms contribute to elevated organic matter loading:

organic matter delivered to the reservoir from upstream sources, organic matter produced as a result of elevated nutrient loading from upstream, and internal recycling of nutrients within the reservoir that result in algal growth within the reservoir. Blooms that form as a result of elevated nutrient levels can act to increase dissolved oxygen in surface water through photosynthesis. However, when algal death rates exceed algal growth rates, chemical processes in decomposition can act to consume dissolved oxygen faster than re-aeration from photosynthesis or mixing (IPCo, 1999d).

Historical Data. Data collected from 1968 to 1974 by the US EPA in the Brownlee Reservoir segment (RM 335 to 285) (near Brownlee Dam) show dissolved oxygen levels that average 7 mg/L in all available samples. No depth information is available with these data so location and water column variations are not known. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

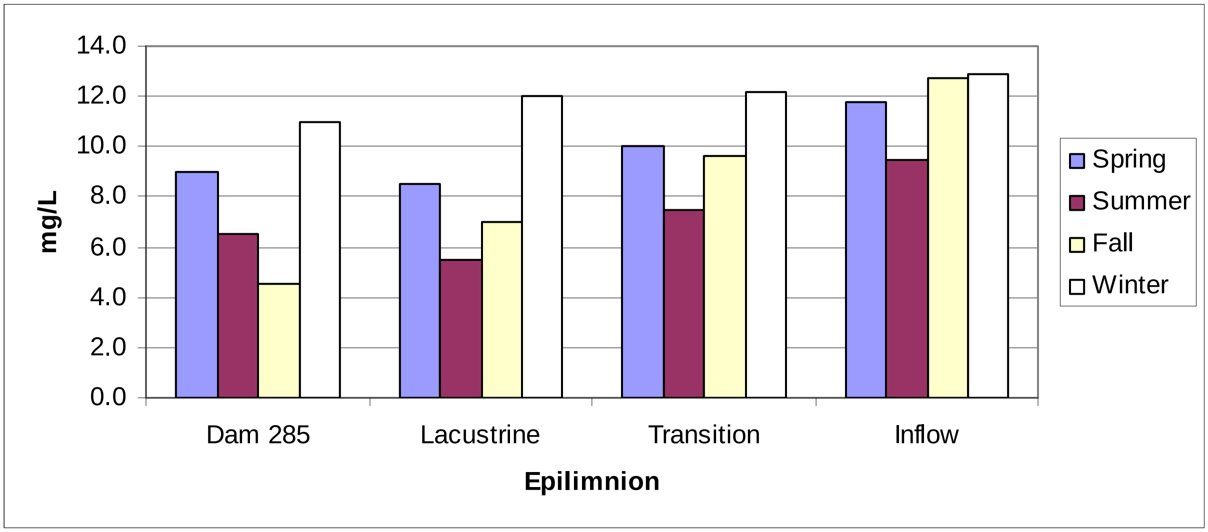
Current Data. As outlined in Table 2.3.14, dissolved oxygen concentrations have been monitored in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach for some time. Data currently available for this segment of the SR-HC TMDL reach includes dissolved oxygen monitoring at various locations and depths within the reservoir. While some dissolved oxygen data are available from US EPA (US EPA, 1998a), the majority of in-reservoir data has been collected by IPCo. A data set of dissolved oxygen concentrations measured at and below the thermocline, near the dam and in the lacustrine portion of the reservoir, shows that the water quality targets established by the SR-HC TMDL for cool and cold water aquatic life (6.5 mg/L) are not met nearly 100 percent of the time during July, August and September in dry and average water years. In wet years, targets are not met over 80 percent of the time during the months of July and August. Data collected during early summer and fall months (May and June, and October and November, respectively) show that the 6.5 mg/L dissolved oxygen targets are not met over 60 percent of the time in dry and average water years, and over 23 percent of the time in wet years. These same data show that targets are met routinely during the winter and spring months for all water years at and below the thermocline.

Table 2.3.14 Dissolved oxygen monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Dissolved Oxygen Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	Monthly 1990 to present 1967 to 1996	IPCo, 1999d, 2000c US EPA STORET data, 1998a

Above the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data show that the water quality targets established by the SR-HC TMDL for cool and cold water aquatic life (6.5 mg/L) are not met approximately 50 percent of the time during the summer and fall months (July, August, September, October and November) in most water years. In the transition zone and the inflow to the reservoir, dissolved oxygen levels are generally in excess of the targets established by the SR-HC TMDL. These data show that targets are met above the thermocline in all sections of the reservoir routinely during the winter and spring months for all water years.

Dissolved oxygen concentrations vary seasonally and with variation in annual precipitation amounts. Low dissolved oxygen levels are most common in late summer, when water levels are low and air and water temperatures are high.



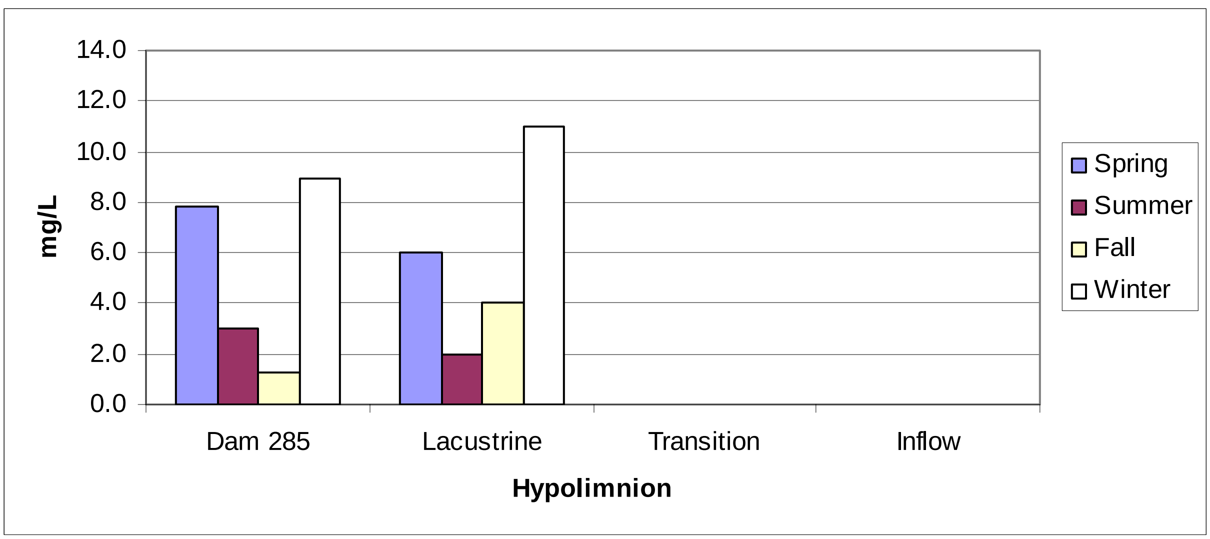


Figure 2.3.14 Mean dissolved oxygen concentrations for the Brownlee Reservoir segment of the Snake River - Hells Canyon TMDL (RM 335 to 285). Upper plot shows epilimnion dissolved oxygen concentrations, lower plot shows hypolimnion dissolved oxygen concentrations.

<u>Segment Status</u>. Within the reservoir, strong thermal stratification occurs during summer months (stratification usually occurs from March through November, but is strongest in July and August) (IPCo, 1999d). The position of the thermocline is well correlated with the level of the powerhouse penstocks, and extends approximately 25 miles upstream of the dam. Below the thermocline, notable anoxia (dissolved oxygen concentrations of less than 6.5 mg/L) has been observed to occur, especially during summer months (Figure 2.3.15). Dissolved oxygen concentrations from 0.5 to 2.0 mg/L are common during this time period in the lower levels of

the reservoir where cooler temperatures occur. This phenomenon is thought to be primarily the result of high levels of organic material in the water column as opposed to high sediment oxygen demand (IPCo, 1999d). Hypoxia occurs most extensively within the lacustrine sections of the reservoir during low and average flow years, although some volume of the deeper water level has experienced low levels of dissolved oxygen in high flow years also. A similar situation occurs in the transition zone of the reservoir. This hypoxic zone forms at the bottom of the water column, but can extend nearly to the surface and includes a substantial volume of the transition zone during low and average flow years (IPCo, 1999d).

The upper layers of the transition zone of Brownlee Reservoir show a very strong increase in dissolved oxygen (10 to 16 mg/L) during the late summer (August and September) which correlates well with the observed algal productivity in the river at this time (IDEQ, 1993a; IPCo, 1999d). Low dissolved oxygen, combined with high summer water temperatures can have significant negative affects on fish and other aquatic life. In July of 1990, low dissolved oxygen throughout the water column resulted in an extensive fish kill in the transition zone of Brownlee Reservoir. The fish kill included all species including at least 28 white sturgeon (IPCo, 1999d).

Although the Snake River historically may have experienced some level of algal production and probably some depletion of dissolved oxygen, the system was changed substantially with the completion of the Hells Canyon Complex. Decreases in dissolved oxygen concentrations stemming from nutrient and organic loading to the system have been exacerbated by the physical modifications that have been made to the system. Thus dissolved oxygen concerns in the reservoir result from both external loading and physical modification to the river system. Reductions in incoming nutrients and organic matter (including algae) from upstream sources, together with correlated efforts to improve dissolved concentration on the part of IPCo will act to improve water quality within the reservoir system.

Available data and information indicate that the cold water aquatic life and salmonid rearing designated beneficial uses are impaired during the summer months in Brownlee Reservoir. Concerns related to increased mercury methylation due to anoxia and presence of excessive organic matter are also present, especially in the upstream segment of the reservoir.

Available data from the tributaries to Brownlee Reservoir show that most meet the 6.5 mg/L minimum water column target for cool and cold water aquatic life year round IPCo, 2000a, USGS, 1999; US EPA, 1998a). These tributaries provide cold water refugia during the summer months for some species in the reservoir.

Mercury.

The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed as water quality limited due to human fish consumption advisories issued by the states of Oregon and Idaho for mercury (Appendix D). Additional, more detailed information on mercury is included in Section 3.1.

General Concerns. In addition to the general information available in Section 2.2.4.2, methylation of mercury is of specific concern within the reservoir environment. Low dissolved oxygen levels and the presence of a substantial amount of organic material near the

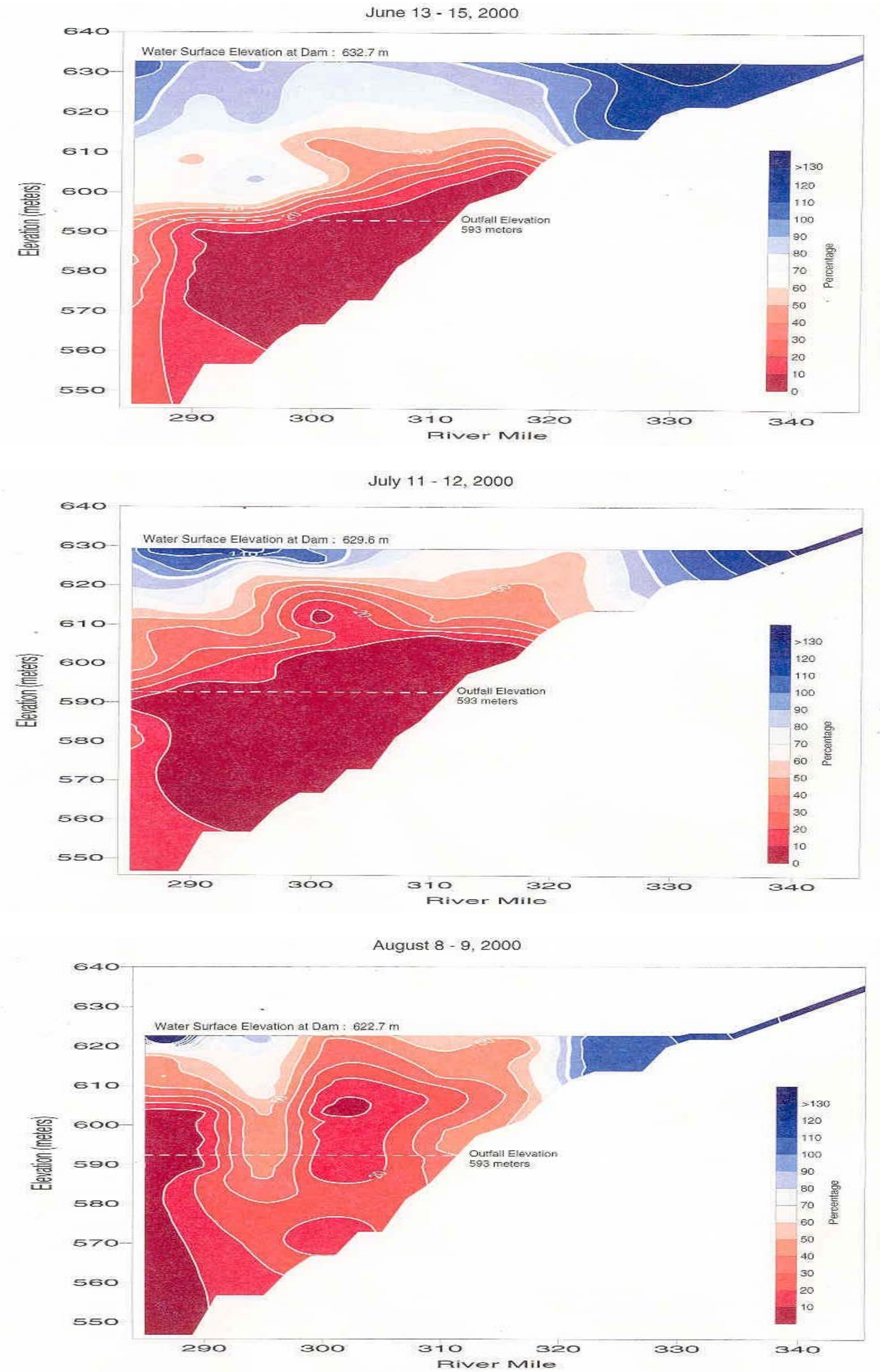


Figure 2.3.15 Dissolved oxygen isopleths for Brownlee Reservoir (data collected and plots prepared by Boise City Public Works).

sediment/water interface can result in higher rates of methylmercury production, as available hydrocarbon materials from the organic matter are available to bond with elemental mercury. Methylmercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds as it is much more soluble in water and therefore much more mobile within both the physical reservoir system and the metabolic systems of living organisms living in or using the water.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2.
Sediment samples collected and analyzed for mercury content in both the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) showed that the highest concentrations of sediment-associated mercury were observed at RM 335 and RM 340. However, sediment related mercury has been observed within the Brownlee Reservoir segment as well (IPCo, 2000d).

Historical Data. The earliest mercury measurements in this segment date to the early 1970s, post construction of the Hells Canyon Complex as shown in Table 2.3.15. However with changes in sampling and analytical techniques it is difficult if not impossible to correlate monitoring prior to 1970 with current data.

Current Data. As outlined in Table 2.3.15, mercury levels have been monitored in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach over an extended period of time. The most recent data collection and analysis occurred in 1997 (Clark and Maret, 1998) and 1999 (IPCo, 2000d). However, the data available for Brownlee Reservoir are fish tissue and sediment concentrations, with no associated water column concentration data.

Table 2.3.15 Mercury monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	**Mercury Monitoring Dates**	**Source**
Brownlee Reservoir (RM 335 to 285)	Jan 1970 April 1994 Aug 1997 Summer 1999	Buhler *et al.*, 1971 (OSU) IDEQ data Clark and Maret, 1998 (USGS) IPCo, 2000d

Segment Status. Because of the lack of water column data, it is not possible to compare data directly to the SR-HC TMDL water column mercury target. However an indication of the mercury status of this segment can be found in the fish tissue and sediment data. It is apparent that from the 1970s until present, this segment has exhibited mercury levels in fish tissue that are of concern for human health (US EPA, 2001a, 2001b, 2001c).

The data collected in 1994 and 1997 indicate that exceedences of the State of Oregon action level may be occurring in individual fish tissue samples. Data collected in 1990 and 1997 (Table

2.3.16) show a decrease in average methylmercury concentration, however, this data set is insufficient to demonstrate a conclusive downward trend for two reasons: 1. Data from 1970 cannot be compared directly due to differences in analytical techniques. 2. Size, age, weight and species differ from data set to data set and are therefore not directly comparable. Further monitoring, during the first phase of implementation may help to determine if the lower fish tissue methylmercury concentrations observed in the recent data collected from the Brownlee Reservoir (RM 335 to 285) segment of the SR-HC TMDL reach are representative of actual conditions.

Table 2.3.16 Mercury in fish tissues in the Brownlee Reservoir segment (RM 335 to 285) over the past 30 years. Note: All averages represent data over several species and age classes.

Year	Number of Samples	Mean* Mercury (mg/kg wet weight)
1970	33	0.51 (range = 0.24 to 0.97)
1994	130	0.39 (range = 0.24 to 0.60)
1997	5	0.26 (range = 0.11 to 0.33)

* These values are means. The range is based on the mean measured methylmercury concentration observed for a species, not an individual fish. Therefore, in 1994 some individual fish tissue data exceed the action levels set by both the State of Oregon and the State of Idaho. In 1997, some individual fish tissue data may exceed the action level established by the State of Oregon.

Methylmercury produced in this section of the river has the potential to effect not only local aquatic life, but that downstream as well, as the methylmercury produced will be carried downstream by the water flowing further into Brownlee Reservoir and on into downstream segments. Increased availability of methylmercury in this and the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach can be directly related to the production and deposition of organic material (algae, periphyton, etc.).

The action level for fish tissue mercury concentrations for the State of Oregon is 0.35 mg/kg. The action level for fish tissue mercury concentrations for the State of Idaho is 0.5 mg/kg (wet weight). All fish tissue data available in the SR-HC TMDL reach were positive for mercury. The Oregon and Idaho levels of concern for methylmercury in fish tissue were exceeded by 80 percent and 52 percent respectively. Based on these data, both states have fish consumption advisories in place.

Data show impairment of the designated beneficial use of fishing. Available data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, domestic water supply designated beneficial uses, and any trends that may be occurring.

Nutrients.

The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed as water quality limited due to nuisance algal growth from excessive nutrient loading. This condition generates concern due to the negative effect excessive algal growth can have on dissolved oxygen and pH. Additional, more detailed information on nutrients is included in Section 3.2.

General Concerns. See Section 2.2.4.3

Water Quality Targets. See Section 2.2.4.3 and Table 2.2.2.

Common Sources. In addition to the common sources described in Section 2.2.4.3, additional sources of nutrients to the Brownlee Reservoir segment (RM 335 to 285) may include natural levels of phosphorus carried in by the Snake River from the mountains that rim the southeastern border of the Snake River Basin as discussed previously. Anthropogenic releases of phosphorus to the Snake River from roadways and vehicle-related disturbances, livestock grazing, mining and smelting of phosphate ores upstream (US EPA, 1974a) are also carried into the reservoir by the inflowing Snake River.

Historical Data. Anecdotal information for upstream segments indicates that algal growth may have occurred at noticeable levels before extensive anthropogenic impact to this reach from agricultural practices or urbanization occurred (US EPA, 1974a). While there is no available mechanism to extrapolate this information to algal or nutrient concentrations in the river, one logical interpretation of this would be that noticeable algal growth accumulated in the river system. Data collected from 1968 to 1974 by the US EPA in the Brownlee Reservoir segment (near Brownlee Dam) show total phosphorus levels that average of 0.08 mg/L. Similarly, nitrate/nitrite levels in this segment averaged 0.5 mg/L. No depth information is available with these data so location and water column variations are not known. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

Current Data. As indicated in Section 2.2.4.3, the two major nutrients of concern in algal productivity are phosphorus and nitrogen. In systems dominated by cyanobacteria (blue-green algae), such as the Brownlee Reservoir segment (RM 335 to 285) at some times of the year, phosphorus is usually the limiting agent.

Available data for Brownlee Reservoir includes water samples from within the reservoir and tributaries discharging into the Brownlee Reservoir segment of the SR-HC TMDL reach (Tables 2.3.17 and 2.3.18). The data represents both grab samples and depth-integrated information. While some nutrient and chlorophyll *a* data are available from US EPA (US EPA, 1998a), the majority of in-reservoir data has been collected by IPCo.

Total Phosphorus. At and below the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data show that the water quality target established by the SR-HC TMDL for total phosphorus is routinely not met during July, August, September and October.

Table 2.3.17 Nutrient monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Nutrient Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	Monthly 1990 to present 1967 to 1996	IDEQ, 1993a IPCo 1999d, 2000c US EPA STORET data, 1998a

Table 2.3.18 Algae monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Algae Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	Monthly 1990 to present 1978 to 1996	IDEQ, 1993a IPCo 1999d, 2000c US EPA STORET data, 1998a

Data collected during winter and spring months show the lowest levels of total phosphorus (0.04 mg/L to 0.08 mg/L). Data collected during September and October show the highest total phosphorus concentrations (0.4 mg/L to 0.6 mg/L). These data show that while nutrient targets are not routinely met at or below the thermocline during the winter and spring months, values are routinely lower overall during this time period.

Above the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data show that the water quality target established by the SR-HC TMDL for total phosphorus is routinely not met during July, August, September and October. Data collected during early summer months show the lowest levels of total phosphorus (0.02 mg/L to 0.03 mg/L). Data collected during September and October show the highest total phosphorus concentrations (0.1 mg/L to 0.2 mg/L). These data show that while nutrient targets are not routinely met above the thermocline during the winter and spring months, values are routinely lower overall during this time period.

In the transition and inflow portions of the reservoir, combined data show that the water quality target established by the SR-HC TMDL for total phosphorus is routinely not April, May, June, July, August and September. Data collected during the winter months show the lowest total phosphorus concentrations (0.03 mg/L to 0.06 mg/L). Data collected during the spring months show the highest levels of total phosphorus (0.4 mg/L to 0.6 mg/L). These data show that while nutrient targets are not routinely met during the fall and winter months, values are routinely lower overall during this time period.

Ortho-Phosphate. At and below the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected during the spring and early summer months show the lowest levels of ortho-phosphate (0.03 mg/L to 0.06 mg/L). Data collected during September, October and November show the highest ortho-phosphate concentrations at or below the thermocline (0.3 mg/L to 0.4 mg/L).

Above the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected during early summer months show the lowest levels of ortho-phosphate (0.01 mg/L to 0.02 mg/L). Data collected during September and October show the highest ortho-phosphate concentrations at or above the thermocline (0.10 mg/L to 0.12 mg/L).

In the transition and inflow portions of the reservoir, combined data collected during the spring and summer months show the lowest ortho-phosphate concentrations (0.01 mg/L to 0.02 mg/L). Data collected during the fall months show the highest levels of ortho-phosphate (0.3 mg/L to 0.4 mg/L.

Chlorophyll a. At and below the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected during the late summer months show the lowest levels of chlorophyll *a* (~0 ug/L to 1 ug/L). Data collected during November and December show the highest chlorophyll *a* concentrations (5 ug/L to 10 ug/L). These data show that the threshold value of 15 ug/L chlorophyll *a* is not routinely exceeded in this area of the reservoir.

Above the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected during the winter months show the lowest levels of chlorophyll *a* (2 ug/L to 6 ug/L). Data collected during the early spring and summer show the highest chlorophyll *a* concentrations (50 ug/L to 80 ug/L). These data show that the threshold value of 15 ug/L chlorophyll *a* is routinely exceeded during the early spring and summer months in this area of the reservoir.

In the transition and inflow portions of the reservoir, combined data collected during the mid-summer and winter months show the lowest chlorophyll *a* concentrations (1 ug/L to 25 ug/L). Data collected during the spring and late summer months show the highest levels of chlorophyll *a* (200 ug/L to 275 ug/L). These data show that the threshold value of 15 ug/L chlorophyll *a* is routinely exceeded during the spring and late summer months in this area of the reservoir.

Mean values of total and ortho-phosphate (Figure 2.3.16) in Brownlee Reservoir show a decreasing trend with increasing distance downstream. During the critical summer months (May through September) when conditions for algal growth are optimal, concentrations at RM 335 (in the riverine section near Farewell Bend) average 0.14 mg/L total phosphorus, 0.03 mg/L ortho-phosphate and 30 ug/L chlorophyll *a* (1995 to 1999). At RM 325 (near the upstream end of the transition zone) concentrations average 0.12 mg/L total phosphorus, 0.02 mg/L ortho-phosphate and 48 ug/L chlorophyll *a* (1995 to 1999). At RM 315 (in the middle of the transition zone) concentrations average 0.09 mg/L total phosphorus, 0.04 mg/L ortho-phosphate and 23 ug/L chlorophyll *a* (1995 to 1999). At RM 305 (near the downstream end of the transition zone) concentrations average 0.08 mg/L total phosphorus, 0.04 mg/L ortho-phosphate and 18 ug/L chlorophyll *a* (1995 to 1999). At RM 285 (in the lacustrine zone near the dam) concentrations average 0.06 mg/L total phosphorus, 0.04 mg/L ortho-phosphate and 6 ug/L chlorophyll *a* (1995 to 1996).

Data collected for determination of phosphorus concentrations (both reservoir and inflow data) vary seasonally and with variation in annual precipitation amounts. Inflow data varies seasonally with changes in agricultural recharge, dilution from spring runoff, and subsurface contributions. Annual variations also result from relative precipitation amounts, frequencies and intensities.

Reservoir data varies with depth, season, level of stratification, dissolved oxygen concentration and location within the system. Substantial depositional differences may also result from storm events and drawdown or release scenarios; depending on precipitation amounts, frequencies and intensities.

Because of the interaction of nutrients, algae, dissolved oxygen and pH, algal biomass has been monitored through sampling and analysis for chlorophyll *a* and pheophytin (a metabolite of chlorophyll *a*). Data available from both nutrient and algal monitoring has been identified as an

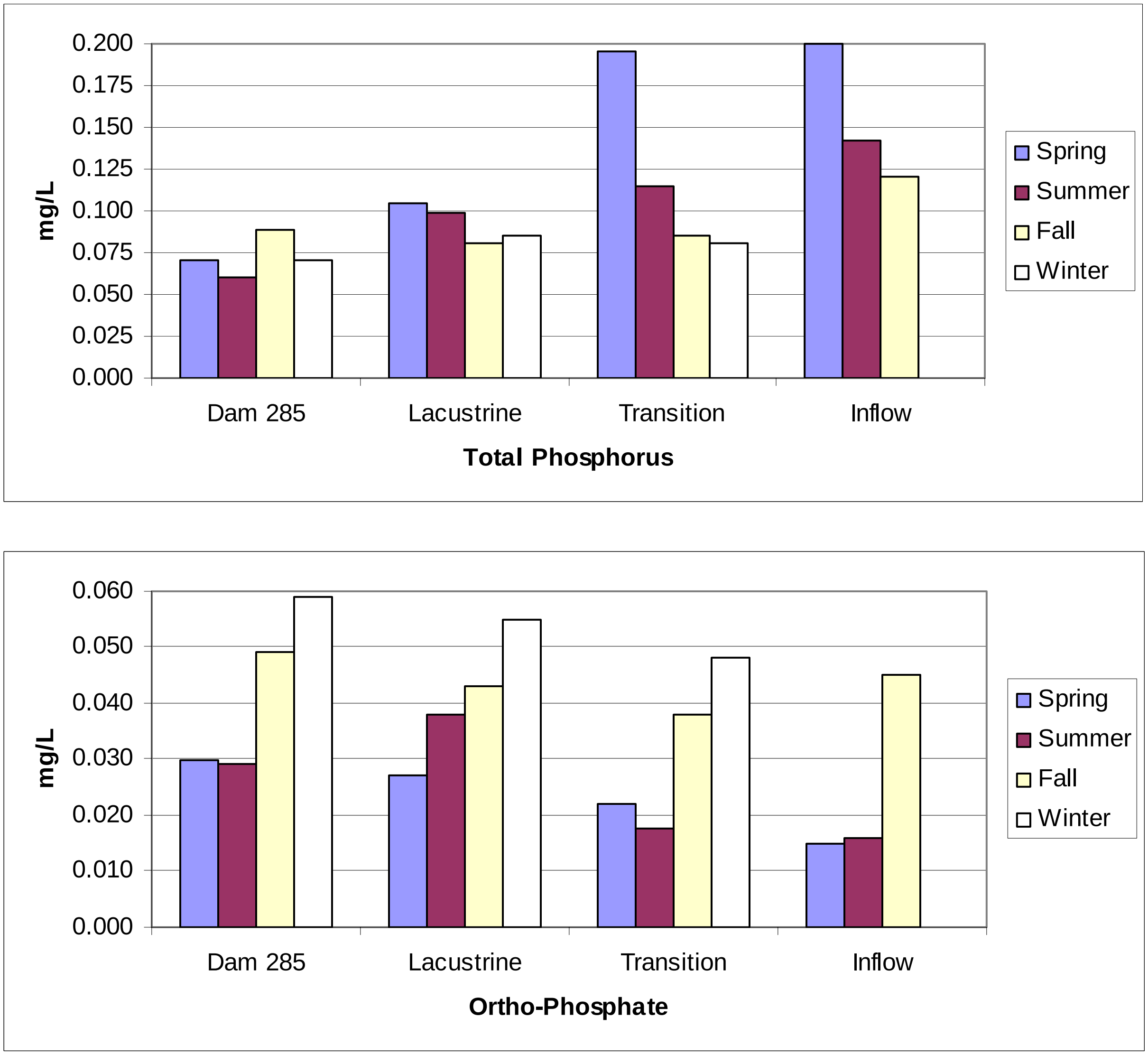


Figure 2.3.16 Mean total phosphorus (upper plot) and ortho-phosphate (lower plot) concentrations for the Brownlee Reservoir segment of the Snake River - Hells Canyon TMDL (RM 335 to 285).

important part of the assessment of water quality. Therefore, these data have been included in the monitoring information on algae even though they are not specifically listed as parameters on the 303(d) list.

Segment Status. Recent monitoring shows that within the Brownlee Reservoir segment (RM 335 to 285), incoming water quality influences in-reservoir water quality (IPCo, 1999d; IDEQ, 1993a). In the case of phosphorus loading, a less than or equal to 0.07 mg/L total phosphorus concentration is the SR-HC TMDL target. Total phosphorus monitoring data collected from inflows to Brownlee Reservoir consistently exceed these values. Available data show that in years with low and average annual precipitation levels (1992 to 1996), the median total phosphorus concentration in inflowing water was consistently 0.12 to 0.24 mg/L. Median

Brownlee Reservoir concentrations (Figure 2.3.17) at the same time were approximately 0.1 mg/L (IDEQ, 1993a; USGS, 1999; US EPA, 1998a). Ortho-phosphate made up approximately 30 percent of the total load in the mainstem Snake River, and averaged 57 percent of the total load from the inflowing tributaries. In an average water year (1995 to 1996) the median total phosphorus concentration in inflowing tributary waters ranged from 0.2 to over 0.3 mg/L. Median mainstem Snake River concentrations at the same time ranged from approximately 0.1 to 0.2 mg/L (IPCo, 1998a, 1999d, 2000a, 2000c, 2000d; US EPA, 1998a; USGS, 1999). Ortho-phosphate made up approximately 50 percent of the total load in the mainstem Snake River and the inflowing tributaries. Dissolved reactive phosphorus isopleths, are shown in Figure 2.3.18.

In general, total phosphorus concentrations observed at the mouth of the Burnt and the Snake Rivers are the highest of the inflows while those in the Powder River are the lowest in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. In general, ortho-phosphate concentrations observed at the mouth of the Burnt River are the highest of the inflows while those in the Powder and Snake Rivers are lower.

Within the reservoir, stratification occurs during summer months, resulting in dramatically different phosphorus concentrations above and below the thermocline. Total phosphorus concentrations below the thermocline tend to be higher than those above the thermocline, averaging 0.25 and 0.1 mg/L respectively (IPCo, 1999d). Ortho-phosphate concentrations also differ above and below the thermocline. When anoxic conditions occur within the reservoir, ortho-phosphate is released from bottom sediments and enters the water column. Because of strong stratification, much of this desorbed ortho-phosphate is trapped below the thermocline and is not available for algal production in the reservoir during the critical growing season. This is evidenced by ortho-phosphate concentrations in the waters at or below the thermocline that average from 3 to 5 times higher than those observed in the surface waters.

Seasonal nitrate and total kjeldahl nitrogen concentrations are shown in Figure 2.3.19 for the separate reservoir zones. Nitrate concentrations below the thermocline tend to be higher than those above the thermocline. Nitrate concentrations in the surface layers average 0.61 mg/L, which is considerably lower than those below the thermocline, which average 1.3 mg/L (IPCo, 1999d; US EPA, 1998a).

In addition to the nutrient loads entering the system, algae is both grown in place in the reservoir and delivered to this segment from the inflowing tributaries. Growing season reservoir conditions provide adequate light penetration as occurrences of high turbidity are generally associated with spring runoff, and temperatures within the upper water column will support growth. Available data show that chlorophyll *a* concentrations are generally highest in the riverine zone of the reservoir (RM 333 to 340) (Figure 2.3.20). Blooms also tend to occur most commonly in the transition zone of the reservoir (RM 302 to 328) during the late spring (March and April) and late summer months (August and September) (IPCo, 1999d).

A study completed during a very dry water year (IDEQ, 1993a) showed that chlorophyll *a* ranged from 70 to 100 ug/L above and at the transition zone respectively. Data collected near the dam during this same time frame (IPCo, 1999d) show chlorophyll *a* concentrations were

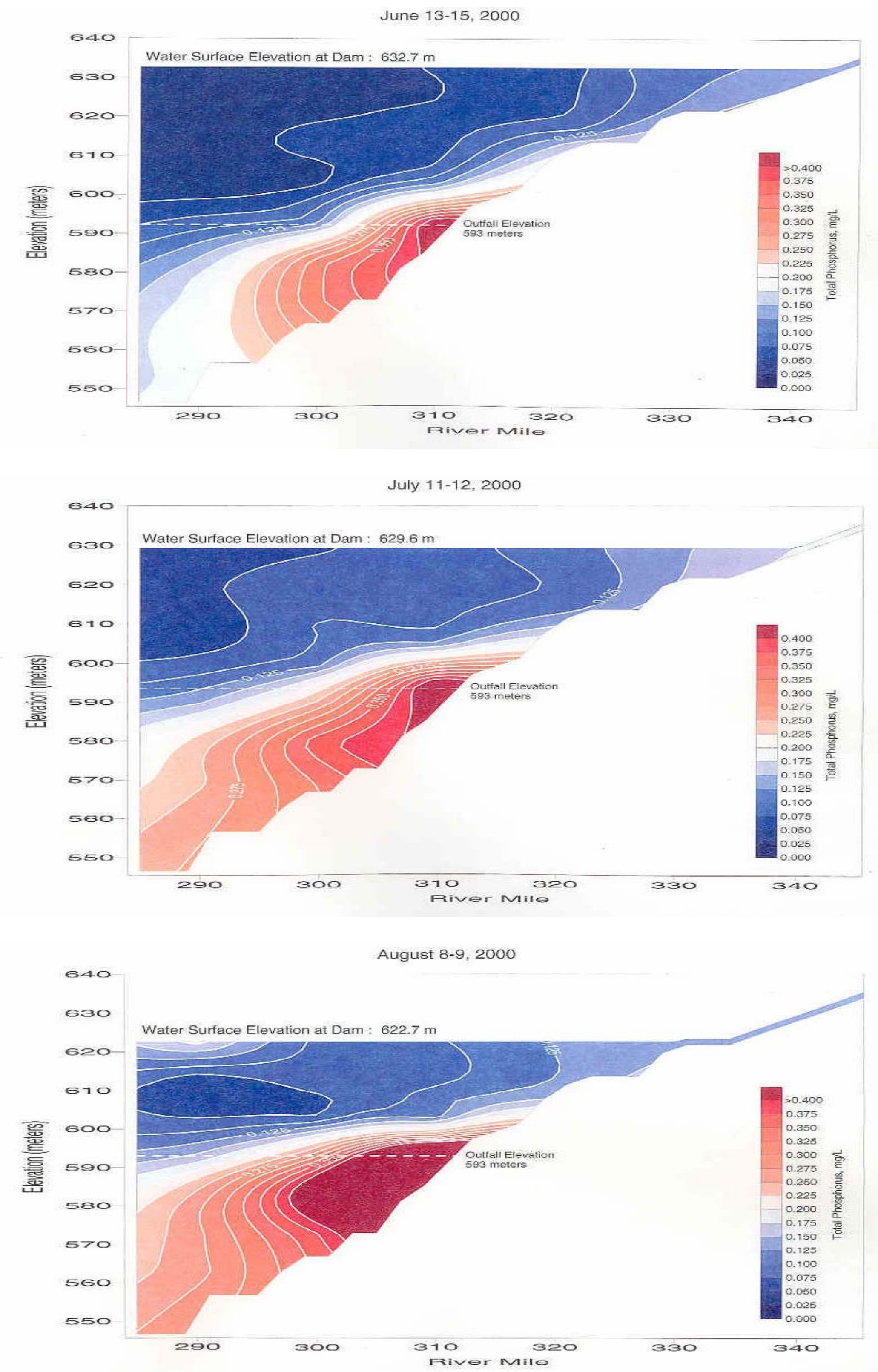


Figure 2.3.17 Total phosphorus isopleths for Brownlee Reservoir (RM 335 to 285). Data collected and plots prepared by Boise City Public Works.

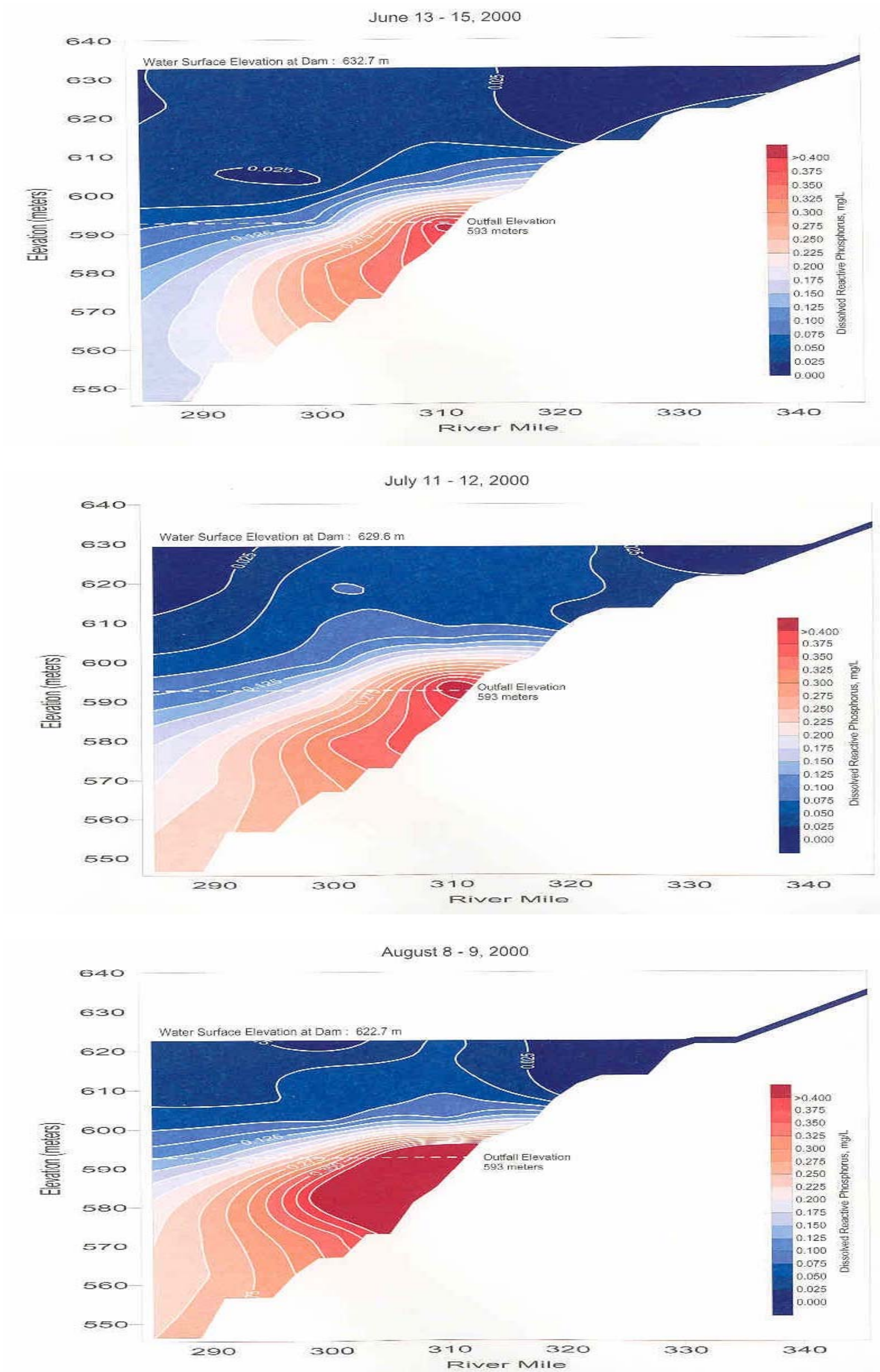
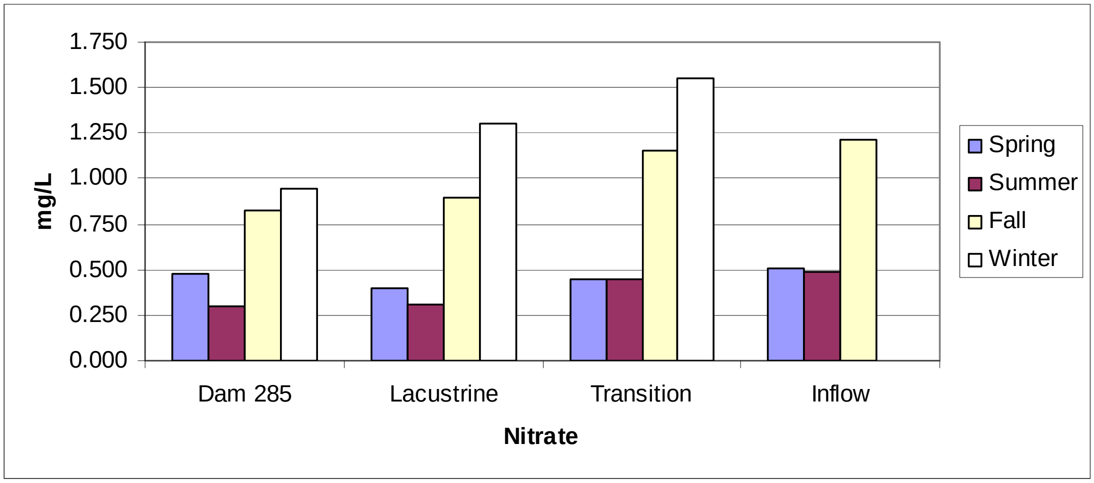


Figure 2.3.18 Dissolved reactive phosphorus isopleths for Brownlee Reservoir (RM 335 to 285). Data collected and plots prepared by Boise City Public Works.



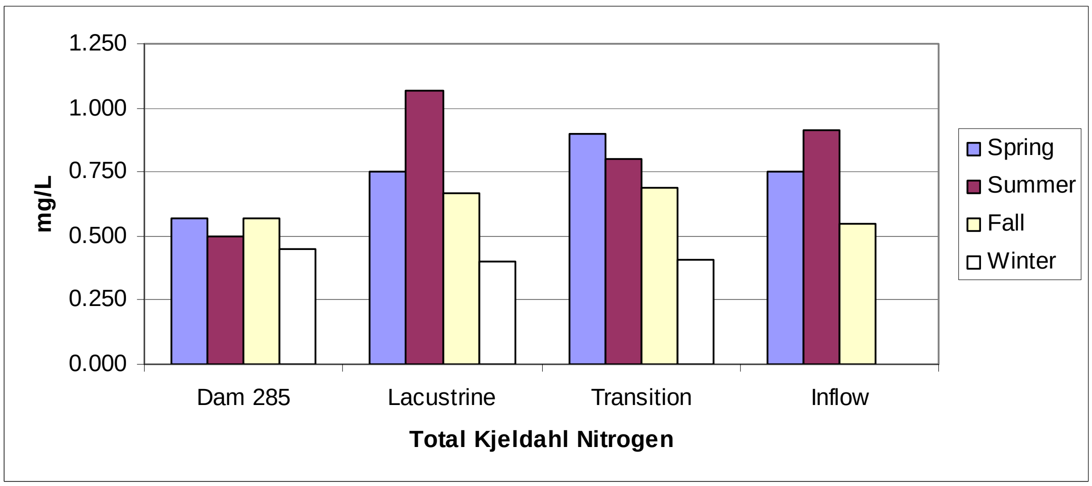


Figure 2.3.19 Mean nitrogen concentrations for the Brownlee Reservoir segment of the Snake River – Hells Canyon TMDL reach (RM 335 to 285).

markedly lower (5 to 10 ug/L). More recent monitoring (1995 through 1997) supports this trend with chlorophyll *a* levels in the riverine and transition zone routinely observed to be five times higher than those observed near the dam.

The algal populations within the reservoir change from upstream to downstream reservoir segments. The riverine zone in Brownlee Reservoir, with faster moving water and less stratification provides more favorable conditions for diatom species than for blue-greens, which is similar to the Upstream Snake River segment (RM 409 to 335). When the water enters the lacustrine section of the reservoir however, cyanobacteria (blue-green algae) become more prevalent due to high inflowing nutrient levels and slower water velocities.

Cyanobacteria (blue-green algae) have small sacs or vacuoles inside their cell membranes. By adding air to these sacs (rather than respiring to the outside) the algae can increase their buoyancy and move upward in the water column. Similarly, by removing air from these

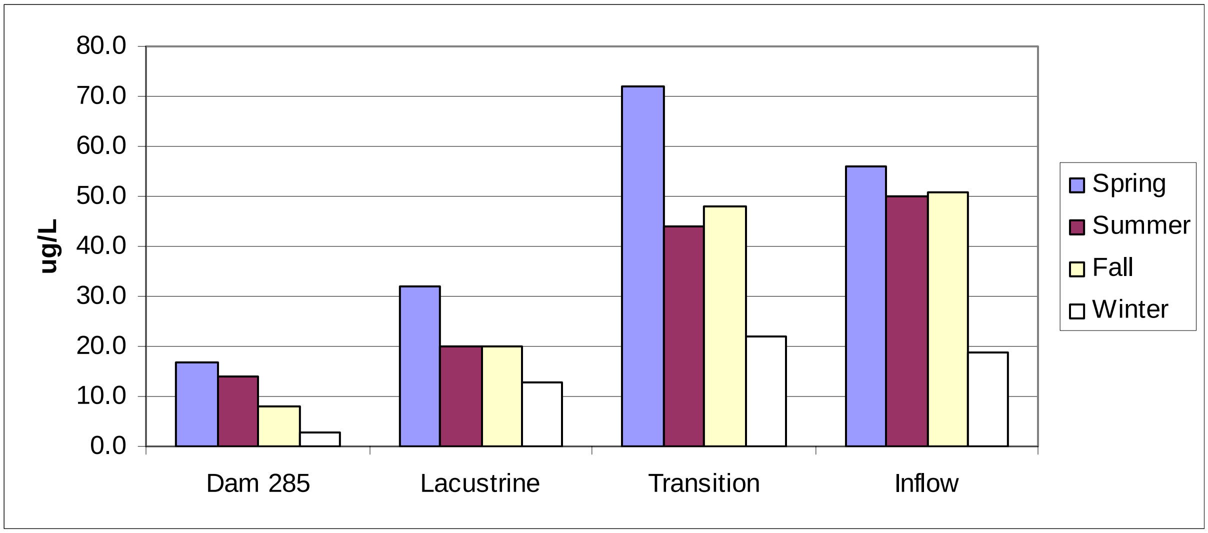


Figure 2.3.20 Mean chlorophyll *a* concentrations for the Brownlee Reservoir segment of the Snake River – Hells Canyon TMDL reach (RM 335 to 285).

vacuoles, the algae can move downward in the water column when nutrients in the immediate surface layers are depleted. This allows the algae to have a greater chance at surviving during major bloom events that remove dissolved nutrients from the upper layers of the water column. This ability of cyanobacteria (blue-green algae) to regulate their position in the water column becomes a greater advantage in this section of the reservoir and allows the blue green species to dominate (IPCo, 1999d). Dense blooms often occur in the transition zone, located between these two distinct sections, contributing to hypoxia in this zone of the reservoir.

While surface blooms of cyanobacteria (blue-green algae) may occur in the reservoir, total algal biomass tends to be higher in the river and riverine zone of the reservoir. It should also be noted that while cyanobacteria (blue-green algae) may be more likely to occur in Brownlee Reservoir and the immediate upstream waters, IDEQ (1993a) also observed cyanobacteria (blue-green algae) in the Snake River, and in 1999 and 2000, several canine deaths were ruled to be caused by ingestion of water containing high concentrations of cyanobacteria (blue-green algae) and associated toxins from the Snake River near Burley, Idaho.

When algae in the riverine and transition zones of Brownlee Reservoir die, they are carried further into the reservoir. Their decomposition leads not only to the reduction of oxygen in the water column but also the conversion of particulate organic phosphorus to highly available, highly mobile, dissolved ortho-phosphate. Data collected from the outflow of the reservoir indicates that 50 to 80 percent of the total phosphorus is exported (20 to 50% is being retained). However, the percentage of ortho-phosphate is higher in the outflow than in the inflow to Brownlee Reservoir. This could be due to a number of factors including the hypothesis that ortho-phosphate is low relative to total phosphorus coming into Brownlee because most of the total phosphorus is bound in algal cells rather than in solution as ortho-phosphate (IPCo, 1999d).

Available data and information show impairment of aesthetic and recreational uses due to excessive algal growth and slime production in the upstream sections of the reservoir.

Available data and information indicate that the cold water aquatic life and salmonid rearing designated beneficial uses are often impaired during the summer months in Brownlee Reservoir due to low dissolved oxygen concentrations. Concerns related to increased mercury methylation due to anoxia and presence of excessive organic matter are also present, especially in the upstream segment of the reservoir.

pH.
The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed for pH. Additional, more detailed information on pH is included in Section 3.4.

General Concerns. See Section 2.2.4.4.

Water Quality Targets. See Section 2.2.4.4 and Table 2.2.2.

Common Sources. See Section 2.2.4.4.

Historical Data. Data collected from 1968 to 1974 by the US EPA in the Brownlee Reservoir segment (near Brownlee Dam) show pH values that average 8.0. No depth information is available with these data so location and water column variations are not known. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

Current Data. As outlined in Table 2.3.19, pH levels have been monitored over a long period of time in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Currently available inflow pH data for the SR-HC TMDL reach includes the inflowing tributaries and the mainstem Snake River. These data show the lowest pH observed in the Brownlee Reservoir to be 7.4. The highest pH observed was 9.6. Less than 5 percent of the data were outside of the pH target established for this TMDL process (n = 529, 25 data points showed exceedences, 4.7%).

Table 2.3.19 pH monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	pH Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	1990 to Present 1959 to 1996	IPCo, 1999d, 2000c US EPA STORET data, 1998a

Segment Status. An evaluation of all inflowing and mainstem pH data showed that less than 5 percent of the data exceed water quality targets. The lowest pH observed in the Brownlee Reservoir was 7.4. The highest average pH observed was 9.6. Of 529 data points, 25 showed extremes outside of the pH target established for this TMDL process. Figure 2.3.21 shows a summary of pH data for 1992, 1995, and 1997.

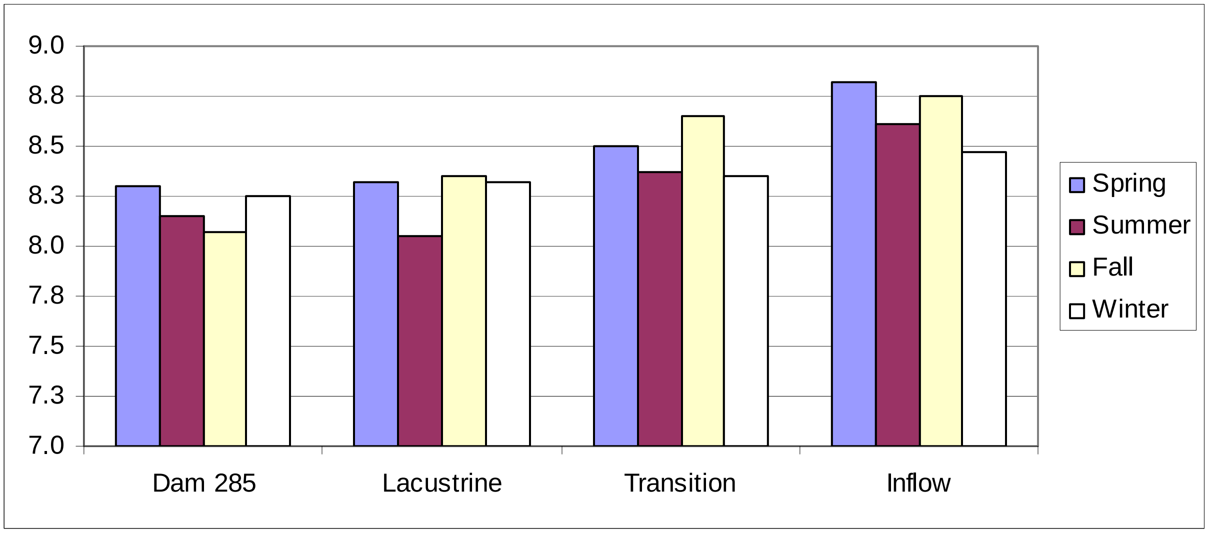


Figure 2.3.21 Mean pH values for the Brownlee Reservoir segment of the Snake River - Hells Canyon TMDL reach (RM 335 to 285).

Based on all the data, a recommendation has been made to delist the mainstem Snake River (RM 335 to RM 285, Brownlee Reservoir) for pH on the State of Idaho, 303(d) list. This proposed delisting will be included as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL. However, monitoring of pH levels will continue to be an integral part of the water quality monitoring of the Brownlee Reservoir segment (RM 335 to RM 285).

Sediment.

The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed for sediment. Additional, more detailed information on sediment is included in Section 3.5.

General Concerns. See Section 2.2.4.5. Additional concerns are associated with sediment-bound mercury, pesticides and nutrients.

Water Quality Targets. See Section 2.2.4.5 and Table 2.2.2.

Common Sources. See Section 2.2.4.5

Sediment transport, and the transport and delivery of sediment-bound pollutants are directly associated with increased flow volumes and high velocities. The change in velocity within Brownlee Reservoir acts to deposit sediments within the reservoir and alters the more random distribution of sediment and sediment-bound pollutants that would be expected in a free-flowing system. Larger size sediment particles (sands and gravels) and the associated sediment-bound pollutants tend to accumulate in the upper portion of Brownlee Reservoir near the transition zone. Smaller particles are carried further downstream in the reservoir. Silt and clay particles tend to drop out closer to the dam site, while even smaller particles and the colloidal matter are often carried through the dam and further downstream. While this deposition acts to reduce the overall concentration of such sediment and sediment-bound pollutants downstream, it localizes the sediment and pollutant mass which can lead to substantial effects on water quality if the reservoir experiences low dissolved oxygen levels at the sediment/water interface. Both sediment-bound mercury and adsorbed nutrients can be released under anoxic conditions and become highly mobile through methylation or dissolution processes. Sediment can also be re-entrained in the water column if management practices result in substantial drawdowns (as in high-water years where Brownlee Reservoir is drawn down for flood control under the direction of the US Army Corps of Engineers).

Deposition in Brownlee Reservoir can also lead to conditions where designated beneficial uses are negatively impacted by a decrease in naturally occurring sediment in the downstream segments. For example, reduced availability of gravel-sized particulate downstream may reduce available spawning habitat for bed spawning fish species.

Historical Data. Anecdotal information available indicates that this segment of the SR-HC TMDL reach has historically carried a substantial sediment load particularly during spring runoff. However there is little quantitative data from earlier periods (particularly prior to the construction of the Hells Canyon Complex).

Current Data. Total suspended sediment data have been collected for the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach as shown in Table 2.3.20. Currently available inflow and in-reservoir data for Brownlee Reservoir include aqueous samples from within the reservoir and major tributaries discharging into the Brownlee Reservoir segment of the SR-HC TMDL reach. The data represent both grab samples and depth-integrated information. While some total suspended sediment data are available from US EPA (US EPA, 1998a), the majority of in-reservoir data has been collected by IPCo.

Table 2.3.20 Total suspended solids (TSS) monitoring for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Sediment Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	1992, 1995, 1997 1967 to 1996	IPCo, 1999d, 2000c US EPA STORET data, 1998a

At and below the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected during the late summer months show the levels of total suspended sediment to range between 2 mg/L and 20 mg/L. While these data do not show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. However, the maximum concentrations observed are well below the 50 mg/L monthly average sediment target established by the SR-HC TMDL.

Above the thermocline, near the dam and in the lacustrine portion of the reservoir, combined data collected show the levels of total suspended sediment to range between a low of 2 mg/L to 20 mg/L, and a high of 25 mg/L to 32 mg/L. While these data do not show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. However, the maximum concentrations observed are well below the 50 mg/L monthly average sediment target established by the SR-HC TMDL.

In the transition and inflow portions of the reservoir, combined data collected during the mid-summer and winter months show the levels of total suspended solids to range between a low of 2 mg/L to 12 mg/L, and a high of 71 mg/L to 196 mg/L. The highest total suspended solids values were observed in March, April and May. While these data show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. However, the maximum concentrations observed are well above the 50 mg/L monthly average sediment target established by the SR-HC TMDL.

Segment Status. Figure 2.3.22 displays the mean total suspended solids concentrations for four representative sections of Brownlee Reservoir as observed from data collected between 1970 and 1999. Total suspended solids data from RM 284 to RM 290 were averaged to show levels for the reservoir near the Brownlee Dam (5.4 mg/L). Total suspended solids data from RM 305 to RM 317.5 were averaged to show levels for the downstream, lacustrine section of the reservoir (9.4 mg/L). Total suspended solids data from RM 320 to RM 330 were averaged to show levels for the transition zone of the reservoir (30.8 mg/L). Total suspended solids data from RM 333 to RM 340 were averaged to show levels for the inflowing river system (56.5 mg/L).

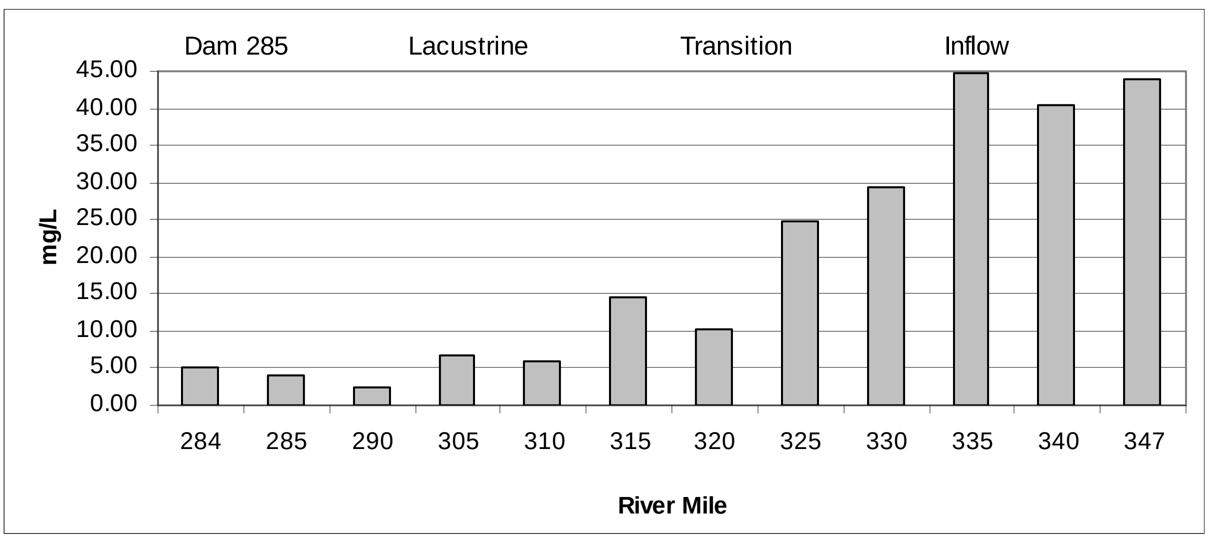


Figure 2.3.22 Mean total suspended solids (TSS) concentrations for the Brownlee Reservoir segment of the Snake River - Hells Canyon TMDL reach (RM 335 to 285).

Total suspended solids concentrations decrease substantially with increasing distance downstream from the reservoir inflow. Depositional and bathymetric assessments of Brownlee Reservoir have shown that the majority of sediment deposition occurs upstream of RM 310 (IPCo, 1999d). An examination of the reservoir at low pool shows that coarse sediment particles drop out in the upstream section of the reservoir near the transition zone while finer silt and clay are carried further downstream. Given the information shown in Figure 2.3.22, events that produce sediment concentrations that exceed the sediment target for the SR-HC TMDL reach would more probably occur in the upstream, riverine and transition zone sections of the reservoir near the inflow of the mainstem Snake River, than in the lacustrine sections of the reservoir closer to the dam.

Available data do not contain duration information and therefore are not sufficient to determine if cold water aquatic life, salmonid rearing, or residential fish and aquatic life designated beneficial uses are impaired due to direct sediment effects. Therefore, sediment targets are set to be protective of these uses. Additionally, due to the fact that sediment acts as a primary transport mechanism for adsorbed pollutants, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

Temperature.

The Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach is listed for temperature due to violations of the Oregon and Idaho water quality standards, including numeric and narrative criteria for salmonid rearing/cold water aquatic life, resident fish and aquatic life. Additional, more detailed information on temperature is included in Section 3.6.

General Concerns. See Section 2.2.4.6.

Water Quality Targets. See Section 2.2.4.6 and Table 2.2.2.

Common Sources. See Section 2.2.4.6.

Historical Data. Available historical temperature data from 1957 collected at the Brownlee Reservoir Dam site (USFWS, 1958) show daily maximum and average temperature measurements that exceed the temperature targets for salmonid rearing/cold water aquatic life identified in the SR-HC TMDL (see Table 2.3.21 and Figure 2.3.23).

Table 2.3.21 Water temperature data for 1957 for the Brownlee Dam site. RM 285 (USFWS, 1958).

	Temperature (°C)	
Month	**Mean Daily Average**	**Mean Daily Maximum**
January	1.6	1.8
February	2.5	2.7
March	6.8	7.1
April	10.0	10.3
May	13.7	14.1
June	18.0	18.6
July	21.6	22.1
August	20.8	21.2
September	17.9	18.3
October	12.3	12.7
November	6.3	6.6
December	3.9	4.1

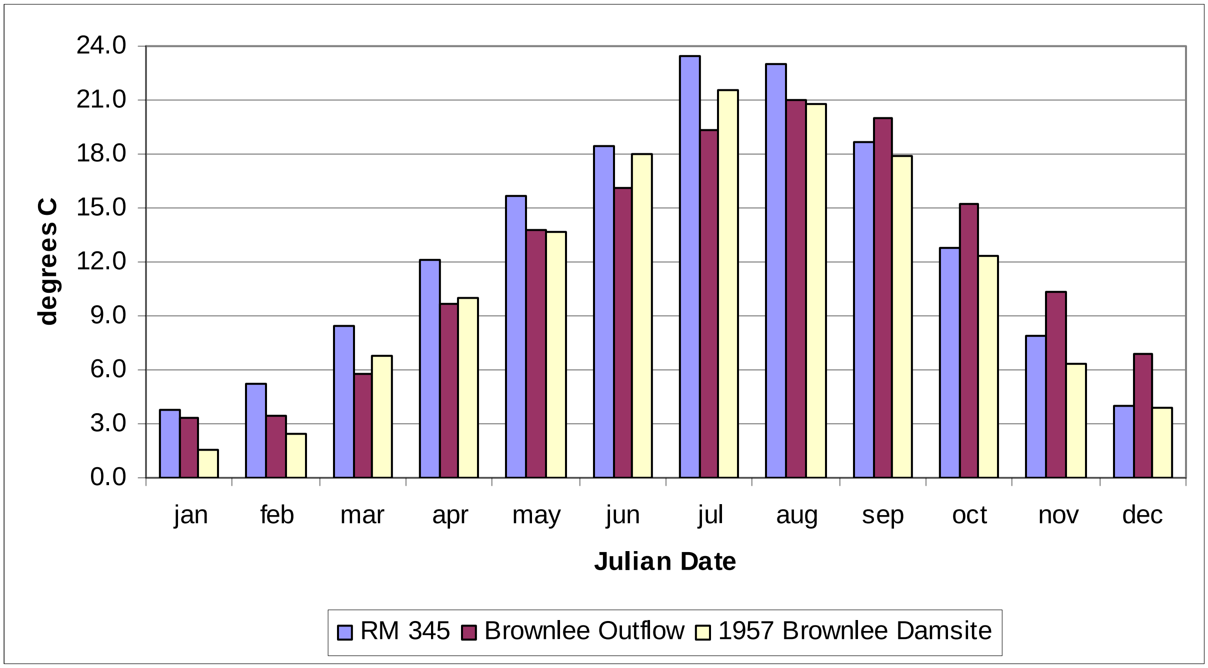


Figure 2.3.23 Current (1990s) vs. historic (1957) mean monthly water temperatures for the Brownlee Reservoir segment of the Snake River - Hells Canyon TMDL reach (RM 335 to 285). (RM 345 is plotted to show the temperature of water inflowing to Brownlee Reservoir.)

Photo 2.3.3. The mainstem Snake River upstream of the Brownlee Dam site (RM 285), circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

These data, when combined with information on historical water management occurring upstream of RM 285 and available air temperature data, indicate that waters in this segment probably experienced warming due to both anthropogenic and non-anthropogenic sources prior to dam construction. Data collected from 1968 to 1974 by the US EPA in the Brownlee Reservoir segment (near Brownlee Dam) show temperature values that average 14.5^{o} C. No depth information is available with these data so location and water column variations are not known. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a and 1975).

Current Data. Current temperature data available for the Brownlee Reservoir segment (RM 335 to 285) include monitoring of both tributary and mainstem values (Table 2.3.22). Extensive water temperature data was collected for Brownlee Reservoir from 1990 to present. Water temperature data have been collected for many areas of the Brownlee Reservoir segment and a variety of depths. Collection frequency and data type (daily max, daily average, instantaneous measurements, etc.) vary widely. Concurrent air temperature data for some areas extends back to the 1950's and represents a range of seasonal and annual climate variations. Daily maximum, mean and minimum air temperatures are recorded for the last 10 years for the Brownlee Reservoir station (SNOTEL, 2000).

Table 2.3.22 Temperature monitoring information for the Brownlee Reservoir segment (RM 335 to 285) of the Snake River - Hells Canyon TMDL reach.

Segment	Temperature Monitoring Dates	Source
Brownlee Reservoir (RM 335 to 285)	1993 1957 1992, 1995, 1997 1960, 1967 to 1996	IDEQ, 1993a USFWS, 1958 IPCo, 1999d US EPA STORET data, 1998a

Segment Status. A plot of 1957 (pre-dam completion) vs. current temperature in the Brownlee Reservoir Segment (RM 335 to 285) is shown in Figure 2.3.23. A single year of data is available for pre-impoundment conditions so comparisons can be made to this year only and may not be indicative of overall trends. The location of the 1957 data is referenced only as the Brownlee Dam site (USFWS, 1958) so it is assumed that the location is that of the present-day dam site, RM 285. The current data shown are average surface-water temperatures from 1991 through 2001 from RM 285 (the dam site) and RM 345 (the inflow to the reservoir). The plotted data show that the magnitude of surface water temperatures at RM 285 pre- and post-impoundment are relatively similar, with the post-impoundment temperature maxima being approximately 1 ^{o}C cooler than the pre-impoundment maxima observed in 1957. The timing of temperature maxima has shifted slightly later in the year in the post-impoundment data set from RM 285, with the temperature maxima occurring approximately one month (30 days) later in the 1990s than in 1957. Data sets from both pre- and post-impoundment at RM 285 show substantially cooler summer maximum temperatures (approximately 4 ^{o}C) than those currently observed at the inflow to Brownlee Reservoir (RM 345).

Brownlee Reservoir undergoes strong thermal stratification during summer months (stratification usually occurs from March through November, but is strongest in July and August, exhibiting a ~ 10 ^{o}C change within 60 vertical feet (IPCo, 1999d)). The position of the thermocline is well correlated with the level of the powerhouse penstocks, and extends approximately 25 miles upstream of the dam (IPCo, 1999d).

Temperatures that exceed the SR-HC TMDL targets for salmonid rearing/cold water aquatic life have been observed routinely at the inflow of Brownlee Reservoir and throughout the length of the reservoir in the surface waters. Most of these exceedences occur during the months of July and August, with surface temperature readings of 22 to 24 ^{o}C (72 to 75 ^{o}F) not uncommon.

Unlike Oxbow and Hells Canyon reservoirs, which receive cooled inflows from Brownlee Reservoir, the major source of inflowing water to Brownlee Reservoir is the Snake River. As discussed above, as the water in the mainstem Snake River moves downstream between RM 409 and 335, it maintains a relatively wide, shallow profile in a predominately dry and sparsely forested climate region. As this incoming water passes through Farewell Bend and into the transition zone of the reservoir, there is little opportunity for shading. During summer months, the daily average air temperatures at Brownlee Reservoir routinely reach 29 ^{o}C (84 ^{o}F) with 32 to 35 ^{o}C (90 to 95 ^{o}F) common as a daily maximum average in July and August. Inflowing water temperatures for these months reflect these elevated air temperatures with averages of 22 to 24 ^{o}C (72 to 75 ^{o}F) (IPCo, 1999d; IDEQ, 1993a).

Within the reservoir, deep water (below the thermocline) maintains a fairly stable summer temperature of 10 ^{o}C (50 ^{o}F) or less at the dam (Ebel and Koski 1968; IPCo, 1999c), while surface waters in the same area vary from 20 to 28 ^{o}C (68 to 82 ^{o}F). During the winter season, the reservoir is not strongly stratified and the difference between deep water temperature averages (4 ^{o}C (39 ^{o}F)) and surface water temperature averages (4 to 6 ^{o}C (39 to 43 ^{o}F)) is less. Due to the short residence time, the temperature of the surface water moving downstream through Brownlee reservoir in the summer changes by about 2 to 4 ^{o}C (4 to 6 ^{o}F) from Farewell Bend to Brownlee Dam. There are relatively few watershed-based anthropogenic temperature sources within the Brownlee Reservoir area. Both the Powder and the Burnt Rivers flow into Brownlee Reservoir, contributing 2.9 percent and 0.7 percent of the total flow respectively. Both river systems pass through relatively hot, dry, sparsely vegetated drainages before inflowing to the reservoir.

Temperatures that exceed the SR-HC TMDL salmonid rearing/cold water aquatic life at the inflow of the Powder River have been observed to occur from July through September. A temperature TMDL is scheduled to be written by the State of Oregon in 2006 for the Powder River system. Seasonal temperature increases within the Powder River are most likely influenced to some extent by natural heat exchange through high air temperatures and solar radiation, i.e. lack of shade.

Temperatures that exceed the SR-HC TMDL targets for rearing/cold water aquatic life have also been observed at the mouth of the Burnt River. Most of these events occurred during the months of July and August. A temperature TMDL is scheduled to be written by the State of Oregon in 2006 for the Burnt River system. As noted for the Powder River system above, seasonal temperature increases within the Burnt River are most likely influenced to some extent by natural heat exchange through high air temperatures and solar radiation.

The flow contribution of both the Powder and the Burnt Rivers is relatively small (less than 4%) when compared to the total flow within Brownlee Reservoir. Changes in temperature within Brownlee Reservoir due to the Powder and Burnt River inflows are therefore assumed to be minimal.

Please note: Assessments of water quality data in reference to the SR-HC TMDL targets for the tributary inflows to the Brownlee Reservoir segment (RM 335 to 285) are based on the operating assumption that salmonids and other cold water aquatic life within the reservoir have the potential to use the mouths of the inflowing tributaries for cold water refugia during summer months. These assessments are not intended to imply that salmonid rearing and cold water aquatic life (if not currently designated beneficial uses) are or should be designated beneficial uses of the tributaries, or that standards violations are occurring upstream within the tributary drainages.

Available data show exceedences of temperature criteria throughout the surface waters of the SR-HC TMDL reach during the months of June, July, August and September. Cold water aquatic life and salmonid rearing designated uses are supported in the Brownlee Reservoir segment (RM 335 to 285) due to the presence of cold water refugia.

2.3.2.3 Data Gaps

See Section 2.4

2.3.2.4 Pollutant Sources

See Section 2.5

Point Sources

There are no known permitted point sources that discharge directly to Brownlee Reservoir, however, permitted discharges to the inflowing Burnt River and Powder River systems do occur. These include treated municipal sewerage discharges, municipal stormwater discharges and industrial discharges.

Point sources discharging to tributaries will not receive a separate waste load allocation. A “bulk” load allocation has been identified for the mouths of the tributaries. The identification of load and waste load allocations specific to the tributary loading will be accomplished through the tributary TMDL process in the case of those tributaries that do not yet have a TMDL in place and as part of the TMDL implementation plan process in the case of tributaries where a TMDL is already in place.

Nonpoint Sources

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.
A minor amount of the agricultural land (3.0 %) within the SR-HC TMDL reach is located in the drainage areas of the Burnt and Powder river systems that drain into the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Predominant agricultural practices within these drainages include irrigated and dryland pasture (grazing). A limited amount of cropping occurs within the Brownlee Reservoir drainage. Only very minimal agricultural return flows have been identified within the Brownlee Reservoir segment of the SR-HC TMDL reach. Grazing occurs throughout this segment but animal densities are minimal.

Recreational.
Due to its proximity to populated urban areas and the excellent recreational opportunities available, Brownlee Reservoir is a major destination site year-round. Water-based recreational activities peak in the summer season with heavy use observed between Memorial Day weekend and Labor Day weekend, when the reservoir is used by many boaters, swimmers, campers and anglers. The average use of the reservoir (May 1997 through October 1998) is estimated at 591,887 visitor hours annually. Peak use during a week has been estimated at 45,959 visitor hours (July 4th), and monthly peak use levels estimated at 13,878 visitor hours (June). Camping and bank-fishing use is also substantial (IPCo, 2000b; HCNRA, 1998a and 1998b, 1999a and 1999b).

Urban/Suburban.
A minimal amount of the urban/suburban land within the SR-HC TMDL reach is located in the drainage areas of the Burnt and Powder River systems that drain into the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Rural residential housing supported by septic systems is present within this segment but densities are minimal.

Ground Water.
Many natural springs and ground-water inflows have been observed in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. These inflows occur in the tributary drainages and the reservoir system, entering both above and below the water level in many locations. Subsurface recharge from irrigation water use is estimated to be minimal in the Brownlee Reservoir segment due to low irrigation water usage in this area. Natural ground-water inputs are estimated to dominate over subsurface recharge in most areas of this segment.

Background and Natural Contributions.
The natural sources discussed in Section 2.5 are known to be present to some degree in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. The occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River and Brownlee Reservoir segments than in the segments located downstream.

Internal Recycling and Reservoir Water Levels.
As discussed previously, the placement and operation of hydroelectric impoundments within the SR-HC TMDL reach, in combination with poor inflow water quality have the potential to exacerbate declining water quality conditions. The Hells Canyon Complex impoundments alter the physical characteristics of the mainstem Snake River and contribute to changes in water quality, aquatic habitat, and designated beneficial use support. Riverine characteristics affected by the hydroelectric impoundments include water velocity, discharge, water depth, and water retention times. Water quality parameters potentially affected by the operation of the Hells

Canyon Complex hydropower projects include dissolved oxygen, water temperature, gas supersaturation, sedimentation, and instream processing of nutrients and organic matter. While the hydropower plants do not add nutrients or organic matter to the river, processing is altered and flushing of pollutants downstream is reduced. The impoundments behind the dams have an effect on the ability of the river to process sediment and nutrients (USDA-USFS, 1997), and organic matter.

Water quality in the SR-HC TMDL reach is degraded due to point and nonpoint source pollutant loads, compounded by managed, altered, or reduced flows and velocities due to storage and diversion throughout the watershed. These factors, in combination with natural climatic and pollutant sources, have resulted in the increased growth of nuisance aquatic vegetation and decreased dissolved oxygen levels. High productivity in the upstream Snake River and the transition and riverine zones of the reservoir, and decomposition of aquatic vegetation in both the river and reservoir causes low dissolved oxygen levels in the water column and result in non-support of designated beneficial uses. Oxygen deficits observed throughout the water column in Brownlee Reservoir commonly occur during the summer months (low dissolved oxygen occurs in both stratified and non-stratified areas) and become increasingly oxygen poor as the summer stratification strengthens (IPCo, 1999d).

As previously stated, hydroelectric projects do not add nutrients to the river, instead nutrient processing is intensified and flushing of pollutants downstream is reduced. The impoundments behind the dams may affect the ability of the river to process sediment and nutrients. Thus, the dams in the SR-HC TMDL reach have modified water quality conditions in two ways: (1) altering the processing (including sedimentation) of nutrients and organic matter within Brownlee Reservoir and (2) reduced nutrient and sediment loading to Oxbow and Hells Canyon reservoirs, and the river downstream of Hells Canyon Dam. The general result is increased sediment deposition within the reservoir and decreased movement of sediment and, to some extent, associated pollutant loads downstream.

In addition to the physical and flow changes discussed above, phosphorus contained in river and reservoir bed sediments represents a potential loading source to the water column. While the reservoir acts as a nutrient sink under most conditions, some nutrients are released from the sediments. Most nutrient release occurs during periods of anoxia (Figure 2.3.15, 2.3.17, and 2.3.18), when stratification acts to inhibit transport of higher nutrient concentrations to the surface waters. Due to this fact, most of the recycled nutrients within the reservoir are not directly available to algal growth in Brownlee, but are discharged through the dam into the downstream reservoirs of Oxbow and Hells Canyon. The deposition, release and dissolution of this phosphorus is dependent on both physical and chemical processes within the watershed, river and reservoir. Physical processes dominate in the transport of phosphorus contained within or adsorbed to sediment and particulate matter. Chemical processes dominate in the transport of dissolved phosphorus and in the transformation of phosphorus from one form or state (i.e. free or adsorbed) to another, within both the transport pathway through the reservoir and the water column.

Phosphorus within the water column can be divided into two major sources: suspended, particulate-bound or sorbed phosphorus (both organic and inorganic), and dissolved phosphorus.

Suspended matter can be colloidal in nature (under 0.45 μm in diameter) and resist settling forces because the surface area to mass ratio is high enough that internal buoyancy counteracts gravitational forces. Sediment and organic matter that has settled to the river and reservoir bed may also become re-suspended and act as a source of dissolved phosphorus as the chemical environment within the water column or channel substrate changes. (Note: This is also true in the Snake River upstream, where sediment bound phosphorus is continually recycled into the water column and constant interchange occurs between the water column and sediments). Dissolved phosphorus may be present in the mainstem and tributary inflows, or as phosphorus released from bed-sediments.

Phosphorus release from bed sediments has been observed under anaerobic conditions (IPCo, 1999d). This release, along with phosphorus release from deposition/decomposition processes can be observed in the data plotted in Figures 2.3.17 and 2.3.18. An increase in both total and dissolved reactive phosphorus is observed to occur at approximately RM 310 in Brownlee Reservoir. This location corresponds well with known depositional processes within the reservoir, and can be correlated with finer, suspended sediment and algae that would potentially be transported slightly farther than the coarse material that deposits near RM 325. The increase in concentration observed is most likely a combination of both benthic release and decomposition/dissolution processes occurring at the sediment/water interface.

Low dissolved oxygen is a primary mechanism in the benthic release of adsorbed constituents. Phosphorus sorption sites are related to the charge state and concentration of iron and aluminum within sediment particles. Under anaerobic conditions, the charge state of iron is changed, resulting in the release of bound phosphorus to the overlying water column as sorption potential is decreased (Sharpley *et al.*, 1995). Low dissolved oxygen concentrations lead to increased sediment release of bound phosphorus in this manner. In comparing Figures 2.3.15, 2.3.17 and 2.3.18, areas of low dissolved oxygen are well correlated with areas of increased phosphorus concentration at the sediment/water interface. Similar processes can occur in a riverine environment where intergravel anoxia occurs. Again, because the upper boundary of the hypolimnion is generally located at a depth of approximately 45 meters in Brownlee Reservoir, most of this recycled phosphorus is retained in the hypolimnion and is generally not available for primary productivity.

Similar to benthic release of nutrients, anoxic conditions can act to increase the conversion of elemental and inorganic mercury to methylmercury as mentioned previously. This process, and the associated aquatic life, wildlife, and human consumption concerns are discussed in greater detail in Section 3.1.

Strong thermal stratification within Brownlee Reservoir during the summer months acts to reduce the transport of dissolved and desorbed phosphorus, and methylmercury to the surface waters. During stratification, cooler, denser water layers tend to remain relatively stationary within the lower levels of the reservoir. Increased phosphorus and/or methylmercury concentrations occurring within these waters are not immediately equilibrated with surface waters due to a lack of circulation within the stratified reservoir system. Equilibration occurs with winter turnover or mixing of the reservoir, commonly later in the year when surface water temperatures are no longer ideal for algal growth.

Availability of sediment-bound phosphorus and potential leaching into surface water can also be affected by operational conditions controlling the water depth over the reservoir sediments and by thermal stratification within the reservoir. Fluctuating water levels that periodically expose sediments or alter the aerobic/anaerobic conditions at the sediment/water interface affect the sink/source characteristics of these sediments. Under extreme drawdown conditions, sediment phosphorus availability may be increased, further contributing to the enrichment of the water column and increased algal productivity. This is not thought to represent as important a process as the nutrient cycling described previously however.

Note: The organic matter processing in Brownlee Reservoir reduces organic matter loads to downstream reservoirs and river reaches. While this leads to dissolved oxygen problems in Brownlee Reservoir and downstream, it limits organic matter deposition and related low dissolved oxygen levels in the salmon spawning gravels below the reservoirs. However, it is better for water quality within the system as a whole to limit the initial organic matter loading rather than to rely on instream processing (ODEQ, 1999)

2.3.2.5 Pollution Control Efforts

See Section 2.6

Other TMDL Efforts

In addition to this SR-HC TMDL effort, sediment TMDLs are scheduled for the Burnt and Powder rivers and many of the smaller tributaries to the SR-HC system. It is expected that, if successfully implemented, these TMDL efforts will result in improvement of sediment concentrations within these segments.

No other TMDLs or watershed management plans are currently in place in the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach.

2.3.3 Oxbow Reservoir (RM 285 to 272.5):

The Oxbow Reservoir segment (RM 285 to 272.5) includes Oxbow Reservoir from the outflow of Brownlee Dam to Oxbow Dam (Figure 2.3.24). This segment is much smaller than the Brownlee Reservoir segment (RM 335 to 285), and has an average retention time of only 1.4 days (Table 2.3.23). Oxbow Reservoir has a surface area of about 1,000 acres and approximately 26 miles of shoreline. Flow into Oxbow Reservoir is almost exclusively the outflow of Brownlee Reservoir. Wildhorse River, the only major tributary to this segment, flows directly into the reservoir near the Brownlee Dam and constitutes less than 1 percent of the total inflow. Total reservoir volume is 57,500 acre-feet. Flow and residence time within the reservoir are controlled by the releases from Brownlee Reservoir and the releases from Oxbow Dam. Oxbow Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with the reservoir boundaries (IPCo, 1999a, 1999c).

Table 2.3.23 Physical characteristics of Oxbow Reservoir.

Date Closed	1961
Full Pool (feet msl)	1,805
Minimum Pool (feet msl)	1,795
Total Volume (acre-feet)	57,500
Surface Area (acres)	1,157
Mean Depth (feet)	50
Length (river miles)	12
Mean Width (feet)	795
Shoreline (miles)	26
Average Retention Time (days)	1.4

2.3.3.1 INTRODUCTION

For a discussion on the effect of impoundments within the SR-HC TMDL reach see Section 2.1.1.4

While most of the processes discussed in Section 2.1.1.4 can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Brownlee Reservoir, located in the farthest upstream position in the Hells Canyon Complex, acts as a sink for both sediment and nutrients within the Hells Canyon Complex and downstream river segments; deep-water releases also act to lower water temperatures in downstream segments. To a lesser degree, Oxbow Reservoir acts in this same capacity and reduces sediment and attached pollutants that might otherwise enter downstream segments. While these changes in transport can act to improve water quality, the agencies prefer to prevent the initial pollutant loading into a water system than to depend on instream treatment systems (ODEQ, 1999).

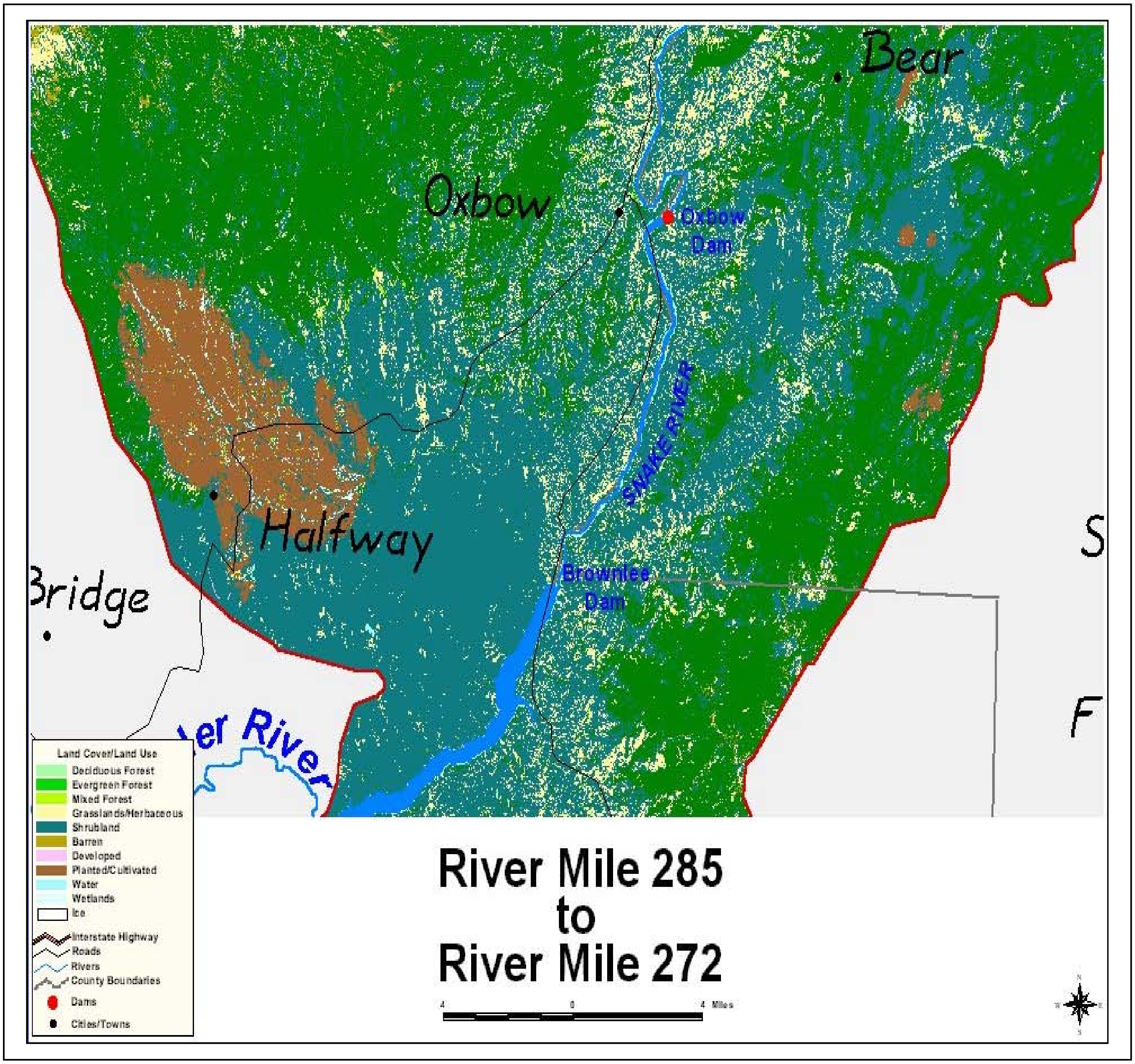


Figure 2.3.24 Oxbow Reservoir segment of the Snake River – Hells Canyon reach.

2.3.3.2 Water Quality Concerns/Status

General Information

The waters in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach are listed as water quality limited for temperature, mercury, pesticides, sediment and nutrients (Table 2.3.24). A more detailed examination of the data available for this assessment has identified two of these pollutants (pesticides and mercury) for which the listings depend on data and interpolation from upstream sources. The rest of the pollutants appear, from the existing data (historical as well as current), to be limiting the attainment of the designated beneficial uses in this segment. Each of the pollutants and its potential impact on this segment of the SR-HC TMDL reach is described in more detail in the following sections.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.24 summarizes the listed pollutants and designated beneficial uses for the Oxbow Reservoir segment (RM 285 to 272.5). A more detailed description of each of the designated beneficial uses is included in Section 2.2.2. A more detailed description of the listed pollutants and the assessment process is located in Section 3.0 through 3.7.

Table 2.3.24 Listing information for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 285 to 272.5 Oxbow Reservoir	Nutrients, sediment, pesticides	Cold water aquatic life primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower

* Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

The primary salmonid species in this segment are rainbow trout and mountain whitefish. The general spawning periods for these two species are March 01 to July 15 and November 01 to March 30, respectively. Resident fish include cool and warm water fish as bass, crappie, and catfish. The dominant community in the Oxbow Reservoir segment (RM 285 to 272.5) is the resident cool and warm water fish.

Summary and Analysis of Existing Water Quality Data

Mercury.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed as water quality limited due to a human fish consumption advisory for mercury by the State of Oregon (Appendix D).

General Concerns. In addition to the general information discussed in Section 2.2.4.2, methylation of mercury is of specific concern within the reservoir environment. Low dissolved oxygen levels and the presence of a substantial amount of organic material near the sediment/water interface can result in higher rates of methylmercury production, as hydrocarbon materials from the organic matter are available to bond with elemental mercury. Methylmercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds as it is much more soluble in water and therefore much more mobile within both the physical reservoir system and the metabolic systems of living organisms living in or utilizing the water.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2.

Historical Data. There are no known historical mercury data for the Oxbow segment (RM 285 to 272.5) of the SR-HC TMDL reach available in either an anecdotal or numeric format.

Table 2.3.25 Mercury monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Mercury Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	None	None (see sources for Brownlee and Upstream segments)

Current Data. There are no known current mercury data for this segment, such as those cited for the Upstream Snake River, Brownlee Reservoir, and Downstream Snake River segments of the SR-HC TMDL reach.

Segment Status. Because the only mercury data available that is applicable (albeit indirectly) to the Oxbow Reservoir segment are from studies conducted in upstream and downstream waters, some interpolations of transport have been made. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow (greater than 99%).
- The majority of sediments delivered to Oxbow Reservoir come from the Brownlee Reservoir outflow. However, many of the heavier sediments that enter Brownlee are

contained there and most mercury adsorbed to or contained within these sediments would be retained in Brownlee.

- Due to the depositional nature of Brownlee Reservoir, the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway potential for mercury from Brownlee into Oxbow Reservoir.
- Because there are no other significant inflows to Oxbow Reservoir, the major source of mercury in Oxbow is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, mercury concentrations in Oxbow Reservoir are not expected to exceed those observed in Brownlee Reservoir (RM 335 to 285) or the Upstream Snake River segment (RM 409 to 335). In a conservative assessment, mercury concentrations in Oxbow Reservoir can be assumed to be equal to or less than those observed in Brownlee Reservoir. It then follows that meeting water quality targets for mercury in Brownlee Reservoir would lead to meeting the targets in Oxbow Reservoir as well.

Upstream data show impairment of the designated beneficial use of fishing. Available upstream data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, and domestic water supply designated beneficial uses.

Nutrients.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed as water quality limited due to nuisance algal growth from excessive nutrient loading. This condition is of concern because of the effect excessive algal growth can have on dissolved oxygen and pH.

<u>General Concerns</u>. See Section 2.2.4.3.

<u>Water Quality Targets</u>. See Section 2.2.4.3 and Table 2.2.2.

<u>Common Sources</u>. See Section 2.2.4.3. The majority of nutrient loading to Oxbow Reservoir is from upstream loading and internal processing within Brownlee Reservoir.

<u>Historical Data</u>. While no historic data exist to document early nutrient concentrations in the this segment Snake River, anecdotal information for upstream segments indicates that algal growth may also have occurred at noticeable levels prior to extensive anthropogenic impact to this reach from agricultural practices or urbanization occurred (US EPA, 1974a).

<u>Current Data</u>. As indicated in Section 2.2.4.3, the two major nutrients of concern in algal productivity are phosphorus and nitrogen. In systems dominated by cyanobacteria (blue-green algae), such as the Brownlee Reservoir segment (RM 335 to 285) at some times of the year

(which represents the primary source of inflow to Oxbow reservoir), phosphorus is usually the limiting agent.

Currently available inflow and in-reservoir data for Oxbow Reservoir include aqueous samples from within the reservoir and from the discharge of Brownlee Reservoir upstream (Tables 2.3.26 and 2.3.27). The data represents both grab samples (primarily within a foot of the surface) and some depth-integrated sampling. While some nutrient and chlorophyll *a* data are available from US EPA (US EPA, 1998a), the majority of in-reservoir data has been collected by IPCo.

Table 2.3.26 Nutrient monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Nutrient Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1974 to 1981	IPCo, 2000c US EPA STORET data, 1998a

Table 2.3.27 Chlorophyll *a* monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Algae Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1991 to 1999	IPCo, 2000c

Total Phosphorus. Within Oxbow Reservoir, combined data show that the water quality targets established by the SR-HC TMDL for total phosphorus are not met nearly 100 percent of the time. Data collected during May, June and July show the lowest levels of total phosphorus (0.03 mg/L to 0.05 mg/L). Data collected during March and April show the highest total phosphorus concentrations (0.2 mg/L to 0.3 mg/L). While these data show a substantial decrease over the concentrations observed in the Upstream Snake River segment (RM 409 to 335) and above the thermocline in Brownlee Reservoir, they also indicate that nutrient targets are routinely not being met during the spring months, and are met less than 25 percent of the time during the fall and winter as total phosphorus concentrations of 0.1 mg/L are commonly observed during the months of August through February.

In the case of phosphorus loading, a less than or equal to 0.07 mg/L phosphorus concentration is the target for the SR-HC TMDL. Total phosphorus monitoring data collected from inflows to Oxbow Reservoir (from Brownlee Reservoir) routinely exceed these values. Available data show that the median total phosphorus concentration in-reservoir was above 0.08 mg/L and the highest total phosphorus levels were 0.23 mg/L in March 1995 (IPCo, 2000c).

Ortho-Phosphate. Combined data collected during May, June and July show the lowest levels of ortho-phosphate (0.01 mg/L to 0.03 mg/L). Data collected from August through February show the highest ortho-phosphate concentrations (0.08 mg/L to 0.1 mg/L).

Because of the interaction of nutrients, algae, dissolved oxygen and pH; algal biomass has been monitored through sampling and analysis for chlorophyll *a* and pheophytin (a metabolite of chlorophyll *a*). Data available from both nutrient and algal monitoring has been identified as an important part of the assessment of water quality. Therefore, these data have been included in the monitoring information on algae even though they are not specifically listed as parameters on the 303(d) list.

Chlorophyll a. Combined data collected during the summer, fall and winter months (July through December) show the lowest levels of chlorophyll *a* (0 ug/L to 3 ug/L). Data collected during the spring and early summer months (April, May and June) show the highest chlorophyll *a* concentrations (12 ug/L to 65 ug/L). While these data show a substantial decrease over the concentrations observed in the Upstream Snake River segment (RM 409 to 335) and above the thermocline in Brownlee Reservoir, they also indicate that the threshold value of 15 ug/L chlorophyll *a* is routinely exceeded during these months in the reservoir.

During the critical summer months (June through September) when conditions for algal growth are optimal, concentrations in Oxbow Reservoir at the Brownlee Dam outflow average 0.07 mg/L total phosphorus, 0.04 mg/L ortho-phosphate and 3 ug/L chlorophyll *a* (1995 to 1999).

<u>Segment Status</u>. Nutrient concentrations in Oxbow Reservoir are shown in Figures 2.3.25 and 2.3.26. Recent monitoring shows that within the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach, water quality tends to be fairly static upstream to downstream.

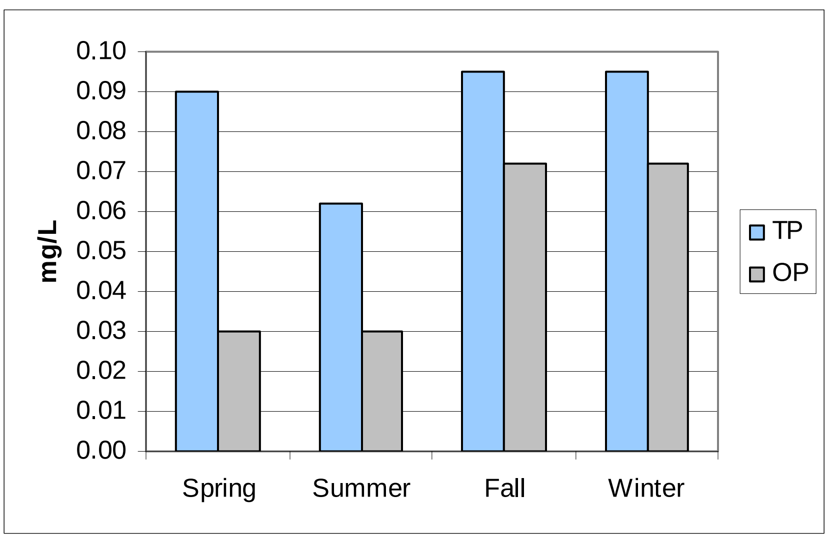


Figure 2.3.25 Mean total phosphorus (TP) and ortho-phosphate (OP) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

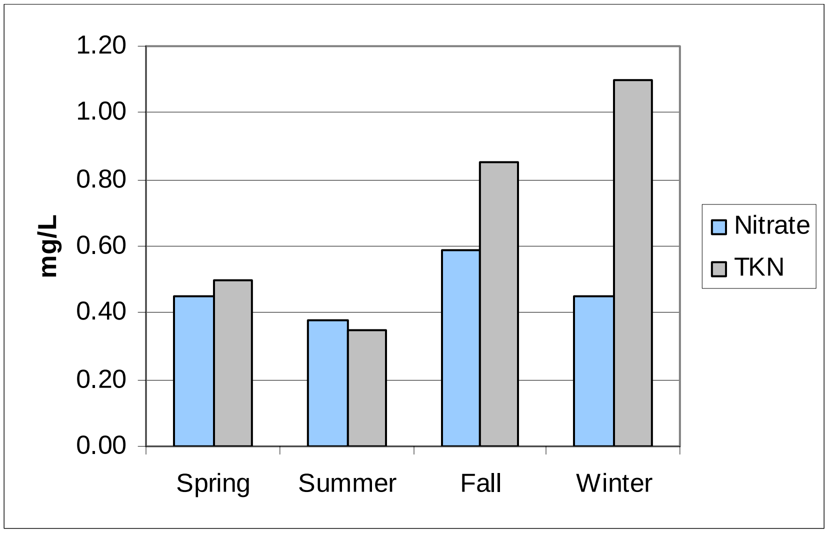


Figure 2.3.26 Mean nitrate and total jeldahl nitrogen (TKN) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Samples for total phosphorus taken at the discharge from Brownlee Dam and at Oxbow Dam on the same days vary by less than 10 percent. For ortho-phosphate, the difference upstream to downstream is 3 percent. Chlorophyll *a* concentrations vary by 35 percent upstream to downstream, exhibiting much less variability than Brownlee Reservoir where concentrations vary by an average of 82 percent upstream to downstream. Oxbow Reservoir is relatively small and fast flowing; therefore water column constituents are fairly well mixed and evenly distributed upstream to downstream. Due to the highly correlated nature of the Oxbow and Brownlee Reservoir systems, water-chemistry and algal loading in the Brownlee Reservoir outflow heavily influences water quality within Oxbow Reservoir. Average ortho-phosphate concentrations in Oxbow Reservoir are observed to be slightly higher than those observed in Brownlee Reservoir during the growing season. Average total phosphorus concentrations in Oxbow Reservoir are somewhat lower, and average chlorophyll *a* concentrations dramatically lower than those seen in Brownlee Reservoir during the growing season.

In addition to the nutrient loads entering the reservoir from upstream, algae can be both grown in place in the reservoir and delivered to this segment from inflowing waters. Growing season reservoir conditions provide adequate light penetration (low turbidity, as sediment loads are primarily deposited in Brownlee Reservoir), and temperatures for algal growth. Although chlorophyll *a* data for the Oxbow Reservoir is limited, algal blooms are observed to occur in the late spring (March and April) and summer months (July and August) (IPCo, 2000c), throughout the relatively short length of the reservoir. Blooms have not been observed to be as excessive as those observed in the upstream portions of Brownlee Reservoir. Decomposition of dead algae leads to the reduction of oxygen in the water column and the conversion of particulate organic phosphorus to highly available, highly mobile, dissolved ortho-phosphate.

Pesticides.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed because of concern over elevated levels for pesticides. Available data (Rinella *et al.*, 1994; Clark and

Maret, 1998) from upstream indicates that the pesticides of concern are legacy pesticides that are no longer licensed for use. These include the chlorinated hydrocarbon insecticide DDT and its breakdown products, and the cyclodiene insecticide dieldrin.

General Concerns. Pesticide residues represent a water quality concern as these substances can be composed of organic chemicals or inorganic elements that are toxic to aquatic life at relatively low concentrations. These substances can kill aquatic life directly or affect the food chain by building up (bioaccumulating and bioconcentrating) to concentrations in lower organisms that can be toxic to the consumers at the upper end of the food chain (including humans).

Water Quality Targets. Pesticide levels of concern for the protection of aquatic life and human health for tissue and water consumption are available through the US EPA toxics rule (used by IDEQ) and ODEQ Table 20, as cited in Table 2.1 of this document. In order to meet the water quality criteria of both states and to support the designated uses of fishing and domestic water supply, the following targets have been established for the SR-HC TMDL reach: 0.024 ng/L water column DDT; 0.83 ng/L water column DDD; 0.59 ng/L water column DDE; and 0.07 ng/L water column dieldrin (Table 2.2.2).

Common Sources. The primary source of these legacy pesticide residues in the SR-HC TMDL reach is upstream historical use of agricultural chemicals for pest control. These compounds have extremely slow degradation rates and therefore are persistent in the environment.

Historical Data. There are no known historical pesticide data available in either an anecdotal or numeric format for this segment.

Current Data. All of the pesticide data available are fish tissue and sediment data in the Upstream Snake River, Brownlee Reservoir, and Downstream Snake River segments of the SR-HC TMDL reach. No pesticide data specific to Oxbow Reservoir are known to exist. There are also no water column pesticide data available except for those collected in the Upstream Snake River segment (RM 409 to 335) (Rinella *et al*., 1994).

Table 2.3.28 Pesticide monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Pesticides Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	None	None (See Clark and Maret, 1998; Rinella *et al.*, 1994 for Brownlee and Upstream segments)

Segment Status. The only pesticide data available that is applicable (albeit indirectly) to the Oxbow reservoir segment (RM 285 to 272.5) are from studies conducted in upstream and downstream waters. These data are primarily from fish and sediment analysis with only a very small data set from the water column.

Many of the same physical and chemical processes that control mercury transport also control pesticide transport. Therefore the same interpolations of transport made for mercury have been applied to the assessment of legacy pesticides. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow (greater than 99%).
- The majority of sediments delivered to Oxbow Reservoir come from the Brownlee Reservoir outflow.
- Due to the depositional nature of Brownlee Reservoir, the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway for the pesticides (observed in Brownlee Reservoir) to move into Oxbow Reservoir.
- Because there are no other significant inflows to Oxbow Reservoir, the major source of pesticides in Oxbow Reservoir is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, pesticide concentrations in Oxbow Reservoir are not expected to exceed those observed in Brownlee or the upstream Snake River segments. In a conservative assessment, pesticide concentrations in Oxbow can be assumed to be less than or equal to those observed in Brownlee. Average pesticide fish tissue levels in Brownlee are: 60 ug/kg DDT; 1600 ug/kg DDD; 216 ug/kg DDE; and 51.5 ug/kg dieldrin (Rinella, *et al.*, 1994; Clark and Maret, 1998). However, the existing data set is very small (18 fish tissue data points, 4 water column data points, 8 sediment data points). Therefore, more data would be very helpful in the determination of impaired, threatened or full support status of these designated beneficial uses.

Sediment.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for sediment. Additional, more detailed information on sediment is included in Section 3.5.

<u>General Concerns</u>. See Section 2.2.4.5.

<u>Water Quality Targets</u>. See Section 2.2.4.5 and Table 2.2.2.

<u>Common Sources</u>. See Section 2.2.4.5. The majority of sediment loading to Oxbow Reservoir is sediment processed through Brownlee Reservoir.

<u>Historical Data</u>. Anecdotal information available indicates that this segment of the SR-HC TMDL reach has historically carried a substantial sediment load particularly during spring runoff. However there is little quantitative data from earlier periods (particularly prior to the construction of the Hells Canyon Complex).

<u>Current Data</u>. Total suspended sediment data has been collected for the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach as shown in Table 2.3.29. While some total suspended sediment data are available from US EPA (US EPA, 1998a), the majority of the

data have been collected by IPCo and are from the Brownlee Dam outflow. These data should be representative of the system as a whole as the Brownlee Dam outflow constitutes over 99 percent of the flow into Oxbow Reservoir.

Data collected show the concentration of total suspended sediment ranges between low values of 2 mg/L to 8 mg/L (early winter months), and high values of 11 mg/L to 26 mg/L (April and May) and 8 mg/L to 215 mg/L (late winter months). While these data show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. However, the maximum concentrations observed during the late winter months are well above the 50 mg/L monthly average sediment target established by the SR-HC TMDL.

Segment Status. The data listed in Table 2.3.29 represent outflow total suspended sediment data from Brownlee Dam and limited data available from habitat assessments of the Wildhorse River inflow. Because over 99 percent of the total inflow to Oxbow Reservoir comes directly from the Brownlee Reservoir outflow, total suspended sediment levels in Oxbow Reservoir are expected to be similar to those observed in the outflow from Brownlee Reservoir. Figure 2.3.27 shows available total suspended sediment concentrations for the Oxbow Reservoir segment (RM 285 to 272.5). The increase in total suspended sediment concentration observed in the winter months is most probably due to the release of water from Brownlee Reservoir for flood control during late winter months. Fine sediments entrained in the release flows from Brownlee Reservoir along with sediments in the tail waters of Oxbow Reservoir disturbed by the incoming water combine to increase total suspended sediment for a brief period of time.

Wildhorse River experiences seasonal and precipitation-driven variability in total suspended sediment concentrations. Higher total suspended sediment concentrations occur with snowmelt and precipitation events that result in increased flow volume and velocity. These inputs contribute a relatively small amount of sediment to the reservoir and are not projected to represent a substantial source of the overall sediment load to the reservoir.

Table 2.3.29 Total suspended solids monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Sediment Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1974 to 1981	IPCo, 2000c US EPA STORET data, 1998a

Using the Brownlee Reservoir outflow as the primary source of flow to the reservoir, total suspended sediment concentrations in Oxbow Reservoir would be expected to average less than or equal to 5.4 mg/L near the inflow. Sediment constituents are expected to be weighted toward finely divided particles, (most probably silt and clay) due to the settling effect observed in Brownlee Reservoir. Due to the relatively short length of the Oxbow Reservoir (12 miles), and the relatively short retention time (1.4 days), a substantial portion of the suspended particles would be expected to pass through to the downstream segments of the SR-HC TMDL reach.

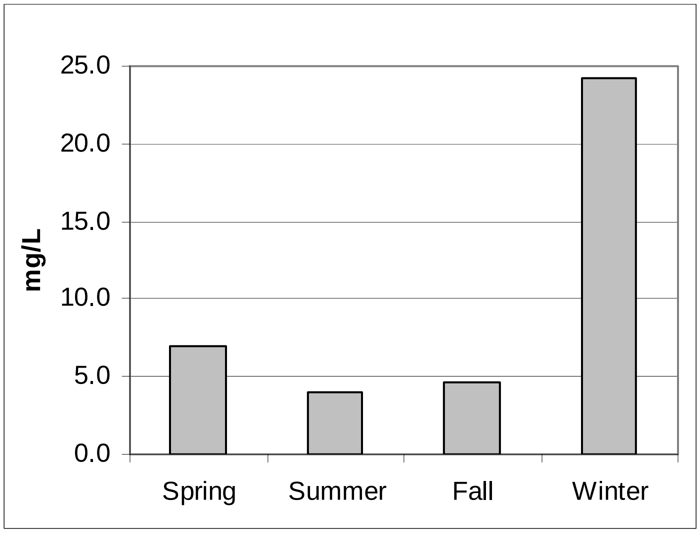


Figure 2.3.27 Mean total suspended solids (TSS) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Sediment transport, and the transport and delivery of sediment-bound pollutants are directly associated with increased flow volumes and high velocities. Sedimentation process within Oxbow Reservoir (and Hells Canyon Reservoir downstream to an even greater degree) is reduced due to the depositional processes that occur in Brownlee Reservoir. (For more detail see the discussion of sedimentation in Brownlee Reservoir in Section 2.3.2.) Larger size particles (sands and gravels) and the associated sediment-bound pollutants are not often transported to Oxbow Reservoir, as they tend to accumulate in the upper portion of Brownlee Reservoir. Sediment in Oxbow Reservoir is expected to consist predominantly of smaller silt and clay particles and some heavier colloidal matter. As Oxbow Reservoir is not operated for flood control, it is not expected that this sediment is often re-entrained into the water column by processes other than significant increases in flow due to flood control releases from Brownlee Reservoir and exceptional runoff events such as the 1997 flooding.

Available data do not contain duration information and therefore are not sufficient to determine if cold water aquatic life, salmonid rearing, or residential fish and aquatic life designated beneficial uses are impaired due to direct sediment effects. However, measured concentrations do not indicate that sediment caused impairment is occurring for cold water aquatic life or salmonid rearing designated beneficial uses. Sediment targets are set to be protective of these uses. Additionally, due to the fact that sediment acts as a primary transport mechanism for adsorbed pollutants, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

Temperature.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for temperature due to violations of Oregon water quality standards, including numeric and narrative criteria for salmonid rearing/cold water aquatic life, and resident fish and aquatic life.

General Concerns. See Section 2.2.4.6.

Water Quality Targets. See Section 2.2.4.6 and Table 2.2.2.

Common Sources. See Section 2.2.4.6.

Historical Data. Available historical temperature data from 1954 through 1957 at the Oxbow Reservoir Dam site (USFWS, 1957 and 1958) show daily maximum and average temperature measurements that exceed the temperature targets for the SR-HC TMDL (see Table 2.3.30). The sampling location of the 1950s data is given only as the Oxbow Dam site so it is assumed to be the same as the current dam site, RM 272.5. These data, when combined with information on historical water management occurring upstream of RM 272.5 and available air temperature data, indicate that waters in this segment probably experienced warming due to both anthropogenic and non-anthropogenic sources prior to dam construction.

Table 2.3.30 Temperature measurements from Oxbow Reservoir Dam site from 1954 to 1957 (USFWS 1957, 1958).

	Temperature (°C)							
Month	**1954**		**1955**		**1956**		**1957**	
	Mean Ave.	Mean Max.	Mean Ave.	Mean Max.	Mean Ave.	Mean Max.	Mean Aver.	Mean Max.
January	n.a.	n.a	0.9	1.1	2.9	3.2	1.1	1.3
February	5.8	6.2	1.7	1.9	1.8	2.1	2.9	3.0
March	6.9	7.5	5.0	5.4	6.3	6.6	7.1	7.2
April	11.6	12.2	9.5	9.9	10.7	11.0	10.7	11.1
May	15.7	16.3	14.2	14.7	14.8	15.3	15.0	15.5
June	17.7	18.4	19.2	19.8	17.8	18.4	19.0	19.5
July	23.9	24.6	22.2	22.8	24.6	25.1	22.4	22.7
August	20.9	21.4	23.0	23.5	22.3	22.8	21.7	22.0
September	17.7	18.1	18.9	19.2	19.2	19.6	18.1	18.5
October	11.6	12.9	13.0	13.3	n.a.	n.a.	12.7	13.0
November	7.9	8.1	5.1	6.2	n.a.	n.a.	6.9	7.1
December	2.3	2.6	3.4	3.6	n.a.	n.a.	4.2	4.4

Current Data. Current temperature data available for the Oxbow Reservoir segment (RM 285 to 272.5) include monitoring of both tributary and mainstem values. Water temperature data for some areas of the drainage extend back to the early 1960's, and represent a variety of high and low annual precipitation levels. Daily maximum, mean and minimum water temperatures are recorded at the inflow to Oxbow Reservoir but collection frequency and period of record for the other areas of the reservoir varies considerably. Table 2.3.31 contains data sources for water temperatures observed in Oxbow Reservoir.

Table 2.3.31 Temperature monitoring information for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Temperature Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1965 to 1980	IPCo, 2000c US EPA STORET data, 1998a

Photo 2.3.4. The mainstem Snake River near the Oxbow Dam site (RM 272.5), circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

Segment Status. A plot of historic vs. current temperature in the Oxbow Reservoir segment (RM 285 to 272.5) is shown in Figure 2.3.28. The plotted data show that pre- and post-impoundment temperature values are relatively similar over all.

The primary source of water inflowing to Oxbow Reservoir is Brownlee Reservoir, immediately upstream (greater then 99% of the total inflow). Water released from the deep penstocks of Brownlee Dam maintains a fairly stable temperature. The average summer temperature of inflowing water is 18 ^{o}C (64.4 ^{o}F). The average winter season temperature of inflowing water is approximately 5 ^{o}C (41 ^{o}F). Due to the short residence time, the temperature of water moving downstream through Oxbow Reservoir increases only minimally (less than 3 ^{o}C (5.4 ^{o}F) over the length of the reservoir). As there are relatively few anthropogenic influences on temperature in the Oxbow Reservoir area outside of the hydropower facilities themselves, temperature increases within the surface layers of the reservoir are most likely due to solar radiation and high summer air temperatures. Daily maximum and minimum water temperatures show a wider overall range

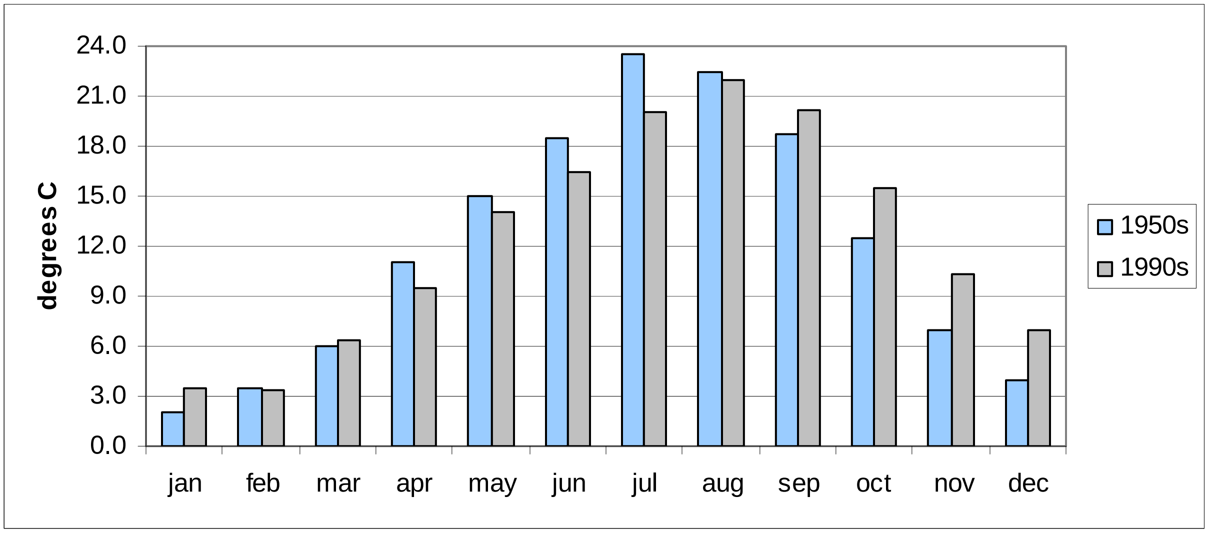


Figure 2.3.28. Pre-impoundment (1950s) vs. post-impoundment (1990s) water temperatures at Oxbow Dam (RM 272.5) in the Snake River - Hells Canyon TMDL reach.

and greater total variance as distance from Brownlee Dam increases. The data presented in Figure 2.3.28 show cooler maximum water temperatures (approximately 3.5 ^{o}C) in the summer months post-impoundment as compared to pre-impoundment water temperatures. The plotted data also show a temporal shift in maximum temperatures similar to that observed in the outflow from Brownlee Dam (Figure 2.3.23). The timing of temperature maxima post-impoundment is shifted slightly later in the year as compared to pre-impoundment maxima. The magnitude of the shift is comparable to that observed in the outflow from Brownlee Dam, approximately one month (~30 days).

Wildhorse Creek flows into Oxbow Reservoir immediately below Brownlee Dam. Water temperatures in Wildhorse Creek exhibit more seasonal variability than the penstock releases from Brownlee Dam, with annual maximum temperatures reaching 20 ^{o}C (68 ^{o}F), usually in July or August; and annual minimum temperatures dropping to less than 4 ^{o}C (39 ^{o}F) in the winter months of December or January. As the relative flow contribution of Wildhorse Creek is so small (less than 1% of the total inflow), changes in temperature within Oxbow Reservoir due to Wildhorse inflows are assumed to be minimal.

Available data show exceedences of temperature criteria throughout the surface waters of the SR-HC TMDL reach during the months of June, July, August and September. Cold water aquatic life and salmonid rearing designated uses are supported in the Oxbow Reservoir segment (RM 285 to 272.5) due to the presence of cold water refugia.

Total Dissolved Gas.

General Concerns. See Section 2.2.4.7.

Water Quality Targets. See Section 2.2.4.7 and Table 2.2.2.

Common Sources. See Section 2.2.4.7.

Historical Data. There are no historical total dissolved gas data available.

Current Data.. The current data on total dissolved gas have been collected by IPCo. Spill tests were conducted at Brownlee Dam on June 4, 1998 at a spill level of 39,000 cfs. The total dissolved gas levels observed from spilling through the upper gates averaged 114 percent of saturation while spill through the lower gates averaged 127.7 percent of saturation. Spill from Brownlee Dam was identified as the largest influence on total dissolved gas concentrations within Oxbow and Hells Canyon Reservoirs (IPCo, 1999b, 1999f). However, while elevated total dissolved gas concentrations from spill at Brownlee Dam have been observed to have an effect on the total dissolved gas in Oxbow and Hells Canyon reservoirs, the effect is not observed to extend to the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach.

Segment Status. Exceedences of the total dissolved gas target of less than 110 percent occur in both Oxbow and Hells Canyon reservoirs (as related to spill from Brownlee Dam in excess of 2,000 to 3,000 cfs).

Elevated total dissolved gas levels from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas levels that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

During the period of no spill, the state standard of less than 110 percent of saturation total dissolved gas within the Snake River below Hells Canyon Dam was always met (IPCo, 1999b).

2.3.3.3 Data Gaps

See Section 2.4

2.3.3.4 Pollutant Sources

See Section 2.5

Point Sources

There are no known permitted point sources that discharge directly to Oxbow Reservoir outside of the permit for discharge from Brownlee Dam. This permit applies to miscellaneous discharge water only, not water released directly through the dam.

Nonpoint Sources

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.

A very limited amount of cropping occurs within the Oxbow Reservoir drainage. No known agricultural return flows have been identified within the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. Grazing occurs to a limited extent in some areas within this segment but animal densities are minimal.

Recreational.

Due to its proximity to populated urban areas and the excellent recreational opportunities available, Oxbow Reservoir is a major destination site year-round. Water-based recreational activities peak in the summer season with heavy use observed between Memorial Day weekend and Labor Day weekend, when the reservoir is used by many boaters, swimmers, campers and anglers. The average use of the reservoir (May 1997 through October 1998) is estimated at 721,124 visitor hours annually. Peak use during a week has been estimated at 48,436 visitor hours (July 4th), and monthly peak use levels estimated at 145,310 visitor hours (July). Camping and bank-fishing use is also substantial in this segment (IPCo, 2000b; HCNRA, 1998a and 1998b, 1999a and 1999b).

Urban/Suburban.

A minor amount of the urban/suburban land within the SR-HC TMDL reach is located in the drainage area of the Oxbow Reservoir segment (RM 285 to 272.5). Rural residential housing supported by septic systems is present within this segment but densities are minimal.

Ground Water.

Many natural springs and ground-water inflows have been observed in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. These inflows occur in the tributary drainages and the reservoir system, entering both above and below the water level in many locations. Subsurface recharge from irrigation water use is estimated to be minimal in the Oxbow Reservoir segment due to low irrigation water usage in this area. Natural ground-water inputs are estimated to dominate over subsurface recharge in most areas of this segment.

***Background and Natural Contributions*.**

The natural sources of pollutants discussed in Section 2.5 are known to be present to some degree in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. However, the occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) than in the Oxbow Reservoir segment (RM 285 to 272.5).

2.3.3.5 Pollution Control Efforts

See Section 2.6.

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2.3.4 Hells Canyon Reservoir (RM 272.5 to 247):

The Hells Canyon Reservoir segment (RM 272.5 to 247) includes Hells Canyon Reservoir from the outflow of Oxbow Dam to Hells Canyon Dam (Figure 2.3.29). This segment is also fairly small and fast flowing with a total volume of 170,000 acre-feet and an average retention time of 4 days (Table 2.3.32). The reservoir has a surface area of about 2,500 acres and approximately 56 miles of shoreline (IPCo, 1999a). Flow into Hells Canyon Reservoir is almost exclusively the outflow of Oxbow Reservoir. Pine Creek, which flows directly into the reservoir near the Oxbow Dam, constitutes less than 1 percent of the total inflow. Flow and residence time within the reservoir are controlled by the releases from Oxbow Reservoir and the releases from Hells Canyon Dam. Hells Canyon Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with the reservoir boundaries.

Table 2.3.32 Physical characteristics of Hells Canyon Reservoir.

Date Closed	1967
Full Pool (feet msl)	1,688
Minimum Pool (feet msl)	1,678
Total Volume (acre-feet)	170,000
Surface Area (acres)	2,412
Mean Depth (feet)	70
Length (river miles)	25
Mean Width (feet)	1000
Shoreline (miles)	56
Average Retention Time (days)	4

2.3.4.1 INTRODUCTION

For a discussion on the effect of impoundments within the SR-HC TMDL reach see Section 2.1.1.4

While most of the processes discussed in Section 2.1.1.4 can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Brownlee Reservoir, located in the farthest upstream position in the Hells Canyon Complex, acts as a sink for both sediment and nutrients within the Hells Canyon Complex and downstream river segments; deep-water releases also act to lower water temperatures in downstream segments. To a lesser degree, Hells Canyon Reservoir acts in this same capacity and reduces sediment and attached pollutants that might otherwise enter downstream segments. While these changes in transport can act to improve water quality, the agencies prefer to prevent the initial pollutant loading into a water system than to depend on instream treatment systems (ODEQ, 1999).

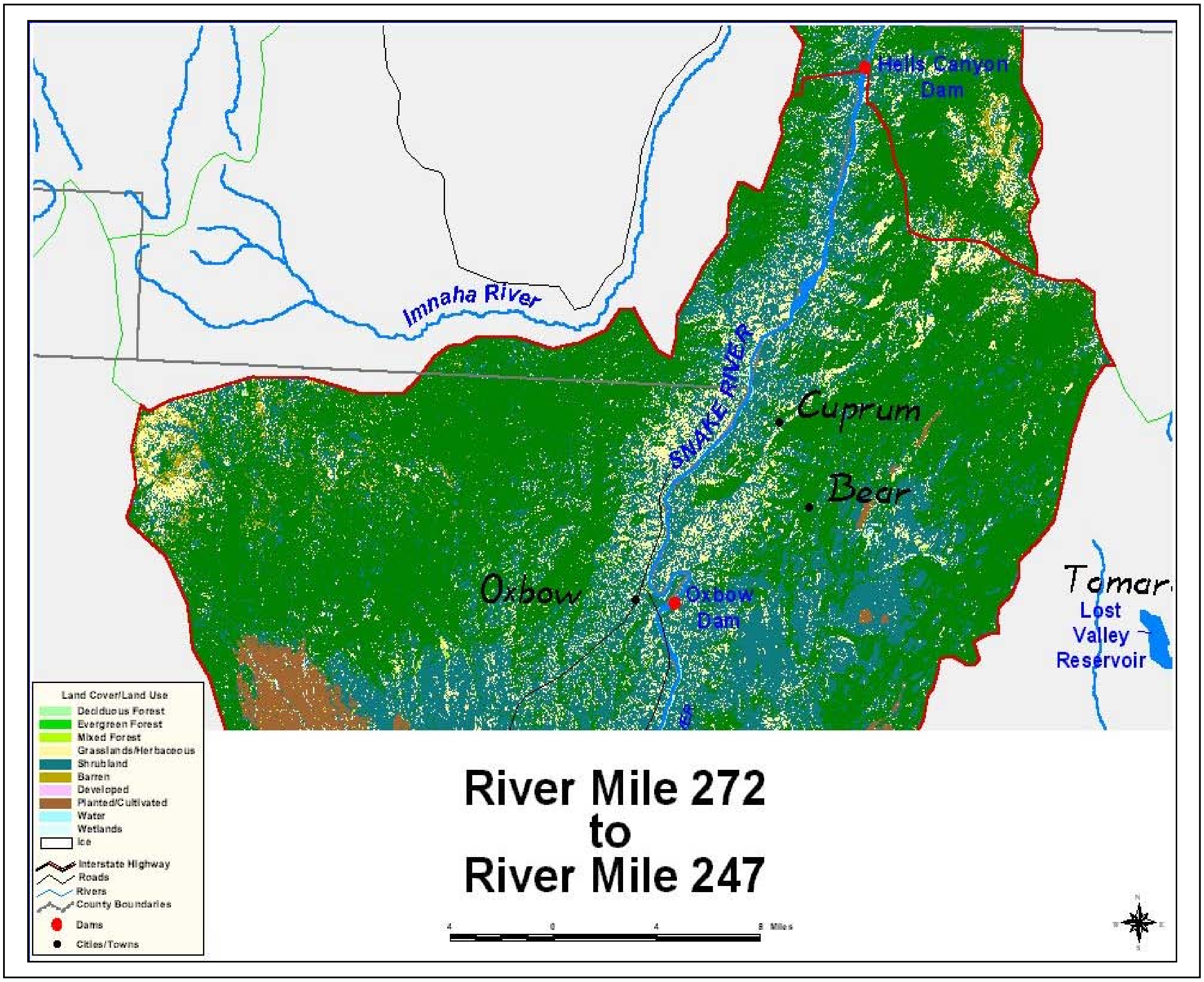

Figure 2.3.29 Hells Canyon Reservoir segment of the Snake River – Hells Canyon reach.

2.3.4.2 WATER QUALITY CONCERNS/STATUS

General Information

The waters in the Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach are listed as water quality limited due to mercury and elevated temperatures (Table 2.3.33). A detailed examination of the data available to this assessment has identified that the listing for mercury depends on data and interpolation from upstream sources.

Table 2.3.33 Listing information for the Hells Canyon Reservoir segment (RM 272.5 to 247) of the Snake River - Hells Canyon TMDL reach.

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 272.5 to 247 Hells Canyon Reservoir	Not listed	Cold water aquatic life primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower
Snake River: RM 260 to 188 Lower half of Hells Canyon Reservoir Downstream Snake River (Grande Ronde Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics anadromous fish passage commercial navigation and transport

* Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

Both of the pollutants and their potential affects on the Hells Canyon Reservoir segment (RM 272.5 to 247) are described in more detail in the following sections.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.33 summarizes the listed pollutants and designated beneficial uses for the Hells Canyon Reservoir segment (RM 272.5 to 247). A more detailed description of each of the designated beneficial uses is included in Section 2.2.2. A more detailed description of the listed pollutants and the assessment process is located in Section 3.0 through 3.7.

Salmonid rearing as well as resident fish are designated as beneficial uses in this segment. The primary salmonid species in this segment are rainbow trout and mountain whitefish however; bull trout have been documented in the Hells Canyon Reservoir. Resident fish include such cool and warm water fish as bass, crappie, and catfish. The resident cool and warm water fish form the dominant fish community in the Hells Canyon Reservoir segment (RM 272.5 to 247).

Summary and Analysis of Existing Water Quality Data

Mercury.

The Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach is listed as water quality limited due to a human fish consumption advisory for mercury from the State of Oregon (Appendix D).

General Concerns. In addition to the general information available in Section 2.2.4.2, methylation of mercury is of specific concern within the reservoir environment. Low dissolved oxygen levels and the presence of a substantial amount of organic material near the sediment/water interface can result in higher rates of methylmercury production, as hydrocarbon materials from the organic matter are available to bond with elemental mercury. Methylmercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds as it is much more soluble in water and therefore much more mobile within both the physical reservoir system and the metabolic systems of living organisms living in or utilizing the water.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2. The majority of mercury loading to Hells Canyon Reservoir is from mercury processed through Brownlee and Oxbow Reservoirs.

Historical Data. There are no known historical mercury data for the Hells Canyon reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach available in either an anecdotal or numeric format.

Current Data. There are no known current data for Hells Canyon Reservoir, such as those cited for the Upstream Snake River (RM 409 to 335), Brownlee Reservoir (RM 335 to 285), and Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach.

Table 2.3.34 Mercury monitoring for the Hells Canyon Reservoir segment (RM 272.5 to 247) of the Snake River - Hells Canyon TMDL reach.

Segment	Mercury Monitoring Dates	Source
Hells Canyon Reservoir (RM 272.5 to 247)	None	None (see sources for Brownlee and Upstream segments)

Segment Status. Because the only mercury data available that is applicable to the Hells Canyon Reservoir segment (RM 272.5 to 247) are from studies conducted in upstream and downstream waters, some interpolations of transport have been made. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow Reservoir (greater than 99%).
- The outflow from Oxbow Reservoir represents the predominant source of water for the Hells Canyon Reservoir segment (greater than 99%).
- The majority of sediments delivered to Oxbow and then Hells Canyon Reservoir come from the Brownlee Reservoir outflow.
- Due to the depositional nature of Brownlee Reservoir the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter. There would be some further but much more limited deposition of larger particles in Oxbow Reservoir.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway potential for mercury from Brownlee Reservoir into Oxbow Reservoir and on into Hells Canyon Reservoir.
- Because there are no other significant inflows to either Oxbow Reservoir or Hells Canyon Reservoir, the major source of mercury in Hells Canyon Reservoir is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, mercury concentrations in Hells Canyon Reservoir are not expected to exceed those observed in Brownlee or the upstream Snake River segments. In a conservative assessment, mercury concentrations in Hells Canyon Reservoir can be assumed to be less than or equal to those observed in Brownlee Reservoir.

Upstream data show impairment of the designated beneficial use of fishing. Available upstream data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, domestic water supply designated beneficial uses.

Temperature.

The Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach is listed for temperature due to violations of the Oregon and Idaho water quality standards, including the numeric and narrative criteria for salmonid rearing/cold water aquatic life, resident fish and aquatic life.

General Concerns. See Section 2.2.4.6.

Water Quality Targets. See Section 2.2.4.6 and Table 2.2.2.

Common Sources. See Section 2.2.4.6.

Historical Data. There are no known historical temperature data for this segment available in either an anecdotal or numeric format.

Current Data. Current temperature data available for the Hells Canyon Reservoir segment (RM 272.5 to 247) include monitoring of both inflow and mainstem values. Water temperature data for some areas of the drainage extend back to the 1990's and represent a variety of high and low annual precipitation levels. Daily maximum, mean and minimum water temperatures are recorded at the inflow to Hells Canyon Reservoir, but collection frequency and period of record varies in other areas of the reservoir.

Table 2.3.35. Surface water temperature monitoring information for the Hells Canyon Reservoir segment (RM 272.5 to 247) of the Snake River - Hells Canyon TMDL reach.

Segment	Temperature Monitoring Dates	Source
Hells Canyon Reservoir (RM 272.5 to 247)	1990 to 1999 1973 to 1982	IPCo, 2000c US EPA STORET data, 1998a

Segment Status. The primary source of water inflowing to Hells Canyon Reservoir is from Oxbow Reservoir, immediately upstream (more than 99% of the total inflow). The average summer temperature of inflowing water is 19°C (66°F). The average winter season temperature of inflowing water is approximately 5°C (41°F). Due to the short residence time, the temperature of water moving downstream through Hells Canyon Reservoir increases only minimally (less than 3°C (5.4°F) over the length of the reservoir). As there are relatively few anthropogenic sources of elevated temperature in the Hells Canyon Reservoir area outside of the hydropower facilities themselves, temperature increases within the reservoir are most likely due in most part to solar radiation and high summer air temperatures. Daily maximum and minimum water temperatures show a wider overall range and greater total variance as distance downstream from Oxbow Dam increases.

Pine Creek flows into Hells Canyon Reservoir below Oxbow Dam. Water temperatures in Pine Creek exhibit some seasonal temperature variability, with annual maximum temperatures reaching 20°C (68°F), usually in July or August; and annual minimum temperatures dropping to ~4°C (39°F) in the winter months of December or January. As the relative flow contribution of Pine Creek is quite small (less than 1% of the total inflow), changes in temperature within Hells Canyon Reservoir due to Pine Creek inflows are assumed to be minimal.

Available data show exceedences of temperature criteria throughout the surface waters of the SR-HC TMDL reach during the months of June, July, August and September. Cold water aquatic life and salmonid rearing designated uses are supported in the Hells Canyon Reservoir segment (RM 272.5 to 247) due to the presence of cold water refugia.

Total Dissolved Gas.

General Concerns. See Section 2.2.4.7.

Water Quality Targets. See Section 2.2.4.7 and Table 2.2.2.

Common Sources. See Section 2.2.4.7.

Historical Data. There are no historical total dissolved gas data available.

Current Data. The current data available for total dissolved gas have been collected by IPCo. Spill tests were conducted at Brownlee Dam on June 4, 1998 at a spill level of 39,000 cfs. The total dissolved gas levels observed from spilling through the upper gates averaged 114 percent of saturation while spill through the lower gates averaged 127.7 percent of saturation. Spill from Brownlee Dam was identified as the largest influence on total dissolved gas concentrations within Oxbow and Hells Canyon reservoirs (IPCo, 1998c, 1999b, 1999f). However, while elevated total dissolved gas concentrations from spill at Brownlee Dam have been observed to have an effect on the total dissolved gas in Oxbow and Hells Canyon reservoirs, the effect is not observed to extend to the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach.

Segment Status. Exceedences of the total dissolved gas target of less than 110 percent occur in both Oxbow and Hells Canyon reservoirs (as related to spill from Brownlee Dam in excess of 2,000 to 3,000 cfs).

Elevated total dissolved gas levels from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas levels that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

During the period of no spill, the state standard of less than 110 percent of saturation total dissolved gas within the Snake River below Hells Canyon Dam was always met (IPCo, 1999b).

2.3.4.3 DATA GAPS

See Section 2.4

2.3.4.4 POLLUTANT SOURCES

See Section 2.5

Point Source

The only known permitted point source that discharges directly to Hells Canyon Reservoir is the permit for discharge from Oxbow Dam. The Oxbow Dam permit applies to miscellaneous discharge water only, not water released directly through the dam and the mining permit applies to water discharged from a settling pond that is dry most of the year. The Alta Gold Mine (formerly the Iron Dyke copper and gold mine) located at Homestead is not currently operating and does not discharge to the Snake River.

Nonpoint Source

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.

A minor amount of the agricultural land (less than 0.1%) within the SR-HC TMDL reach is located in the drainage area of Pine Creek that flows into the Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach. No known agricultural return flows have been identified within the Hells Canyon Reservoir segment of the SR-HC TMDL reach. Grazing occurs to a limited extent in some areas within this segment but animal densities are minimal.

Recreational.

Due to its relative proximity to populated urban areas and other recreational opportunities within the Hells Canyon Complex, Hells Canyon Reservoir is a major destination site year-round. Water-based recreational activities peak in the summer season with heavy use observed between Memorial Day weekend and Labor Day weekend, when the reservoir is used by many boaters, swimmers, campers and anglers. The average use of the reservoir (May 1997 through October 1998) is estimated at 120,902 visitor hours annually. Peak use during a week has been estimated at 10,864 visitor hours (July 4th), and monthly peak use levels estimated at 32,592 visitor hours (July). Camping and bank-fishing use occurs at substantial levels (IPCo, 2000b; HCNRA, 1998a and 1998b, 1999a and 1999b).

Urban/Suburban.

A minor amount of the urban/suburban land within the SR-HC TMDL reach is located in the drainage area of the Hells Canyon Reservoir segment (RM 272.5 to 247). Rural residential housing supported by septic systems is present in and around the city of Oxbow but densities are minimal.

Ground Water.

Many natural springs and ground-water inflows have been observed in the Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach. These inflows occur in the tributary drainages and the reservoir system, entering both above and below the water level in many locations. Subsurface recharge from irrigation water use is estimated to be minimal in the Hells Canyon Reservoir segment due to low irrigation water usage in this area. Natural ground-water inputs are estimated to dominate over subsurface recharge in most areas of this segment.

Background and Natural Contributions.

The natural sources discussed above are known to be present to some degree in the Hells Canyon Reservoir segment (RM 272.5 to 247) of the SR-HC TMDL reach. However, the occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) than in the Hells Canyon Reservoir segment (RM 272.5 to 247).

2.3.4.5 POLLUTION CONTROL EFFORTS

See Section 2.6.

2.3.5 Downstream Snake River (RM 247 to 188):

The Downstream Snake River segment (RM 247 to 188) includes the Snake River from below Hells Canyon Dam to immediately upstream of the Salmon River inflow (Figure 2.3.30). This segment is a rapid flowing, narrow river characterized by high, steep canyon walls and stretches of white water. The flow and volume of this segment are almost completely driven by the outflow of the Hells Canyon Complex reservoirs and support significant recreational uses year round.

Photo 2.3.5. The mainstem Snake River downstream of the Hells Canyon Dam site (RM 247), circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

2.3.5.1 INTRODUCTION

For a discussion on the effect of impoundments within the SR-HC TMDL reach see Section 2.1.1.4

While most of the processes discussed in Section 2.1.1.4 can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Brownlee

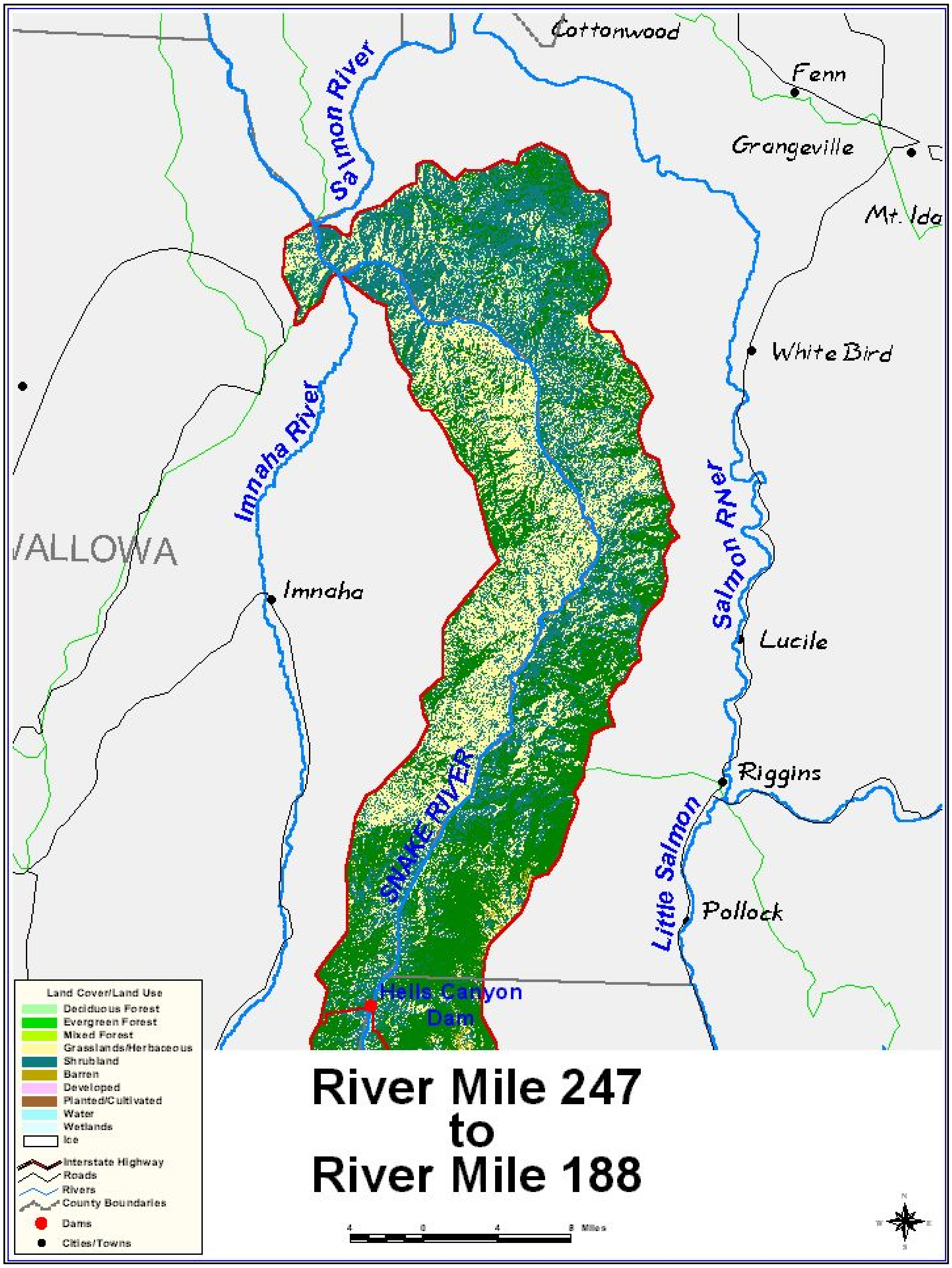

Figure 2.3.30. The Downstream Snake River segment (RM 247 to 188) of the Snake River – Hells Canyon TMDL reach.

Reservoir, located in the farthest upstream position in the Hells Canyon Complex, acts as a sink for both sediment and nutrients within the Hells Canyon Complex and downstream river segments; deep-water releases also act to lower water temperatures in downstream segments. To a lesser degree, Hells Canyon Reservoir acts in this same capacity and reduces sediment and attached pollutants that might otherwise enter downstream segments. While these changes in transport act to improve some aspects of water quality in the Downstream Snake River segment (RM 247 to 188), the agencies prefer to prevent the initial pollutant loading into a water system than to depend on instream treatment systems (ODEQ, 1999).

The Imnaha River (inflow at RM 191.6) represents less than 3 percent of the average total downstream Snake River system flow and drains approximately 622 square miles of land in eastern Oregon. Land use is primarily forested and agricultural, with pastureland grazing being the predominant practice. A TMDL for the Imnaha Basin in Oregon targeting temperature was completed in 2001. Flow patterns within the Imnaha drainage are seasonal in nature. Increasing during spring runoff (usually extending from late February to early April) when mountain snows melt and spring rains increase secondary tributary flows (maximum of 20,200 cfs in January 1997). Irrigation needs and dryer summer weather patterns significantly reduce summer and fall flows. These flows are often less than 7 percent of those observed during the spring melt (minimum of 16 cfs in November of 1931). Average flows vary from 1,930 cfs during spring runoff to an average of 44 cfs during the late summer season (annual averages compiled from 1929 to 1999 USGS flow data from the gauge #13292000). Please note: This gauge station is the only one available for the mainstem Imnaha River with a consistent database for the period of record. While the relative differences in flow from this station are useful in interpreting overall seasonal trends for this system, it is located some distance upstream from the mouth of the Imnaha River. As such, it does not necessarily reflect the total annual average flows at the discharge to the mainstem Snake River.

2.3.5.2 WATER QUALITY CONCERNS/STATUS

General Information

The waters in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach are listed as water quality limited for mercury and elevated temperatures (Table 2.3.36). A detailed examination of the data available to this assessment has identified that no water column mercury data exists so it is not possible to assess compliance with the SR-HC TMDL mercury target. However a fish consumption advisory for mercury is currently in place for the State of Oregon and therefore the designated use of fishing is not fully supported. Elevated water temperatures in excess of the salmonid spawning and salmonid rearing/cold water aquatic life have been observed to occur in this segment. Both the pollutants and their potential affects on this segment of the SR-HC TMDL reach are described in more detail in the following sections.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.36 summarizes the listed pollutants and designated beneficial uses for the Downstream Snake River segment (RM 247 to 188). A more detailed description of each of the designated beneficial uses is included in Section 2.2.2. A more detailed description of the listed pollutants and the assessment process is located in Section 3.0 through 3.7.

Table 2.3.36 Listing information for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 247 to 188 Downstream Snake River (Hells Canyon Dam to Salmon River Inflow)	Temperature	Cold water aquatic life salmonid spawning primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 260 to 188 Lower half of Hells Canyon Reservoir Downstream Snake River (Grande Ronde Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics anadromous fish passage (For notes on absence of hydropower see section 2.2.2) commercial navigation and transport

Salmonid spawning and rearing, and cold water aquatic life and resident fish are designated as beneficial uses in this segment. The salmonid species in this segment include bull, steelhead, and rainbow trout as well as fall and spring/summer chinook. The general spawning and incubation periods for the salmonid species are the following:

bull trout - September 01 to April 01 (upper tributaries only)
rainbow trout – March 01 to July 15 (tributaries only)
steelhead trout - February 01 to July 15 (tributaries only)
redband trout – March 01 to July 15 (tributaries only)

spring chinook – August 01 to April 01 (tributaries only)
summer chinook - August 15 to June 15 (tributaries only)
fall chinook – October 23 to April 15 (mainstem spawning)
mountain whitefish – November 01 to March 30 (mainstem spawning)

Of the salmonid species present, only fall chinook and mountain whitefish spawn in the mainstem Snake River within this segment of the SR-HC TMDL reach. Steelhead and rainbow trout and spring/summer chinook can spawn in the mouths of tributaries but are more likely to spawn further up the tributaries. Bull trout spawn only in the upper tributary reaches. Therefore the salmonid spawning criteria will apply in the mainstem during the fall chinook spawning period (October 23 to April 15) and the mountain whitefish spawning period (November 01 to March 30). The resident fish include such cool and warm water fish as bass, crappie, and catfish. In addition there is a population of white sturgeon in the Downstream Snake River segment (RM 247 to 188). In this segment of the river cold water fish form the dominant community.

Summary and Analysis of Existing Water Quality Data

Mercury.
The Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach is listed as water quality limited due to a human fish consumption advisory for mercury from the State of Oregon.

General Concerns. See Section 2.2.4.2.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2. The majority of mercury loading to the Downstream Snake River segment (RM 247 to 188) is from mercury processed through Hells Canyon Complex.

Historical Data. There are no known historical mercury data available in either an anecdotal or numeric format for this segment.

Current Data. The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River below Hells Canyon Dam, shows that metal toxicity levels in this segment had a “good” rating in 1986 and a “fair” rating in 1988. The overall station conditions for all evaluated pollutants were judged to be “fair” in both years. As outlined in Table 2.3.37, mercury levels have been monitored in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach on a limited basis. The data collection and analysis occurred in 1997 (Clark and Maret, 1998). However these data do not include water column data.

Table 2.3.37 Mercury monitoring for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

Segment	Mercury Monitoring Dates	Source
Hells Canyon Dam to Salmon River Inflow (RM 247 to 188)	Aug 1997	Clark and Maret, 1998 (USGS)

Segment Status. All but one of the mercury samples applicable to the Downstream Snake River segment are from studies conducted in upstream waters. The one sample included only two fish tissue samples, therefore some interpolations of transport have been made. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow and Hells Canyon Reservoirs (greater than 99%).
- Outflow from Hells Canyon Reservoir represents the majority of the water for the Downstream Snake River segment (RM 247 to 188).
- The majority of sediments delivered to Oxbow and Hells Canyon Reservoirs come from the Brownlee Reservoir outflow.

- Due to the depositional nature of Brownlee Reservoir the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter. Further, but limited, retention of all but extremely small particle sizes occurs in Oxbow and Hells Canyon Reservoirs.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway potential for mercury from Brownlee into the lower reservoirs and on into the Downstream Snake River segment (RM 247 to 188).
- Because there are no other significant inflows to this segment known to contain natural geologic or substantial legacy mining mercury activities, the major source of mercury in the Downstream Snake River segment is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, mercury concentrations in the Downstream Snake River segment (RM 247 to 188) are not expected to exceed those observed in the Hells Canyon Reservoir, Oxbow Reservoir, Brownlee Reservoir, or the Upstream Snake River segment (RM 409 to 335). In a conservative assessment, mercury concentrations in the Downstream Snake River segment (RM 247 to 188) can be assumed to be less than or equal to those observed in Brownlee Reservoir.

The one data point available in this segment of the SR-HC TMDL reach, an average of two samples collected in 1997, shows mercury levels at 0.15 mg/kg dry weight fish tissue. This is below the level used by the Oregon Division of Health to establish a mercury fish tissue advisory. It is also below the new US EPA guidance criteria for mercury in fish tissues (US EPA, 2001a, 2001b, 2001c).

Upstream data show impairment of the designated beneficial use of fishing. Available upstream data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, domestic water supply designated beneficial uses.

Temperature.

The Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach is listed for temperature due to violations of the Oregon and Idaho water quality standards, including numeric and narrative temperature criteria for cold water aquatic life, resident fish and aquatic life, and salmonid spawning and rearing.

<u>General Concerns</u>. See section 2.2.4.6.

<u>Water Quality Targets</u>. See Section 2.2.4.6 and Table 2.2.2.

<u>Common Sources</u>. See Section 2.2.4.6.

<u>Historical Data</u>. Data collected roughly monthly from 1969 to 1974 by the US EPA in the Downstream Snake River segment at RM 247 (below Hells Canyon Dam) show temperatures ranging from 2 ^{o}C in January and February, 1972 (air temperature at 6.5 ^{o}C and 7.5 ^{oC} respectively) to 22 ^{o}C in August, 1970 and 1972 (air temperature at 32 ^{o}C). When compared to

the 13 ^{o}C maximum weekly maximum temperature target identified by the SR-HC TMDL for salmonid spawning in interstate waters (because these are instantaneous data, there is no way to determine an average daily temperature) the data show that the target was routinely exceeded in September (100%) and October (57%). Roughly 26 percent of all available data show temperatures above the salmonid rearing/cold water aquatic life temperature target of 17.8 ^{o}C (all occurring during late July, August or September). The data set contained 54 data points. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974a, 1975, 1998a).

<u>Current Data</u>. Data collected roughly monthly from 1975 to 1991 by the US EPA in the Downstream Snake River segment at RM 247 (below Hells Canyon Dam) show temperatures ranging from 1 ^{o}C in January, 1979 and 1985 (air temperature at -4.5 ^{o}C and 2 ^{o}C respectively) to 24 ^{o}C in July, 1975 and September, 1987 (air temperature at 35 ^{o}C and 30 ^{o}C respectively) (Figure 2.3.31 a and b). When compared to the 13 ^{o}C maximum weekly maximum temperature target identified by the SR-HC TMDL for salmonid spawning in interstate waters (because these are instantaneous data, there is no way to determine an average) the data show that the target was routinely not met during September (82%) and October (47%). Targets were not met in November only 7 percent of the time. Roughly 22 percent of all available data show temperatures above the salmonid rearing/cold water aquatic life temperature target of 17.8 ^{o}C (all occurring during late July, August or September). This set contained 148 data points. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1975, 1998a).

Table 2.3.38 Temperature monitoring information for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

Segment	Temperature Monitoring Dates	Source
Hells Canyon Dam to Salmon River Inflow (RM 247 to 188)	Summer sampling 1980 to 1992 1968 to 1992	USGS data US EPA STORET data, 1998a

The 1986 and 1988 Water Quality Status reports for the State of Idaho (IDEQ, 1986 and 1988a), using a WQI rating for the Snake River below Hells Canyon Dam, show that temperature levels in this segment had a “good” rating both years while the overall station conditions for all evaluated pollutants were judged to be “fair” in both years. Current temperature data available for the Downstream Snake River segment (RM 247 to 188) include monitoring of both inflow and mainstem values (Figures 2.3.31 a and b). Water temperature data for some areas of the drainage extend back to the 1960’s and represent a variety of high and low annual precipitation levels. Daily maximum, mean and minimum water temperatures are recorded in some areas of the Downstream Snake River segment, but collection frequency and period of record varies.

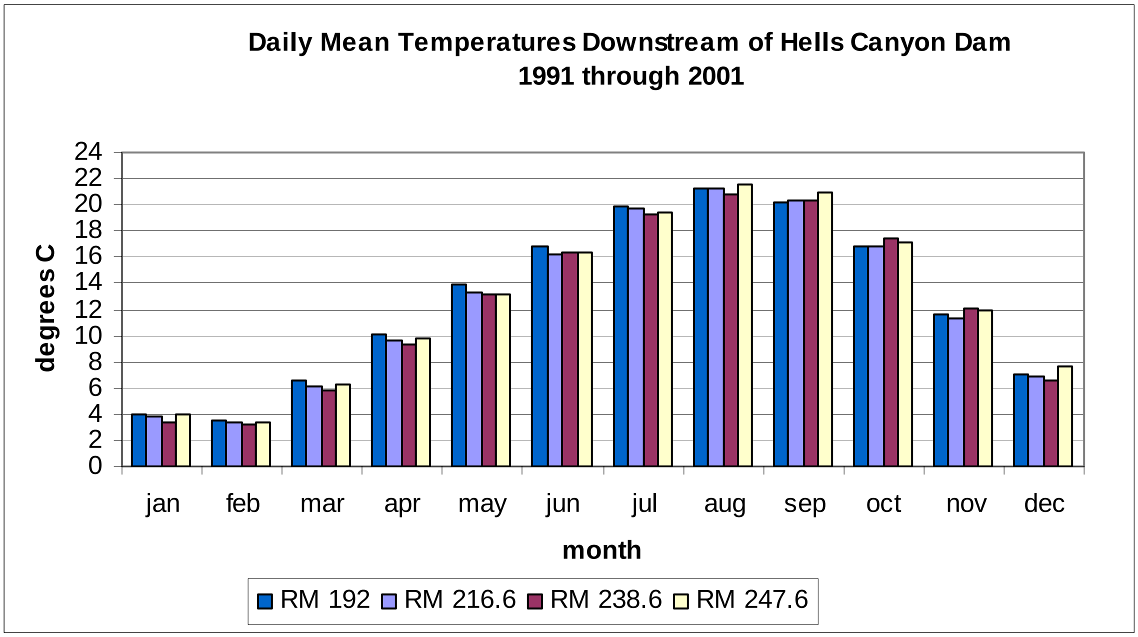

Figure 2.3.31a Mean water temperatures for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

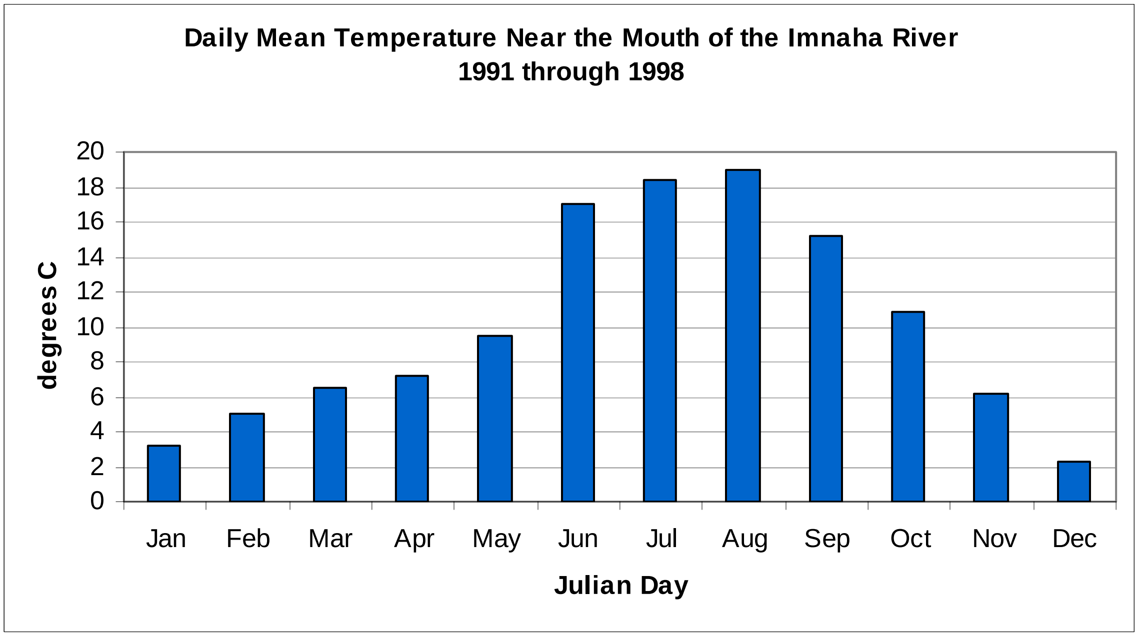

Figure 2.3.31b Mean water temperatures for the mouth of the Imnaha River at the inflow to the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

Segment Status. The primary source of water inflowing to the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach is Hells Canyon Reservoir, immediately upstream (more than 95% of the total inflow). Figure 2.3.31a and b show that the average summer temperature of inflowing water to be 20 ^{o}C (68 ^{o}F). The average winter season temperature of inflowing water is approximately 6^{o} C (43 ^{o}F). Due to the high, narrow canyon walls that provide a high degree of shading, the temperature of water moving downstream of Hells Canyon Dam does not increase rapidly. As there are relatively few anthropogenic sources of elevated temperature in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach, temperature increases within the segment are most likely due to solar radiation and high summer air temperatures, and the influence of upstream sources. Daily maximum and minimum water temperatures show a wider overall range and greater total variation as distance downstream from Hells Canyon Dam increases. Temperature changes from the outlet of Hells Canyon Dam (RM 247) to the inflow of the Salmon River at RM 188 generally average 3 ^{o}C (5.4 ^{o}F) during the summer season. The average summer temperature of inflowing water from the Salmon River is 20 ^{o}C (68 ^{o}F). The average winter season temperature of inflowing water is approximately 7 ^{o}C (45 ^{o}F).

Available data show that exceedences of the salmonid rearing/cold water aquatic life target of 17.8 ^{o}C occur during July, August and September. However, the magnitude of the observed exceedences is lower due to the effect of deep water releases from the Hells Canyon Complex upstream. Cold water aquatic life and salmonid rearing designated uses are supported in the Downstream Snake River segment (RM 247 to 188) due to this cooling effect and the presence of cold water refugia.

Available data show that exceedences of the salmonid spawning target of less than or equal to 13 ^{o}C maximum weekly maximum temperature occur during the first days of the fall chinook spawning period (starting October 23). This exceedence is due in part to the temporal shift in water temperature caused by the Hells Canyon Complex Reservoirs. However, the level of impairment (if any) of fall chinook spawning resulting from this shift has yet to be determined.

Total Dissolved Gas.

General Concerns. See Section 2.2.4.7.

Water Quality Targets. See Section 2.2.4.7 and Table 2.2.2.

Common Sources. See Section 2.2.4.7.

Historical Data. There are no historical total dissolved gas data available.

Current Data. The current data available for total dissolved gas have been collected by IPCo. Spill tests were conducted at Hells Canyon Dam on June 3, 1998 at a spill level of 28,000 cfs. The total dissolved gas levels observed from spilling through the upper gates averaged 139 percent of saturation while spill through the lower gates averaged 135 percent of saturation.

Spill episodes at Hells Canyon Dam over 19,000 cfs caused exceedences of the less than 110 percent total dissolved gas target throughout the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL. Total dissolved gas levels did not drop below 110 percent upstream of RM 188 at this level of discharge. Target exceedences from spill volumes between 9,000 cfs and 13,400 cfs were not observed downstream of RM 200, and spill volumes of 2,400 cfs showed target exceedences extending downstream to RM 230 only. During the period of no spill, the target of less than 110 percent of saturation within the Snake River below Hells Canyon Dam was always met. Total dissolved gas in the tailwater area of Hells Canyon Dam ranged from 108 percent to 136 percent while spill was occurring from Hells Canyon Dam. Nearly all levels of spill monitored resulted in total dissolved gas levels above the total dissolved gas target.

Segment Status. Spills from Hells Canyon Dam in excess of 2,000 to 3,000 cfs result in total dissolved gas levels exceeding the total dissolved gas target in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach (IPCo, 1998c, 1999b, 1999f).

Elevated total dissolved gas levels from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas levels that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

During the period of no spill, the state standard of less than 110 percent of saturation total dissolved gas within the Snake River below Hells Canyon Dam was always met (IPCo, 1999b).

2.3.5.3 Data Gaps

See Section 2.4

2.3.5.4 Pollutant Sources

See Section 2.5

Point Source

There are no known permitted point sources that discharge directly to the Downstream Snake River segment (RM 247 to 188) outside of the permit for discharge from Hells Canyon Dam. This permit applies to miscellaneous discharge water only, not water released directly through the dam.

Nonpoint Source

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.

A minor amount of the agricultural land (0.2%) within the SR-HC TMDL reach is located in the drainage area of the Imnaha River. This system flows into the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach. Agricultural practices within this drainage include dryland crops and pasture (grazing), only very limited use of irrigation is reported. Only very minimal agricultural return flows have been reported within this segment. Grazing occurs to some extent in areas of this segment but animal densities are minimal.

Recreational.
Even with its distance from populated urban areas, the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach is a popular recreational destination year-round, due to its proximity to other recreational opportunities within the Hells Canyon Complex, and the unique whitewater opportunities it represents. Water-based recreational activities peak in the summer season with heavy usage observed between Memorial Day weekend and Labor Day weekend, when the river is used by many boaters, swimmers, campers, whitewater rafters, jet-boat enthusiasts and anglers. Camping and bank-fishing use is also substantial (IPCo, 2000b; HCNRA, 1998a and 1998b, 1999a and 1999b).

Urban/Suburban.
A minor amount of the urban/suburban land within the SR-HC TMDL reach is located in the drainage areas of the Downstream Snake River segment (RM 247 to 188) and the inflowing Imnaha River drainage. Rural residential housing supported by septic systems is present within this segment but densities are quite minimal.

Ground Water.
Many natural springs and ground-water inflows have been observed in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach and the associated Imnaha River drainage. These inflows occur in the tributary drainages and the reservoir system, entering both above and below the water level in many locations. Subsurface recharge from irrigation water use is estimated to be minimal in the Downstream Snake River segment (RM 247 to 188) due to low irrigation water usage in this area. Natural ground-water inputs are estimated to dominate over subsurface recharge in most areas of this segment.

Background and Natural Contributions.
The natural sources discussed in Section 2.5 are known to be present to some degree in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach. However, the occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) than in the Downstream Snake River segment (RM 247 to 188).

2.3.5.5 POLLUTION CONTROL EFFORTS

See Section 2.6

Other TMDL Efforts
No TMDLs or watershed management plans are currently in place in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach with the exception of the Hells Canyon National Recreation Area Comprehensive Management plan amendment to the Wallowa-Whitman National Forest Plan (USDA-USFS, 1997), and the TMDL for temperature completed for the Imnaha River Basin by ODEQ (2001).

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2.4 Data Gaps

It is the responsibility of the states of Oregon and Idaho to write TMDLs using available data. The SR-HC TMDL has a very robust data set available for the evaluation of water quality impairment, pollutant load analyses and source identification. It is the states' discretion to accept or reject data. TMDLs are to use best available data and to include margins of safety to account for unknown factors. Both IDEQ and ODEQ believe there is sufficient data to develop a scientifically accurate TMDL for the SR-HC TMDL reach of the Snake River. The current TMDL schedules for both the State of Oregon and the State of Idaho do not directly address the amount of available data. The States are charged to write TMDLs using the best available data. Reasonable existing data sets have been identified to meet the needs of the SR-HC TMDL. The fact that more data could be collected is not a viable basis for delaying a TMDL.

Available data has been used in making the initial assessment of the TMDL and implementation targets for the SR-HC system. The phased implementation process discussed previously is in part intended to allow data to be collected for those constituents for which additional data would be helpful. If these additional data show that initial water quality targets should be refined, the appropriate changes will be undertaken. This assessment has identified those areas in which additional data is required in order to finalize the TMDL process, and those areas in which additional data would be helpful to refine the current designated use support determination. These are identified by pollutant category below.

Bacteria:

- Available data is adequate.

Dissolved Oxygen:

- Intergravel dissolved oxygen data or sediment/water interface data are required to accurately assess the level of impairment of aquatic life designated uses within the Upstream Snake River segment (RM 409 to 335). While only the upper section (RM 409 to RM 396.4) of the Upstream Snake River segment is listed for dissolved oxygen, data collected throughout the segment would be helpful in assessing the support status of the mainstem river.
- Currently available qualitative information show anaerobic conditions are occurring in the Upstream Snake River segment (RM 409 to 335) but are not adequate to quantify the level of dissolved oxygen available at the sediment/water interface.

Mercury:

- Additional water column mercury data is necessary to determine the current system loading and assign wasteload allocations. Water column data is especially critical in the Upstream Snake River segment (RM 409 to 335). Very little water column mercury data is available within the SR-HC TMDL reach (RM 409 to 188). US EPA does not recommend using fish tissue data and bioconcentration factors to determine water column concentrations. This TMDL has been delayed until 2006 (US EPA approved action) to allow data collection and additional watershed assessment to occur.

Nutrients:

- Additional chlorophyll *a* data would be helpful to refine current estimates of biomass loading to the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285).
- Additional information on periphyton and other aquatic growth would be helpful to refine current estimates of biomass loading to the Upstream Snake River and Brownlee Reservoir segments.
- Irrigation drain and return flow and concentration information (total and ortho-phosphate, and chlorophyll *a*) would also be helpful in refining the current estimates of loading.
- Data supplying information on ground-water inputs (flow and total and ortho-phosphate concentration) to the SR-HC TMDL reach (RM 409 to 188) would be helpful in refining the current estimates of loading.

pH:

- Available data are adequate.

Pesticides:

- Fish tissue data and water column data for both DDT and dieldrin in Oxbow Reservoir are critical for the assessment of use impairment in the listed segment. Similar additional data in the Brownlee Reservoir (RM 335 to 285) and Upstream Snake River segment (RM 409 to 335) are critical to the refinement of designated use impairment assessments in these segments as the current data set is limited. Water column data is critical to the determination of compliance with the SR-HC TMDL targets, and the calculation of loads.

Sediment:

- Sediment data that identify both concentration and duration are critical to the accurate assessment of aquatic life designated use support in the Upstream Snake River (RM 409 to 335) and upper Brownlee Reservoir (RM 335 to RM 315) segments. The current database contains instantaneous measurements only.

Temperature:

- Available data are adequate for a rough assessment of relative temperature influences in the Upstream Snake River (RM 409 to 335) and upper Brownlee Reservoir (RM 335 to RM 285) segments. Additional data would be helpful to refine this initial assessment. Concurrent monitoring of all appropriate stations (Murphy, Nyssa and Weiser on the mainstem Snake River, and all appropriate gage sites on the inflowing tributaries is not currently available. These data would greatly improve the accuracy of the current assessment. They would make possible the application of site potential modeling (SSTEMP or similar).
- Temperature data for Oxbow (RM 285 to RM 272.5) and Hells Canyon Reservoirs (RM 272.5 to 247), and the Downstream Snake River segment (RM 247 to 188) are currently being collected and will be available as part of the re-licensing process for the Hells Canyon Complex. These data will be of value to the implementation planning process.

- Data from the tributaries identifying the relative influences of anthropogenic and natural sources will be available as part of the TMDL process for those tributaries listed for temperature. These data will help to refine the current estimates of loading.
- Irrigation drain and return flow temperature data would also be helpful in refining the current estimates of loading.
- Data supplying information on ground-water inputs (flow and temperature) to the SR-HC TMDL reach (RM 409 to 188) would be helpful in refining the current estimates of loading.

Total Dissolved Gas:

- Available data are adequate for an initial assessment of the total dissolved gas loading to the Oxbow (RM 285 to 272.5) and Hells Canyon Reservoirs (RM 272.5 to 247), and the Downstream Snake River segment (RM 247 to 188).
- Total dissolved gas data for Oxbow and Hells Canyon reservoirs, and the Downstream Snake River segments are currently being collected and will be available as part of the re-licensing process for the Hells Canyon Complex. These data will be valuable to the implementation of load allocations for total dissolved gas.

Monitoring efforts in both the mainstem and the tributaries are currently underway and many will be ongoing under the direction of various agencies and stakeholder groups throughout the implementation process. The information developed through these efforts may be used to revise portions of the TMDL, and determine and adjust appropriate implementation measures and control efforts. If changes to the TMDL are deemed appropriate, they are not expected to result in the production of a new TMDL document. Minor changes will potentially be handled through a letter amending the existing document(s). More extensive changes may require supplementary documentation or replacement of existing chapters or appendices. The goal will be to build upon rather than replace the original work wherever practical. The schedule and targets for reviewing new data will be addressed in the implementation plans. The opportunity to potentially revise the TMDL and necessary control measures is consistent with current and recently developed TMDL guidance, which emphasizes an iterative approach to TMDL development and implementation. However, any additional effort on the part of the DEQs to revise the TMDL or implementation plan and control efforts will most likely be addressed on a case-by-case basis.

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2.5 Pollutant Sources

The SR-HC TMDL reach and its tributaries exhibit altered streamflow dynamics. Flows in the SR-HC TMDL reach (RM 409 to 188) are highly regulated for agricultural irrigation, flood control, and hydropower generation. Additional anthropogenic activities have adversely impacted water quality through increased pollutant loading to the Snake River system. As discussed previously, these activities have resulted in changes to pollutant loading, transport, processing and deposition within the SR-HC TMDL reach. The degradation of water quality in the SR-HC TMDL reach (RM 409 to 188) is caused to some degree by pollutant sources related to agricultural activities, flood control, flow modifications, hydroelectric activities, industrial activities, impoundments, mining, municipal waste, and urbanization.

2.5.1 Watershed Discussion

The SR-HC watershed contains two major types of pollutant sources: point sources and nonpoint sources. Several NPDES permitted point sources discharge directly to the mainstem Snake River; many others discharge to the inflowing tributaries under NPDES permits. The discharges to the mainstem Snake River represent a minor contribution to the total pollutant loading to the SR-HC TMDL reach (RM 409 to 188) due to their extremely small contribution to overall flow. The predominant source of pollutant loading to the SR-HC TMDL reach is from nonpoint source loads to both the mainstem and the inflowing tributaries (IDEQ, 1988a and 1988b; IDEQ, 1997a; USDOE, 1985; IDEQ, 1985).

2.5.2 Point Source Pollution

For the SR-HC TMDL reach (RM 409 to 188), point sources discharging directly to the mainstem Snake River include: food processors, hydroelectric facilities, industries and municipalities (Table 2.5.0). Certain municipal, industrial and construction sources of stormwater runoff are considered point sources and are regulated by NPDES permits, either general or site specific. Most stormwater permits require pollution prevention plans. A more detailed listing of point source dischargers is available in the loading analysis sections (Section 3.0).

2.5.3 Nonpoint Source Pollution

Nonpoint sources within the SR-HC TMDL reach (RM 409 to 188) include: agricultural land-use including irrigated and non-irrigated croplands, and irrigated and dryland pasture (grazing); urban/suburban land use including urban storm sewers, runoff from impervious surfaces and construction activities; recreational uses, including both land and water-based activities; silvicultural practices and legacy mining activities. Associated pollutants include: sediment, nutrients, pathogens, salts, toxic substances, petroleum products and pesticides, which contribute to surface and ground-water quality degradation (US EPA, 2000d, 2000e). Each nonpoint source category is discussed in greater detail in the following sections.

Table 2.5.0. Permitted point sources discharging directly to the Snake River within the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

Point Source	NPDES Permit Number	Location (RM)	Treatment Type	Current Design-flow (MGD)
City of Nyssa	101943 OR0022411	385	Activated sludge	0.8
Amalgamated Sugar	101174 OR2002526	385	Seepage ponds	Seepage
City of Fruitland	ID0020907	373	Facultative lagoon	0.5
Heinz Frozen Foods	63810 OR0002402	370	Activated sludge	3.4
City of Ontario	63631 OR0020621	369	Facultative lagoon	3.1
City of Weiser (WWTP)	ID0020290	352	Activated sludge	2.4
City of Weiser (WTP)	ID0001155	352	Settling pond	0.5 MGD (max) 0.09 MGD (avg)
Brownlee Dam (IPCo) [1]	ID0020907	285		15
Oxbow Dam (IPCo)[1]	101275 OR0027286	272.5		11
Hells Canyon Dam (IPCo)[1]	101287 OR0027278	247		9

1. Facilities sump discharge and turbine cooling water, not a waste treatment source.

In the discussion of nonpoint pollutant sources and in the segment-specific sections earlier, specific land use practices are identified as resulting in negative water quality impacts and increased pollutant loading. It should be kept in mind that these land use practices, when managed in a responsible and conscientious fashion do not result in decreased water quality. However, these land uses can lead to decreased water quality where poor management, or inadequate controls are practiced.

For example, grazing is identified below as a potential source of bacteria, nutrient and sediment loading to the watershed. This should not be interpreted as implying that all grazing results in degraded water quality. Rather, poorly managed or improper grazing practices may result in increased pollutant loading, while proper management and location considerations in a grazing plan can be expected to result in minimal if any impact to water quality. Therefore, the discussion below should not be interpreted as an identification of land use practices in general as being detrimental to water quality. It should be noted that poor land use practices can be improved and direct, long term benefits to water quality can be realized.

2.5.3.1 Agricultural Management Sources

Agricultural land use totals 140,000 acres within the SR-HC TMDL reach (RM 409 to 188). The largest portion of this acreage, dryland pasture and dryland hay, accounts for 51 percent of the agricultural acreage, irrigated row crops make up 17 percent of the acreage and small grain crops account for 32 percent of the total agricultural acreage in the SR-HC TMDL reach (Figure 2.5.1).

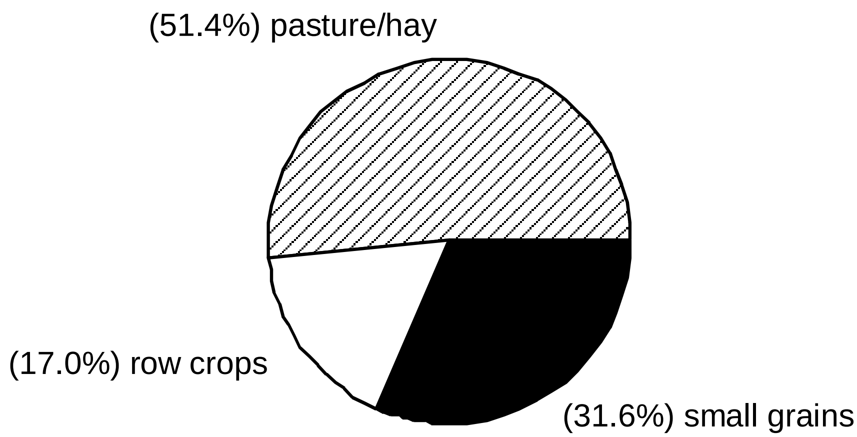

Figure 2.5.1 Agricultural land use distribution in the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

The primary pollutants associated with agriculture are sediment and nutrients present in both dissolved and sediment-bound forms as shown in Table 2.5.1. Related impacts are alteration of stream flows and temperatures. Pesticides are also associated with agricultural land uses; however, the pesticides of concern within the SR-HC TMDL are legacy pesticides no longer used in agricultural practices. The incidence and transport of these compounds are therefore not associated with application and use schedules, rather, they are associated with the movement of sediment and organic matter within the SR-HC TMDL reach (RM 409 to 188). The generation and transport of pollutants from agricultural nonpoint sources are influenced by the health of riparian areas through which water is transported to the mainstem Snake River and its tributaries, overland flow from runoff and snow-melt, irrigation practices, pasture and grazing management and fertilizer application (NRCS, 1995a, 1995b).

Cropping

Effects from inappropriate cropping practices include direct and indirect effects related to sediment, nutrient and pesticide loading. Primary transport mechanisms for sediment and other associated pollutants are wind and water erosion. Previously, agricultural practices that left soil bare for extended periods of time often resulted in substantial erosion rates. Improved conservation tillage practices are reducing the impacts of erosion on surface waters.

In both irrigated and non-irrigated cropland, runoff containing sediment and other associated pollutants (most commonly nitrogen, phosphorus and pesticides) generally occurs during winter

Table 2.5.1 Potential pollutant loading from agricultural management sources

Management Practices	Resulting Status of Sediment Loads	Resulting Status of Nutrient Loads	Resulting Status of Other Pollutants
Non-irrigated Cropland	Increased sediment load during winter snowmelt and spring rain when soil is least protected by plant growth	Nutrient transport during storm events, correlated with sediment transport and fertilizer application Nitrogen transport in early winter	Increased bacterial levels from manured fields Potential transport of Ag. pesticides
Irrigated Cropland (sprinkler, row and flood irrigation techniques)	Irrigation induced erosion and sediment transport Increased sediment load during winter snowmelt and spring rain when soil is least protected by growth	Nutrient transport during storm events, correlated with sediment transport and fertilizer application Nitrogen transport in early winter	Increased bacterial levels from manured fields Potential transport of Ag. pesticides
Riparian Grazing and Watering	Increased sediment load Increased erosion Vegetation reduction/removal Higher stream temps	Increased nutrients from animal waste deposition and transport within the channel Greater dissolution of nutrients at elevated temps	Increased bacterial levels
Over Utilization of Pasture	Increased erosion-sheet and rill Increased transport of sediment Decreased stubble height Soil compaction leading to reduced water infiltration	Increased nutrient load from animal waste deposition Increased nutrient transport from overland flow caused by soil compaction and decreased stubble height	Increased bacterial levels
Flood Irrigation	Removal of soil fines from surface and subsurface Increased bank erosion from subsurface drainage and recharge Subsurface saturation, decreased permeability and increased erosion from surface runoff	Prolonged saturation leads to anaerobic soil conditions and decreased capacity for phosphorus sorption Removal of soil fines decrease surface area of soils and decreases available capacity for phosphorus sorption	

and spring snowmelt, and during rainfall conditions where the soil is least protected by plant growth. Irrigation induced erosion is the major contributor of sediment and associated pollutants to surface waters from irrigated croplands. The most serious irrigation induced erosion is from surface applied systems, primarily furrow irrigation. Erosion from sprinkler irrigation can also be substantial if the rate of water application exceeds the soil infiltration capacity (IDEQ, 1993a; USDA, 1996).

Tilled cropland is additionally susceptible to erosion during the spring when crops are newly planted and furrows are not well established. The majority of sediment transported by water movement in cropped land is fine particulate containing many adsorption sites for nutrients and other pollutants. Heavy or large particle sizes are not commonly transported off-site by moving water or wind. The preferential removal of fine particle size sediment from a cropped field can result in increased pollutant transport in surface water due to greater availability of adsorption sites in the small particles, and decreased adsorption capacity in the field due to removal of soil fines.

The small particle-size soil fractions preferentially removed from the subsurface through irrigation practices are deposited within the flow channel after irrigation flows discharge to streams and tributaries. Material deposited in this fashion can function as a pollutant source to the overlying water column. Natural processes act to maintain equilibrium between pollutant concentrations in the bed-sediments and the flowing water. Thus, if pollutant concentrations in the overlying water are less than concentrations occurring within the deposited sediments, sorbed pollutants will be more readily desorbed from the sediments and dissolved into the flowing water. This process acts to enrich tributary inflow concentrations to the mainstem Snake River system, and to extend the peak input period to the mainstem Snake River system beyond the traditional irrigation season (Sonzongi, 1982).

Additionally, improper timing or excessive application of fertilizers to cropped fields can result in nutrient transport to surface and ground waters. Similarly, agricultural pesticides may be transported to surface waters or leached to ground water if improperly applied. Best management practices and recommended application protocols for fertilizers and pesticides can reduce the potential for negative impacts to the environment (IDEQ, 1993a; Olness *et al.*, 1975; Sharpley *et al.*, 1992; Sharpley *et al.*, 1991; Tisdale *et al.*, 1993; USDA, 1996)

Grazing

Effects from inappropriate grazing practices include direct and indirect effects related to sediment and nutrient loading. Local streams represent the major source of water for livestock and a secondary source of forage. Access to streams is generally unrestricted. Cattle grazing along the stream banks and within the channel exacerbate erosion in two main ways. The shearing action of hooves on stream banks destabilizes the soil and increases the potential for significant erosion as loose sediments are rapidly removed by flowing water. Grazing cattle also remove or substantially reduce riparian vegetation (Platts and Nelson, 1985a, 1985b; Platts 1983; Armour *et al.*, 1991). Bank erosion is accelerated where riparian vegetation has been removed or heavily grazed. Streambank vegetation acts to stabilize bank sediments and reduce the erosive force of flowing water. It also serves as a depositional area for sediment already in the stream. Water entering vegetated reaches slows down because of the resistance plant stems create within the flow path. As flow velocity decreases, sediment particles settle out within the riparian areas. Reduction or removal of riparian vegetation decreases bank stability through the loss of root mass within the soil profile and decreases settling and sedimentation at the edges of the stream channel. As a result, stream banks have become unstable in many stream reaches.

In addition to increased erosion and sediment transport effects, inappropriate grazing practices can also contribute to nutrient loading through the deposition and transport of animal wastes. A small portion of the available phosphorus in plant material is used in growing and maintaining bones and teeth, grazing animals partition nearly all phosphorus intake into manure. Manure has a slower physical decomposition rate than plant material on the surface. This results in increased accumulation of soluble phosphorus in a physically unstable form within the pasture (Khaleel *et al.*, 1980; USDA, 1996). Such deposition is especially noticeable when correlated with the spatial distribution of animals in grazing and bedding routines. Cattle within a grazed pasture rarely spread out and cover the entire acreage evenly. Rather, they tend to congregate around areas where water is readily available and forage is plentiful. Because greater numbers of livestock are concentrated in such areas, a greater proportion of the manure produced is deposited in or near stream channels and riparian areas. Manure concentration per unit of land is relatively small because the total grazed-land area is commonly large, however, manure concentration correlates well with major water bodies, resulting in a greater potential for direct transport.

The phosphorus contained within manure is in a highly soluble, readily bioavailable form. Because of the high solubility, phosphorus loading and transport from a manured field can exceed those from a non-manured field by many times (Khaleel *et al.* 1980; Olness *et al.* 1975; Omernik *et al.* 1981; Reddell *et al.*, 1971; Hedley *et al.*, 1995; Sharpley *et al.* 1992). Erosive processes occurring within an ungrazed or forested watershed would require a significantly greater amount of time and transport to produce the same effect on bioavailable phosphorus loading as a direct deposition of phosphorus-rich animal wastes into the channel or flood plain of a stream.

Related impacts include increased water temperatures in the tributaries due to removal of streamside vegetation, allowing greater dissolution of adsorbed phosphorus and other nutrients from sediment-bound forms. Also, monitoring performed above and below grazed land in other watersheds has shown higher levels of bacterial loading in waters below the grazed area than in those above (Lappin and Clark, 1986; USDA, 1996; Zimmer, 1983). This is most probably due to deposition of manure in and around streams and overland transport of manure through storm events and spring runoff. Additionally, improper grazing practices can alter floodplain and hydrologic characteristics, resulting in an increase in width-to-depth ratios of streams, exposing more of the flow volume to the air.

Erosion from storm events, combined with reduced vegetation from improper grazing management also results in increased sediment transport to stream channels. In a related fashion, over utilization of pasture land can result in subsurface compaction of soils as hoof action combined with animal weight create a pressure wave that compresses the soil profile, resulting in the formation of a dense layer of low permeability twelve to fifteen inches below the soil horizon (Weltz *et al.*, 1989; Orodho *et al.*, 1990; Mapfumo *et al.*, 1999; Gilley *et al.*, 1996). In storm events and spring melt, water cannot penetrate this compacted layer, and the volume and velocity of overland flows are increased, as is the total suspended sediment and nutrient load. Vegetation in over-utilized pasture areas is commonly insufficient to retain sediment carried by overland flow and deposited manure is easily transported directly into the channel and downstream within natural stream and/or irrigation channels (NRCE, 1996).

It should be noted that the grazing impacts identified above commonly associated with poor management of domesticated livestock can also occur as a result of the management of wild game such as deer, elk and wild horses if populations are manipulated to levels greater than those that would occur without human intervention. For example, elk herds can trample vegetation in a manner similar to cattle and have been known to destroy newly established riparian vegetation in the upstream sections of tributaries to the Snake River (IDFG, 2000).

Irrigation
Flood and sub-flood irrigation, commonly used to irrigate pastureland, also impact sediment and nutrient loading if practiced in an inappropriate manner. In flood and sub-flood irrigation, water diverted from natural streams is applied in excess to pasture land through a series of canals and ditches. These canals are filled and water is allowed to saturate the surrounding soil, creating an artificially high water table. Practices like flood and sub-flood irrigation that substantially alter the water table can lead to changes in the mobility of phosphorus within the shallow subsurface.

Phosphorus has been observed to move more easily through soils that are consistently waterlogged because the majority of the iron present in these soils is no longer in the chemical form (Fe^{+3}) required for greatest sorption potential. As a result, adsorption occurs less efficiently or at greatly reduced rates within the soil profile (Sharpley *et al.*, 1995). In addition, movement of water in subsurface layers results in the preferential loss and transport of small particle-size soil fractions, which represent the primary source of phosphorus sorption sites in the soil. These particles carry a significant amount of sorbed phosphorus with them when they are removed and leave the remaining soil deficient in sorption sites. Therefore, not only is the subsurface water enriched directly through the sorbed phosphorus on the particulates, but further runoff from the original soils will be enriched due to the decrease in phosphorus sorption capacity (Hedley *et al.*, 1995). In addition, phosphorus sorption-desorption characteristics, buffer capacity and the sorption index of the transported sediments are altered, and the equilibrium phosphorus content of the runoff waters is usually enriched (Shapely *et al.*, 1995).

The small particle-size soil fractions preferentially removed from the subsurface through flood and sub-flood irrigation practices are deposited within the flow channel after irrigation flows discharge to streams and tributaries. Material deposited in this fashion can function as a nutrient source to the overlying water column. Natural processes act to maintain equilibrium between nutrient concentrations in the bed-sediments and the flowing water. Thus, if nutrient concentrations in overlying water are less than nutrient concentrations occurring within the deposited sediments, sorbed nutrients will be more readily desorbed from the sediments and dissolved into the flowing water. This process acts to enrich tributary inflow concentrations to the mainstem Snake River system, and to extend the peak nutrient input period to the mainstem Snake River system beyond the traditional irrigation season (Sonzongi, 1982).

Irrigation recharge and surface runoff created by flood and sub-flood irrigation practices are diverted to local streams or returns as shallow subsurface recharge. These waters generally contain high concentrations of phosphorus and nitrogen as compared to ambient concentrations of local streams (IDEQ, 1988b; Omernik *et al.* 1981; Shewmaker, 1997). These same irrigation systems funnel and accelerate delivery of runoff from snowmelt during spring thaw. In addition, inefficient irrigation water management practices can reduce stream flows unnecessarily, resulting in increased water temperatures.

In many areas of the Snake River watershed flood and sub-flood irrigation return flows are discharged into streams and rivers. While it has the potential to be enriched in nutrients, this subsurface recharge can act to increase instream flows, resulting in lower temperatures and improved fish habitat in some areas (IDFG, 2000, IDEQ, 1998b). In addition, these practices have created subsurface flow and resulted in the formation of wetland areas in many pasturelands (IDEQ, 1998b). Similarly, when irrigation practices occur in proximity to natural or man-made surface water systems, subsurface recharge can result in the extension of riparian zones and improved bank stabilization by increased riparian vegetation. Well managed irrigation flows can act to extend the health of such riparian or "created" wetlands into the late summer months. Without these surface and subsurface flows, this vegetation would normally only be present in the spring and early summer months.

2.5.3.2 RECREATIONAL SOURCES

A variety of recreational opportunities are available in the SR-HC TMDL reach (RM 409 to 188) and the surrounding watersheds. Potential impacts from recreational uses are varied, ranging from increased erosion potential caused by irresponsible off-road vehicle use, to direct contamination of surface water by personal watercraft or accidental fuel spills. Pollutants of concern generated by recreational use in the watershed include (but are not limited to) bacterial and nutrient contamination from human and animal waste from improper sanitary disposal, organic material from fish cleaning, hydrocarbons from outboard motors, and nutrients, grease and oils from parking lot runoff at camp grounds and boat ramps (Table 2.5.2). Sediments are also contributed by erosion of banks around popular beach areas and camping sites, and heavy use of native-surface roads, particularly during the wet season. Because recreational activities occur predominantly on the water or at the shoreline, delivery potential for recreational pollutant sources is very high. Therefore, the majority of the pollutants generated by recreational activities have the potential to directly influence water quality.

Table 2.5.2 Potential pollutant loading from recreational activities.

Management Practices	Resulting Status of Sediment Loads	Resulting Status of Nutrient Loads	Resulting Status of Other Pollutants
Recreational Users	Increased sediment from off-road and irresponsible camping vehicle use	Increased nutrient load from improperly disposed wastes	Increased bacterial levels from improperly disposed human, fishing, and hunting wastes Increased petroleum products in water column from motorized boats and/or personal watercraft use and maintenance and/or fueling practices

2.5.3.3 URBAN/SUBURBAN SOURCES

Urban/suburban land use totals 6,700 acres within the SR-HC TMDL reach (RM 409 to 188). The largest portion of urban/suburban acreage in the reach (72%) is contained in private and public roads and highways, and their respective right-of-ways. Low intensity residential acreage (rural subdivisions and city impact areas) accounts for 24 percent of the urban/suburban acreage in the reach and suburban/recreational residential acreage makes up the remaining 4 percent, as shown in Figure 2.5.2. High intensity (urban) development exhibiting from 80 to 100 percent impervious coverage does not occur within the SR-HC TMDL reach (RM 409 to 188), but is present in some of the tributary watersheds. The City of Boise and its associated urban area are located in the Lower Boise River watershed (HUC 17050114), and the City of Ontario and its associated urban area are located in the Owyhee River watershed (HUC 17050110). (Note: USBR GIS coverage locates the City of Ontario in the Owyhee River watershed as stated above. A separate GIS coverage used by US EPA shows the City of Ontario as located in the Hells Canyon watershed (HUC 17060101).)

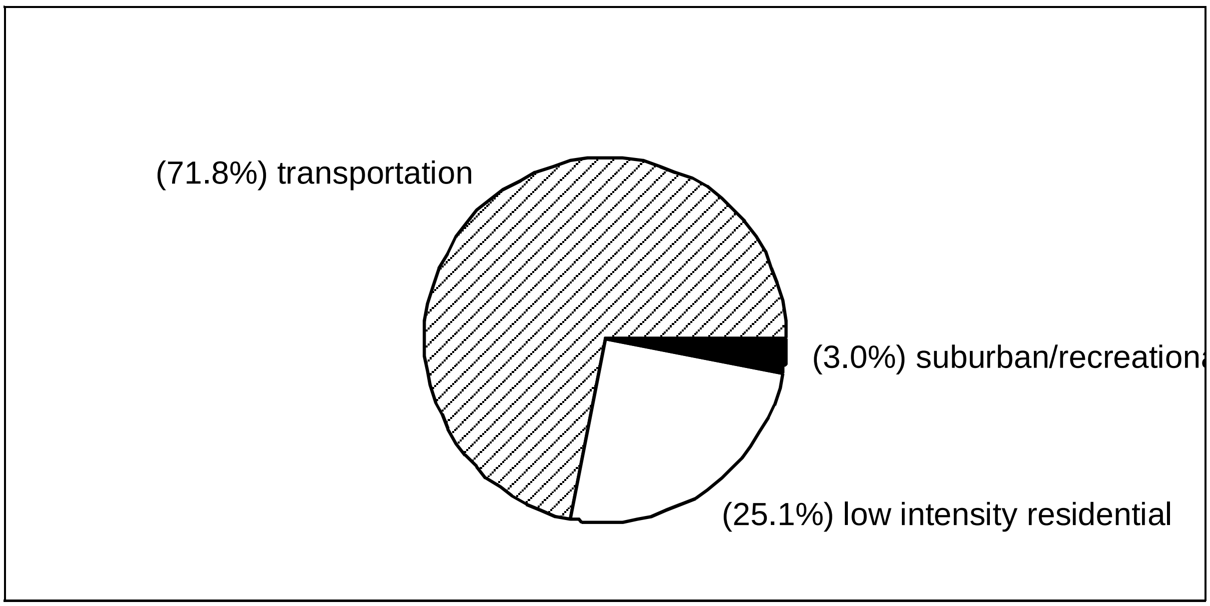

Figure 2.5.2 Urban/suburban land use distribution in the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

As outlined above, there are three primary components to urban/suburban land use in the SR-HC TMDL reach (RM 409 to 188): low intensity residential land use, suburban/recreational residential land use, and transportation corridors (roads and highways). Pollutant sources of concern associated with urban/suburban land use include (but are not limited to) stormwater and other impervious surface runoff, improperly functioning septic systems and construction-based loading concerns. Potential effects from urban/suburban management practices are listed in Table 2.5.3.

Stormwater Runoff

Stormwater runoff, occurring when precipitation and runoff events result in excess water movement through urban/suburban systems, road and other major construction projects can result in substantial degradation to water quality if not properly treated. These event-driven flows often act to remove pollutants from impervious surfaces and transport pollutant loads through storm sewers, road swales and drainage ditches to discharge directly to surface and ground-water systems. While most major municipalities within the SR-HC system have stormwater management plans in place or in progress, many other stormwater collection and delivery systems discharge to surface and ground water with little or no pre-treatment.

In most rural residential areas the quantity and quality of stormwater runoff is unknown. However, several well-validated and extensively used models have been developed for quantifying urban runoff and stormwater pollutant loads (Chandler, 1994, 1993; FHWA, 1987; Schueler, 1987; USGS, 1995; US EPA, 1992c). Pollutant sources of concern associated with urban stormwater and other impervious surface runoff includes nutrients from lawn fertilizers and improperly disposed of animal wastes, sediment from erosion of conveyance systems, private properties and ditches, oils, pesticides and bacteria. Certain municipal, industrial and construction sources of stormwater runoff are considered point sources and are regulated by NPDES permits, either general or site specific. Most stormwater permits require pollution prevention plans.

Table 2.5.3 Potential pollutant loading from urban/suburban management practices.

Management Practices	Resulting Status of Sediment Loads	Resulting Status of Nutrient Loads	Resulting Status of Other Pollutants
Stormwater Runoff	Increased sediment from snow management and construction practices	Increased sediment-bound nutrients from runoff and construction	Petroleum products and home/ lawn care chemicals
Failing Septic Systems	Nominal: construction induced increases only	Increased nutrient load in highly bioavailable form	Increased bacterial levels
Ranchettes and other suburban development	Increased sediment transport from high road and livestock density	Increased nutrient loads from increased animal waste deposition and transport	Increased bacterial levels Increased storm- water pollutants
Sewage Effluent	Nominal: construction induced increases only	Increased nutrient load in highly available form	Increased bacterial levels
Road and Highway Management	Increased sediment from snow management and construction practices	Increased sediment-bound nutrients from runoff and construction	Petroleum products, vehicle wastes and snow/ice management chemicals

Septic Systems

Many rural residential and recreational housing developments within the SR-HC TMDL reach rely on septic systems for the treatment of household and human wastes. Septic systems, if improperly constructed, located or maintained, can act as a source of nutrients and pathogens to surface and ground-water systems due to inadequate retention time and treatment of septic tank effluent. Improper construction of septic systems may be due to age (construction prior to current regulations), or inappropriate capacity or materials (tanks sized too small for usage, tank materials not appropriate for location characteristics or not sealed properly). Improper placement may be due to high ground-water tables, evidence of existing ground-water contamination, and high septic tank density (IDEQ, 1997a; Postma *et al.*, 1992; Alhajjer *et al.*, 1989).

Nutrient and pathogen contributions from septic tank effluent can also be the result of soil characteristics that are inappropriate for septic systems (Reckhow and Simpson, 1980; IDEQ, 1997a) or how well the soil matrix functions in binding and reducing the transport of phosphorus through shallow ground water. The most important soil mechanisms responsible for immobilizing phosphorus are the formation of insoluble iron and aluminum phosphate compounds and the adsorption of phosphate ions onto clay particles (Tilstra, 1972). Seasonal high ground-water tables may also increase the mobilization of phosphorus, ultimately transporting all phosphorus from septic tank effluent to surface and ground-water systems.

Recreational or seasonal housing which depends on septic systems may also represent a nutrient and pathogen source to surface and ground-water systems even if the septic tank and drainfield is properly constructed and located because inconsistent or intermittent usage does not result in the adequate formation of treatment mats within the drainfield (Postma *et al.*, 1992). These mats are formed of organic material and stationary bacterial growth that act to treat outflowing water. In intermittently used systems these mats do not form to the same degree as in continually used systems. Treatment of septic effluent therefore is less effective overall in intermittently used septic systems.

2.5.3.4 LEGACY MINING ACTIVITIES

Legacy mining activities represent a potential source of mercury loading to the SR-HC TMDL reach (RM 409 to 188). In most cases, legacy mining operations were located on tributaries to the mainstem Snake River, however, there are a few located on the mainstem as well. The mercury in these mining sites was used primarily to amalgamate gold and silver. In this process mercury is added in excess to the mined material with the excess being drained away from the site. In some cases, legacy mining activities represent a source of both dissolved and sediment-bound mercury. In addition to the mercury load already present within the mainstem Snake River, existing slag, refuse and leach piles at old mining sites may represent continuing enrichment sources to the SR-HC system. This problem has been observed in other historical mining areas in the western states (CRWQCB, 2000)

2.5.3.5 GROUND WATER

Ground water within the SR-HC watershed can be divided into two major categories: natural ground water and subsurface recharge. Within this document, natural ground water refers to ground water that is present due to geological and non-anthropogenic hydrological processes. It occurs at a variety of subsurface levels, but is predominantly located from 40 to 500 feet below the ground surface. Subsurface recharge refers to sub-surface water present due to anthropogenic practices such as flood and sub-flood irrigation. The water applied in such practices is often perched between the soil surface and one of several existing clay layers known as "hard-pan" or "clay-pan." These layers occur within the watershed at depths ranging from 2 to 10 or more feet below the surface. Because of their relative impermeability, they prohibit infiltration of the water to lower levels and promote an artificially raised water table. This water moves under hydraulic pressure toward low lying areas, discharging into existing stream channels through outlets in the stream banks and eventually into the mainstem river system and tributaries.

Natural ground water within the SR-HC TMDL reach (RM 409 to 188) is commonly of high quality, although general ground-water quality trends in the Snake River watershed indicate an increasing occurrence of nitrate and, to a lesser extent, pesticide contamination in areas with heavy agricultural, urban or industrial impacts. Nutrient concentrations in natural ground water in Idaho commonly average less than 0.02 mg/L total phosphorus and less than 0.75 mg/L nitrate (USGS, 1999; Seitz and Norvitch, 1979; Yee and Souza, 1984). Data on natural ground-water concentrations in Oregon is less available, but shows a similar concentration range (ODEQ, 2000b; USGS, 1999). Sediment loading from natural ground water is minimal for all but the smallest particle sizes due to the sieving effect of transport through the soil matrix.

Nutrient concentrations in subsurface recharge within the Snake River watershed are observed to be higher than those in natural ground water, averaging 0.5 mg/L total phosphorus and 2.25 mg/L nitrate in Idaho (USGS, 1999), with similar concentrations observed in Oregon waters (ODEQ, 2000b; USGS, 1999). As with natural ground water, sediment loading from subsurface recharge is minimal for all but the smallest particle sizes due to the sieving effect of transport through the soil matrix.

2.5.3.6 BACKGROUND AND NATURAL CONTRIBUTIONS

Natural Loading

For the purposes of this document, natural loading is defined as the loading within a water system that originates solely from natural, non-anthropogenic sources. In general, TMDL processes move toward the attainment of natural loading levels rather than requiring the reduction of natural loads. Natural loading to the SR-HC TMDL reach (RM 409 to 188) occurs from a variety of different sources. Sources differ substantially from pollutant to pollutant, and to a lesser degree from segment to segment.

Natural sources of bacteria (and other pathogens) and nutrients include indigenous wildlife and wildfowl that utilize the watershed. While these populations are relatively stable throughout much of the year, substantial increases in some populations are observed with spring and fall migration patterns. Fluctuations in the levels of bacteria from waterfowl are especially noticeable as migration effects are directly correlated with surface water and wetland areas within the watershed.

Increased nutrient loading is often associated with increases in algal mass and chlorophyll *a*, decreases in dissolved oxygen levels, and changes in pH that commonly occur following a major bloom. Natural sources of nutrient loading that may trigger such occurrences include elevated levels of nutrients from natural ground-water inflows or springs, coincident with high solar radiation and low flow velocities associated with low water levels during the dry summer season;

and geological sources of nitrogen and phosphorus such as the Phosphoria deposit located on the mainstem Snake River upstream of the SR-HC TMDL reach. Additional sources of natural nutrient loading include runoff and sediment/erosion associated with natural soils and geologic features, landslides and high velocity flows.

Natural sources of sediment within the SR-HC system include streambank erosion, commonly most significant during high flow and spring runoff conditions (December to June); naturally induced landslides and debris flows that deposit material in the stream channel; and erosion induced by other natural occurrences such as forest fires where native vegetation is removed leaving exposed soils more susceptible to extreme precipitation and runoff events (Beaty, 1994; Saa *et al.*, 1994). All of the sources listed are highly variable in nature and difficult to predict accurately.

Natural sources of increased temperature are predominantly the result of the hot, dry climate of the SR-HC TMDL reach (RM 409 to 188). The area enjoys an average of 124 clear, sunny days, most of which (71%) occur during the summer months. Monthly records for sunshine for the Upstream Snake River segment (RM 409 to 335) show an average of 67 percent of possible sunshine per year with an average of 3.6 cloudless hours/day in December and an average of 13.4 cloudless hours/day in July (US EPA, 1975; SNOTEL, 2000; WRCC, 2000). In addition, native vegetation in much of the watershed is relatively low growing and sparse, providing little shading to some tributary waters. Summer daily maximum air temperatures in the SR-HC TMDL reach averaged 32 ^{o}C (90 ^{o}F) from 1980 to 1999.

No natural sources of the pesticides of concern (DDT and metabolites, and dieldrin) exist within the SR-HC TMDL reach (RM 409 to 188).

Mercury occurs naturally in several geological landforms within the SR-HC TMDL reach (RM 409 to 188). The Owyhee, Malheur and Weiser drainages contain geological landforms known to yield mercury ores. Unsubstantiated anecdotal information from early explorers and settlers in these areas indicate that mercury was present historically at high concentrations in geological outcroppings in close proximity to water systems (IDFG, 2000). Transport and deposition of mercury within the tributaries and the mainstem Snake River system would most likely have been highly correlated with sediment transport in most cases.

Background Loading

For the purposes of this document, background loading is the load delivered to a segment by inflowing upstream waters. Background loads can contain pollutants originating from both natural and anthropogenic sources. In general, TMDL processes move toward reductions in the anthropogenically induced fraction of background loading. In this manner, background load reductions can be assessed and achieved in most systems.

This TMDL process is somewhat unique in the manner of load allocation assessment proposed. Tributary inflows to the SR-HC TMDL reach (RM 409 to 188) will be assessed load allocations at their respective inflows, and tributary-based TMDL processes will work to distribute load allocations upstream, rather than the SR-HC TMDL. Due to this load allocation mechanism, and the inherent connectivity it represents within the Snake River system, background contributions will not be assessed separately from overall loading contributions for inflowing tributary systems within the SR-HC TMDL process. Pollutant loads will be assessed for all major inflowing tributaries directly, including the inflowing Snake River mainstem. The distinction of background loading vs. total loading for each tributary system will be the responsibility of the tributary-based TMDL processes.

2.6 Summary of Past and Present Pollutant Control Efforts

2.6.1 Point Source Efforts

The permitted point sources specific to the SR-HC TMDL reach (RM 409 to 188) are listed in Table 2.5.0.

As stated earlier, the majority of point sources in the SR-HC TMDL reach are located in the Upstream Snake River segment (RM 409 to 335). Point source pollution control efforts within this segment have been centered almost exclusively on improvements to wastewater treatment mechanisms. Substantial improvements have been observed in nutrient, temperature and total suspended solids loading, and in loading of materials resulting in increased oxygen demand, from municipal and industrial wastewater treatment plants since the 1980s. These efforts have the potential to improve water quality in many of the tributary drainages and in turn to improve water quality within the mainstem Snake River.

2.6.2 Nonpoint Source Efforts

The main focus of past and present nonpoint source pollution control efforts has been the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. These efforts have the potential to improve water quality in many of the tributary drainages and in turn to improve water quality within the mainstem Snake River.

There has been a long history of research, regional planning, and implemented progress within the SR-HC TMDL reach (RM 409 to 188). In crop production regions, massive conversion from surface irrigation to sprinkler irrigation has helped reduce surface erosion and reduce nitrate leaching by deep percolation through the soil to groundwater (Shock *et al.*, 2001).

This voluntary, proactive tradition in agriculture is present in both Oregon and Idaho. Malheur County residents have written formal regional plans to reduce the losses of sediment and nutrients induced by irrigation in 1980 by a local committee, in 1988 to 1996 through the HUA process, and again in 2000 through the LAC. Malheur Soil and Water Conservation District was formed in Vale in 1953. The Adrian Soil and Water Conservation District was organized in 1958. The two districts consolidated into the Malheur County Soil and Water Conservation District in 1974. Every year, plans have been made for individual properties. Annual reports are available for the above mentioned years to the current 2000. The Ontario Hydrologic Unit Area reports are from 1990 to 1997. Individual annual reports and a final report for 1990 to 1997 are in the SWCD Ontario Office (Shock *et al.*, 2001). A listing of water quality plans is shown in Table 2.6.1.

Improvements in practices were supported by numerous federal, state and local programs including the Conservation Reserve Program (CRP), the Habitat Improvement Program (HIP), Wildlife Habitat Incentive Program (WHIP), Wetland Reserve Program (WRP), and the Environmental Quality Incentives Program (EQIP).

Table 2.6.1 Management plans for water quality improvements in the Snake River - Hells Canyon TMDL drainage area.

Plan	Location	Author
Progress Report First Year Sampling Program (Malheur and Owyhee)	Malheur and Owyhee drainage, Oregon	Malheur County Planning Office. 1979, NPSWQMPP, Vale, OR.
Technical Inventory Report for May to September 1978 (Malheur and Owyhee).	Malheur and Owyhee drainage, Oregon	Malheur County. 1978.
Two-year Sampling Program, Malheur County Water Quality Management Plan, 1981.	Malheur County, Oregon	Malheur County. 1981.
Draft Watershed Management Plan.	Malheur County, Oregon	Malheur County. 2000.
Malheur River Basin Agricultural Water Quality Management Area Plan (Draft).	Malheur County, Oregon	Malheur River Basin Local Advisory Committee. 2000.
Malheur Basin Action Plan.	Malheur County, Oregon	Technical Malheur-Owyhee Watershed Council. 1999.
Harney County Comprehensive Plan, Water Element	Harney County, Oregon	Harney County, Oregon
Lower Payette River and Implementation Plan	Gem County, Idaho	IDEQ, 1999
Lower Boise River and Implementation Plan	Ada County, Idaho	IDEQ, 1998

2.6.3 Upstream TMDL Efforts

Many of the projects mentioned above are the result of upstream and tributary TMDL processes. TMDLs and agricultural management plans are currently in place in the Mid-Snake (RM 638.7 to RM 544.7), Owyhee, Boise, Payette, and Malheur river watersheds. The implementation measures associated with these plans represent mechanisms specifically targeted to reduce bacteria, nutrient, sediment and temperature impacts to the upstream and tributary watersheds. In many cases, tributary-based implementation has already begun and is showing positive trends in water quality. These improvements may lead to water quality benefits in the SR-HC TMDL reach (RM 409 to 188).

2.6.4 Potential for Achievement of Water Quality Standards with Present and Planned Activities

If the TMDLs currently in place are fully implemented, and the pollutant reduction measures identified perform at the expected efficiencies, achievement of water quality standards and full support of designated beneficial uses are expected to result in the respective tributary drainages for which TMDLs have been approved. If the pollutant reduction measures identified perform at efficiencies below those expected, the iterative assessment processes present in the TMDL will be called upon to identify additional measures for reduction. In this manner, achievement of water quality standards and full support of designated beneficial uses in the tributaries will be realized, but through an extended time frame. The implementation of planned pollutant loading reduction activities is expected to benefit from the evaluation of reduction efficiencies in those measures already in place. Those measures observed to function efficiently, with consideration for both water quality benefits and cost per reduction realized, would be expected to be considered for more wide-spread implementation within the watershed.

The potential exists for water quality improvements within the SR-HC TMDL reach (RM 409 to 188) due to implementation of upstream and tributary TMDLs. However, tributary TMDLs currently in place do not address all of the pollutants of concern in the SR-HC TMDL reach, and do not address the direct needs and status of designated beneficial uses in the SR-HC TMDL reach.

2.6.5 Adequacy of Efforts to Date

To date, the pollutant control measures currently in place have not resulted in attainment of state-specific water quality criteria for dissolved oxygen, mercury, nutrients, sediment, pesticides and temperature for those segments of the SR-HC TMDL reach (RM 409 to 188) specifically listed for these pollutants. As a result, the designated beneficial uses of fishing, salmonid spawning and rearing, cold water aquatic life, and resident fish and aquatic life, within the SR-HC TMDL reach have not been brought back into full support status through these upstream and tributary-based efforts.

Additional efforts specific to the SR-HC TMDL process are expected to be necessary to allow the SR-HC TMDL reach (RM 409 to 188) to meet water quality criteria and fully support designated beneficial uses. However, it should be clearly noted that many of the improvement efforts associated with upstream and tributary TMDLs require an extended time period to achieve the water quality targets identified. It should also be recognized that due to the relatively short time since approval of these TMDLs, sufficient time has not elapsed for full implementation and effective operation to be realized. Water quality trends are expected to improve within the upstream and tributary drainages as full implementation is achieved and specific projects mature to full operational efficiency.

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Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Section 3.0 Loading Analyses

3.0 Loading Analyses

3.0.1 General Information

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a waste load allocation (WLA); and nonpoint sources, which receive a load allocation (LA). Natural background (NB), when present, is considered part of the load allocation, but is often identified separately because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (40 CFR § 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity (LC) that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human-caused pollutant sources. This can be summarized as the equation:

$$LC = MOS + NB + LA + WLA = TMDL.$$

The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the loading capacity is determined. Then the loading capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation is completed, the TMDL must equal the loading capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. Also a required part of the loading analysis is that the load capacity be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads, and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

This document represents the loading analyses for the pollutants addressed by the Snake River - Hells Canyon (SR-HC) Total Maximum Daily Load (TMDL). These include the pollutants listed in Table 3.0.1.

Table 3.0.1 Segment specific listing information for the Snake River - Hells Canyon TMDL reach

Segment	Idaho 303(d) Listed Pollutants	Oregon 303(d) Listed Pollutants
Snake River: RM 409 to 396.4 Upstream Snake River (OR/ID border to Boise River Inflow)	(downstream from ID border) bacteria, dissolved oxygen, nutrients, pH, sediment	mercury, temperature
Snake River: RM 396.4 to 351.6 Upstream Snake River (Boise River Inflow to Weiser River Inflow)	bacteria, nutrients, pH, sediment	mercury, temperature
Snake River: RM 351.6 to 347 Upstream Snake River (Weiser River Inflow to Scott Creek Inflow)	bacteria, nutrients, pH, sediment	mercury, temperature
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	dissolved oxygen, mercury, nutrients, pH, sediment	mercury, temperature
Snake River: RM 285 to 272.5 Oxbow Reservoir	nutrients, sediment, pesticides	mercury, temperature
Snake River: RM 272.5 to 247 Hells Canyon Reservoir	not listed	mercury, temperature
Snake River: RM 247 to 188 Downstream Snake River (Hells Canyon Dam to Salmon River Inflow)	temperature	mercury, temperature

Because of the extensive scope of this TMDL, the SR-HC TMDL process has divided the SR-HC reach into five separate segments based on similar hydrology, pollutant delivery and processing mechanisms, and operational, management or implementation strategies. The five segments are:

- The Upstream Snake River segment (RM 409 to 335)
- The Brownlee Reservoir segment (RM 335 to 285)
- The Oxbow Reservoir segment (RM 285 below Brownlee Dam to RM 272.5)
- The Hells Canyon Reservoir segment (RM 272.5 below Oxbow Dam to RM 247)
- The Downstream Snake River Segment (RM 247 below Hells Canyon Dam to RM 188)

Pollutant sources within the SR-HC TMDL reach include point sources, nonpoint sources and tributary inflows. These sources will each be discussed in the context of the segment to which they discharge.

Permitted point sources are listed in Table 2.5.0. This category includes those sources that discharge from a discrete point under the requirements of a discharge permit. For the SR-HC TMDL reach there are 9 permitted point sources, some of which have multiple discharges. For example, until recently IPCo had cooling water, sump water, and wastewater discharges associated with the Oxbow Dam and hydropower facility. The majority of the facilities in Table 2.5.0 are wastewater treatment facilities and industries with wastewater, process water, cooling water and permitted stormwater discharges.

Nonpoint sources are generally those sources that discharge over a diffuse area. They are generally not permitted and are more difficult to quantify than point sources due to the disperse nature of their discharges. Nonpoint source discharge occurs in all segments of the SR-HC TMDL reach and includes agriculture, forestry, urban/suburban, stormwater, groundwater and natural loading.

Tributary inflows to the SR-HC TMDL reach include the mainstem Snake River upstream of RM 409, the Owyhee, Boise, Malheur, Payette and Weiser rivers and numerous small streams. For the purposes of this TMDL, the tributary inflows have been treated as discrete nonpoint sources. Although it is recognized that pollutant loads to the tributaries stem from a variety of point and nonpoint sources within the tributary drainage, the mixed loading that reaches the Snake River is considered to be nonpoint source in nature.

A general discussion of methods available for the determination of pollutant loading, and a general water balance determination and hydrology assessment is available in Appendix G.

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3.1 Mercury Loading Analysis

Due to the fact that essentially no water column data are available to this effort, a TMDL cannot be established for mercury for the SR-HC TMDL reach. Therefore, IDEQ and ODEQ have determined it is in the public interest to reschedule the mercury TMDL for the SR-HC TMDL reach. IDEQ will reschedule the mercury TMDL to 2006 in order to gather additional data to better determine the sources and extent of mercury contamination. ODEQ's schedule for the mercury TMDL coincides with this date.

The state of Oregon is developing capability to model site-specific bioaccumulation factors. Also, Oregon's mercury TMDL is not due until 2006. This schedule change will allow a better use of these capabilities and the opportunity to collect additional data.

Both Idaho and Oregon have interim measures in place to deal with mercury contamination such as sediment controls and fish consumption advisories as described in Section 3.1. It is the opinion of the DEQs that this schedule change will not present an adverse impact to the SR-HC TMDL reach.

The discussion of mercury loading presented below is a preliminary assessment only. This assessment will be augmented with additional data and evaluation tools as monitoring and modeling efforts progress. A final loading analysis and load allocation will be completed by December 2006. The final assessment will replace the preliminary assessment presented below.

3.1.1 Water Quality Targets and Guidelines: Current and Pending

The purpose of TMDL development is to meet applicable water quality standards. As a bi-state TMDL addressing interstate waters, the applicable targets for this effort have been identified as the most stringent of each state's water quality standards. In this way the attainment of these targets will ensure that the water quality requirements of both states will be met. The water quality standards and guidance values appropriate to mercury in the SR-HC TMDL are discussed below.

3.1.1.1 FEDERAL.

The US Food and Drug Administration (US FDA) has established a criterion of 1 part-per-million (mg/kg) methylmercury in fish tissue (US FDA, 1984) as an action level to protect against potential health risks for human consumption of fish. Recently (US FDA, 9 March 2001), the US FDA also announced an advisory on methylmercury in fish, specifically recommending that pregnant women, women of childbearing age who may become pregnant, nursing mothers and young children not eat certain types of ocean fish that may contain high levels of methylmercury.

Mercury criteria promulgated by the US EPA identify a water column concentration of 0.051 ug/L as a maximum for waters where fish are being harvested for human consumption, and a water column concentration of 0.050 ug/L, for waters where fish harvest occurs in combination with water being used as a domestic water supply (Federal Register 63, No 237, 68357, 1998). In response to further study and assessment nationwide, the US EPA has recently released new guidance under section 304(a) of the Clean Water Act (US EPA, 2001a) that identifies a criterion for methylmercury in fish tissue of 0.3 parts-per-million (mg/kg) to protect the health of consumers. This criterion has been developed to address the consumption of larger fish portions (17.5 grams as opposed to 6.5 grams previously) by the general public. The US EPA expects this criterion to be used as guidance by states when in establishing or updating water quality standards and fish consumption advisories.

3.1.1.2 STATE OF OREGON.

The State of Oregon has adopted an action level of 0.35 parts-per-million (mg/kg) for methylmercury in fish tissue for Oregon waters. This level is used as a screening factor in determining the need for establishing fish consumption advisories to protect human health. The State of Oregon has also adopted a water column criterion of 0.144 ug/L for methylmercury (OAR 340-41-725, 765, 805, 845 (2) (p)(B) which references an earlier version of EPA Table 20).

3.1.1.3 STATE OF IDAHO.

The State of Idaho has adopted an action level of 0.5 parts-per-million (mg/kg) for methylmercury in fish tissue for Idaho waters. This level is used as a screening factor in determining the need for establishing fish consumption advisories for the protection of human health. The State of Idaho has also adopted a water column criterion of 0.012 ug/L for methylmercury based on extrapolation of the US FDA target of 1.0 parts-per-million (mg/kg) methylmercury in fish tissue using a US EPA report documenting the use of bioconcentration factors for the determination of water column criteria (US EPA, 1984). In response to recent advances in analytical technology and better understanding of methylmercury transport and uptake in living systems, the State of Idaho action level for methylmercury in fish tissue, and the associated guidelines for issuing fish consumption advisories are currently undergoing review. New action levels and guidelines are expected to be identified late in 2003 (personal communication, M. Wen, IDHW-EHS, May 2001).

The most stringent applicable water quality standards for mercury in the SR-HC TMDL area are the 0.012 ug/L water column methylmercury adopted by the State of Idaho, and the 0.35 parts-per-million (mg/kg) fish tissue concentration criteria established by the State of Oregon. These represent preliminary targets for mercury for the SR-HC TMDL. The final TMDL, to be completed in 2006, will identify final targets for mercury in the SR-HC TMDL reach.

3.1.2 Designated Beneficial Use Impairment

The SR-HC reach is listed from RM 409 to RM 188 for mercury. To date, data available show that mercury concentrations in the SR-HC reach of the Snake River exceed the fish tissue target established by this TMDL. Water column data is not available to allow an assessment of the use support status of aquatic life uses due to mercury concentrations within the SR-HC system.

All fish tissue data available in this reach were positive for mercury. A summary of these data show that the Oregon and Idaho levels of concern were exceeded by 80% (0.35 mg/kg) and 52% (0.5 mg/kg) respectively. Both states have acted to issue fish consumption advisories based on these exceedences. The US FDA action level for fish tissue (1.0 mg/kg) was exceeded in less than 10% of the fish tissue samples taken from the Upstream Snake River segment, and less than

3% of the fish tissue samples taken from the Brownlee Reservoir segment. The very limited data set available show no (0%) measured exceedences of the 0.050 ug/L US EPA water column criteria, however, detection limits were above this value by almost an order of magnitude in most cases.

The two samples in the Upstream Snake River segment exceeding the US FDA criteria occurred in channel catfish collected from the Snake River near the mouth of the Owyhee River and near Nyssa, Oregon. The three samples exceeding the US FDA criteria in Brownlee Reservoir occurred in channel catfish, crappie and smallmouth bass collected from Brownlee Reservoir near the mouth of the Burnt River.

Although there are no data available that show direct impairment of aquatic life uses due to mercury concentrations within the SR-HC system, the designated beneficial use of fishing is not fully supported due to fish consumption advisories for methylmercury established by the states of Oregon and Idaho. Therefore, the 303(d) listing of non-support is based on the presence of fish consumption advisories rather than the violation of water quality standards for mercury. Because of this, an appropriate initial target by which to evaluate the support status of the designated fishing use is the fish tissue target of 0.35 parts-per-million (mg/kg) identified by the SR-HC TMDL. There is insufficient data to determine the use support for aquatic life uses or for the wildlife and hunting use designation.

3.1.3 Mercury in Surface Waters

Mercury is a naturally occurring element, present in the environment in three principal forms: elemental, inorganic and methylated (or organic) mercury. Geologic deposits of mercury occur naturally in an inorganic form as the mineral cinnabar (HgS) in several areas of the SR-HC watershed, mainly the Owyhee and Weiser River drainages (Koerber, 1995; Gebhards *et al.*, 1971).

Air deposition and sediment transport and deposition processes (erosion) can result in mercury entering surface water systems. Once in the water, mercury can be converted from one form to another. Particle-bound mercury can be concentrated in areas of sediment deposition through particle settling, and then later released by diffusion or re-suspension. Much of the inorganic mercury entering surface water systems attaches to particles and sinks to the bottom. While inorganic or sediment-bound mercury can be absorbed by aquatic organisms, the rate and efficiency of the uptake is much lower than that for methylated or organic mercury. Inorganic forms of mercury can be converted to organic forms by microbial action. In an organic form (commonly methylmercury), mercury can easily enter the food chain, or it can be released back to the atmosphere by volatilization (USGS, 1995). Many factors influence the form, concentration and transport of mercury in the environment, these include the concentration of dissolved organic carbon (DOC), the pH of the water system, and the concentration of dissolved oxygen in the water (Hurley, 2001).

In aquatic systems, the majority of mercury binds to organic matter and fine particulates, the transport of mercury bound to larger, bed-sediment particles in rivers and lakes is generally less substantial than that observed for smaller, finer sediment fractions (US EPA, 2001a and 2001e).

Particulate-bound mercury has been shown to move through the food chain through ingestion by filter feeding organisms and through conversion to dissolved forms. Mercury-bound particle sizes range from colloidal materials (diameters less than a micron) to particles with diameters of tens of microns (MASCO, 2001).

In the bottom sediments, the most important conversion is the bacterially mediated methylation of mercury involving the addition of methyl groups to the mercuric ion (Hg^{2+}) by means of enzymatic activity (Agostino, 2001; MASCO, 2001; NWF, 2001). This conversion of inorganic to organic mercury occurs at different rates in different waterbodies. That is why some waterbodies with high levels of total mercury, but low rates of conversion to methylmercury, may not carry fish advisories while others do.

The exact mechanism(s) by which mercury is converted to methylmercury and readily enters the food chain remain largely unknown, and probably vary among ecosystems. It is known however, that certain bacteria play an important initial role. Many anaerobic bacteria, living at the sediment/water interface, including many strains of *Staphylococci*, *Streptococci*, yeasts and *Escherichia coli* (present in human intestines), are able to convert inorganic or elemental mercury into methylmercury (Ely, 1970; MASCO, 2001; NWF, 2001).

Studies have shown that bacteria that process sulfate (SO_4^{2-}) in the environment take up mercury in its inorganic form, and through metabolic processes convert it to methylmercury. According to current understanding, some of the “right” ingredients for producing methylmercury are found in systems that are rich in carbon, and low in dissolved oxygen (Hurley, 2001). The conversion of inorganic mercury to methylmercury is important for two reasons: (1) methylmercury is much more toxic than inorganic mercury, and (2) organisms require considerably longer to eliminate methylmercury (USGS, 1995). Methylmercury has low aqueous solubility and tends to accumulate in the lipid-rich tissues of aquatic organisms.

While most people and wildlife can generally tolerate extremely low levels of mercury. When mercury enters the body it becomes concentrated in tissue, an effect known as bioaccumulation. Since this element is toxic at very low concentrations, even slight increases in the minute concentrations naturally present in the environment can have serious effects on humans and wildlife (NWF, 1997).

Methylmercury is absorbed by tiny aquatic organisms such as phytoplankton and then zooplankton, which are in turn eaten by small fish. The chemical is stored in the fish tissue and is passed on at increasing concentrations to larger predator fish. People and wildlife at the top of the food chain are consequently exposed to elevated amounts of methylmercury through the contaminated fish they consume (NWF, 1997). Additionally, methylmercury is not eliminated effectively by metabolic systems and will continue to accumulate in fish as they age (Allen-Gil *et al.*, 1995; Allen and Curtis, 1991; Benson *et al.* 1976), creating the greatest risk for bioaccumulation in older, predatory fish species (Agostino, 2001). Bioconcentration factors of 63,000 for freshwater fish, 10,000 for salt-water fish, 100,000 for marine invertebrates, and 1,000 for freshwater and marine plants have been observed (US EPA, 2001b).

Studies have shown that for the same species of fish taken from the same region, increasing the acidity of the water (decreasing pH) and/or the dissolved organic carbon content generally results in higher body burdens in fish, possibly because lower pH increases ventilation rate and membrane permeability, accelerates the rates of methylation and uptake, affects partitioning between sediment and water, or reduces growth or reproduction of fish (US EPA, 2001e; USGS, 1995). However, many of the details of the aquatic mercury cycle are still unknown, and remain areas of active research.

While many factors are known to influence the accumulation of mercury in aquatic organisms (pH, water temperature, the amount of dissolved organic material present, etc.), how these factors relate to each other and to the bioaccumulation of methylmercury is still poorly understood. No single factor has been generally correlated with level of mercury accumulation in aquatic organisms. Therefore, even though two water bodies may be very similar in physical characteristics, the measured concentrations of methylmercury in fish may be very different between the two (US EPA Mercury Web Site and 2001b).

In addition, the transformation of inorganic mercury to methylmercury is not well defined. It is currently linked to both chemical and microbial processes and often occurs in a cyclic fashion within surface water systems. Thus, inorganic mercury in a surface water system represents a potential source of methylmercury if appropriate conditions exist (US EPA Mercury Web Site and 2001b).

The evaluation of mercury within aquatic systems is still an evolving science. Analytical methods have improved dramatically over the last few years as evidenced by increased accuracy and lower detection limits, and state and federal policy and guidance have undergone many changes.

3.1.4 Sources

Both natural and anthropogenic sources of mercury are known to occur in the SR-HC TMDL drainage. External sources of mercury loading to this reach include natural and background loads from the watershed and air deposition from point and nonpoint sources.

3.1.4.1 NATURAL GEOLOGICAL SOURCES.

Natural sources of mercury include volcanic rocks and mineral deposits in the rocks and soils in several areas of the SR-HC drainage. Cinnabar, the most commonly occurring ore of mercury, contains 86.2% mercury and can occur as impregnations and vein fillings in near-surface environments from solutions associated with volcanic activity and hot springs. Cinnabar can also occur as placer type concentrations produced with the erosion of mercury-bearing rocks (ADEQ, 1999a and 1999b). Natural weathering and erosive processes can increase the transport and mobility of the mercury associated with these deposits. Concentrations of mercury identified in various rocks and soils are shown in Table 3.1.1.

Mercury concentrations identified in the Owyhee River drainage are notably higher than those identified in other areas. Some of these deposits contain enough mercury that they have been mined profitably. These deposits represent potential sources of natural loading to the SR-HC reach. Additionally, given the high level of geothermal activity in the Owyhee River drainage, natural, geothermal releases may also be a significant and persistent source of mercury in the

Table 3.1.1. Identified concentrations of mercury in different rock and soil types.

Type or location	Mercury (ppm)	Reference
Igneous rocks (international)	0.01 to 0.1	Fleischer *et al.*, 1970; ATSDR, 1994a
Sedimentary rocks	0.01 to 0.05	ATSDR, 1994a
Owyhee River Basin rocks	<0.1 to 6.2	Koerber, 1995
Background rocks	0.01 to 0.05	Andersson, 1979
Western soils	0.5	Hill, 1973
Average of all soils	0.02 to 0.625	ATSDR, 1994a
SE Oregon and N Nevada soils	0.032 to 0.051	Schacklette and Boerngen, 1984
Owyhee River Basin soils	0.1 to 565.0	Koerber, 1995

area (Allen and Curtis, 1991). Mercury deposits have also been identified in the Weiser River drainage (IDEQ, 1985), although mining activities in this drainage were more limited in scope.

Anthropogenic sources of mercury in the SR-HC area include historic use of fungicides and seed treatments in the Snake River Basin, sewage sludge and compost, landfills and industrial processes, legacy mining activities, current mining activities, air deposition from sources both inside and outside the area, cement plants and coal-fired power plants. Tributary flows to the Snake River also potentially deliver mercury from both natural and anthropogenic sources within tributary drainage areas.

3.1.4.2 SEED TREATMENTS.

From the 1950's to the 1980's, chemical treatments containing mercury were used on seed grains in the US. During 1970, mercurial seed treatment on winter and spring wheat in Idaho was estimated to be equivalent to 720 pounds (327 kg) of mercury annually (Gebhards *et al.*, 1971). The use of these seed treatments was discontinued in the 1980's. Historically, the mercury in these treatments may have contributed to water contamination due to field drainage and irrigation water return in some areas. While the use of these treatments has primarily been discontinued in the US, residual mercury in agricultural soils may still be contributing a small amount of mercury to the SR-HC system through sediment transport and erosion.

Assuming the usage estimated for 1970 is representative of the average usage during the time that seed grains treated with these compounds were used in Idaho, a total of 25,200 pounds (11,454 kgs) of mercury would have been applied in the form of seed treatments in Idaho. The majority of the upstream drainage for the SR-HC TMDL is contained in the state of Idaho. Approximately 67% of the total grain grown in Idaho in 1970 was produced in the Snake River Basin upstream of Hells Canyon Dam (USDA-NASS, 2001). Assuming that the 1970 distribution of agricultural land devoted to grain production throughout the state is representative of the distribution during the time when mercury-containing seed treatments were used (roughly 1950 to 1985), 67% of the total mercury from seed treatments (16,884 pounds, 7,675 kgs) would have been applied in the Snake River Basin. In Oregon, assuming that use of seed treatments in the southeastern portion of the state was similar to that in Idaho, 1,077 pounds of mercury (489 kgs) in the form of seed treatments was applied during this same 35-year period. Total mercury from usage of seed treatments in the drainage above Hells Canyon Dam is estimated at 17,961 pounds (8,164 kgs) over the 35 year time period (513 pounds/year, 233 kgs/year).

While a percentage of this total could leach, over time, to the Snake River system and be transported downstream, treated seed grains were planted over a very large area (roughly 642,000 acres). Assuming that all acres were planted with the same density of seed, the calculated mercury loading is 0.013 kg per acre. Not all land on which mercury-treated seeds were planted is still in agricultural use, however, irrigation and cropping practices on current agricultural lands are much improved from those used previously. Flood and furrow irrigation has been replaced in many areas with sprinkler or drip irrigation systems that result in substantially lower erosion and sediment transport. Management techniques currently in use such as straw mulching and PAM application have also been reported to reduce sediment transport. With reduced erosion and sediment transport probability, and the cessation of use in the mid 1980's, the mercury from legacy seed treatments in the Snake River Basin is not identified as a substantial source of current mercury loading to the SR-HC reach.

3.1.4.3 Sewage Sludge (or Biosolids) and Wastewater Treatment Plants.

Mercury concentrations in domestic wastewater sludge range from 0 to 2.2 mg/L. The average concentration defined by the US EPA is 0.28 mg/L (US EPA, 1984b). The application of sewage sludge to croplands can result in increased levels of mercury in soil. However, land application operations are permitted activities and are generally monitored for heavy metals accumulation in soils. They are also sited and managed such that the risk of discharge of either runoff water or eroded materials into surface water systems is low. Under general circumstances, therefore, these facilities are not identified as a substantial source of mercury loading to the SR-HC system.

Wastewater treatment plants have been observed to discharge elevated concentrations of mercury due to the waste from dental offices and medical waste disposal. Four wastewater treatment plants currently discharge to the Snake River in the SR-HC TMDL reach. Industrial discharges can also carry substantial concentrations of mercury depending on what is being manufactured. Battery and florescent light-bulb manufacturers have been documented to elevate mercury levels in their waste-streams. No such manufacturing facilities discharge directly to the Snake River within the SR-HC TMDL reach.

No mercury monitoring is currently available to determine the loading to the SR-HC TMDL reach that these sources represent.

3.1.4.4 Landfills.

A number of landfills are sited in the SR-HC drainage basin. The US EPA has identified the greatest source of mercury loading in landfills to be associated with the disposal of batteries (the primary source), and other items such as broken florescent bulbs and thermometers. However, due to their relative sparseness and general locations in the area (away from surface and ground water influences), these facilities are not identified as a substantial source of mercury loading to the SR-HC system.

3.1.4.5 MINING.

Gold, silver and mercury mining has occurred historically in the SR-HC drainage area between 1860 and 1920, primarily in the area of the Owyhee River watershed. Mercury ore (cinnabar) deposits have been identified in the Owyhee and Weiser drainages (Koerber, 1995; Gebhards *et al.*, 1971). Transport and deposition of mercury from these sources may contribute to the soil and water concentrations within the SR-HC drainage area (Koerber, 1995). The Weiser River drainage also experienced mining in the early to mid 1900's. The Idaho-Almmaden mine located about 11 miles east of the City of Weiser, produced over 600 tons of liquid mercury in a process where ore is roasted and then mercury vapors are condensed and collected. The mine operated between 1939 and 1942 (152 tons), then reopened and operated between 1955 and 1961 (456 tons) (Alt and Hyndman, 1989).

Mercury was used historically in the extraction process to remove gold from raw ore. Before the beginning of the 20th century, mercury amalgamation of gold ores was a common practice throughout the Western US (Hill, 1973; Allen-Gil *et al.*, 1995; Allen and Curtis, 1991; ADEQ, 1999a and 1999b). Most of the mercury in the amalgam was recovered, but some washed out with the fines. Amalgam furnaces may also have resulted in soil contamination through short-range deposition (ADEQ, 1999a and 1999b). Mercury in mine tailings is commonly in the elemental form. However, stream sediments in the area of tailings piles are often enriched in elemental and exchangeable forms of mercury (ADEQ, 1999a and 1999b). Observed mercury concentrations in legacy gold and silver tailing piles can range up to 5 mg/kg at various sites throughout North America (Lacerda, *1990*; Allen-Gil *et al.*, 1995; Allen and Curtis, 1991). Additionally, while gold and silver mining do not directly increase the availability of mercury within the watershed, rock-crushing activities associated with the extraction process that reduce the particle size of mercury-containing rock and increase the amount of mercury available in a readily erodable form (ADEQ, 1999a and 1999b).

A study conducted jointly by IDHW and IDFG in 1970 showed that bottom fish collected from areas in the Snake River Basin with substantial legacy mining activities exhibited mercury concentrations in muscle tissue that averaged 0.520 mg/kg. Rainbow trout in the same area averaged muscle tissue mercury concentrations of 0.231 mg/kg. Bottom fish and rainbow trout from an area outside the influence of mining activities averaged muscle tissue mercury concentrations of 0.275 mg/kg and 0.102 mg/kg respectively. While the date of this study indicates that the analytical technology used is not as robust and accurate as that available today, a relative comparison of values remains valid. The data indicate that the levels of mercury in fish tissue in fish exposed to mining wastes is nearly double that of fish in the same geologic area (e.g. exposed to natural sources of mercury) but not exposed to mining wastes (Gebhards *et al.*, 1971).

The Owyhee River flows into the Snake River in the Upstream Snake River segment of the SR-HC TMDL at RM 396.7. Mercury concentrations in bed sediments of Owyhee Reservoir average 1.4 ug/g, with most of the mercury (92%) being associated with sediment particles greater than 1 mm in diameter. Water column mercury measured in the Owyhee Reservoir averaged 0.37 ug/L (range 0.07 to 0.67 ug/L) (Allen-Gil et al., 1995; Allen and Curtis, 1991). Given the 715,000 acre-foot volume of the reservoir, this represents a total mass of 327 kg of mercury in a dissolved and therefore fairly mobile form. The mean mercury concentration in sediment reported for Owyhee Reservoir was higher than that reported for numerous other lakes in the Northwest (Allen-Gil et al., 1995; Allen and Curtis, 1991).

Mercury loading in Owyhee Reservoir is most likely derived from natural deposits exacerbated by legacy mercury, gold and silver mining in the area. It is estimated that more than 76 pounds of mercury were lost daily during mining years in Idaho (Hill, 1973; Allen-Gil *et al.*, 1995; Allen and Curtis, 1991). The Idaho Historical Society reported that one mill in the Owyhee River drainage (Silver City) "lost" 2.5 tons of mercury between 1866 and 1888. Free mercury was visible in the soil and rock crevices at a mill site in the same area as late as 1971 (Gebhards *et al.*, 1971).

Mercury concentrations in sediments from the Weiser River were also evaluated (Buhler *et al.*, 1984). The mean sediment mercury concentration in the mainstem Weiser River was 0.054 mg/kg (dry weight). The mean sediment mercury concentration in tributaries to the Weiser River was 1.30 mg/kg (dry weight).

Little information is available to determine the mercury loading to the Snake River from the Owyhee River drainage or from any of the other tributaries to the Snake River in the SR-HC reach. One of the major problems encountered is the lack of water column data. The majority of water column data available was collected prior to 1990 and is therefore not easily correlated with current analytical technology. In addition, this data, and that collected in the 1990's show no measurable concentrations above the detection limits. The elevated concentrations of mercury in the soils and water of the Owyhee River drainage indicate that it represents a substantial source of potential loading from both natural and anthropogenic sources. Anthropogenic loading is assumed to be primarily the result of legacy mining activities.

3.1.4.6 AIR DEPOSITION.

Air deposition of mercury has recently been identified as a substantial source of mercury loading in the US (US EPA, 1997a and 1997b). The anthropogenic air deposition rate for the SR-HC reach estimated by this report is 1 to 3 ug/m^2/yr (US EPA, 1997a and 1997b). Using a mean value of 2 ug/m^2/yr, this yields a potential deposition of 13 kg/year of mercury to the land area directly discharging to the SR-HC TMDL reach and 380 kg/year of mercury to the land area in the Snake River drainage area above Hells Canyon Dam. The primary source of atmospheric mercury identified by this report is the combustion of fossil fuels. Current emissions of mercury from manufacturing sources are low compared to combustion sources, with the exception of chlor-alkali plants and portland cement manufacturing plants.

Recent guidance on mercury deposition released by US EPA in 2001 report a "typical low level air deposition load" as 10 ug/m^2. A study of the San Francisco area measuring wet and dry deposition rates for the San Francisco estuary at 4.2 ug/m^2/year and 19 ug/m^2/year, respectively (Tsai, 2001). Adjustment of the original calculated loading from air deposition to reflect the updated UP EPA deposition loads increases the original estimate to a potential deposition of 65 kg/year of mercury to the land area directly discharging to the SR-HC TMDL reach and 1,900 kg/year of mercury to the land area in the Snake River drainage area above Hells Canyon Dam.

Even without site-specific data, assuming that actual deposition loads are bracketed by these two estimates gives a strong indication that air deposition represents a substantial source of mercury loading to the SR-HC TMDL reach.

3.1.4.7 Portland-Process Cement Plants.

There is currently one operating cement plant in the immediate SR-HC drainage, the Ash Grove plant at Durkee, OR. Monitoring indicates that this plant produces emissions containing approximately 109 pounds (49.5 kg) of mercury per year.

3.1.4.8 Coal-Fired Power Plants.

There is only one coal-fired power plant operating in the Snake River region. The power plant at Boardman, OR is located in the Willow Creek subbasin in Oregon, near the Oregon/Washington border, approximately 100 miles northwest of the northern extent of the SR-HC TMDL reach. This plant produces emissions containing approximately 186 pounds (84.5 kg) of mercury per year when operating at full capacity.

The prevailing wind direction in the SR-HC watershed is from west to east. As both of these facilities are located west of the SR-HC area, there is a potential for at least some of the mercury loading from these plants to reach the SR-HC TMDL drainage. Probability is higher that the Ash Grove cement plant will be a greater contributor however as it is located nearly due west of the SR-HC reach while the Boardman plant is located to the northwest of the SR-HC TMDL area. Mercury emitted from these types of sources can travel for long distances depending on the chemical form it is in and the climate. Areas of relatively low precipitation offer less chance for the mercury to be deposited close to the source, as wet deposition will not occur regularly. Dry deposition, where mercury adsorbs to suspended particles usually results in longer-range transport than wet-deposition where mercury is captured in rain or snow and falls down with the drops. Dry deposition is expected to be the most common form of air deposition for mercury in the SR-HC reach.

3.1.5 Transport and Delivery

Sediment transport of mercury is expected to be highest in drainages where steep slopes, relatively sparse vegetation and precipitation occurring primarily in the form of snowfall combine. Sparse vegetation and timing of snowmelt in the Owyhee and Weiser River drainage, and in much of the rest of the SR-HC drainage where geologic deposits of mercury occur, produce conditions favoring high surface runoff and sediment transport.

Flooding can also enhance mercury transport and bioaccumulation. Flooding results in a surge of mercury and other materials into local reservoirs where methylation occurring in flooded shorelines and near shore sediments may result in higher rates of bioaccumulation. This mechanism has been documented (Phillips *et al.*, 1987) in the Upper Missouri River Basin where northern pike were observed to exhibit higher mercury concentrations in the year following significant flooding than in previous or succeeding years.

Additionally, land use patterns may play a role in determining the behavior of mercury in reservoir systems (Allen-Gil *et al.*, 1995; Allen and Curtis, 1991; Sorensen *et al.* 1990). Land use patterns may act to influence mercury transport within a drainage area to surface water systems and within reservoir systems. Unfortunately, the relative impact of land use practices is not quantifiable with the available data for the SR-HC system.

A report prepared by CH2MHill for IPCo (IPCo, 2000d) identified sediment mercury levels and associated particle sizes within the SR-HC reach. As discussed in more detail in Section 3.1.6, the samples containing the greatest concentrations of mercury in the Upstream Snake River segment (RM 409 to 335) contained larger-size sediment particles, suggesting that the mercury is present in either its native form or as cinnabar (HgS) (IPCo, 2000d) and is most likely deposited in this stretch through erosion and transport processes.

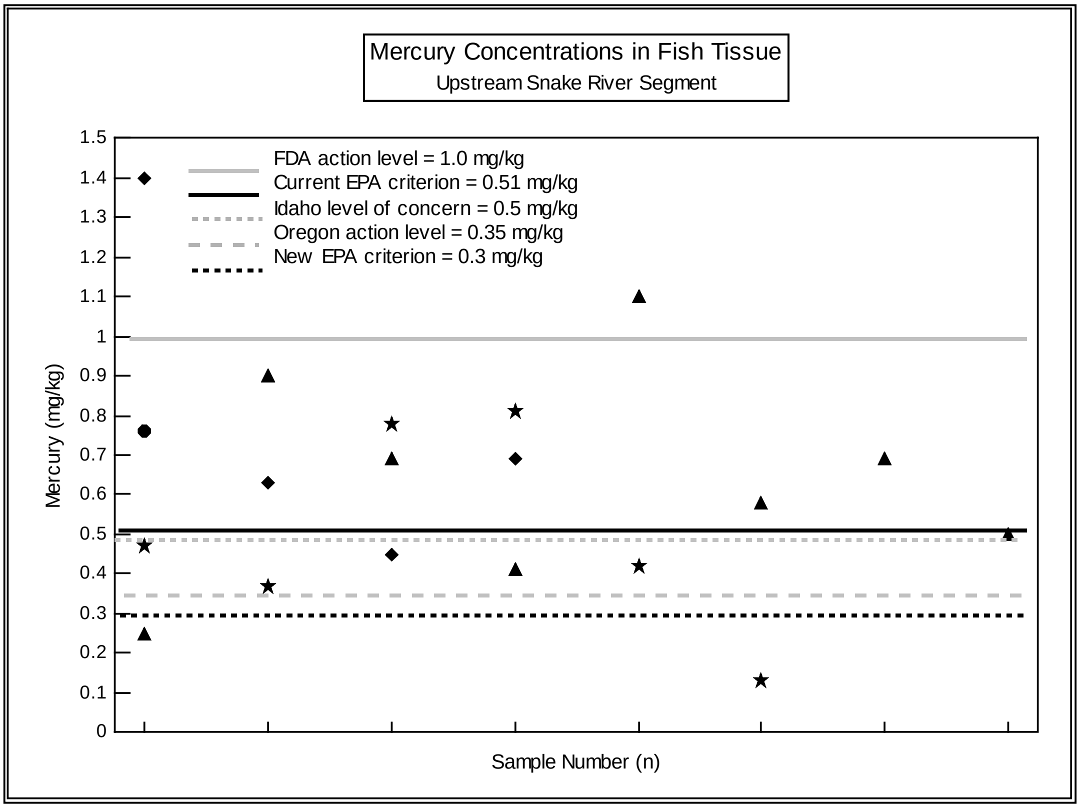
3.1.6 Data Available for the Snake River - Hells Canyon Reach

Mercury data available to this TMDL effort are almost exclusively in the form of fish tissue concentrations. Few data points identifying water column concentrations of mercury are available. Water column data are reported as <0.1 ug/L (Rinella *et al.*, 1994) or are reported as "below the detection limit" of 0.5 (the majority of the data set) or 0.2 ug/L, and were collected before 1990. There are 23 water column samples collected in 1990 that reported concentrations below detection limits of 0.2 ug/L mercury (US EPA STORET). Additionally, information collected by the City of Fruitland as part of the monitoring associated with the City's wastewater treatment plant show three data points for the Snake River (near the discharge point of RM 373). All samples were taken early in 2002 and show water column mercury concentrations in the Snake River to be less than the detection limit of 0.010 ug/L. These values are below the preliminary water column target of 0.012 ug/L established by the SR-HC TMDL.

Mercury data is available from the 1970's and the 1990's. However, due to substantial changes land management, sampling and analytical techniques and dramatic improvements in detection limits, the data collected in the 1990's is assumed to be more representative of actual conditions than that collected in the 1970's. Data collected in the 1970's are discussed in a general fashion within this section. Data from the 1990's are used as a basis for determining designated beneficial use impairment and management/control measures appropriate for the system. Data are shown in Figure 3.1.1 and Table 3.1.2.

Studies conducted in the 1970's (Benson *et al.*, 1976; Maret, 1995) characterized mercury concentrations in fish populations in Brownlee Reservoir (76 samples) and the Downstream Snake River (18 samples) segment as compared to upstream populations in the Snake River (31 samples).

The data collected in the 1990's contain a small fish tissue methylmercury data set for the Upstream Snake River segment (21 data points), a larger fish tissue methylmercury data for the Brownlee Reservoir segment (129 data points), and a single data point for the Downstream Snake River segment. There are no known fish tissue methylmercury data available for the Oxbow Reservoir or Hells Canyon Reservoir segments. No measured water column and little sediment mercury data are available to this effort. Water column data indicate only that concentrations were below the below detection limits, they do not give quantitative, measured concentration values.



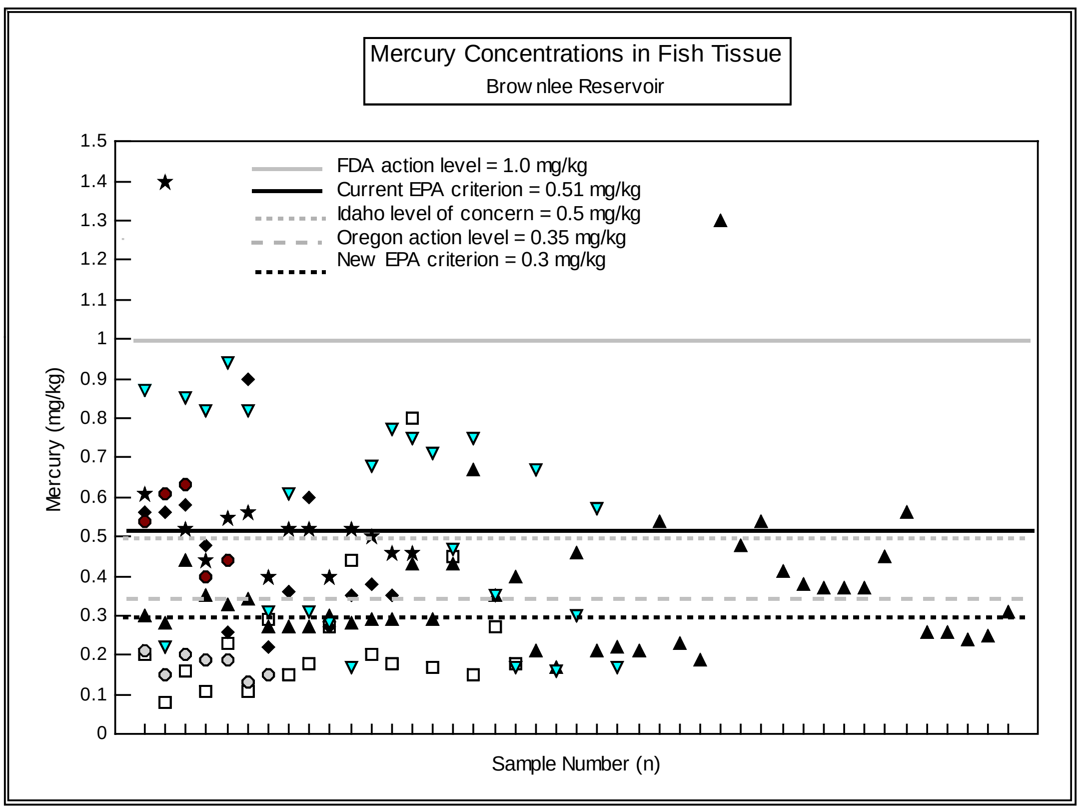


Figure 3.1.1. Mercury concentrations in fish tissue samples from the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir Segments of the Snake River - Hells Canyon TMDL reach.

Table 3.1.2. Mercury data available for the Snake River - Hells Canyon TMDL (1970 through 1997).

Sample Site	Sample Group	Fish species	Year*	Average Hg (mg/kg wet weight)	n
Upstream	OSU	Channel Catfish	1970	0.61	11
Brownlee Res.	OSU	Channel Catfish	1970	0.97	5
Brownlee Res.	IDFG	Largemouth Bass	1970	0.37	3
Brownlee Res.	IDFG	Smallmouth Bass	1970	0.53	2
Brownlee Res.	IDFG	Bluegill	1970	0.60	1
Brownlee Res.	IDFG	Channel Catfish	1970	0.37	16
Brownlee Res.	IDFG	Carp	1970	0.24	1
Brownlee Res.	IDFG	Pike Minnow	1970	0.73	1
Brownlee Res.	IDFG	Sucker	1970	0.30	9
			Average	**0.51**	**38**
Upstream	IDFG/IDHW	Catfish	1975	0.33	20
Upstream	IDFG & Others	Water	1975 to 1977	<0.5 ug/L	72
Upstream	IDFG & Others	Water	1977 to 1987	<0.5 to <0.2 ug/L	67
Upstream	IDFG & Others	Water	1987 to 1989	<0.2 ug/L	19
Brownlee Res.	IDFG/IDHW	Idaho Catfish	1975	0.50	20
Brownlee Res.	IDFG/IDHW	Idaho Bass	1975	0.64	18
			Average	**0.57**	**38**
Hells Canyon	IDFG/IDHW	Idaho Bass	1975	0.79	18
Upstream	USGS	Carp	1990	0.79	4
Upstream	USGS	Channel Catfish	1990	0.64	8
Upstream	USGS	Smallmouth Bass	1990	0.50	6
Upstream	USGS	Crappie	1990	0.24	1
			Average	**0.62**	**19**
Upstream	USGS	Whole Water	1990	<0.1 ug/L	2
Upstream	USGS	Whole water	1989	<0.5 ug/L	3
Upstream	USGS	Whole water	1989	<0.2 ug/L	6
Upstream	USGS	Sediment	1990	0.02 ug/g	2
Brownlee Res.	IDEQ	Smallmouth Bass	1994	0.56	14
Brownlee Res.	IDEQ	Carp	1994	0.60	13
Brownlee Res.	IDEQ	Catfish	1994	0.34	42
Brownlee Res.	IDEQ	Black Crappie	1994	0.24	19
Brownlee Res.	IDEQ	White Crappie	1994	0.53	24
Brownlee Res.	IDEQ	Yellow Perch	1994	0.54	5
Brownlee Res.	IDEQ	Rainbow Trout	1994	0.19	7
			Average	**0.39**	**124**

Sample Site	Sample Group	Fish species	Year*	Average Hg (mg/kg wet weight)	n
Brownlee Res.	USGS & others	Whole water	1990 to 1996	< 0.2 ug/L	23
Upstream	USGS	Sediment	1997	0.04 ug/g	1
Brownlee Res.	USGS & IPCo	Largescale Sucker	1997	0.11	1
Brownlee Res.	USGS & IPCo	Carp	1997	0.32	1
Brownlee Res.	USGS & IPCo	Smallmouth Bass	1997	0.29	1
Brownlee Res.	USGS & IPCo	Crappie	1997	0.27	1
Brownlee Res.	USGS & IPCo	Channel Catfish	1997	0.33	1
			Average	**0.26**	**5**
Brownlee Res.	USGS	Sediment	1997	0.10 ug/g	2
Hells Canyon	USGS & IPCo	Largescale Sucker	1997	0.03	1
Upstream	USGS & IPCo	Channel Catfish	1997	0.21	1
Upstream	USGS & IPCo	Largescale Sucker	1997	0.07	1
			Average	**0.14**	**2**

(*****NOTE: Data collected prior to 1989 to 1990 may show higher levels of error due to differences in sampling and analysis as compared to current technology. Data in this table are from Benson, 1976; Gebhards *et al.*, 1971; Maret, 1995; Rinella *et al.*, 1994; Clark and Maret, 1998; IDEQ, 1994; IDFG-IDHW, 1971 to 1979; IPCo, 2000d; Buhler, 1971; Buhler *et al.*, 1971.)

All fish tissue samples collected from this reach were positive for mercury. A summary of the data show that the Oregon and Idaho levels of concern were exceeded by 80% (0.35 mg/kg) and 52% (0.5 mg/kg) respectively. Both states have acted to issue fish consumption advisories based on these exceedences. The US FDA action level for fish tissue (1.0 mg/kg) was exceeded in less than 10% of the fish tissue samples taken from the Upstream Snake River segment, and less than 3% of the fish tissue samples taken from the Brownlee Reservoir segment. The very limited data set available show no (0%) measured exceedences of the 0.050 ug/L US EPA water column criteria, however, detection limits were above this value by almost an order of magnitude in most cases.

Fish tissue methylmercury data collected in the Upstream Snake River (n = 20) segment show the highest fish tissue methylmercury concentrations in fish taken from the area of the mouth of the Owyhee River (0.73 mg/kg, n = 3), followed by the fish taken from the area of the mouth of the Weiser River (0.64 mg/kg, n = 3). These findings correlate well with the relative levels of natural geological mercury deposits identified and mining activities within these drainages, as compared to the SR-HC reach in general.

Elevated mercury concentrations in fish tissue from the Upper Snake River Basin were identified by Maret (USGS, Maret, 1995) in an intensive evaluation of existing data (1970 to 1990). Mercury concentrations from most sites exceeded the US Fish and Wildlife National Contaminant Biomonitoring Program (NCBP) baseline concentration of 0.11 ug/g, but did not exceed the US FDA action level of 1.0 mg/kg for fish consumption. All fish tissue data from the Snake River show concentrations above the detection limits in all cases except samples from the

Snake River at Flagg Ranch (< 0.05 mg/kg wet weight (Maret, 1995)), the Snake River at Minidoka (< 0.1 mg/kg wet weight (Clark and Maret, 1998)) and the Snake River at Kimberly (< 0.1 mg/kg wet weight (Clark and Maret, 1998)). The areas where fish tissue mercury concentrations were below detection limits correlate well with sediment mercury concentrations, which were below the detection limits only in the Minidoka and Blackfoot areas (both < 0.02 mg/kg (Clark and Maret, 1998)).

Warmwater and nongame species in Idaho were found to contain approximately twice the concentration of mercury as found in coldwater game fish species (Gebhards *et al.*, 1971). This indicates a relationship between diet and age, and mercury accumulation. Fish that are piscivorous (eat other fish) generally contain higher levels of mercury than fish that eat mainly plankton and insects. Some fish (such as rainbow and cutthroat trout) convert from a plankton/insect diet to a small fish diet after reaching a certain age or weight. Therefore older fish, and fish whose diets consist mainly of other fish should be avoided. Fish populations, in association with those human populations most at risk for injury due to mercury consumption, are targeted by the fish consumption advisories in place.

Gebhards (1971) states that geological sources of mercury are probably the major contributors to mercury residues in fish in the SR-HC area where anthropogenic activity is limited. The Oregon fish consumption advisory states that "the mercury in fish is thought to be from natural volcanic and geothermal sources in the upper drainage areas, possibly influenced by historical mining practices". This statement is substantiated by the evaluation of proportional source loads within the SR-HC system.

Some bed sediment mercury information is available for several sites in the Upstream Snake River and Brownlee Reservoir segments. Mercury concentrations in bed sediments of the Snake River upstream of CJ Strike Reservoir range from 0.035 parts-per-million (ug/g) near Blackfoot to 0.09 parts-per-million (ug/g) near Buhl (Maret, 1995).

Mercury in bed sediments sampled by the USGS in Brownlee Reservoir near the inflow of the Burnt River and at Mountain Man Lodge (RM 310) (Clark and Maret, 1998) in 1997 were less than 0.174 parts-per-million (mg/kg), the threshold effects level (TEL) and 0.486 parts-per-million (mg/kg), the probable effects level (PEL) in all cases. The TEL and PEL are concentrations levels published by the National Oceanic and Atmospheric Association (NOAA) for the protection of benthic life.

The CH2MHill report (IPCo, 2000d) identified sediment mercury levels and associated particle sizes within the SR-HC reach. Particle size is an important factor in evaluating the distribution of mercury in sediments as smaller particle sizes have exponentially greater surface areas and are therefore likely to carry much larger adsorbed loads of trace metals and organic compounds. Clays and silts, commonly made up of very fine particles, generally have much higher concentrations of adsorbed constituents than coarser-grained sediments (IPCo, 2000d). Samples were taken from RM 397, downstream to Brownlee Dam (RM 285) including the mouth of the Owyhee, Boise, Malheur, Payette, Weiser, Burnt and Powder rivers. Samples were taken approximately every five miles from RM 340 to RM 285. Three deep core samples were extracted between RM 320 and RM 325 (within Brownlee Reservoir). Samples were collected from December 1998 to January 2000. Deep core samples included materials from approximately 10 feet below the 1952-surveyed water-surface elevation, which represents pre-impoundment conditions.

Data collected in this study showed a generally increasing trend in mercury concentration upstream to downstream. In the lower reservoir (RM 285 through 310) where the percentage of fine particles was the highest (6 samples), no concentrations exceeded the mercury PEL of 0.486 parts-per-million (mg/kg). The TEL (0.174 parts-per-million (mg/kg)) was exceeded for all samples.

In the upper reservoir (RM 312 through 336, 7 samples) the highest concentrations of mercury were observed at RM 335. The TEL was exceeded at this location, but not the PEL. The sediment collected at this location contained essentially no fine particles. This suggests that the mercury is present in either its native form or as cinnabar (HgS) (IPCo, 2000d) and is most likely deposited in this stretch through erosion and transport processes.

In the Upstream Snake River segment (RM 340 to 397, 11 samples), the TEL was exceeded at RM 340 only. This sample, located close to the one discussed at RM 335 above, contained both fine and coarse particle sizes but was analyzed as a composite. Therefore, the higher mercury levels may be due to the coarse grain sizes as at RM 335. The TEL for mercury was not exceeded in any of the tributary samples (IPCo, 2000d).

In the deep core samples (RM 320 to 325, 36 samples from 3 separate cores), none of the samples exceeded the TEL or PEL for mercury, indicating that the majority of mercury loading is probably associated with sediment erosion, transport and deposition within the SR-HC drainage rather than with strata associated directly with the SR-HC channel in Brownlee Reservoir.

Differences between this study and that undertaken by the USGS (Clark and Maret, 1998) are not necessarily indicative of reduced levels of mercury in the bed sediments within the SR-HC reach due to differences in the analytical technique applied. The digestion procedure used to prepare solids for trace metal analysis by the USGS was a more aggressive technique than that used by the CH2MHill study (IPCo, 2000d). A more aggressive digestion step can result in the dissolution of a greater proportion of the inorganic mercury in a sediment sample than that dissolved by a less aggressive digestion procedure. Therefore, reported concentrations would be expected to be higher for the analysis employing the more aggressive dissolution technique.

3.1.7 Determination of Mercury Loading

Determination of pollutant loading to a surface water system is generally accomplished through an association of concentration and flow values. Without the availability of measured water column concentration data for the SR-HC system, alternative methods of assessing mercury loading have been investigated. Without measured data for water column concentrations in the system, relative loading estimates and frequency of fish tissue target exceedences have been used as general indicators of the level of concern and actions necessary. Table 3.1.3 shows the identified sources of mercury to the SR-HC system and the relative contribution, measured or calculated of each. It should be noted that this information is preliminary, based on data and information currently available and may not be representative of the trends identified in the final SR-HC mercury TMDL.

Table 3.1.3. Identified sources of mercury loading to the Snake River - Hells Canyon reach and the relative contribution to total loading.

Source	Timeline	Data Type	Concentration or Potential Load	Relative Proportion of Measured Total
Seed treatments	Historical	Calculated	Estimated 8,164 kg total (0.013 kg/acre)	Unknown – assumed very small
Mercury in land applied domestic wastewater sludges	Current	EPA guidance	Negligible	Negligible
Landfills	Current	EPA guidance	Negligible	Negligible
Industrial processes	Current	EPA guidance	Negligible	Negligible
Mining	Legacy	Literature value	Up to 5 mg/kg tailings	Unknown – assumed moderate to high
Mining	Current	Monitored	No direct discharge	Unknown
Air Deposition - SR-HC direct drainage	Current	EPA guidance	380 to 5,110 kg/year	Unknown – estimated to be substantial
Air Deposition - Snake River Basin	Current	EPA guidance	380 kg/year	Unknown – estimated to be substantial
Ash Grove Cement Plant	Current	Monitored	49.5 kg/year	Small
Coal-Fired Power Plant	Current	Monitored	84.5 kg/year (at 100% capacity)	Small
Tributary loading (non-mining anthropogenic)	Current	Monitored – Water Column	Below detection limits	Unknown – assumed small
Natural loading – Owyhee basin	Historic and current	Monitored rock/soil concentrations	0.1 to 565.0 mg/kg in geologic deposits	Assumed moderate to high given richness of mineral deposits identified
Sediment loading – In channel values	Historic and current	Monitored rock/soil concentrations	0.02 to 0.05 mg/kg from measured data	Unknown – assumed moderate to high
Natural loading – In channel values	Historic and current	Monitored US rock/soil concentrations	0.02 to 0.625 mg/kg	Unknown – assumed moderate to high

Where sufficient data is available, bioaccumulation factors can be calculated for fish species in a mercury-enriched system. Preliminary bioaccumulation factors were developed by US EPA for application on a nationwide basis. However, under peer review, it was determined that these factors contained sufficient variability that they should not be applied in a generalized fashion (US EPA, 2001b). Peer review yielded the following findings and recommendations:

1. Bioaccumulation of methylmercury is highly site-specific in nature in aquatic environments
2. The peer reviewers recommended "developing methylmercury BAFs on a more local or regional scale if not on a site-specific basis…"
3. "After considering various issues about mercury fate in the environment…and the BAF peer review comments, EPA concluded that it is more appropriate at this time to derive a fish tissue…residue water-quality criterion for methylmercury than a water column based water quality criterion."

The recommendation was made that site-specific bioaccumulation factors be developed for systems of concern. Unfortunately, the data available at this time is not sufficient to develop site-specific methylmercury bioaccumulation factors for the SR-HC reach. Therefore, water column concentrations cannot be calculated directly from the available fish tissue data.

Similarly, in response to recent advances in analytical technology and better understanding of methylmercury transport and uptake in living systems, the State of Idaho is initiating a review and potential revision of the current action level for methylmercury in fish tissue. Oregon is willing to participate in this review. The associated guidelines for issuing fish consumption advisories are also currently undergoing review. New action levels and guidelines are expected to be identified late in 2003 (personal communication, M. Wen, IDHW-EHS, May 2001).

Known designated beneficial use impairment due to mercury concentrations within the SR-HC reach is related to the designated use of fishing. This use is not fully supported due to elevated concentrations of mercury identified in fish tissue in the Upstream Snake River and Brownlee Reservoir segments. Elevated mercury concentrations in fish tissue represent a risk for both humans and wildlife consuming fish tissue.

3.1.8 Load Allocations and Other Appropriate Actions

Using the target water column concentration of 0.012 ug/L, a load capacity can be calculated (Table 3.1.5). However, calculation of an existing load or load allocation is not possible due to lack of water column data. Additionally, while relative load comparisons can be estimated, there are not sufficient data available to quantify the loading from legacy mining activities relative to natural loading within the SR-HC system. These assessments will be accomplished as part of the 2006 mercury TMDL.

3.1.9 Determination of the TMDL

Due to the uncertainty of back calculation from fish tissue methylmercury data, and the lack of water column mercury data for the SR-HC reach, a TMDL load cannot be calculated at this time.

The DEQs have assessed the data available (primarily fish tissue data) and do not feel that a load can be accurately back calculated. Current EPA guidance for calculating air deposition-based loading alone would constitute 92% of the allowable calculated capacity. The DEQs do not believe that this accurately characterizes the system. More data is needed to make an accurate assessment.

Due to the magnitude of these concerns, IDEQ and ODEQ have determined it is in the public interest to reschedule the mercury TMDL for Brownlee Reservoir. IDEQ has rescheduled this mercury TMDL to 2006 in order to gather additional data to better determine the sources and extent of mercury contamination. This change has been approved by the US EPA. This timeline is in compliance with ODEQ's existing schedule.

The state of Oregon is developing capability to model site-specific bioaccumulation factors. Also, Oregon's mercury TMDL is not due until 2006. This schedule change will allow a better use of these capabilities and the opportunity to collect additional data.

Both Idaho and Oregon have interim measures in place to deal with mercury contamination such as sediment controls and fish consumption advisories. It is the opinion of the DEQs that this schedule change will not present an adverse impact to the SR-HC TMDL reach.

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3.2 Nutrient Loading Analysis

3.2.1 Water Quality Targets and Guidelines

The purpose of TMDL development is to meet applicable water quality standards. Because the SR-HC TMDL is a bi-state effort, the most stringent of each state's water quality standards have been identified as the targets for this TMDL. In this way the attainment of these targets will ensure that the water quality requirements of both states will be met.

The Upstream Snake River segment (RM 409 to 335), the Brownlee Reservoir segment (RM 335 to 285) and the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach are listed for nutrients on the state 303(d) lists for this TMDL. The water quality standards and guidance values identified for excess nutrients in the SR-HC TMDL are narrative criteria that address both the direct effects of elevated nutrient concentrations and the indirect effects of increased algal growth. These criteria require that nutrients shall not exceed quantities that impair designated beneficial uses, or cause visible slime growths or other nuisance aquatic growths that impair designated beneficial uses. Designated beneficial use impairment by excess nutrients is also linked to low dissolved oxygen concentrations through the growth and decay of algae, other aquatic plants and organic material resulting from elevated nutrient concentrations and loading.

A narrative standard for nutrients is appropriate given that the associated problems (excessive growth, low dissolved oxygen, etc.) can occur under a range of concentrations and are related to system characteristics such as flow, temperature, water column mixing, light penetration and water depth. Interpretation of the narrative standard on a site-specific basis is necessary to identify targets that will be protective of designated beneficial uses within the listed segment. The designated beneficial uses determined to be most at risk from excess nutrients were those associated with recreation and aquatic life. Direct effects on aesthetics and recreational use and indirect effects on aquatic life in the SR-HC TMDL reach are linked to excessive nutrient loading. A more detailed discussion of these concerns is included in the Subbasin Assessment for the SR-HC TMDL.

US EPA previously established guidelines for nutrient concentrations in surface waters specific to those waters discharging into lakes or reservoirs (0.05 mg/L total phosphorus) and those waters not discharging into lakes or reservoirs (0.10 mg/L total phosphorus). These guidelines have since been updated by US EPA with the release of ecoregional guidance values, and nutrient criteria establishment guidance (US EPA, 2000d). Additional methodology is available from other regions of the United States for the identification of algal biomass and chlorophyll *a* targets protective of designated beneficial uses. (Chlorophyll *a* can be used as a surrogate for algal biomass determination.) This guidance was used as an initial starting point for the identification of target concentrations for nutrients in the SR-HC TMDL. Available data from the SR-HC reach and other appropriate segments of the Snake River were evaluated to determine what instream concentrations would result in attainment of water quality standards and support of designated beneficial uses. Both the riverine and the reservoir segments were evaluated.

3.2.1.1 Snake River - Hells Canyon TMDL Water Quality Chlorophyll *a* and Nutrient Targets.

A chlorophyll *a* target of 14 ug/L mean growing season concentration and a nuisance threshold of 30 ug/L chlorophyll *a* with exceedence threshold of no greater than 25 percent has been established as the chlorophyll *a* target for this TMDL. The associated nutrient concentration target established for the SR-HC TMDL is a water column concentration of total phosphorus no greater than 0.07 mg/L. These are seasonal targets that apply from May through September. A more detailed discussion of target determination is included in the following sections.

It is the opinion of IDEQ and ODEQ that:

- These targets represent a valid interpretation of narrative standards.
- These targets will be protective of both recreation and aquatic life uses and water quality, and will thus meet the requirements of the CWA.
- Attainment of these targets, in coordination with the other water quality targets identified by this TMDL will result in full support of the designated beneficial uses within the system.

There has been a substantial amount of discussion within this TMDL process regarding the application of total phosphorus targets as opposed to ortho-phosphate targets. While it is recognized that dissolved ortho-phosphate represents the phosphorus fraction that is the most readily available for growth, it is also understood that ortho-phosphate is not a conservative parameter instream. Ortho-phosphate is a dynamic component of the water column and concentrations can change dramatically in a short distance or time due to growth or die-off of algal blooms and variation in dissolved oxygen concentrations. Ortho-phosphate can convert between forms readily under favorable water column conditions and may not be an accurate representation of the pool of phosphorus available for biological uptake.

3.2.2 Designated Beneficial Use Impairment

The designated beneficial uses determined to be most at risk from excess nutrients were those associated with aesthetics, recreation and aquatic life. Additional concerns related to excessive nutrient loading include risks associated with public drinking water supplies in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach.

3.2.2.1 Recreational Use and Aesthetics.

Direct effects associated with recreational uses include decreased utilization of the SR-HC system or portions thereof due to unfavorable water color, low water clarity and unpleasant odor. Indirect effects associated with aquatic life uses in the SR-HC reach include low dissolved oxygen levels deep in the water column due to the decomposition of algae and other aquatic plant materials and high in the water column due to diurnal effects associated with substantial algae blooms. High pH levels often associated with low dissolved oxygen due to decomposing organic matter have not been observed to occur in the SR-HC TMDL reach, most probably due to the buffering effect of natural mineral compounds dissolved in the water.

A review of concerns related to excess nutrient levels in the SR-HC reach shows that excessive aquatic growth (mostly algae blooms) is commonly observed in the Upstream Snake River segment (RM 409 to 335) and sections of the Brownlee Reservoir segment (RM 335 to 285) during late spring and early summer.

IDEQ has received a number of personal accounts and complaint calls regarding the condition of the Upstream Snake River segment (RM 409 to 335), particularly between the inflow of the Boise River (RM 396.4) and Farewell Bend (RM 335). The majority of the information was received as personal communication associated with recruitment for public participation in the SR-HC TMDL process and during public meetings for the Subbasin Assessment for the SR-HC TMDL. Additional comments were associated with posted public notices for SR-HC PAT meetings. Several complaint calls unrelated to the SR-HC TMDL effort have been received by IDEQ in regards to perceived poor water quality and unpleasant odor.

The majority of people offering information stated that the level of algal growth in the river has been increasing over the last 20 years and is now at a point where they will not swim or allow members of their families to swim in the water over the summer season. Several individuals specifically stated that they had previously used the Snake River near Weiser and Brownlee Reservoir for recreation but that during the last 10 to 15 years they have recreated in the Oxbow and Hells Canyon reservoirs instead as the amount of algal growth was less and their general impression of water quality in the downstream reservoirs was more favorable.

References to unfavorable water quality in regards to boating were fewer in number than those regarding swimming. In general complainants indicated that while they still use the river for boating, they have reduced the number of visits (usually during summer months) because of the added maintenance and cleaning required due to algal growth, and a general perception of poor water quality.

Additionally, several individuals referred to unfavorable odors associated with the water in this section of the Snake River and several referred to a decline in fishing success and quantity.

While the decrease in recreational-use hours described in these comments is difficult to quantify, and acknowledging that the complaints received do not necessarily constitute a representative sampling of recreational users on the SR-HC TMDL reach of the Snake River; they do indicate that there has been a negative effect on recreational use within the SR-HC TMDL reach.

An overall assessment of water quality was conducted by IDEQ during July and August of 2001 (a low water year). The Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir were surveyed visually at several different locations for aesthetic water quality conditions and general perception of visual water quality. A general increase in turbidity and coloration intensity is apparent from upstream to downstream in the Upstream Snake River segment (RM 409 to 335) as documented in the series of photos in Figure 2.3.1. These photos (taken June 2001) illustrate the change in water clarity and color in the mainstem Snake River from Marsing (RM 425) immediately upstream of the SR-HC TMDL reach, to Nyssa (RM 385), midway through the Upstream Snake River segment of the SR-HC TMDL reach, to Weiser (RM 351.2), approximately 16 miles upstream of the headwaters of Brownlee Reservoir. A decrease in aesthetic water quality is evident in these photos. The increase in turbidity and coloration, as

Figure 3.2.1. Photos illustrating change in water clarity and color in the mainstem Snake River from Marsing (RM 425) to Nyssa (RM 385) to Weiser (RM 351.2).

well as odor are most likely due to a combination of algae and other suspended sediment in the water column.

As aesthetic water quality and public perception are difficult to measure directly, those characteristics of water that are generally considered unappealing were evaluated. Dominant factors in the perception of water quality are coloration, odor and level of aquatic growth. Because it is correlated with all of these factors, algae was identified as a good indicator of aesthetic water quality. A commonly employed surrogate measure of algal growth is chlorophyll *a*. Chlorophyll *a* was used as a mechanism or surrogate measure of aesthetic water quality for the purposes of this assessment.

Chlorophyll is the green pigment in plants associated with photosynthesis (the process where-by plants combine light energy, nutrients and carbon to generate organic matter). A measure of chlorophyll gives information on the relative amount of photosynthesizing plants that are in the water column. Traditional methods of chlorophyll analysis give a measure of all green pigments in plants whether they are alive or dead. More current technology allows chlorophyll measurements to be corrected to remove the byproducts of chlorophyll degradation. Thus pheophytin-corrected chlorophyll *a* concentrations can be measured that report only that portion of the total chlorophyll that was actively photosynthesizing when the sample was collected, therefore, corrected chlorophyll *a* can be used to determine the amount of living algae (and other living plant material) in the water column. The chlorophyll *a* data utilized in this loading analysis was (to the extent possible) pheophytin-corrected chlorophyll *a*.

Other sources of chlorophyll *a* in the SR-HC TMDL reach may include sloughed periphyton and entrained plant materials (aquatic plants, tree leaves, etc.). Chlorophyll *a* is very labile (unstable) and does not last long once the plant materials have become detached (senescent). Algae (planktonic algae and periphyton) are presumed to be the dominant source of chlorophyll *a* in the water column during the summer months. In this manner, corrected chlorophyll *a* measurements have been used as a surrogate measure for algal biomass in the SR-HC TMDL reach. Sloughing of periphyton during spring and late fall time periods has not yet been quantified so the relative chlorophyll *a* and biomass concentrations related to this occurrence is unknown.

In order to better evaluate what concentration of chlorophyll *a* (algae) was acceptable through public perception for recreational purposes, a review of literature references to chlorophyll *a* targets based on aesthetics was conducted. Several targets were identified (Table 3.2.1), covering a range of maximum allowable chlorophyll *a* concentrations from 15 ug/L to 50 ug/L.

While Table 3.2.1 does not represent an exhaustive list, it serves to illustrate a range of chlorophyll *a* values identified to be appropriate to support of aesthetic and recreational needs. It is important to note that these values represent maximum acceptable concentrations, not averages. Individuals recreating on surface water systems do not perceive “average” water quality, they see the instantaneous conditions and use these characteristics as the basis for their perception of water quality. Therefore, these guidance values were established as maximum concentrations to support aesthetic and recreation designated uses.

Table 3.2.1 Chlorophyll *a* guidance from other states and British Columbia for aesthetic and primary contact recreation.

Location	Chlorophyll *a*
Colorado	< 15 ug/L
New Hampshire	< 15 ug/L
Minnesota	< 20 ug/L
South Dakota	< 33 ug/L
North Carolina	< 40 ug/L
British Columbia	< 50 ug/L
New Mexico	< 50 ug/L

Mean chlorophyll *a* concentrations in the mainstem Snake River between Weiser (RM 351) and RM 325 (in the upstream portion of Brownlee Reservoir) are routinely greater than 50 ug/L. These target values were identified as appropriate by several states and British Columbia. These values were (for the most part) specific to primary contact recreation and aesthetic uses. They were developed to act as a numeric representation of the maximum chlorophyll *a* concentrations that recreational users of a water system would judge to be acceptable; or as values below which algae concentrations would not result in reduced recreational usage. These values were used as a general range in determining what appropriate levels of chlorophyll *a* may be within the SR-HC TMDL reach. They are not, however, the sole driver, as other designated beneficial use concerns are associated with excessive nutrient loading.

3.2.2.2 AQUATIC LIFE.

Data available show indirect negative effects on aquatic life in the form of low dissolved oxygen (in the reservoir complex) and high productivity levels (in both the Upstream Snake River segment (RM 409 to 335) and the upstream portion of Brownlee Reservoir).

Low dissolved oxygen concentrations have been documented in Brownlee Reservoir from as early as 1968 (IPCo, 1998a and 1998b) to the present. A major fish kill occurred in Brownlee Reservoir in July of 1990, involving all fish species, including sturgeon. Dissolved oxygen concentrations observed during this event indicate that anoxia in the upper end of Brownlee

Reservoir was the dominant cause of fish mortality (IPCo, 1999c). These data indicate that the designated uses of cold water aquatic life/salmonid rearing and related aquatic life uses are not being fully supported in the downstream portion of the Upstream Snake River segment and in Brownlee Reservoir.

Organic material (algae, detritus, etc.) produced and transported within the upper SR-HC TMDL reach is the primary cause of low dissolved oxygen in Brownlee Reservoir (IPCo, 1999d, 2000a, 2000e; IDEQ, 1993b), and potentially in the lower sections of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach as well. Dissolved oxygen concentrations in Brownlee Reservoir need to increase substantially (by more than 4 mg/L in some conditions), in order to meet the SR-HC TMDL target of 6.5 mg/L for support of salmonid rearing/cold water aquatic life.

Brownlee Reservoir is a narrow, deep channel with a relatively short retention time. The deep sections of the reservoir, below the thermocline, are well below the photic zone and provide little growth potential. These deep layers (the hypolimnion) are relatively stagnant during stratification and experience little if any circulation or recharge during the summer months. The metalimnion (volume near the thermocline) and epilimnion (volume above the thermocline), however, experience greater turnover throughout the summer season. The metalimnion may occupy the lower depths of the photic zone and may experience some mixing due to reservoir releases and, to a lesser degree, wind action at the surface. The epilimnion occupies the upper reaches of the photic zone and experiences more surface-driven mixing.

Both the metalimnion and the epilimnion offer greater potential for habitat than the hypolimnion. The middle layers of the reservoir (the metalimnion and the epilimnion below the immediate surface layers) provide adequate temperature conditions throughout much of the summer. During late summer and early fall, cold water tributaries provide refugia for coldwater species living in the reservoir (Section 3.6). These upper layers (the upper column of the metalimnion and the lower volume of the epilimnion) represent the portion of the reservoir most likely to support aquatic populations. Improvements in dissolved oxygen in these areas will therefore provide greater, more immediate benefits to aquatic life within the reservoir. These areas have been targeted directly as high priorities for improvements in dissolved oxygen.

Areas of the hypolimnion are known to experience low dissolved oxygen as a result of chemical and biological processes associated with stratification. This phenomenon is recognized by Idaho State standards (IAC 250.02.a). Due to this occurrence, and the fact that they are located well below the photic zone of the reservoir, these deep waters represent less of a viable habitat than do the waters above the hypolimnion. Because of this, they have been targeted as a secondary priority for dissolved oxygen improvement.

3.2.2.3 Anoxia at the Sediment/Water Interface and in the Substrate.

In addition to concerns centering on low dissolved oxygen concentrations in the water column, anoxia in the substrate represents a concern to aquatic life within the system. Many fish species, including white sturgeon and mountain whitefish deposit eggs at the sediment/water interface. Low dissolved oxygen from decaying algae and other organic matter presents a harmful or potentially lethal condition for these young fish. White sturgeon populations in the Upstream

Snake River (from Swan Falls to Brownlee Dam) are below the expected values (personal communication, J. Chandler, IPCo, August 2002). Low dissolved oxygen levels at the sediment/water interface may play a role in the reduced populations and low recruitment observed.

Elevated concentrations of chlorophyll *a* have been observed in the Upstream Snake River segment (RM 409 to 335) and the headwaters of Brownlee Reservoir (BCPW, 2001; IPCo, 1999d, 2000a, 2000e; IDEQ, 1993b). These levels indicate that substantial algal blooms occur consistently in this area. Additionally, excessive levels of periphyton have been observed in the Snake River at the USGS gage near the inflow of the Weiser River (personal communication, P. Woods, USGS, 2001). Decomposition of organic material from these algal blooms and other nutrient-induced growth deposited within the SR-HC TMDL system has been suspected to result in low dissolved oxygen levels within the sediments and at the sediment/water interface within the Upstream Snake River segment (RM 409 to 335) and the headwaters of Brownlee Reservoir.

As discussed previously, low dissolved oxygen associated with depositional areas in Brownlee Reservoir has been well documented (IPCo, 1999d, 1999g, 2000c; BCPW, 2001). Investigation of similar conditions in the Upstream Snake River segment (RM 409 to 335) is currently in progress.

No sediment/water interface or substrate dissolved oxygen data from the Upstream Snake River segment (RM 409 to 335) is available to this TMDL process at this time, however, data from artificial redd studies conducted upstream of RM 409 by IPCo in 1999 to 2000 and 2000 to 2001 (IPCo, 2001c) show that dissolved oxygen concentrations drop to very low levels (less than 2.0 mg/L) during the late spring and summer months at the sediment/water interface. Artificial redds were constructed at RM 450.4, 447.8 and 441.8. These locations are between Swan Falls and the upstream portion of the SR-HC TMDL reach.

Intergravel dissolved oxygen measurements collected in the artificial redds in 1999 to 2000 showed concentrations below 6 mg/L at RM 450.4 and 441.8 by late February, 2000. Dissolved oxygen concentrations at these two sites were below 4.0 mg/L by April 2000 and below 2.0 mg/L May through June of 2000 (data are not available for the summer months). Intergravel dissolved oxygen measurements in the artificial redd at RM 447.8 showed concentrations above 6 mg/L December 1999 through early May 2000. Dissolved oxygen concentrations below 6.0 mg/L were observed late May through June 2000 at this site (IPCo, 2001c).

Intergravel dissolved oxygen measurements were collected in the artificial redds at RM 450.4 and 447.8 during 2000 to 2001. These data showed concentrations below 6 mg/L at both sites by late March 2001. Dissolved oxygen concentrations at both sites were below 4.0 mg/L by April 2001 and below 2.0 mg/L May through June of 2001 (IPCo, 2001c).

Initial, qualitative assessments of the Upstream Snake River segment of the SR-HC TMDL reach (RM 409 to 335), have identified conditions similar to those observed in the Snake River at the location of these artificial redds (e.g. similar flow and temperature conditions combined with a thick layer of decomposing organic material located at the sediment/water interface). These initial, qualitative investigations, combined with the data collected by IPCo upstream, suggest that low dissolved oxygen concentrations similar to those observed in the artificial redds occurs at the sediment/water interface in the Upstream Snake River segment (RM 409 to 335). This is likely one of the factors contributing to the decline in white sturgeon populations in this segment of the Snake River.

3.2.2.4 PRODUCTION OF METHYLMERCURY.

Of additional concern to this TMDL is the conversion of inorganic or elemental mercury within the SR-HC TMDL reach to methylmercury. While inorganic or sediment-bound mercury can be absorbed by aquatic organisms, the rate and efficiency of the uptake is much lower than that for methylated or organic mercury, which can easily enter the food chain (USGS, 1995). Many factors influence the form, concentration and transport of mercury in the environment, these include the concentration of dissolved organic carbon (DOC), the pH of the water system, and the concentration of dissolved oxygen in the water (Hurley, 1995).

Sediment samples collected and analyzed for mercury content in both the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) show that the highest concentrations of sediment-associated mercury are at RM 335 and RM 340. Both samples exceeded the threshold effects level (TEL) of 0.174 parts-per-million (mg/kg), the concentration level published by the National Oceanic and Atmospheric Association (NOAA) for the protection of benthic life. These elevated levels of mercury, when combined with organic material resulting from excessive algal growth and the associated organic matter in this area, represent a substantial potential for methylmercury production.

There is a relationship between mercury concentrations observed in bed sediments and those observed in the tissue of resident fish. Methylmercury produced in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285), has the potential to affect not only local aquatic life but also downstream species as well, as the methylmercury produced will be carried downstream by flowing water. Organic matter accumulating from algal growth and nutrient enrichment in the Upstream Snake River segment (RM 409 to 335) is of particular concern as it accumulates in the area between RM 340 and RM 320, the location identified as exhibiting the highest concentrations of sediment-associated mercury within the TMDL reach. This condition has the potential to exacerbate the conversion of inorganic mercury to methylmercury within this reach and contribute to higher methyl-mercury concentrations in the Hells Canyon Complex reservoirs and further downstream.

Low dissolved oxygen conditions in Brownlee Reservoir also have the potential to contribute to higher methyl-mercury concentrations in downstream waters.

All fish tissue data available in the SR-HC TMDL reach were positive for mercury. Water column data available were below the 0.050 ug/L concentration value established by the US EPA, however, detection limits were greater than the threshold limit by almost an order of magnitude in most cases so violations of the criteria could occur within these samples even though concentrations are reported as below the detection limit. The Oregon and Idaho levels of concern for methylmercury in fish tissue were exceeded by 80 percent (0.35 mg/kg) and 52 percent (0.5 mg/kg) respectively. Based on these data, both states have fish consumption advisories in place.

An evaluation of sediment and fish tissue data from the Snake River mainstem as a whole showed that in areas where sediment-associated mercury concentrations were below the detection limits, fish tissue concentrations were also (Section 3.1). All fish tissue data collected from the mainstem Snake River show concentrations above the detection limits except samples from the Snake River at Flagg Ranch (< 0.05 mg/kg wet weight (Maret, 1995a and 1995b)), the Snake River at Minidoka (< 0.1 mg/kg wet weight (Clark and Maret, 1998)) and the Snake River at Kimberly (< 0.1 mg/kg wet weight (Clark and Maret, 1998)), areas well upstream of the SR-HC TMDL reach. The areas where fish tissue mercury concentrations were below detection limits correlate well with sediment mercury concentrations. Sediment mercury concentrations below the detection limits were observed in the Minidoka and Blackfoot areas (both < 0.02 mg/kg (Clark and Maret, 1998)) only.

Warmwater and nongame species in Idaho were found to contain approximately twice the levels of methylmercury as found in coldwater game fish species (Gebhards et. al., 1971). This finding is of concern as the majority of fish species within the SR-HC TMDL reach are warm water fishes. Fish populations, in association with those human populations most at risk for injury due to mercury consumption, are targeted by the fish consumption advisories in place for both Oregon and Idaho within the SR-HC TMDL reach.

Deposition of organic matter on the surface of the river channel occurs throughout the Snake River system. Deposition within the Upstream Snake River segment (RM 409 to 335) occurs most efficiently in areas of reduced flow velocity (eddies, backwaters, pools, etc). Deposition within Brownlee Reservoir has been observed to occur in the upstream sections of the reservoir (RM 325 to 310). Both organic and inorganic materials are deposited in these areas. Decomposition of organic matter removes oxygen from the water column. This results in anaerobic conditions at the sediment/water interface. Under these conditions the conversion of inorganic mercury to methylmercury has been observed to occur more readily. Therefore, increased availability of methylmercury in the SR-HC TMDL reach can be directly related to the production and deposition of organic material (algae, periphyton, etc.), and associated anoxic or low oxygen conditions.

While data available to the SR-HC TMDL indicate that the dominant source of mercury is naturally occurring geological deposits which are (at best) difficult to control, the conversion of the inorganic mercury contained within these sediments to methylmercury (the form most related to health concerns for both aquatic life and humans) is related to available organic material and anoxic substrate conditions. Given the current understanding of the methylation process, reductions in organic matter within the SR-HC TMDL reach are possible, and are projected to result in reductions in the amount of methylmercury produced. Reductions in algal growth have a high priority in this TMDL as they represent one of the most effect mechanisms for control of mercury already within the SR-HC TMDL system in addition to the direct benefits to water quality that would result.

3.2.2.5 Domestic Water Supply.

The US EPA identifies nutrient enrichment as a serious health problem in the context of drinking water supplies. Trihalomethanes are carcinogenic (cancer causing) compounds that can be produced when water containing organic compounds is chlorinated or brominated as part of the treatment and disinfection processes in drinking water facilities. The organic compounds commonly associated with the trihalomethane formation process are humic substances, algal metabolites and algal decomposition products (US EPA, 2000d). According to references in the recent US EPA nutrient guidance document for rivers and streams, the density of algae and the level of eutrophication in raw water supplies have been correlated with the production of trihalomethanes in drinking water (US EPA, 2000d).

In addition to the human health concerns associated with eutrophic drinking water supplies, taste and odor problems associated with algal growth have been reported nationwide. Many of the chemical compounds that algae secrete can result in unpleasant tastes and odors. These compounds are difficult to remove with standard equipment or treatment processes. They often require activated carbon treatment, direct, in-river treatment of the water supply or other such mechanism. Additionally, increased treatment costs from clogged filters, corrosion of intake pipes, increase in the amount of chemicals necessary to treat the water, increased back-flushing of filters and additional settling times to attain acceptable water quality can result from nutrient impairment of domestic water supplies (US EPA, 2000d).

Two cities within the SR-HC TMDL reach use the Snake River as a source of drinking water, the City of Ontario, Oregon (RM 369) and the City of Weiser, Idaho (RM 352). The designation of the SR-HC TMDL reach as a domestic water supply requires that the needs of this beneficial use be considered in the management of the SR-HC TMDL reach, namely, decreased total biomass to decrease the potential for trihalomethane production, decreased total biomass for reduction of filter clogging, reduction of nutrient concentrations to reduce pipe corrosion, and etc.

Finally, the production of neuro- and hepato-toxins by cyanobacteria (blue-green algae) blooms is of concern. When present at excessive concentrations cyanobacteria often produce toxins that can result in skin irritation to swimmers, and illness or even death in animals ingesting the water. The deaths of 23 cattle in Cascade Reservoir (located on the Payette River) were reported in 1993 due to excessive cyanobacteria blooms. This phenomenon is not confined to lake and reservoir systems, however, and has occurred previously in the Snake River. Two canine deaths due to ingestion of blue-green algal toxins were confirmed (November, 2000) and several others suspected (Fall 1999) below the Minidoka Dam along the Snake River between Rupert and Burley, Idaho (Eyre, 2001), approximately 265 miles upstream from the SR-HC TMDL reach.

3.2.2.6 ENDANGERED AND THREATENED SPECIES.

The portion of the SR-HC TMDL reach listed for excessive nutrients provides habitat for the Idaho spring snail, (*Pyrgulopsis idahoensis,* formerly *Fontelicella idahoensis* (Frest and Johannes, 2001)). Distribution includes the mainstem Snake River from RM 422 to 393 and from RM 372 to 340 (IPCo, 2001a). This snail species is listed as threatened under the Federal Endangered Species Act (ESA). It requires cold, clear, well-oxygenated water for full support. These snails have been observed to live on rocks and sediment at the sediment/water interface within the Snake River channel.

Given the information discussed above, and the current understanding of the SR-HC TMDL reach, it is the professional opinion of IDEQ and ODEQ that excessive nutrient levels are impairing designated beneficial uses in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Data available show impairment of aesthetic and recreational uses, and indicate a level of concern for cold water aquatic life/salmonid rearing, resident fish and aquatic life, domestic water supply designated beneficial uses within the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285). Impairment of the Oxbow Reservoir segment (RM 285 to 272.5) cannot be determined at this time but will be directly related to the water quality in Brownlee Reservoir due to inflow and retention characteristics. It is also the professional opinion of IDEQ and ODEQ that attainment of the SR-HC TMDL chlorophyll *a* target of 14 ug/L mean growing season concentration and a nuisance threshold of 30 ug/L chlorophyll *a* with exceedence threshold of no greater than 25 percent, combined with the nutrient target of less than or equal to 0.070 mg/L total phosphorus, in combination with other SR-HC TMDL pollutant targets will result in full support of the designated beneficial uses within the system.

3.2.3 Sources

Both natural and anthropogenic sources of phosphorus are known to be present in the SR-HC TMDL drainage. Anthropogenic loading includes both point and nonpoint sources. A brief overview of nutrient sources is discussed below. A more detailed description is available in the Subbasin Assessment for the SR-HC TMDL.

3.2.3.1 NATURAL SOURCES.

A general discussion of natural sources of nutrient loading is available in Section 2.2.4.3. Natural sources of nutrients include erosion of phosphorus-containing rock and soils through wind, precipitation, temperature extremes and other weathering events. Natural deposits of phosphorus (Hovland and Moore, 1987) have been identified in the Snake River drainage near Pocatello, Idaho (RM 731.2). Geological deposits in the Blackfoot River watershed (inflow at RM 750.6) contain phosphorus in sufficient concentrations that they have been mined. The Snake River flows through this area some distance upstream of the SR-HC TMDL reach.

In an effort to assess the potential magnitude of natural phosphorus concentrations in the mainstem Snake River due to these geological deposits, total phosphorus concentrations occurring in the mainstem near the Blackfoot and Portneuf River inflows (RM 750.6 and 731.2 respectively) were evaluated. Data was available for the Snake River near Blackfoot, Idaho (USGS gage # 13069500, RM 750.1) and for the Blackfoot and Portneuf Rivers (USGS, 2001a). The mainstem Snake River and these tributary river systems, where they flow through the natural mineral deposits represent a worst-case scenario for evaluation of natural phosphorus loading and were identified as potential sources of naturally occurring phosphorus to the SR-HC reach. USGS gaged flow data and water quality data from the 1970’s to the late 1990’s is available for the Blackfoot and Portneuf Rivers ((USGS gage # 13068500, and #13075500 respectively). Because both the mainstem and tributary watersheds have been settled for some time, and land and water management has occurred extensively, the data compiled represent both natural and anthropogenic loading.

Total phosphorus concentrations in the Snake River mainstem, measured near Blackfoot, Idaho (RM 750.1), from 1990 to 1998 averaged 0.035 mg/L (range = <0.01 to 0.11 mg/L, median =

0.03 mg/L, mode = 0.02 mg/L) (USGS, 2001a). Nearly 40 percent (23 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling was slightly less frequent (approximately 19% of the total) than spring, summer or fall.

Natural phosphorus concentrations were not assessed as part of the Blackfoot River TMDL (IDEQ, 2001b). Total phosphorus concentrations in the Blackfoot River, measured near the mouth, from 1990 to 1999 averaged 0.069 mg/L (range = <0.01 to 0.43 mg/L, median = 0.04 mg/L, mode = 0.03 mg/L) (USGS, 2001a). Nearly 23 percent (12 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling was less frequent (approximately 13% of the total) than spring, summer or fall.

Natural phosphorus concentrations were not assessed for the Portneuf River TMDL (IDEQ, 1999d). Total phosphorus concentrations in the Portneuf River, measured near the mouth, from 1990 to 1998 averaged 0.085 mg/L (range = <0.01 to 0.28 mg/L, median = 0.069 mg/L, mode = 0.03 mg/L) (USGS, 2001a). Nearly 21 percent (6 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling represented approximately 22 percent of the total.

The fact that very low total phosphorus concentrations were observed routinely (more than 20% of the time) in the mainstem Snake River, the Blackfoot River and the Portneuf River, all watersheds with a high level of use and management show that the natural loading levels are likely below detection limit concentrations. The additional fact that these low concentrations were observed in watersheds in much closer proximity to the rich geological phosphorus deposits indicates that these deposits likely do not represent a significant source of high, natural loading to the SR-HC TMDL reach, located well downstream from the mineral deposits identified.

Given the above discussion, the natural background concentration for total phosphorus in the mainstem Snake River has been estimated as at or below 0.02 mg/L for the SR-HC TMDL reach. This value is based on the available data set. Data from the Snake River upstream of RM 409 was included in this data set to address the concern of enrichment of surface waters by the phosphoric deposits located in central and eastern Idaho (Hovland and Moore, 1987). Due to the fact that there are substantial anthropogenic influences in Snake River Basin, the lower 15th percentile value for total phosphorus concentration was selected as a conservative estimate of natural phosphorus concentration. In this manner, natural concentration levels for the mainstem Snake River were calculated conservatively. This initial estimate will be reviewed as additional data become available and revisions will be made as appropriate.

The estimated natural background loading concentration for the mainstem Snake River (0.02 mg/L) is most likely an overestimation of the natural loading but represents a conservative estimate for the purposes of load calculation. In addition, this concentration correlates well with other studies that have been completed and closely approximates the total phosphorus concentration identified for a reference system (relatively un-impacted) by the US EPA (US EPA, 2000d; Dunne and Leopold, 1978).

A necessary set of data to establish natural loading or concentration values for the tributary streams is not currently available. Therefore, natural background concentrations for all tributaries will be determined as part of upcoming TMDL development on the Weiser, Owyhee, and Malheur Rivers, and tributary implementation plans for the Payette and Boise Rivers.

3.2.3.2 ANTHROPOGENIC SOURCES.

Anthropogenic nutrient sources to the SR-HC TMDL reach include permitted point sources that discharge directly to the Snake River within the SR-HC TMDL reach (as listed in Table 2.5.0), nonpoint source discharges in the direct drainage, and man-made sources that discharge to tributaries of the SR-HC TMDL reach. Point source discharges to tributary systems are a recognized component of overall loading to the SR-HC reach, but are identified as nonpoint source tributary loading in this TMDL. Load calculations and load allocations will be made to the mouth of the tributaries and the tributary-specific TMDL process will determine point and nonpoint source load allocation mechanisms. Those point sources that discharge to tributary systems are not included in the point source loading calculations for the SR-HC TMDL.

Anthropogenic nonpoint sources of phosphorus in the SR-HC area include (among others) agricultural sources such as runoff from fertilized fields, sediment-bound transport from plowing, and flood and furrow irrigation, as well as organic enrichment; sediment-bound transport and organic enrichment from forestry sources such as logging and streambank disturbance; and urban/suburban sources including stormwater runoff, improperly functioning septic and sewer systems and lawn fertilizers.

Elevated phosphorus concentrations have been observed in the Upstream Snake River segment (RM 409 to 335), in the inflowing tributaries and in many of the agricultural drains where they enter the Snake River (US EPA, 1974; IDEQ, 1998a; IPCo, 1998a and 1998b; BCPW, 2001) as shown in Figure 3.2.2 plots a through j (multiple pages).

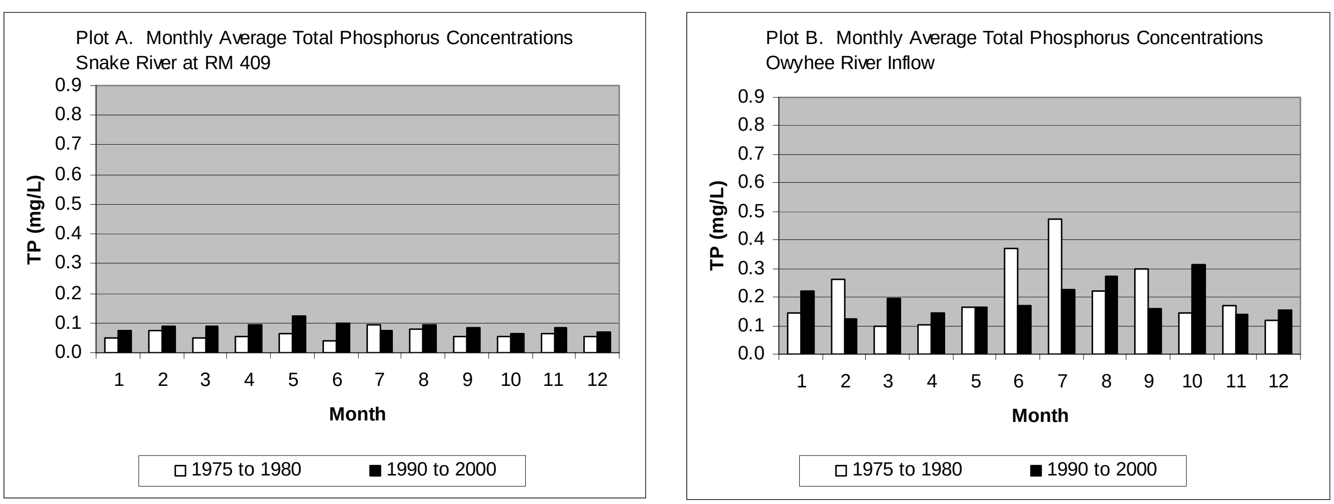

Figure 3.2.2. Mean monthly total phosphorus concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

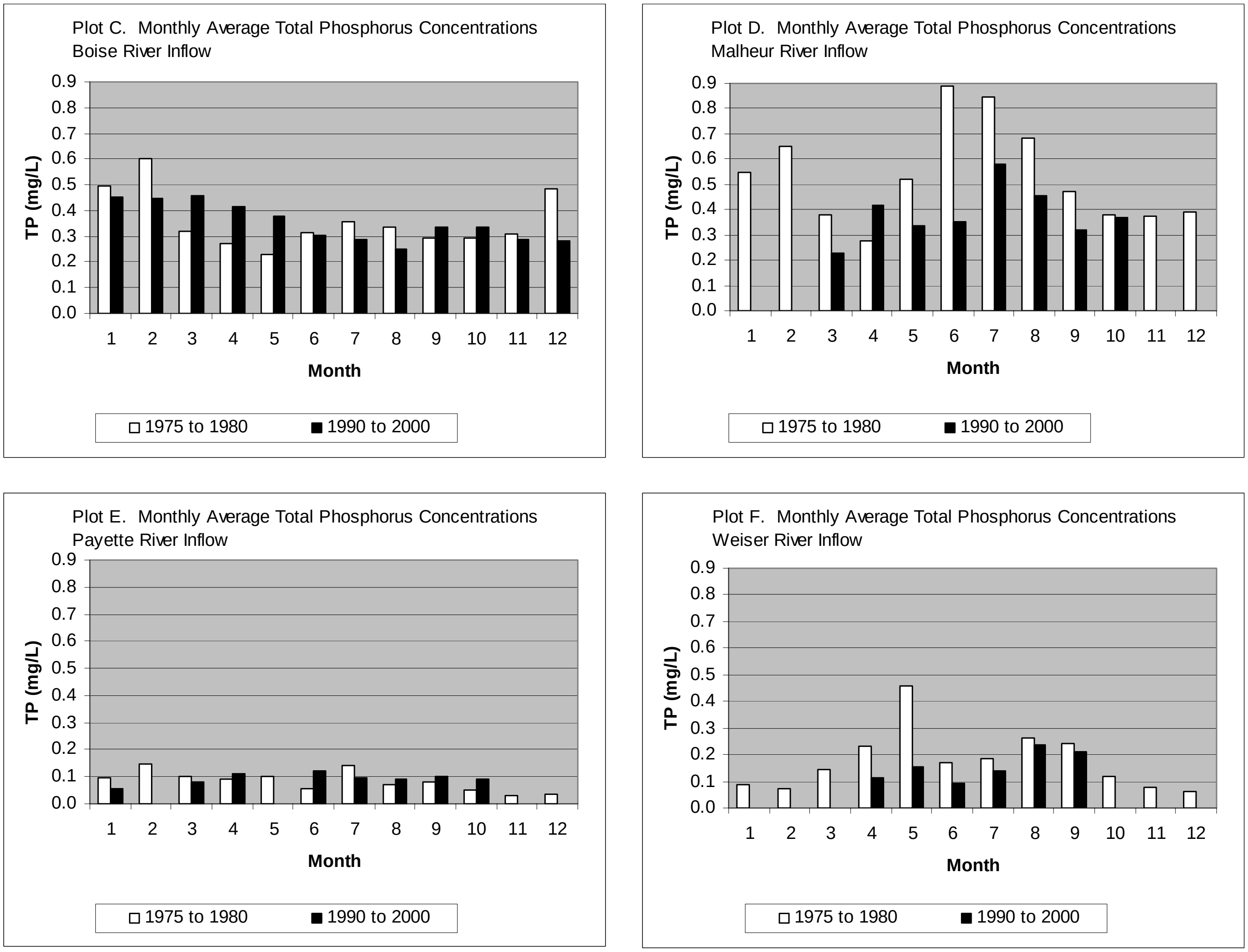

Figure 3.2.2. (cont.) Mean monthly total phosphorus concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

Concentrations tend to increase in correlation with the summer growing and irrigation season. The concentration data available represent the sum of natural and anthropogenic loading from the identified tributaries and mainstem locations. Data from 1975 to 1980 and data from 1990 to 2000 are summarized.

The Malheur River (plot D) shows substantial reduction in total phosphorus concentrations between 1975 to 1980 and 1990 to 2000. In most other cases, a level trend or a slight increase in concentration is observed between the two data sets. The data sets displayed do not contain equal numbers of data points for the 1975 to 1980 and 1990 to 2000 time periods.

In most cases, more data was available in the 1990 to 2000 time period than in the 1975 to 1980 time period. Lack of data or smaller than average data sets occurred in some years and at some locations. These limited data may not be representative of average conditions. Scales on all plots were normalized to allow for an easier comparison of relative concentration differences.

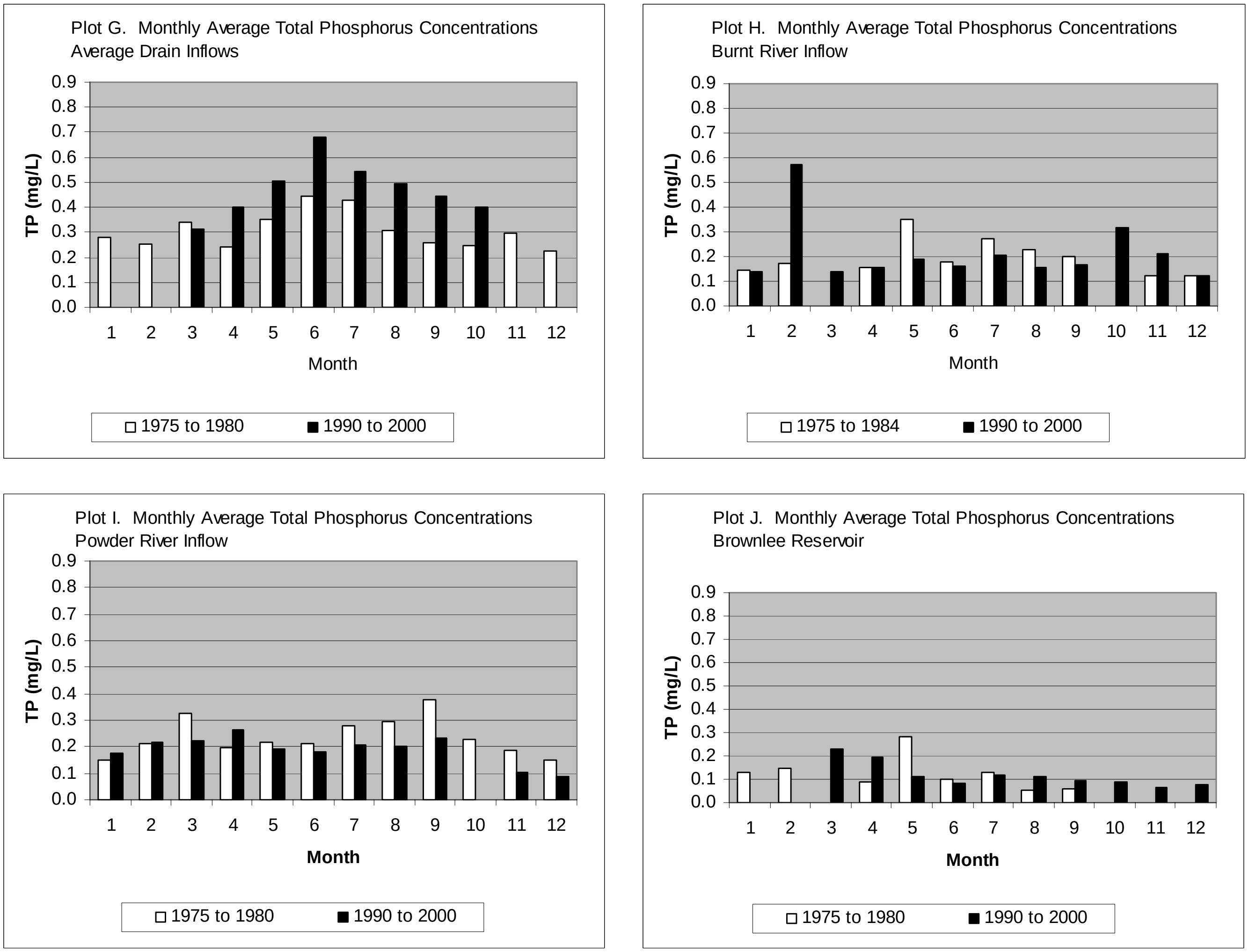

Figure 3.2.2. (cont.) Mean monthly total phosphorus concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

Studies performed throughout the United States have shown that "conditions that allow periphyton/plankton biomass to accumulate (i.e. adequate light, optimum current velocity for periphyton, sufficient water detention for plankton, as well as low loss to aquatic grazers) will not result in high biomass without sufficient nutrient supply. Nutrients, especially phosphorus, are the key stimulus to increased and high algal biomass" (US EPA, 2000d). This is supported by data collected in the Snake River system as shown in Figure 3.2.3. It is observed that lower phosphorus concentrations within the Snake River system correlate with lower concentrations of chlorophyll *a* than those observed at higher total phosphorus concentrations.

Conditions resulting in high water temperatures, elevated nutrient loading and low flow conditions are favorable to cyanobacteria species. Control of two of these three conditions is not feasible for the SR-HC TMDL. First, elevated water temperatures within the SR-HC TMDL

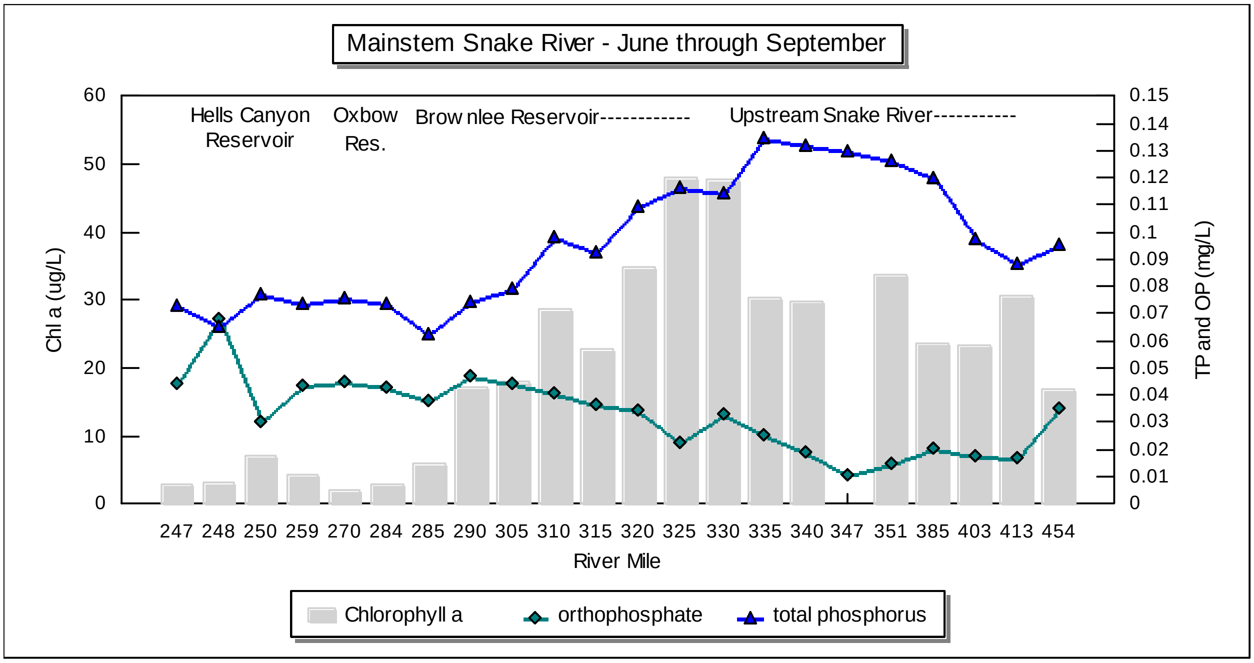

Figure 3.2.3. Spatial distribution of mean phosphorus and chlorophyll *a* concentration data within the Snake River - Hells Canyon TMDL reach (June through September, 1990 to 2000).

reach have been shown to be predominantly the result of natural atmospheric and non-quantifiable thermal loading. Second, changes to flow conditions are outside of the scope of this TMDL. The third condition, elevated nutrient loading, can be controlled under the auspices of the TMDL and implementation processes.

3.2.4 Transport and Delivery

The primary mechanism for nutrient transport in the SR-HC reach is surface and subsurface water flow. Nutrients can be dissolved in the water column or adsorbed onto the surface of soil and sediment particles, and organic matter. The sediment fractions most commonly associated with the greatest nutrient loading are the fine and very fine particles that have the largest surface area to volume ratio and therefore the largest adsorption capacity. These particles can be transported long distances before they drop out of the water column. Once deposited, these particles can act as a source of phosphorus enrichment in two ways: through direct re-entrainment of solid particles with an increase in flow, and through desorption of attached nutrients to the water column. This cycle is discussed in greater detail in the sediment loading analysis (Section 3.5) and the Subbasin Assessment (Section 2.2).

As with sediment loading, land use and management may influence nutrient transport and delivery within the watershed. Long-term saturation of soils can result in anoxic conditions that cause the release of adsorbed phosphorus. This can occur in flooded soils in the watershed, from intentional flooding as is used in some irrigation practices, or unintentional flooding such as in a poorly drained lawn or garden area. It also occurs at the sediment/water interface in anoxic areas of a reservoir system. This type of de-sorption results in a form of phosphorus that is much more readily available for uptake by aquatic plants.

3.2.5 Data Available for the Snake River - Hells Canyon TMDL Reach

As discussed in the general loading assessment, a fairly robust data set for phosphorus (total and ortho) was available to the SR-HC TMDL effort. The data available for a nitrogen loading assessment was more limited. However, the nitrogen data available show trends similar to those observed for phosphorus within the SR-HC system.

Nutrient data has been collected over the time period from 1975 to current for both the mainstem Snake River and tributary sites. Mean values, concentration ranges and number of data points available are shown in Table 3.2.2 a through c.

Table 3.2.2 a. Distribution of total phosphorus (TP) data available for the Snake River - Hells Canyon TMDL (1975 through 2000).

Sample Site	Number of Samples	Mean TP concentration (mg/L)	Maximum (mg/L)	Minimum (mg/L)
Snake River Inflow (RM 425 to 403)	96	0.081	0.550	0.007
Tributary Mouths				
Owyhee (RM 396.7)	161	0.195	1.46	0.082
Boise (RM 396.4)	255	0.362	2.00	0.07
Malheur (RM 368.5)	80	0.444	1.46	0.06
Payette (RM 365.6)	115	0.101	0.57	0.02
Weiser (RM 351.6)	120	0.172	1.43	0.03
Drains	205	0.340	1.58	0.06
Upstream Snake River Mainstem (RM 409 to 335)	490	0.112	0.885	0.01
Brownlee Reservoir	199	0.110	0.610	0.019
RM 335 to 319		0.148		
RM 320 to 304		0.109		
RM 305 to 285		0.076		
Burnt River (RM 327.5)	92	0.203	2.33	0.081
Powder River (RM 296)	170	0.214	0.694	0.02
Oxbow Reservoir (RM 285 to 272.5)	179	0.087	0.154	0.02
Hells Canyon Reservoir (RM 272.5 to 247)	128	0.083	0.36	0.016
Downstream Snake River Segment (RM 247 to 188)	201	0.079	0.39	0.005

Data in this table are from US EPA STORET, 1998a; IPCo, 1999d and 2000a; USGS, 1999, and Boise City Public Works, 2001.

Table 3.2.2 b. Distribution of dissolved ortho-phosphate (DOP) data available for the Snake River - Hells Canyon TMDL (1975 through 2000).

Sample Site	Number of Samples	Mean DOP concentration (mg/L)	Maximum (mg/L)	Minimum (mg/L)
Snake River Inflow (RM 425 to 403)	22	0.01	0.08	0.001
Tributary Mouths				
Owyhee (RM 396.7)	148	0.070	0.65	0.021
Boise (RM 396.4)	160	0.287	0.58	0.051
Malheur (RM 368.5)	76	0.251	0.39	0.053
Payette (RM 365.6)	103	0.036	0.12	0.005
Weiser (RM 351.6)	13	0.07	0.15	0.02
Drains	nd	nd	nd	nd
Upstream Snake River Mainstem	394	0.027	0.12	0.002
Brownlee Reservoir	184	0.037	0.18	0.005
RM 335 to 319		0.035		
RM 320 to 304		0.034		
RM 305 to 285		0.043		
Burnt River (RM 327.5)	90	0.120	0.40	0.052
Powder River (RM 296)	163	0.149	0.13	0.008
Oxbow Reservoir (RM 285 to 272.5)	179	0.0465	0.13	0.005
Hells Canyon Reservoir (RM 272.5 to 247)	125	0.0426	0.16	0.005
Downstream Snake River Segment (RM 247 to 188)	109	0.054	0.11	0.004

Data in this table are from US EPA STORET, 1998a; IPCo, 1999d and 2000a; USGS, 1999, and Boise City Public Works, 2001. (nd = no data available)

Data has been collected in the form of total phosphorus, ortho-phosphate, and numerous other unique analytical methodologies. Data sets for total phosphorus (n = 2,494) and dissolved ortho-phosphate (dissolved ortho-phosphate (DOP) concentrations and soluble reactive phosphorus (SRP) data, total n = 1,766) were the most robust and were selected for use with the SR-HC TMDL.

Within the available data set, total phosphorus and chlorophyll *a* concentrations are observed to increase markedly from upstream to downstream within the Upstream Snake River segment (RM 409 to 335) (Figure 3.2.3). The total phosphorus concentration in the Upstream Snake River segment is nearly 40 percent higher than that observed at the inflow to this reach (RM 409). Several tributaries discharge water with notably elevated total phosphorus concentrations in this reach.

Table 3.2.2 c. Distribution of chlorophyll *a* (Chl *a*) data available for the Snake River - Hells Canyon TMDL (1975 through 2000).

Sample Site	Number of Samples	Mean Chl *a* concentration (ug/L)	Maximum (ug/L)	Minimum (ug/L)
Snake River Inflow (RM 413 to 403)	115	20.3	115	0.9
Tributary Mouths				
Owyhee (RM 396.7)	34	6.3	14.6	0.3
Boise (RM 396.4)	8	7.6	38.5	0.8
Malheur (RM 368.5)	52	12.6	56.7	0.8
Payette (RM 365.6)	16	8.8	22.1	0.8
Weiser (RM 351.6)	3	2.8	3.4	2.2
Drains	nd	nd	nd	nd
Upstream Snake River Mainstem	316	30.7	179	1
Brownlee Reservoir	1012	28.4	727	0
RM 335 to 319		56.2	727	19
RM 320 to 304		9.0	19	3
RM 305 to 285		1.3	3	0
Burnt River (RM 327.5)	76	9.2	136	0.5
Powder River (RM 296)	117	8.8	74	0
Oxbow Reservoir (RM 285 to 272.5)	354	6.0	117	0
Hells Canyon Reservoir (RM 272.5 to 247)	425	5.6	65	0
Downstream Snake River Segment (RM 247 to 188)	145	4.4	28	0

Data in this table are from US EPA STORET, 1998a; IPCo, 1999d and 2000a; USGS, 1999, and Boise City Public Works, 2001. (nd = no data available)

These tributary inflows are the primary source of phosphorus enrichment in the SR-HC reach. Average total phosphorus concentrations in the Boise and Malheur rivers are greater than four times the concentration in the inflowing Snake River (at RM 409). Average total phosphorus concentrations measured in agricultural drains discharging to the Snake River are only slightly less, still more than four times greater than the mainstem Snake River. All inflowing tributaries contribute water that is higher in average total phosphorus concentration than the mainstem Snake River at RM 409.

A marked decrease in total phosphorus and chlorophyll *a* concentration is observed between where the Snake River enters Brownlee Reservoir (RM 335) and where it exits Hells Canyon Reservoir (RM 247) as show in Figure 3.2.3. The Hells Canyon Complex acts as a phosphorus sink, reducing the average total phosphorus concentration by approximately 33 percent by the time the Snake exits the complex at Hells Canyon Dam. The majority of concentration decrease occurs in Brownlee Reservoir. The decreasing trend in phosphorus concentration is evident from the inflow at approximately RM 335 to the outlet of the dam at RM 285. The overall concentration decrease within Brownlee Reservoir averages approximately 30 percent. Several differences and similarities are evident in the data displayed in Tables 3.2.2 a through c. The average total phosphorus concentrations and the range of concentration values for the Boise and Malheur rivers, and for the averaged agricultural drains are very closely correlated. This same relationship holds for the Boise and Malheur Rivers for ortho-phosphate concentrations as well. In all cases, the Payette River presents a unique set of characteristics quite unlike any of the other tributary systems to the SR-HC reach.

Similar to total phosphorus, dissolved ortho-phosphate concentrations are observed to increase from upstream to downstream (Figure 3.2.3). The dissolved ortho-phosphate concentration at the downstream end of the Upstream Snake River segment (RM 330 to 335) is higher than that observed at the inflow to this reach (RM 409). Ortho-phosphate concentration is notably influenced by uptake from algal growth within the system however, and therefore is not a conservative constituent. Also similar to total phosphorus, tributary dissolved ortho-phosphate concentrations are notably elevated above those observed in the Snake River inflow (Table 3.2.2 b). Tributary inflows are the primary source of dissolved ortho-phosphate enrichment in the SR-HC reach. Average dissolved ortho-phosphate concentrations in the Boise and Malheur rivers are greater than 25 times the concentration in the inflowing Snake River. Dissolved ortho-phosphate concentrations measured in the other tributaries discharging to the Snake River are lower but still several times greater than the mainstem Snake River. All inflowing tributaries contribute water that is higher in dissolved ortho-phosphate than the mainstem Snake River at RM 409. This enrichment of mainstem waters leads to the potential for greater productivity during the summer season.

An increase in dissolved ortho-phosphate concentration is observed as the Snake River moves through the Hells Canyon Complex. The complex acts as a sink for total phosphorus, but internal processing converts a portion of the sediment and/or biota-related phosphorus to dissolved ortho-phosphate (Figure 3.2.4). (This is also evident in the data displayed in a monthly time step in Figures 2.3.17 and 2.3.18.) The relative proportion of ortho-phosphate increases from upstream to downstream within Brownlee Reservoir. This conversion results in an overall increase from the inflowing concentrations at Farewell Bend (RM 335) of nearly 100 percent by the time the Snake exits the complex at Hells Canyon Dam (RM 247). The majority of concentration increase (74%) occurs in Brownlee Reservoir (0.027 mg/L to 0.047 mg/L). However, this increase in available dissolved ortho-phosphate does not result in an increase in algal growth within the reservoir complex and algal blooms are not observed within Oxbow and Hells Canyon Reservoirs or downstream at the same magnitude or intensity with which they occur in the Upstream Snake River segment (RM 409 to 335).

The relationship of total phosphorus, chlorophyll *a* and total suspended solids within the SR-HC TMDL reach provides understanding of transport and processing mechanisms in the riverine and reservoir sections. Figure 3.2.5 shows total suspended solids concentrations decreasing precipitously at the inflow of Brownlee Reservoir (RM 335 to 330). The decrease in chlorophyll *a* describes a less steeply-sloped curve, indicating that algae are among the lighter sediment particles and are therefore transported farther downstream than the more dense (presumably inorganic) solids, which drop out more abruptly. The data available indicate that sediment in this

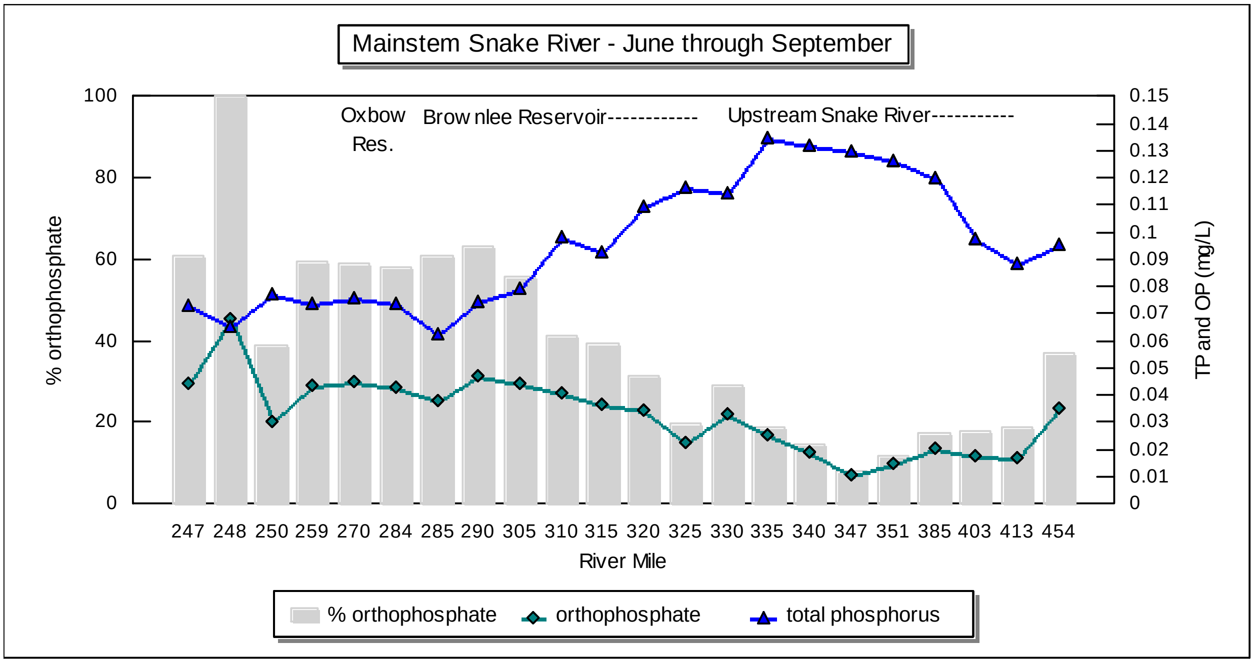

Figure 3.2.4. Spatial distribution of mean phosphorus and chlorophyll *a* concentration data within the Snake River - Hells Canyon TMDL reach (June through September, 1990 to 2000).

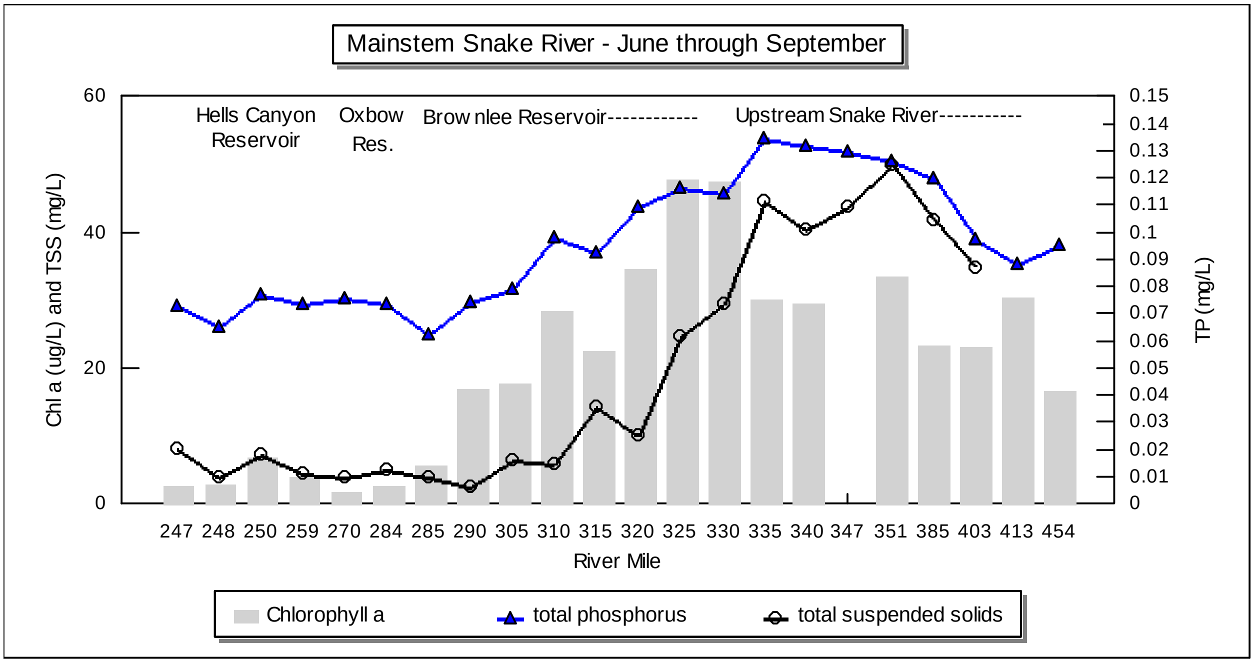

Figure 3.2.5. Spatial distribution of mean total suspended solids, phosphorus and chlorophyll *a* concentration data within the Snake River - Hells Canyon TMDL reach (June through September, 1990 to 2000).

depositional area is predominantly associated with coarser particle sizes, while the smaller, lighter particles are deposited somewhat further downstream.

Total suspended solids concentrations show the most marked decrease between RM 335 and RM 320. Chlorophyll *a* concentrations show the most marked decrease between RM 325 and RM 315. Total phosphorus concentrations show a sustained decrease between RM 335 and RM 285. This indicates that total phosphorus concentrations are the result of both that phosphorus associated directly with the heavier sediment particles (probably inorganic in nature) and that phosphorus originally in the water column that was taken up by algae and incorporated into the biomass moving into the Hells Canyon Complex. A portion of the total phosphorus within the system is also associated with the smaller, lighter inorganic particles (silts and clays) that are transported farther downstream within the system. A portion of this phosphorus, along with that portion associated with the algal biomass is processed within the Hells Canyon Complex and discharged as dissolved ortho-phosphate, as evidenced by the nearly flat curve described by the total phosphorus concentrations in the Oxbow and Hells Canyon Reservoirs.

Chlorophyll *a* concentrations in the inflowing tributaries are relatively moderate, averaging less than 15 ug/L overall. Chlorophyll *a* concentrations are greatest in the Owyhee and Malheur rivers, and least in the Weiser River, but all are relatively low, falling below the action level of 15 ug/L identified by the State of Oregon as a trigger for water quality investigations. All inflowing tributary waters are lower in chlorophyll *a* concentration than the average concentration in the Upstream Snake River segment (RM 409 to 335).

Chlorophyll *a* concentrations were used in this load assessment as a measurement of algae production. The data presented in Table 3.2.2 c show that both the Snake River and the reservoir complex provide an environment suitable for the high levels of algal production. Algal dynamics investigated by IPCo (1998a and 1998b) identified blooms in the lower section of the Upstream Snake River segment (RM 409 to 335) and in the upstream portion of Brownlee Reservoir. Blooms occurred in early May and late June. Concurrent nutrient monitoring indicated that during these blooms, phosphorus was the limiting factor to algal growth. A significant die-off was observed in this study between the two blooms, occurring in mid-May. This trend has been documented to occur with slight variations for a number of years.

The identification of algal populations in major blooms contributing to poor water quality is critical in defining appropriate targets for this TMDL. Several studies have been undertaken to identify algal species in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285). According to work done by Falter in 1999 (reported in IPCo, 1999d), diatoms are the dominant population in the spring and fall in the Snake River. Both green and blue-green algae species are present in the summer.

Algae blooms in the SR-HC reach are observed to be inversely correlated with dissolved ortho-phosphate concentration. During periods of high productivity, chlorophyll *a* concentrations increase while dissolved ortho-phosphate concentrations drop precipitously. With die-off or drop in productivity, dissolved ortho-phosphate concentrations increase, due in part to both lack of uptake and release of dissolved ortho-phosphate from dead and decaying algal materials.

Figure 3.2.6 shows the cyclic relationship observed between chlorophyll *a* and dissolved ortho-phosphate during the course of this bloom.

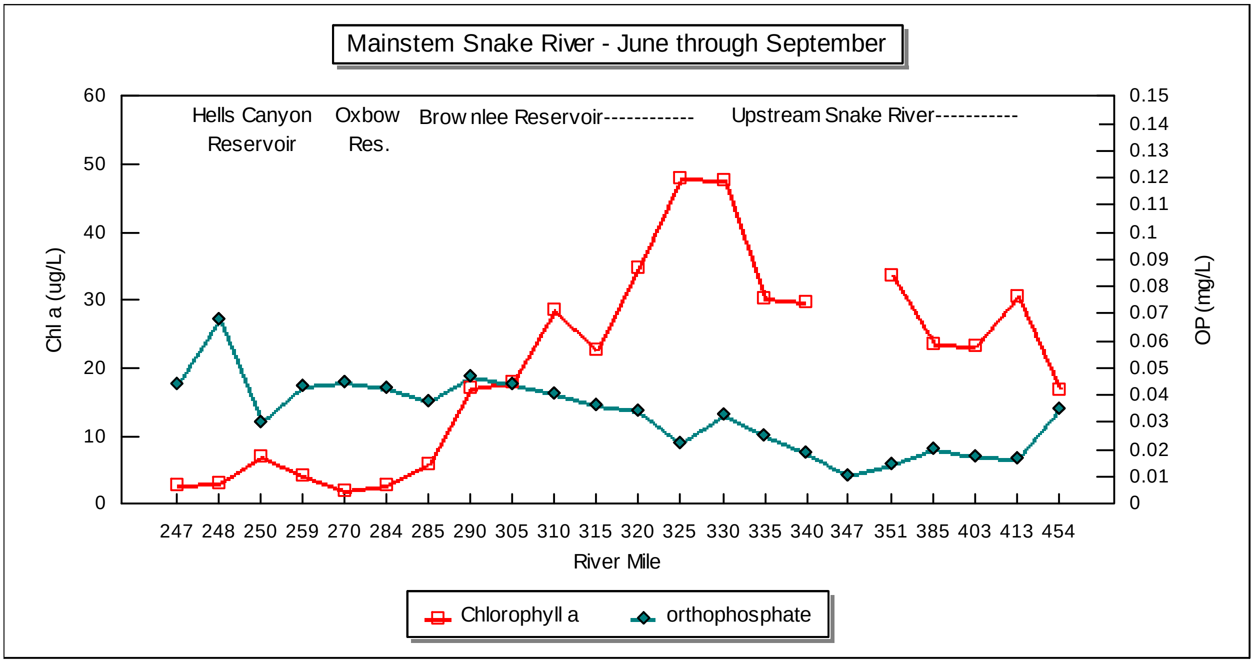

Figure 3.2.6. Algae mass (chlorophyll *a*) vs. dissolved phosphorus concentration for the mainstem Snake River in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285).

The plotted data show relatively low ortho-phosphate concentrations throughout the sections of the SR-HC TMDL reach where chlorophyll *a* concentrations are high. When chlorophyll *a* concentrations start to decrease however, ortho-phosphate concentrations increase. Where chlorophyll *a* concentrations are elevated, a general decrease is observed in the ortho-phosphate concentration.

Relatively low levels of algal production (as identified by chlorophyll *a* measurements) occur in the segment of the Snake River upstream of RM 396. Total phosphorus concentrations in the area of Celebration Park (RM 449) and Adrian, Oregon (RM 403) average approximately 0.08 mg/L over the years for which data are available.

Relatively low levels of chlorophyll *a* are observed in this location, indicating low algal populations in the water column. A visual inspection of the water at Celebration Park shows relatively clear, transparent conditions throughout the summer season, even when the river downstream supports a large algal population.

Several studies of the trophic status of the reservoir complex have been completed (IDEQ, 1993b; IPCo, 1999d), and the reservoirs were identified as being eutrophic. Mechanisms for the determination of trophic status range from relatively simple classifications based on nutrient concentrations to very complex classifications based on a number of interrelated variables. A moderately simple scheme of classification developed by Horne and Goldman (1994) includes four basic characteristics: concentration and supply rates of nutrients, substantial variation in oxygen saturation (supersaturation in the epilimnion and depression of dissolved oxygen concentrations in the hypolimnion), high primary productivity, and cloudy water with relatively low light penetration (Secchi depths 0.1 to 2 m).

Low dissolved oxygen concentrations in the water column have not been documented in the Upstream Snake River segment (RM 409 to 335). During the summer months when low dissolved oxygen concentrations are most likely to occur in areas of slow flow, high algal productivity results in supersaturation of the water column. While low dissolved oxygen is not expected to occur in the river to the degree that it does in the reservoir, due to mixing and shallow water aeration, it is expected that low dissolved oxygen concentrations would occur in areas of slow flow or in places where eddies and backwaters result in sluggish waters, and as a result of diurnal variations in the immediate vicinity of large algal blooms during periods when photosynthesis is not occurring.

As discussed in Section 3.2.2.3, violations of the dissolved oxygen criteria have been documented in data from artificial redd studies conducted upstream of RM 409 by IPCo in 1999 to 2000 and 2000 to 2001 (IPCo, 2001c). These data show dissolved oxygen concentrations of less than 2.0 mg/L during the late spring and summer months at the sediment/water interface between Swan Falls and the upstream portion of the SR-HC TMDL reach. Due to the fact conditions similar to those that occur in the region between Swan Falls and RM 409, also occur in the Upstream Snake River segment (RM 409 to 335), low dissolved oxygen concentrations are likely to occur in areas of the Upstream Snake River segment. Data available on white sturgeon in the Upstream Snake River segment (RM 409 to 335) show that this population is not being supported. Water quality degradation, including low dissolved oxygen at the sediment/water interface is most likely contributing to this lack of support.

3.2.6 Determination of Nutrient Loading

The method used for determination of nutrient loading for the SR-HC TMDL reach is discussed in the general hydrology and loading analysis, and in the sections above.

The available data show that total phosphorus loading into the SR-HC reach originates almost exclusively from the Upstream Snake River segment (RM 409 to 335).

No point source discharge permits in the SR-HC TMDL reach contain phosphorus limitations. One treated wastewater discharger currently monitors for total phosphorus concentrations on a quarterly basis (City of Fruitland). One industrial point source discharger currently monitors for total phosphorus concentrations (Heinz Frozen Foods). The reported concentrations from these monitoring efforts, and estimates available for average discharge concentrations are above the 0.070 mg/L instream target for the SR-HC TMDL. Using available data and estimated discharge concentrations for wastewater treatment plants of 3.5 mg/L, the total phosphorus loading from point source discharges was calculated at 516 kg/year. For facilities discharging part time, only that time when discharge occurred was assessed. Therefore, the calculated point source load for the summer growing season does not include loading from the City of Ontario as this facility utilizes land application in the summer and there is no discharge during the critical period. Point source loading represents approximately 8 percent of the total calculated load to the SR-HC reach. As all point sources discharging directly to the SR-HC TMDL reach do not monitor total phosphorus discharge concentrations, additional data would be necessary to determine actual total phosphorus loading from each permitted point source discharge and the concentration observed at the edge of the mixing zone.

Measured tributary total phosphorus loading to this segment accounts for the majority of the phosphorus load to the SR-HC TMDL reach (76%), with ungaged (estimated) drain flows accounting for 10 percent of the total system load and unmeasured sources accounting for approximately 6 percent of the total. Measured tributary dissolved ortho-phosphate loading to this segment also accounts for the majority of the dissolved ortho-phosphate load to the SR-HC reach (approximately 80%), with ungaged (estimated) drain flows accounting for approximately 7 percent of the total system load and unmeasured sources accounting for approximately 4 percent of the total. Care should be taken in the interpretation of dissolved ortho-phosphate values however, as ortho-phosphate is not a conservative parameter throughout the system.

Sources of unmeasured load may include nonpoint source runoff from anthropogenic sources, precipitation events, unidentified small tributaries and drains, ground-water sources and ground-water sources. As ungaged flows were calculated by subtraction, this may also include error in gaged flow measurements.

Nutrient loads from agricultural drains discharging to the SR-HC reach were determined using concentration and flow data where available. Flow data was not plentiful however, and most flows were estimated using general descriptions and the calculated return flow information by area supplied by the USBR (USBR, 2001). Calculated averages were used in place of concentration values where data were not available. These values therefore should be viewed as best estimates. If additional, drain-specific data become available during the implementation of this TMDL, it will be used in place of these estimates. Land area associated with the drains was calculated at 249,100 acres total (USBR, 2001). A listing of drain names and locations is included in Appendix J.

The relative nutrient loads shown in Table 3.2.3 a and b are calculated for the SR-HC reach using average summer flows (Table 2.1.1).

3.2.7 TMDL Determination

Nutrient standards for both the State of Idaho and the State of Oregon are narrative in nature, identifying that nutrient concentrations that result in the impairment of designated beneficial uses or the production of visible slime growths or other nuisance aquatic growths that impair designated beneficial uses are in violation of the standard.

Given the water quality concerns that can result from excessive nutrient concentrations and the range of concentrations and related system characteristics such as flow, temperature, water column mixing, light penetration and water depth under which these conditions can occur throughout the Pacific Northwest, a narrative nutrient standard is appropriate. Interpretation of

Table 3.2.3 a. Relative point source total phosphorus loads calculated for the Snake River - Hells Canyon TMDL (May through September, 1995, 2000).

Waste Load Type	Location	Design Flow Load (kg/day)	NPDES[1] or other Permit Number
City of Nyssa	RM 385	11	101943 OR0022411
Amalgamated Sugar	RM 385	50	101174 OR2002526
City of Fruitland	RM 373	5.5	ID0020907
Heinz Frozen Foods	RM 370	412	63810 OR0002402
City of Ontario	RM 369	0[1]	63631 OR0020621
City of Weiser	RM 352	32	ID0020290
City of Weiser	RM 352	5.5	ID0001155
Brownlee Dam (IPCo)	RM 285	Unmeasured, assumed minimal[2]	ID0020907
Oxbow Dam (IPCo)	RM 272.5	Unmeasured, assumed minimal[2]	101275 OR0027286
Hells Canyon Dam (IPCo)	RM 247	Unmeasured, assumed minimal[2]	101287 OR0027278
Total Point Source Loading	SR-HC TMDL reach	516	

[1] None of the summer loading produced by the City of Ontario is discharged to the Snake River as land application is employed during the critical months (May through September).
[2] Facilities sump discharge and turbine cooling water, not a phosphorus or waste treatment source.

the narrative standard on a site-specific basis is necessary to identify targets that will protect all designated beneficial uses within the listed segment. The designated beneficial uses determined to be most at risk from excess nutrients were those associated with recreation, aquatic life and domestic water supply. Therefore, establishment of a nutrient target for the SR-HC TMDL reach had to take into account both the concerns associated with the support of designated beneficial uses and the system characteristics that lead to violation of the standard. The process followed to identify nutrient targets for the SR-HC TMDL had two major goals:

1. To identify targets for nutrient loading such that their attainment would result in full support of designated beneficial uses and achievement of water quality standards.
2. To identify the assimilative capacity of the SR-HC reach.

The first goal is directly related to the establishment of a TMDL for nutrients and associated water quality concerns. The second goal is specific to the development of an accurate and equitable load allocation process. Both goals are discussed in greater detail in the following sections.

Table 3.2.3 b. Relative total phosphorus loads calculated for tributaries and other nonpoint sources (NPS) to the Snake River - Hells Canyon TMDL (May through September, based on concentration data from 1995, 1996 and 2000, and mean flow values).

Load Type	Location	Load (kg/day)	Percent of Total NPS Loading
Snake River Inflow	RM 409	1,912	31.5
Owyhee River	RM 396.7	265	4.4
Boise River	RM 396.4	1,114	18.3
Malheur River	RM 368.5	461	7.6
Payette River	RM 365.6	710	11.7
Weiser River	RM 351.6	392	6.5
Drains	Upstream Snake River Segment	660	10.9
Ungaged flows	Upstream Snake River Segment	385	6.3
Agriculture, Stormwater and Forestry	Upstream Snake River Segment (RM 409 to 335)	Included in the ungaged flow loading	
Nonpoint Source Total for the Upstream Snake River Segment (RM 409 to 335)		5,899	97.1
Burnt River	RM 327.5	52	0.9
Powder River	RM 296	126	2.1
Agriculture, Stormwater and Forestry	Brownlee Reservoir segment (RM 335 to 285)	Cannot be calculated, assumed small	
Nonpoint Source Total for the Brownlee Reservoir Segment (RM 409 to 335)			2.9
Agriculture, Stormwater and Forestry	Oxbow Reservoir segment (RM 285 to 272.5)	Cannot be calculated, assumed small	

* NOTE: The values in this column represent the load in the Snake River or tributary at the end of the listed section. For example, the load listed for Brownlee Reservoir is the load that is passed to Oxbow Reservoir at Brownlee Dam. The load listed for the Owyhee River is the load that is transported to the Snake River at the location where the Owyhee joins the Snake. Data in this table are from US EPA STORET, 1998a; IPCo, 1999d and 2000a; USGS, 1999 and Boise City Public Works, 2001.

3.2.8 Identification of Nutrient Targets

Several different processes for identification of nutrient targets have been outlined in the guidance documents for nutrient criteria recently released by the US EPA (US EPA, 2000d). These documents provide information and strategy for establishing nutrient criteria for both rivers and streams, and lakes and reservoirs. The goal of this process was to identify a numeric nutrient target specific to the support of designated beneficial uses in the SR-HC TMDL reach. These documents provided valuable guidance in the establishment of the target. The numeric target was identified to support the narrative criteria already in place for both states.

A first step undertaken in this process was the identification of limiting factors within the SR-HC TMDL system. Two major indicators of limiting factors were evaluated: Nitrogen to phosphorus ratios and algal population dynamics.

3.2.8.1 Nitrogen to Phosphorus Ratio.

The nitrogen to phosphorus ratio (N:P ratio) and its correlation with algal growth has been the subject of a large body of research. Freshwater systems tend to be phosphorus limited. A general rule often applied to N:P ratios in freshwater systems is that if the N:P ratio is greater than ten, the limiting agent is phosphorus and excessive algal growth will usually not occur if phosphorus is reduced appropriately. If the N:P ratio is less than ten, the limiting agent is nitrogen and excessive algal growth will usually not occur if nitrogen is reduced appropriately.

This has been applied using both soluble and total nutrient measurements. However, care must be taken in using soluble nutrient measurements during an algal bloom to identify this ratio as soluble nutrient concentrations can drop to nearly unmeasurable levels due to rapid uptake. Differences and errors in analytical procedures are more marked at very low concentrations and thus represent a greater relative error. The threshold of ten is commonly applied, and was selected in this analysis as a cutoff value between limiting agents, however, a range of N:P ratios over which nitrogen and phosphorus may be co-limiting agents has been identified as from 7 to 15 (US EPA, 2000d).

Where N:P ratios greater than 10:1 occur in a freshwater system, incidence of algal blooms will likely be controlled by total phosphorus concentrations. Bloom severity will be in relation to the excess phosphorus available (Schindler, 1978; Jaworski, 1981). Generally, a phosphate concentration of 0.01 mg/l will support plankton, while concentrations of 0.05 to 0.1 mg/l phosphate or higher are likely to result in nuisance blooms (Dunne and Leopold, 1978; US EPA, 1986b), depending on site specific conditions.

The data available to the SR-HC TMDL reach was evaluated on a monthly average basis to determine the nitrogen to phosphorus ratio (Figure 3.2.7 and 3.2.8). Total nitrogen (as N) and total phosphorus (as P) measurements were used. Soluble nitrogen and soluble phosphorus data sets were not as plentiful and did not cover the same time frames as well as the total nutrient data sets. Not all data sets included the same number of data points. Where there was a substantial discrepancy in the number of data points within compared data sets an average monthly value was calculated.

The N:P ratios for RM 385 and RM 351.2 were all greater than ten with the exception of the July average at RM 385. This is a good indication that phosphorus acts as a limiting agent in the Upstream Snake River segment (RM 409 to 335). In the months immediately preceding algae blooms, April and May, the N:P ratios are substantially above the threshold value of ten, and are also above the range (7 to 15) where nitrogen and phosphorus have been observed to act as co-limiting agents. During this time period, phosphorus acts as the limiting agent.

In the SR-HC TMDL reach, and in the Mid-Snake TMDL reach (RM 547), both segments where nutrient TMDLs have been prepared, the N:P ratios are substantially higher than those observed in the Snake River sections in-between (Figure 3.2.8). This may be due to the relative differences in water quality within the Snake River system, but may also be influenced by the differences in timing and total number of data points in each of the available data sets. The data evaluation involved in the CJ Strike (2004) and Mid-Snake Succor (2002) TMDL efforts will be helpful in refining upstream contributions to the SR-HC TMDL effort.

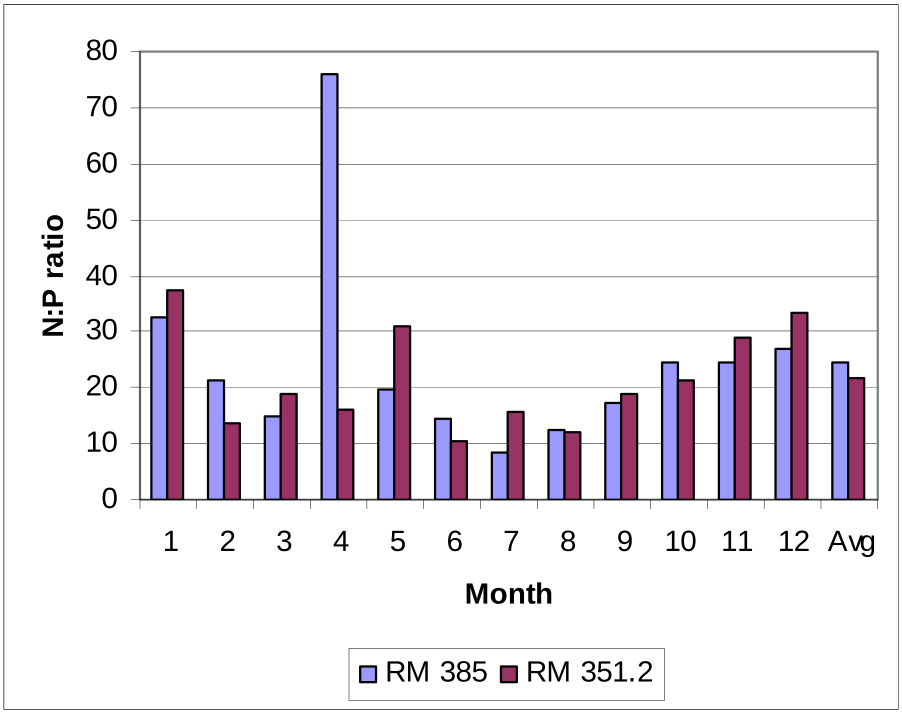

Figure 3.2.7. Nitrogen to phosphorus ratios in the Snake River - Hells Canyon TMDL reach for RM 385 (near Nyssa, Oregon) and RM 351.2 (near Weiser, Idaho).

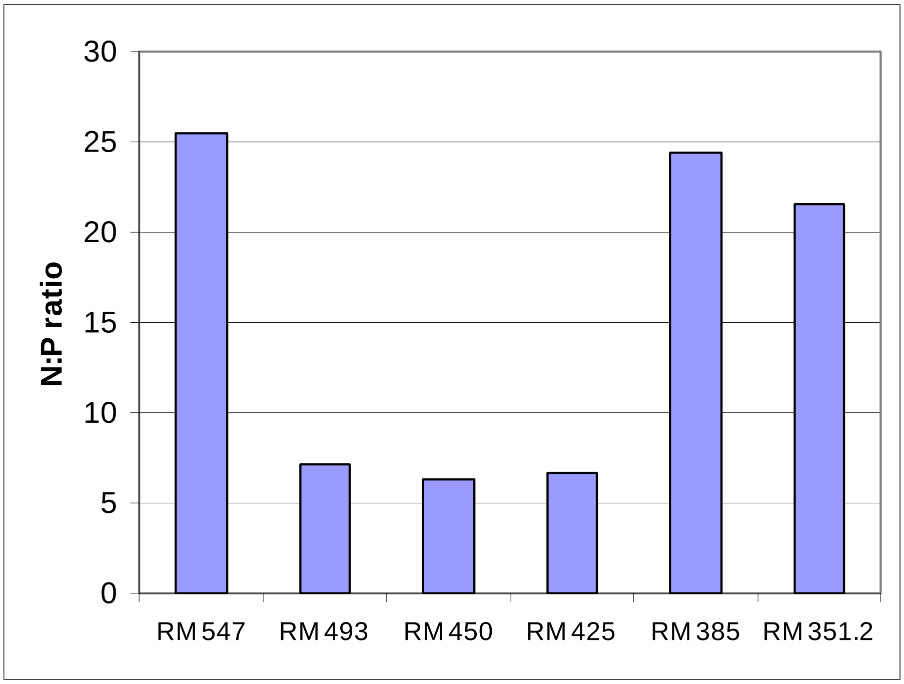

Figure 3.2.8. Nitrogen to phosphorus ratios for different segments of the Snake River. River mile 547 and river mile 385 to 351.2 have been identified as impaired due to excessive nutrient loading on the Idaho State 303(d) list for 1998.

3.2.8.2 Algal Populations.

The identification of algal taxa in major blooms contributing to poor water quality is critical to the identification of limiting agents. The work above shows that throughout the year, phosphorus is the limiting agent in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. During the months of June and August the N:P ratios near the lower end of the Upstream Snake River segment are within the range where nitrogen and phosphorus have been observed to act as co-limiting agents (based on N:P ratios). An identification of the different populations of observed growth in the river is necessary in order to determine with more specificity which nutrient acts as the limiting agent during these time periods.

Several studies have been undertaken to identify algal species in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285). According to work done by Falter in 1999 (reported in IPCo, 1999d), diatoms are the dominant population in the spring and fall in the Upstream Snake River segment (RM 409 to 335). Green and blue-green algae species are present in the summer. Blue-green species dominate where excessive blooms have been identified.

Data collected during a major algal bloom in 1992 in the Snake River between RM 396 and RM 310 showed that the major types of algae present in the Upstream Snake River segment (RM 409 to 335) were cyanobacteria species (*Microcystis aeruginosa*, and *Aphanizomenon flos-aquae*). The algal population in the lower sections of the river were almost exclusively *Anabaena spiroides* (99%), also a cyanobacteria (IDEQ, 1992 to 1993, unpublished data).

A similar study conducted by IPCo in the reservoir complex in 1991, 1993 and 1994 (relatively low flow years) showed the upper end of Brownlee Reservoir dominated by green algae. The middle segment of Brownlee Reservoir showed a mixture of blue-green and green species. Phytoplankton species in the lower segment of Brownlee Reservoir, and the Oxbow and Hells Canyon reservoirs were dominated by cyanobacteria species (IPCo, 1999c).

This information indicates that cyanobacteria species are prominent population types in major algae blooms in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Some cyanobacteria are able to fix nitrogen out of the water both within the water column and at the air/water interface and are therefore difficult if not impossible to control with nitrogen reductions. Phosphorus is therefore the limiting factor in these blooms. Based on this analysis, targets for the SR-HC TMDL reach identify water column concentrations of phosphorus rather than nitrogen. Reductions of phosphorus will likely have the most benefit in reducing blooms composed of these algal species.

3.2.8.3 Target Determination – Scope and Reasoning.

The reasoning behind the determination of a phosphorus target for the SR-HC TMDL reach is outlined in the following sections. This determination was made based on the requirements of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach.

The SR-HC TMDL is a complex system including both river and reservoir segments. In order to determine the assimilative capacity of the SR-HC TMDL reach, the system was divided into manageable sections. The Upstream Snake River segment (RM 409 to 335) represents the dominant inflow to the Hells Canyon Complex reservoirs and the Downstream Snake River segment (RM 247 to 188). If the Upstream Snake River segment (RM 409 to 335) meets water quality standards in river, the water quality in Brownlee Reservoir will be improved. Only that portion of water quality impairment directly attributable to the reservoir systems, and independent of the inflowing water quality, can be identified as the responsibility of the construction and operation of the reservoirs. Therefore, determination of water quality needs in the Upstream Snake River segment (RM 409 to 335) separate from the Hells Canyon Complex segments is critical to the equitable allocation of load and responsibility within the SR-HC TMDL reach.

The identification of the phosphorus target described in the following sections is based on the needs of the Upstream Snake River segment (RM 409 to 335). The additional needs of the reservoir segments are addressed in the allocation of dissolved oxygen improvements discussed in the sections following the target determination discussion. While upstream water quality is not the sole source of water quality exceedences downstream, it is the dominant source of pollutant loading to downstream segments. (Over 95% of the total phosphorus loading to the SR-HC TMDL reach is delivered by the Upstream Snake River segment (RM 409 to 335)). Therefore, improvements in water quality in the Upstream Snake River segment will result in improvements throughout the SR-HC TMDL reach just as degraded water quality in the Upstream Snake River segment now results in degraded water quality downstream.

3.2.8.4 Definition of Reference Conditions.

A definition of reference conditions for determination of appropriate nutrient targets for the SR-HC TMDL was undertaken as part of this TMDL process. In the US EPA nutrient guidance document (US EPA, 2000d) the use of reference reaches is discussed as a mechanism to determine appropriate nutrient criteria. This same approach was utilized in the identification of nutrient targets for the SR-HC TMDL. The size, complexity and use-patterns of the Snake River preclude the use of a reference system to determine appropriate phosphorus targets for the SR-HC TMDL reach.

Data available to this assessment included total phosphorus, dissolved ortho-phosphate, total nitrogen and chlorophyll *a* concentrations from 1975 to 2000. A fairly even distribution of spring and summer conditions in high, medium and low water years were available within this data set. Initially, a database of nutrient and chlorophyll *a* information was assembled for various segments of the Snake River. These sections were selected for climate and flow conditions similar to those observed in the SR-HC TMDL reach. The assessment included three general sections of the Snake River: the mainstem above RM 600, the mainstem between RM 400 and 600, and the mainstem between RM 400 and 335. All of these sections are listed as impaired to some degree. No portion of the Snake River mainstem, where characteristics are similar to those observed in the SR-HC TMDL reach, is identified as un-impaired, therefore no true reference condition exists within the mainstem Snake River.

The mainstem Snake River above RM 600 is a section of the river well upstream of the SR-HC TMDL reach. Some reaches of this section are listed in the State of Idaho 1998 303(d) list as being impaired due to excess sediment (HUC #17040212, #17040209, and #17040206), low dissolved oxygen and excess nutrients (HUC #17040206). For the majority of its length however, this section is not listed for nutrient or dissolved oxygen related concerns. It is therefore, by definition, the "least impaired section" evaluated as part of this assessment.

The mainstem Snake River between RM 400 and 550 is the section of the river immediately upstream of the SR-HC TMDL reach. This section is listed in the State of Idaho 1998 303(d) list as being impaired due to excess sediment and nutrients (HUC #17050101 and part of HUC #17050103), low dissolved oxygen, bacteria, and pH (part of HUC #17050103), and pesticides (HUC #17050101). For the majority of its length this section is listed for nutrient and/or dissolved oxygen related concerns. It is therefore, by definition, "the moderately impaired section" evaluated as part of this assessment.

The mainstem Snake River between RM 400 and 335 is a section of the river included in the Upstream Snake River segment of the SR-HC TMDL reach. This section is listed in the State of Idaho 1998 303(d) list as being impaired due to excess sediment, nutrients, low dissolved oxygen, bacteria, pH (part of HUC #17050103 and HUC #17050115). For the entire length this section is listed for nutrients related concerns. It is therefore, by definition, "the heavily impaired section" evaluated as part of this assessment.

As stated above, data from 1975 to 2000 was utilized in this assessment. Data from single years were not compared to other years; rather, direct correlations between total phosphorus concentrations and chlorophyll *a* concentrations existing within the system at any one time were compared with each other. The identification of the relationship of total phosphorus concentrations to chlorophyll *a* concentrations was the main object of this assessment. Therefore, although the older data may not represent current conditions, they do represent the relationship between total phosphorus and chlorophyll *a* existing within the system at that time.

Many sections of the Snake River where climate and flow conditions were similar to those in the SR-HC TMDL reach did not have data available for use in this TMDL. The sections utilized, therefore, represent those sections where data was available, and where climate and flow conditions are comparable to the SR-HC TMDL reach. It is recognized that the flow volume in portions of the Snake River upstream of the SR-HC TMDL reach is less than the flow volume in the SR-HC TMDL reach, however, this data set represents the best available information and has been used to establish general targets.

A general distribution of concentration values for chlorophyll *a* and total phosphorus is displayed in the box and whisker plots shown in Figures 3.2.9 and 3.2.10. A *box-and-whisker* plot is a visual representation of how data is spread out and how much variation there is within the data set. The "box" shows the data included in the second and third quartiles, with the median marked as a solid line across the box. The "whiskers" show the range of the data (highest and lowest value).

Figure 3.2.9 contains concentration and range information for chlorophyll *a* in the mainstem Snake River. Mean chlorophyll *a* concentrations observed upstream of RM 400 are between 12 ug/L and 15 ug/L. Between RM 350 and 330 a substantial increase is observed to occur, with

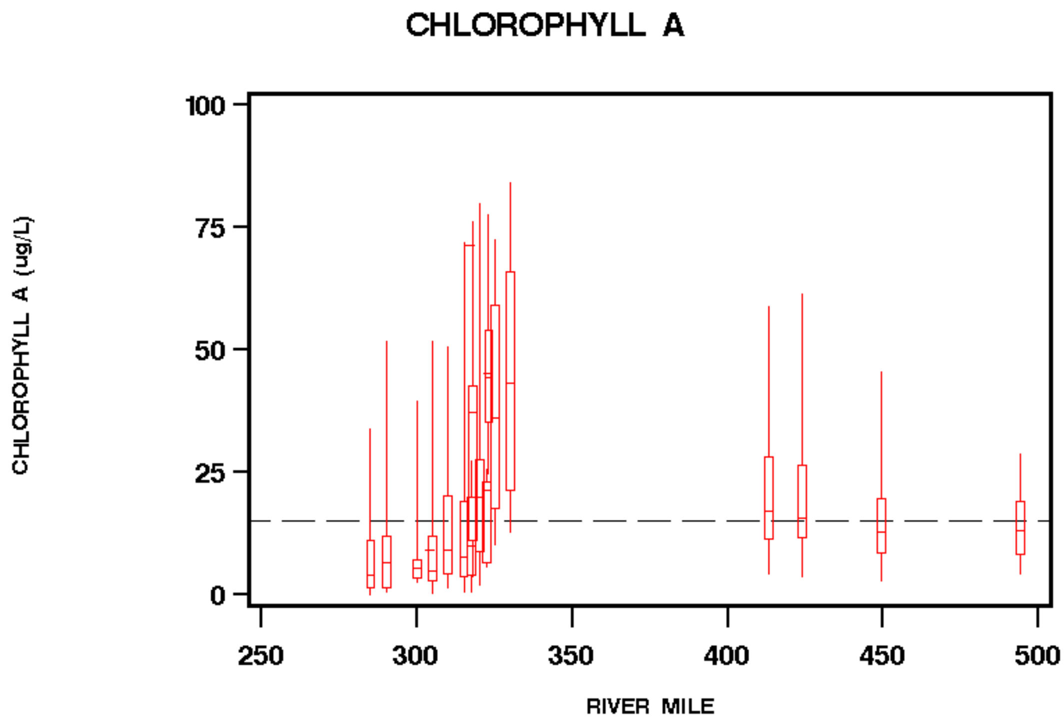

Figure 3.2.9. Box and whisker plot for chlorophyll *a* concentrations within the Snake River system.

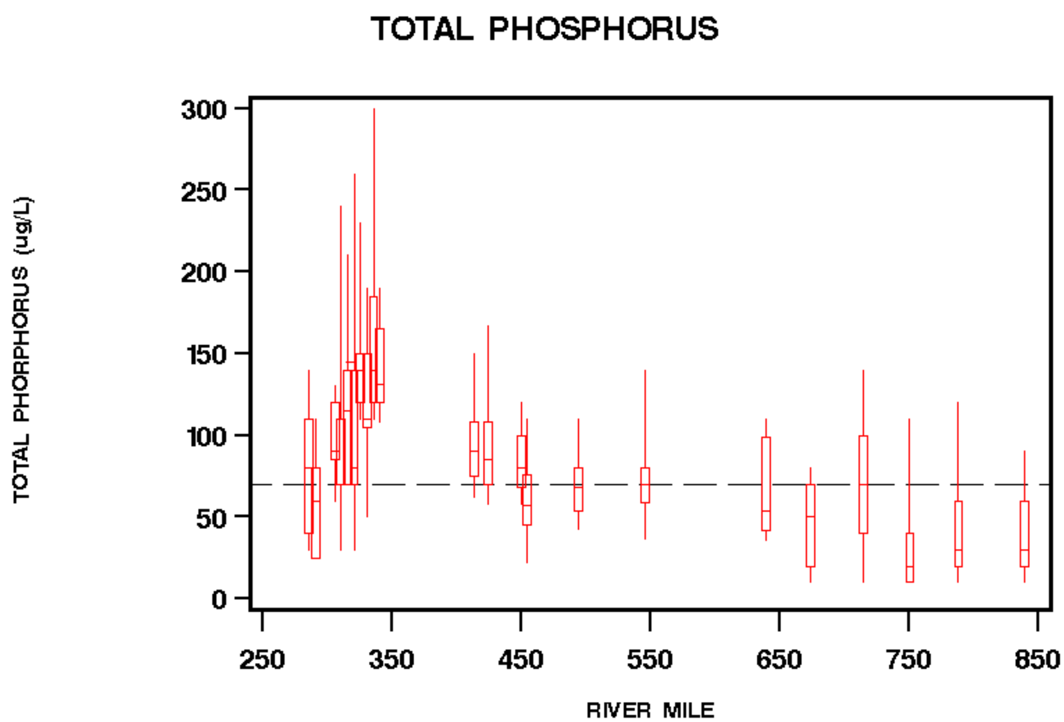

Figure 3.2.10. Box and whisker plot for total phosphorus concentrations within the Snake River system.

mean chlorophyll *a* concentrations between 25 ug/L and 40 ug/L, followed by a substantial decrease downstream of RM 330 (Brownlee Reservoir) to between 7 ug/L and 12 ug/L.

Total phosphorus concentrations displayed in Figure 3.2.10 follow a similar trend. Mean total phosphorus concentrations observed upstream of RM 600 are between 0.03 and 0.07 mg/L. Between RM 400 and RM 600 a slight increase is noted, with mean concentrations between 0.04 and 0.07 mg/L. Between RM 350 and 330 a substantial increase is again observed to occur, with mean total phosphorus concentrations increasing to between 0.09 and 0.14 mg/L, followed by a substantial decrease downstream of RM 330 to approximately 0.06 mg/L.

The concentration data plotted for the Upstream Snake River segment (RM 409 to 335) in Figures 3.2.9 and 3.2.10 show that chlorophyll *a* concentrations observed in the Upstream Snake River segment (RM 409 to 335) are generally 10 ug/L to 15 ug/L higher than those observed in the Snake River upstream of RM 400. Total phosphorus concentrations in this segment are generally 0.05 mg/L to 0.07mg/L higher than those observed in the Snake River upstream of RM 400. This suggests that the Upstream Snake River segment (RM 409 to 335) has a higher loading of both chlorophyll *a* and total phosphorus than the upstream sections of the Snake River as a whole. This relationship is also evident in the data plotted in Figures 3.2.11 and 3.2.12.

Cumulative distribution function (cdf) plots for chlorophyll *a* and total phosphorus for the sections described previously are shown in Figures 3.2.11 and 3.2.12. Cumulative distribution

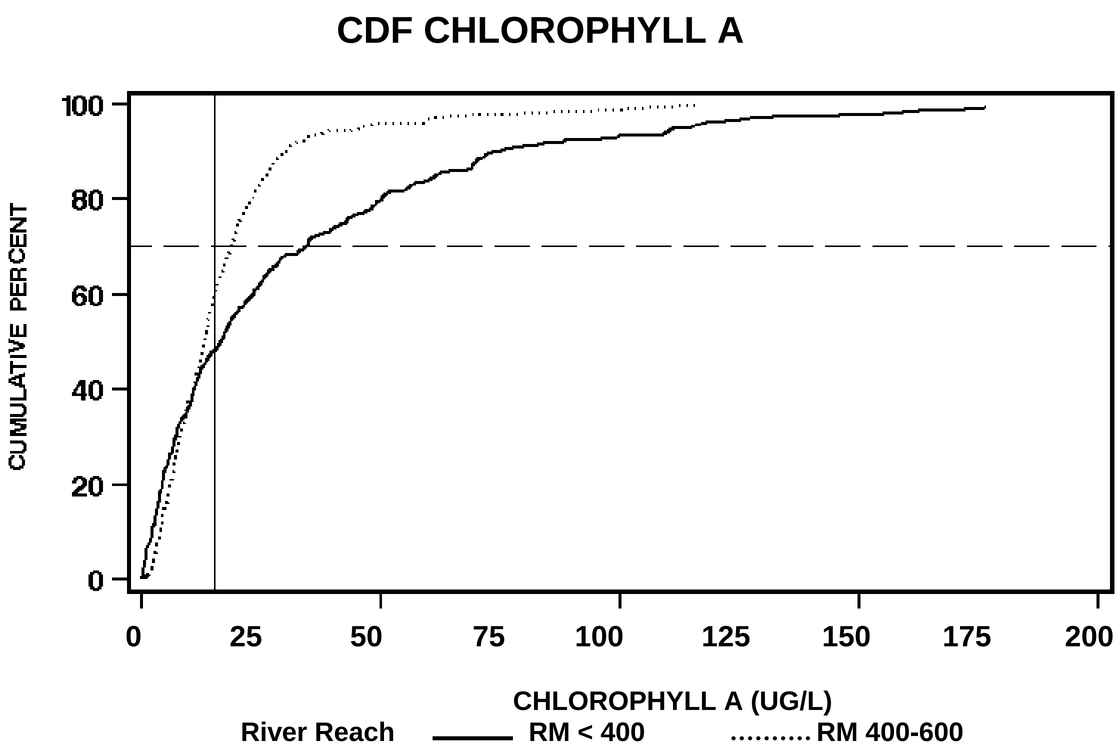

Figure 3.2.11. Cumulative distribution function (cdf) plot of chlorophyll *a* concentrations for two separate sections of the Snake River.

function plots represent the probability that the parameter of concern (in this case the chlorophyll *a* or total phosphorus concentration on the horizontal axis) is less than or equal to a certain percentage (identified on the vertical axis).

The plots for both chlorophyll *a* and total phosphorus show a similar trend in that the downstream section (RM 400 to 335) exhibits notably higher concentrations a greater portion of the time than the upstream sections (RM 400 to 600, or upstream of RM 600). This suggests greater overall loading and greater overall impact to water quality is occurring in the Upstream Snake River segment (RM 409 to 335). For this reason, the Snake River sections upstream of the SR-HC TMDL reach were used in the determination of reference conditions for the SR-HC TMDL reach.

US EPA (2001d) guidance suggests the identification of three concentration ranges based on a frequency distribution as a starting point for determining reference conditions, at risk conditions, and impaired conditions. In order to ensure representative ranges, and minimize the potential that outliers in the data would create a bias, the lowest and highest measured values (5%) were eliminated from consideration. The assessment was accomplished using the data distributed between the 5^{th} and 95^{th} percentiles. This data distribution was then divided evenly into three categories with the 35^{th} percentile concentration defining the threshold below which reference conditions would be defined, and the 65^{th} percentile defining the threshold above which

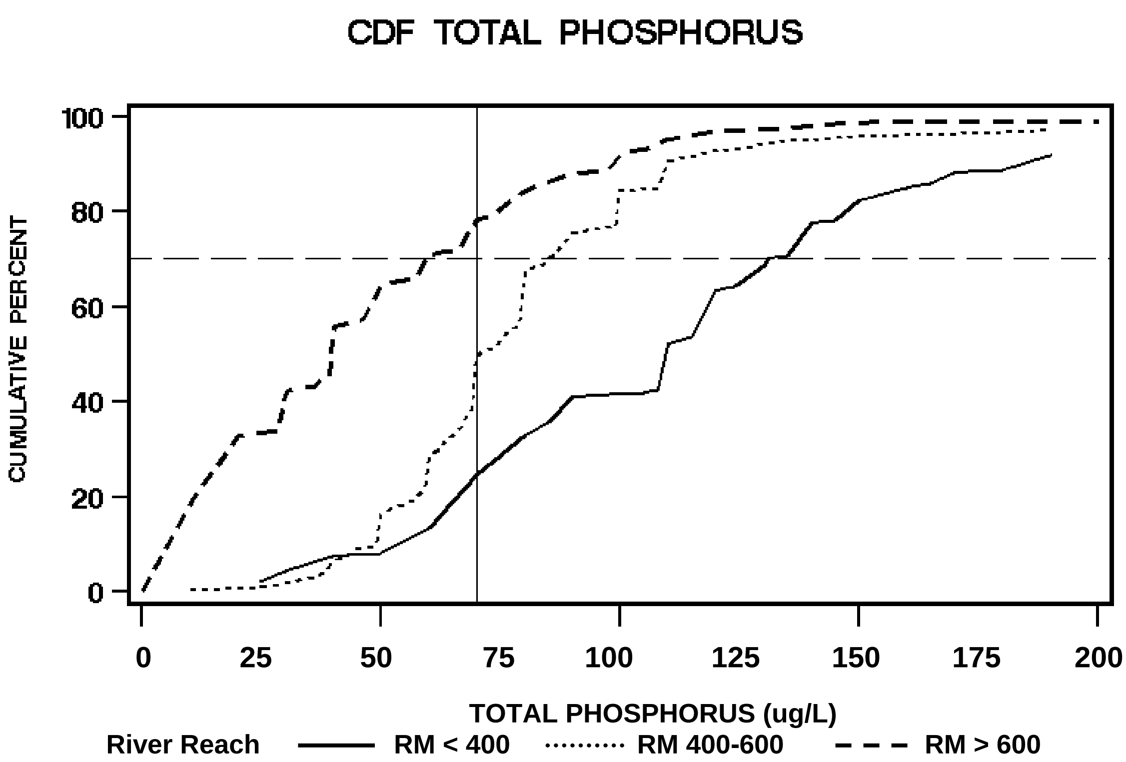

Figure 3.2.12. Cumulative distribution function (cdf) plot of total phosphorus concentrations for three separate sections of the Snake River.

impairment was projected to occur. The concentration range described between the 35th and the 65th percentiles was recommended as a definition of allowable conditions, with lower values tending toward better water quality conditions and higher concentration values being defined as more at risk for impairment. The results of this analysis are tabulated in Table 3.2.4.

Table 3.2.4. Distribution of total phosphorus and chlorophyll *a* data for the Snake River system (1992 through 1995, May through September data).

Data Reach	Data Range	35th Percentile Value	65th Percentile Value
Total Phosphorus (mg/L)			
Snake River System upstream of RM 600	0.01 to 0.28	0.025 mg/L	0.053 mg/l
Snake River between (RM 400 and 600)	0.022 to 0.411	0.065 mg/L	0.077 mg/L
Upstream Snake River segment (RM 409 to 335)	0.01 to 2	0.080 mg/L	0.125 mg/L
Chlorophyll a (ug/L)			
Snake River between (RM 400 and 600)	1 to 115	9 ug/L	16 ug/L
Upstream Snake River segment (RM 409 to 335)	1 to 95	9 ug/L	25 ug/L

Using the general guidance from the US EPA (2000d), the 35th percentile data from the section of the Snake River upstream of RM 600 was used to identify concentration values appropriate to reference conditions for the Snake River system. Using this method, total phosphorus concentrations equal to or less than 0.025 mg/L would represent high quality "reference" conditions. This correlates well with the calculated natural background concentration of 0.02 mg/L based on available data. Applying the 65th percentile concentration value as the threshold concentration above which impairment would be projected to occur would establish an upper concentration limit of 0.053 mg/L for total phosphorus.

The same analysis was performed using the data available from RM 400 to RM 600. Within this data set, total phosphorus concentrations equal to or less than 0.065 mg/L would represent high quality "reference" conditions. Applying the 65th percentile concentration value as the threshold concentration above which impairment would be projected to occur would establish an upper concentration limit of 0.077 mg/L for total phosphorus. This correlates well with the calculated target concentration identified by the Mid-Snake TMDL (IDEQ, 1997c) of 0.075 mg/L for the support of designated beneficial uses and attainment of water quality standards.

To maintain consistency between the total phosphorus and chlorophyll *a* data sets, the 65th percentile values from both the data set collected upstream of RM 600 and the data set from RM 400 to RM 600 were used to establish a range of concentration values (0.053 mg/L to 0.077 mg/L) as a starting point for total phosphorus target determination.

As no chlorophyll *a* data were available from the Snake River upstream of RM 600, data from RM 400 to RM 600 were evaluated using the same methodology to identify preliminary chlorophyll *a* targets for the SR-HC TMDL reach. Based on this analysis, chlorophyll *a* concentrations equal to or less than 9 ug/L would represent high quality "reference" conditions for the SR-HC TMDL, and the threshold concentration above which impairment would be projected to occur would establish an upper concentration limit of 16 ug/L for chlorophyll *a* concentrations in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach.

These values (chlorophyll *a* threshold concentrations of 16 ug/L or less and a total phosphorus threshold target range of 0.053 mg/L to 0.077 mg/L) were used as an initial starting point for identification of targets to attain water quality standards and meet the needs of the designated beneficial uses defined in Section 3.2.2.

Figures 3.2.9 through 3.2.12 and Table 3.2.4 provide evidence that the distribution of chlorophyll *a* and total phosphorus concentrations observed in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach are elevated when compared to those observed upstream of the SR-HC TMDL reach (upstream of RM 409) in the Snake River system.

The 65th percentile value for chlorophyll *a* in the Upstream Snake River segment (RM 409 to 335) is 63 percent higher than the 65th percentile value observed in the Snake River between RM 400 and RM 600. Similarly, the 65th percentile value for total phosphorus observed in the Upstream Snake River segment is 49 percent over the 65th percentile value observed in the Snake River between RM 400 and RM 600. This value is more than two times greater than the 65th percentile value observed in the Snake River upstream of RM 600.

3.2.8.5 Chlorophyll *a* and Total Phosphorus Target Identification.

The statistical determination of reference conditions discussed above supplied a valid range of values for reference and threshold target determination. This range was then related to the unique characteristics of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach to "ground truth" the general characteristics described by using information specific to this segment and identify a specific numeric target for this reach.

Excessive algal growth is the dominant factor in the impairment of designated beneficial uses in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL. Excessive algal growth has both direct and indirect effects on designated beneficial uses. Direct effects include degradation of aesthetic and recreational opportunities, and the concerns associated with excessive organic loading in domestic water supplies. Indirect effects include low dissolved oxygen resulting from the decomposition of decaying algae, and the associated chemical changes that result. Controlling algal growth in the Upstream Snake River segment (RM 409 to 335) will act to improve water quality and address these impacts to designated beneficial use support.

The identification of a target specific to algal growth or biomass is at best cumbersome and difficult to define. Therefore, chlorophyll *a* (commonly used as a surrogate measure for algae biomass) will be used as a target for the Upstream Snake River segment (RM 409 to 335). The chlorophyll *a* target selected has been identified as appropriate to attain water quality standards and be protective of all designated beneficial uses. Designated beneficial uses in the Upstream Snake River segment that were evaluated in this assessment include: aquatic life, domestic water supply, aesthetics and recreation.

Aquatic life:

As the target identified must be protective of all designated beneficial uses, and as aquatic life uses are generally more sensitive than recreational or aesthetic uses, the support of aquatic species is an important consideration. Mountain whitefish, a salmonid species, are known to inhabit the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. However, this TMDL acknowledges that a mixed fishery is present in this segment, made up of warm, cool and cold water species. A review of existing literature regarding nuisance thresholds and chlorophyll *a* standards by Pilgrim et al. (2001) reported chlorophyll *a* standards for waters likely inhabited by salmonids at 10 to 15 ug/L, and for waters not inhabited by salmonids at 25 to 40 ug/L. The 65th percentile threshold target of 16 ug/L is close to the upper range defined for salmonid-supporting waters and below the range defined for non-salmonid supporting waters.

Domestic water supply:

To be protective of domestic drinking water supplies, Rashke (1994) proposed a mean growing season chlorophyll *a* limit of 15 ug/L for surface water bodies utilized as water supplies. The 65th percentile threshold target of 16 ug/L is close to this limit.

Aesthetics and recreation:

In the acknowledgement that of information specific to the local perception of acceptable chlorophyll *a* concentrations was limited, information available from other studies (discussed in Section 3.2.2.1) was also utilized. This information provides a range of between 15 and 50 ug/L for maximum chlorophyll *a* concentrations for the support of aesthetics and recreation in North America (Table 3.2.1). These values are maximum concentrations; mean concentrations observed would therefore be expected to be lower, depending on the allowable level of exceedence. Additional data on water discoloration (Table 3.2.5) shows that an acceptable level of discoloration commonly occurs at chlorophyll *a* concentrations between 10 and 15 ug/L. Above this, deep discoloration is observed to occur, along with the formation of algal scum. The 65th percentile threshold target of 16 ug/L is within the lower end of the range defined for maximum allowable concentrations, and near the upper end of the range defined for allowable water discoloration.

Table 3.2.5 Water discoloration linked to chlorophyll *a* concentrations for water bodies in the southeastern United States (from Raschke, 1993).

Chlorophyll *a* (ug/L)	Degree of Water Discoloration
> 10	No water discoloration
10 to 15	Some discoloration, some development of algal scums
20 to 30	Deep discoloration, frequent algal scum formation
> 30	Very deep discoloration, intense matting of algal scum

The ranges identified above as being protective of designated beneficial uses extend from 10 ug/L to 50 ug/L. The 16 ug/L target identified previously as the threshold above which impairment is likely to occur falls at the low end of the range presented for protection of aesthetics and recreation. This value is near the high end of the range presented for the protection of salmonids but below the range presented for the protection of non-salmonids. This value is very close to that defined as being protective of domestic water supply uses. Therefore, a chlorophyll *a* target of less than or equal to 16 ug/L mean growing season concentration appears to be protective of the more sensitive designated uses for the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. Because this assessment evaluated the relationship between total phosphorus and chlorophyll *a* throughout the system as a whole, recommended associated error included over/underestimation of overall concentration by grab sampling (10% to 25%), and analytical error (3% to 5%). Error ranges were recommended by Dr. Paul Woods of the USGS (sample error) and certified federal and state analytical laboratories (analytical error). Sampling and analytical protocol information is available for USGS, US EPA, and IPCo data utilized in this assessment. These data represent the primary data sources for this evaluation. As all sample collection and analytical work for these data were performed under rigorous, well defined protocols, conservative error estimates were used for all sources. This resulted in an overall MOS of 13 percent. Applying this MOS to the initial 16 ug/L threshold value yields a target of 14 ug/L chlorophyll *a*.

The allowable level of exceedence for this target is recognized as critical factor in the support of designated beneficial uses. Frequency exceedence levels of up to 25 percent were found to be protective for recreational uses by Smeltzer and Heiskary (1990) and have been applied in this assessment. Given the existing data set, based on summer growing season chlorophyll *a* concentrations, this exceedence level, combined with the 14 ug/L mean growing season concentration target results in a nuisance threshold of 30 ug/L chlorophyll *a*.

A 14 ug/L mean growing season chlorophyll *a* concentration and a nuisance threshold of 30 ug/L chlorophyll *a* is projected to be protective of all designated beneficial uses, and to result in the attainment of appropriate water quality within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach, it has been established as the chlorophyll *a* target for this TMDL.

In order to attain the chlorophyll *a* target identified for the Upstream Snake River segment of the SR-HC TMDL reach, reductions in total phosphorus concentrations in the mainstem Snake River must be accomplished. In a ranked, paired distribution of data (Figure 3.2.13 a), the nuisance threshold of 30 ug/L chlorophyll *a*, combined with the 14 ug/L mean growing season concentration target corresponds to total phosphorus concentrations between 0.053 mg/L and 0.077 mg/L. In order to define the appropriate numeric total phosphorus target for the Upstream Snake River segment (RM 409 to 335), several issues were considered.

An inflection point is apparent in the plotted data (Figure 3.2.13a), occurring between 0.065 and 0.072 mg/L total phosphorus. The difference in trend between total phosphorus concentrations below 0.065 mg/L and concentrations above 0.072 mg/L indicates that greater chlorophyll *a* concentrations (and therefore greater total biomass) occur at higher concentrations of total phosphorus. This correlation is somewhat intuitive, but variation in natural systems often makes it difficult to define quantitatively.

While the chlorophyll *a* values at and below the inflection point in Figure 3.2.13 a are very similar, chlorophyll *a* concentrations associated with total phosphorus concentrations greater than 0.072 mg/L, especially maximum concentrations, are substantially greater than those associated with total phosphorus concentrations less than 0.072 mg/L. As shown in Table 3.2.6,

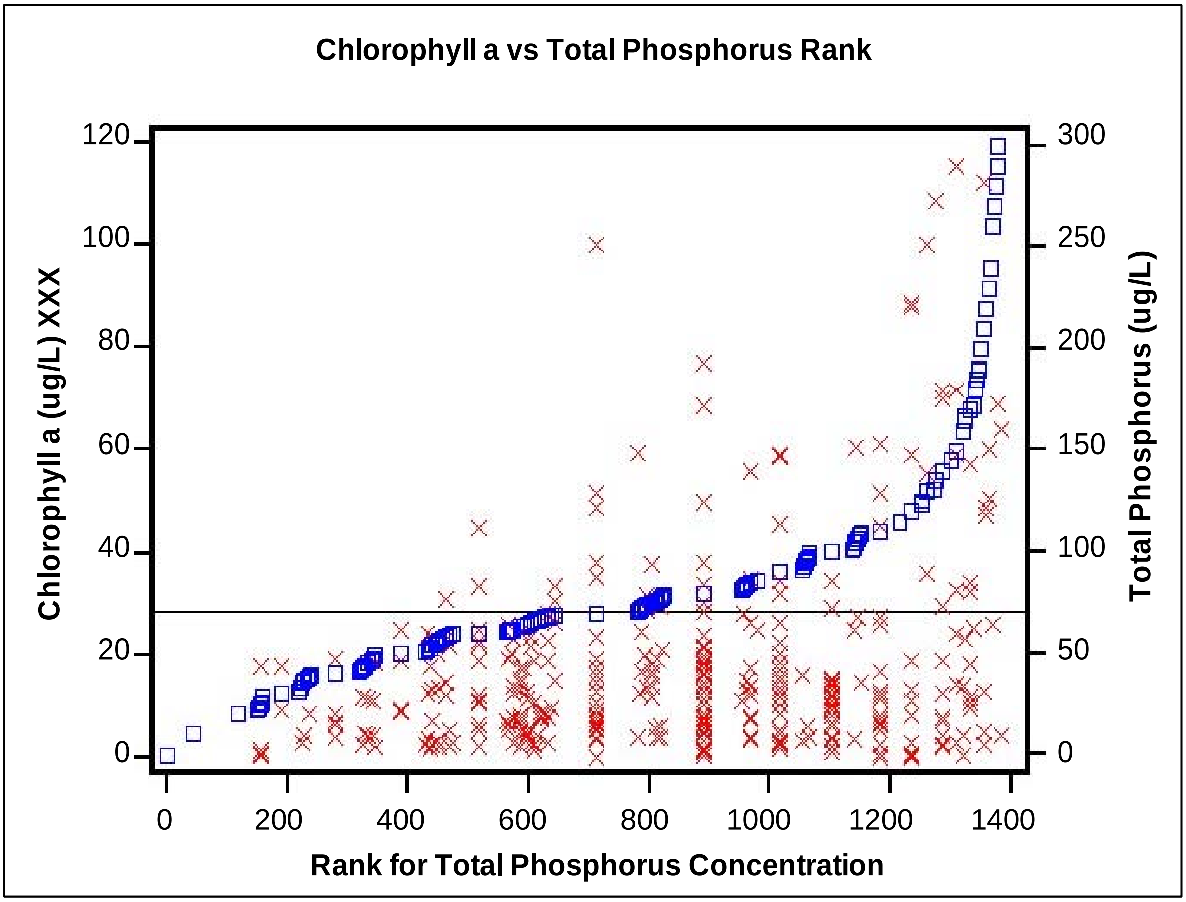

Figure 3.2.13 a. Chlorophyll *a* concentration data as correlated with increasing total phosphorus concentration for the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL.

Table 3.2.6. Correlated total phosphorus and chlorophyll *a* values for Upstream Snake River segment (RM 409 to 335) data.

Total Phosphorus Range	Chlorophyll *a* Range	Chlorophyll *a* mean	Chlorophyll *a* 65th Percentile
0.01 mg/L to 0.065 mg/L	0 ug/L to 44 ug/L	11.8 ug/L	14.6 ug/L
0.065 mg/L to 0.072 mg/L	0 ug/L to 45 ug/L	11.8 ug/L	16.0 ug/L
0.072 mg/L to 2.0 mg/L	0 ug/L to 95 ug/L	24.8 ug/L	30.8 ug/L

the maximum, average chlorophyll *a* values associated with total phosphorus concentrations greater than 0.072 mg/L are double those observed at or below this value. When these values are compared to those observed in the analysis of the larger Snake River system data set, upstream of RM 400, they supply additional information on water quality improvements. The total phosphorus concentrations at the inflection point are within the range described by the previous analysis of the Snake River data, namely 0.053 mg/L to 0.077 mg/L. Additionally, these data show that measurable reductions in algal biomass can be achieved by attaining the 0.072 to 0.065

mg/L concentration, but that reductions below 0.065 mg/L will probably not result in substantially greater improvements than those achieved at 0.065 mg/L. This is important in the consideration of the economic costs of implementation. For this reason, the lower threshold value identified by the data set from upstream of RM 600 (0.053 mg/L) was considered inappropriate to the SR-HC TMDL reach and will not be applied.

The remaining threshold value (0.077 mg/L) was assessed using best professional judgement and estimates of associated error. Because this assessment evaluated the relationship between total phosphorus and chlorophyll *a* throughout the system as a whole, recommended associated error included over/underestimation of overall concentration by grab sampling (10% to 25%), and analytical error (3% to 5%). Error ranges were recommended by Dr. Paul Woods of the USGS (sample error) and certified federal and state analytical laboratories (analytical error). Sampling and analytical protocol information is available for USGS, US EPA, and IPCo data utilized in this assessment. These data represent the primary data sources for this evaluation. As all sample collection and analytical work for these data were performed under rigorous, well defined protocols, conservative error estimates were used for all sources. This resulted in an overall margin of safety of 13 percent. When applied to the threshold values generated by the data set from RM 400 to RM 600 (0.077 mg/L total phosphorus), a target value of 0.067 mg/L total phosphorus was identified, 0.07 mg/L (after rounding). These target concentrations were then evaluated for designated use support within the SR-HC TMDL reach.

3.2.8.6 Target Evaluation for Designated Use Support.

Within the ranked data set it was observed that a general increasing trend in maximum chlorophyll *a* concentration occurred with increasing total phosphorus concentration (Figure 3.2.13a). Although there is variation within the data set, a general correlation of increasing maximum chlorophyll *a* values with increasing total phosphorus concentration was observed in the data.

The target of 0.07 mg/L total P (over the growing season) is projected to result in a median chlorophyll *a* concentration of about 12 ug/L (Figure 3.2.13 a). When median total P concentrations are at 0.07 mg/L, maximum chlorophyll *a* concentrations rarely exceed 30 ug/L in this system (this is because to a first approximation about one-half of the total P in a system is available to the algae). Therefore maximum total P concentrations of 0.07 mg/L will result in substantially lower median seasonal chlorophyll *a* concentrations, probably around 15 ug/L.

This is corroborated when comparing the Snake to other lakes and reservoirs in the Pacific Northwest (Figure 3.2.13 b). Median total P concentrations during the growing season below 0.07 mg/L typically produce median chlorophyll *a* concentrations less than 15 ug/L. If the target of 0.07 mg/L total P in the Snake is realized, median total P will be much less than 0.07 mg/L and the chlorophyll *a* concentrations correspondingly lower. Thus the “average” of 14 ug/L chlorophyll *a* corresponding to a maximum total P of 0.07 mg/L appears to be reasonable. Moreover, the 0.07 mg/L target will eliminate the large peaks in chlorophyll *a* observed in the upper part of the reservoir (Figure 3.2.13 a).

Chlorophyll *a* concentrations correlated with total phosphorus concentrations between 0.02 mg/L and 0.065 mg/L ranged from a minimum of 0 ug/L to a maximum of 44 ug/L (Table 3.2.6). The average chlorophyll *a* concentration over this range was 11.8 ug/L. Chlorophyll *a* concentrations correlated with total phosphorus concentrations between 0.065 mg/L and 0.072 mg/L, ranged from a minimum of 0 ug/L to a maximum of 45 ug/L. The average chlorophyll *a* concentration over this range was 11.8 ug/L. Chlorophyll *a* concentrations correlated with total phosphorus concentrations above 0.072 mg/L ranged from a minimum of 0 ug/L to a maximum of 95 ug/L. The average chlorophyll *a* concentration over this range was 24.8 ug/L.

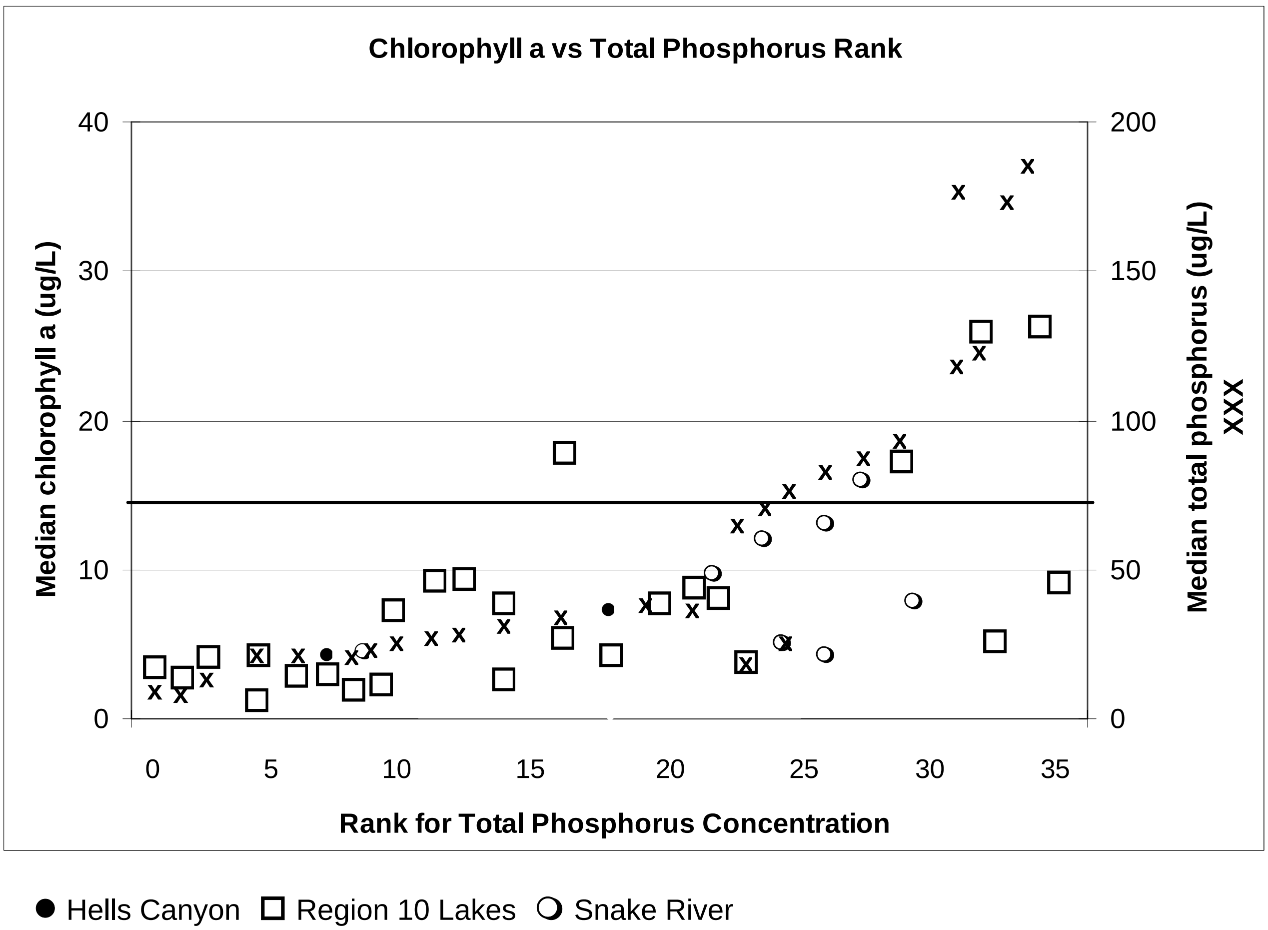

Figure 3.2.13 b. Comparison of median chlorophyll *a* concentration data as correlated with median total phosphorus concentration data for lakes and reservoirs in the Pacific Northwest.

If the 14 ug/L mean growing season chlorophyll *a* target is achieved through attainment of the 0.07 mg/L total phosphorus target, then designated beneficial uses in the Upstream Snake River segment (RM 409 to 335) directly linked to algal growth will be supported. These include domestic water supply, aesthetics and recreation. Full support of the aquatic life designated beneficial uses is dependent on the level of improvement in dissolved oxygen that occurs as a result of reduced algal growth. While algal blooms are expected to occur even with attainment of the 0.07 mg/L total phosphorus target, the frequency of occurrence will be reduced and the peak chlorophyll *a* concentrations should generally remain less than 30 ug/L. This is projected to result in full support of aesthetics and recreational designated beneficial uses and improved dissolved oxygen concentrations.

Attainment of the 0.07 mg/L target value represents a substantial reduction in the current average total phosphorus concentration in the SR-HC TMDL reach. Mainstem total phosphorus concentrations in the Snake River near Weiser average 0.13 mg/L to 0.14 mg/L total phosphorus annually (1999 to 2000 data set). The 0.07 mg/L target will require an overall reduction of 54 percent in total phosphorus concentration in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. When natural loading is accounted for (0.02 mg/L) the anthropogenic-related concentration is calculated at 0.11 mg/L to 0.12 mg/L. Using this concentration, to decrease total phosphorus concentration to 0.07 mg/L will require a 62 percent reduction in overall anthropogenic loading.

Attainment of the 14 ug/L mean growing season chlorophyll *a* target represents a reduction of roughly 44 percent in chlorophyll *a* and associated algal biomass. Approximately 1.5 percent of algal organic matter is chlorophyll *a* (Raschke, 1993). The average chlorophyll *a* concentration in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach during the summer season is 24.8 ug/L (103 ug/L maximum). Translated to algal biomass using the relationship above, in conjunction with 1995 (July average) flows at the Weiser gage of 15,000 cfs, this represents an algal biomass loading of approximately 61,000 kg/day (67 tons/day) near the Weiser gage station in the mainstem Snake River.

The average calculated chlorophyll *a* concentration resulting from attainment of the 0.07 mg/L total phosphorus target is 14 ug/L. This translates to an algal biomass loading of approximately 34,000 kg/day (37 tons/day) near the Weiser gage station. The reduction realized in total algal biomass is 27,000 kg/day (30 tons/day). This calculation does not account for additional reductions in biomass (periphyton and other organic growth) that can be directly influenced by reductions in nutrient concentrations.

In order to evaluate the influence of this reduced biomass on dissolved oxygen in the downstream river and reservoirs, several assumptions were made. It was assumed that the algae-related organic material was 50 percent labile (easily decomposed) and 50 percent refractory (more stable). It was also assumed that the decay of the labile fraction would occur in a day's time. Both of these assumptions are somewhat conservative, but still allow a relative evaluation of the influence of reduced organic loading to the system. Using a conservative organic matter/O_2 demand coefficient of 0.8 (Newbold and Liggett, 1974; Cole and Buchak, 1995), the reduction in organic matter from the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets results in a savings of 16,500 kg/day (18.2 tons/day) of oxygen in the water column. This equates to an approximately 0.3 mg/L dissolved oxygen increase in the water column as a whole or, perhaps more appropriately, 2 mg/L improvement in dissolved oxygen in 20 percent of the water column (improvements in dissolved oxygen would most likely be associated with depositional areas in the river system). The savings in water column oxygen due to reduced organic loading is expected to be of most benefit in those areas currently at risk for low sediment/water interface dissolved oxygen concentrations.

The projected 44 percent reduction in organic mater is conservative as accounts only for reductions in algal growth within the system. It does not account for any corresponding reduction in attached growth (periphyton, attached macrophytes, etc.) resulting from reductions in nutrient loading. Additionally, it does not account for reduced sediment-oxygen demands from erosion-based sediment reductions occurring with implementation progress.

If substrate dissolved oxygen levels require greater improvements than those identified by nutrient reductions, the TMDL will be re-evaluated. It is recognized that improvement in substrate dissolved oxygen levels will not be instantaneous as there is already a substantial store of organic material available within the SR-HC TMDL system. However, sustained reductions in incoming loads of organic material combined with transport and recycling within the system will, over time, result in decrease in the amount of organic material available within the SR-HC TMDL reach, this will improve substrate dissolved oxygen levels and benefit aquatic life using the sediment/water interface

Modeled Evaluation of Total Phosphorus Target Attainment.

A modeling effort using the USACOE CE-QUAL-W2 model has been undertaken by IPCo for the purposes of improving understanding of the Hells Canyon Complex system as part of the FERC re-licensing effort for the Hells Canyon Complex hydropower facilities (IPCo, 1999d). Because of its potential application to the SR-HC TMDL process, this model was evaluated extensively by the DEQs. The IPCo model has been reviewed and evaluated by modeling experts at IPCo and their contractors, and has been peer reviewed by a panel of modeling experts from several different state and federal agencies that were assembled by IPCo. In addition, the DEQs have evaluated this model and its application to the SR-HC TMDL effort and have conducted a separate peer review through a panel of modeling experts assembled by the DEQs in response to requests voiced by some members of the SR-HC PAT.

Although it was recognized in all peer reviews that no model will ever be a perfect fit for any system, all reviewers from all of the peer review efforts indicated that they felt confident with the manner in which the model had been validated and applied to the Hells Canyon Complex. (For more information on this peer review process please contact the IDEQ Boise Regional Office, 1445 North Orchard, Boise, Idaho 83706.) Because of the outcome of the peer reviews conducted, it is the opinion of the DEQs that the IPCo model represents a valid tool for evaluation of water quality conditions within the SR-HC TMDL reach.

The IPCo model was utilized to simulate the water quality response to the 0.07 mg/L total phosphorus target in the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. Modeling work was accomplished by IPCo and contract personnel. Simulations included a projection of both short-term (benefits that would be realized quickly) and long-term (benefits that would take a more extended period of time to occur) water quality improvements based on the attainment of the 0.07 mg/L total phosphorus target. The following section contains a summary of the information provided by IPCo regarding this modeling effort. The full memorandum is attached as Appendix F.

The changes in water quality in the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir were evaluated. The 1995 baseline boundary condition in the Brownlee Reservoir Model is based on the 1995 Southwest Snake River Model (IPCo, 2000a) results calibrated to measured data from Porters Island. The model includes soluble reactive phosphorus and phosphorus tied to organic matter (based on a coefficient for the stoichiometric equivalent between organic matter and phosphorus) (Cole and Wells, 2000; IPCo, 1999d). Thus, organic matter in the boundary condition multiplied by the coefficient represent organic phosphorus in the model.

To evaluate total phosphorus in the model and the reduction to meet the target, total organic matter was calculated as the sum of algae and dissolved and particulate organic matter. Total organic matter was converted to organic phosphorus using a ratio of 100:1 (total organic matter: organic phosphorus) (IPCo, 2000a). Total phosphorus was calculated as the sum of organic phosphorus and soluble reactive phosphorus. The model does not account for inorganic (mineral) phosphorus attached to sediment. The date when total phosphorus exceeded the criteria by the greatest amount was identified in the boundary condition and the difference between the maximum value and the target was calculated. This difference was then used to reduce the algae, organic matter, and soluble reactive phosphorus boundary conditions for the entire year. Model output is displayed in Figure 3.2.14.

As can be seen in Figure 3.2.14, the average modeled chlorophyll *a* concentration in the Upstream Snake River segment (RM 409 to 335) decreases by greater than the calculated 44 percent (estimated ~70%). This is reasonable as the original calculated value focuses on annual average chlorophyll *a* and does not account for other organic matter loads generated instream. Modeled chlorophyll *a* concentrations resulting from the attainment of the 0.07 mg/L total phosphorus target are within the range described in Table 3.2.1 as representing valid maxima for support of aesthetic and recreational designated uses, and match those identified in Table 3.2.6 associated with the 0.07 mg/L total phosphorus target.

To simulate the short term improvements, dissolved phosphorus and organic phosphorus (i.e. organic matter, including algae) were reduced from the 1995 baseline boundary conditions such that inflowing phosphorus levels did not exceed 0.07 mg/L. Long-term phosphorus improvements related to changes in sediment oxygen demand were simulated by replacing baseline sediment oxygen demand values estimated during model optimization with more typical values.

Changes in dissolved oxygen concentrations from each of the simulations were compared to baseline conditions by calculating the percent of volume where dissolved oxygen levels were below dissolved oxygen criteria. Baseline conditions were represented by the peer-reviewed Brownlee Model using 1995 measured boundary conditions, optimized to measured in-reservoir water quality data (IPCo, 1999d).

The simulation results demonstrate improving conditions from short-term conditions without sediment oxygen demand improvements to long-term conditions with sediment oxygen demand improvements. In general, the simulations show an increase in dissolved oxygen in all zones except the riverine zone, where dissolved oxygen is already at super saturated levels as a result

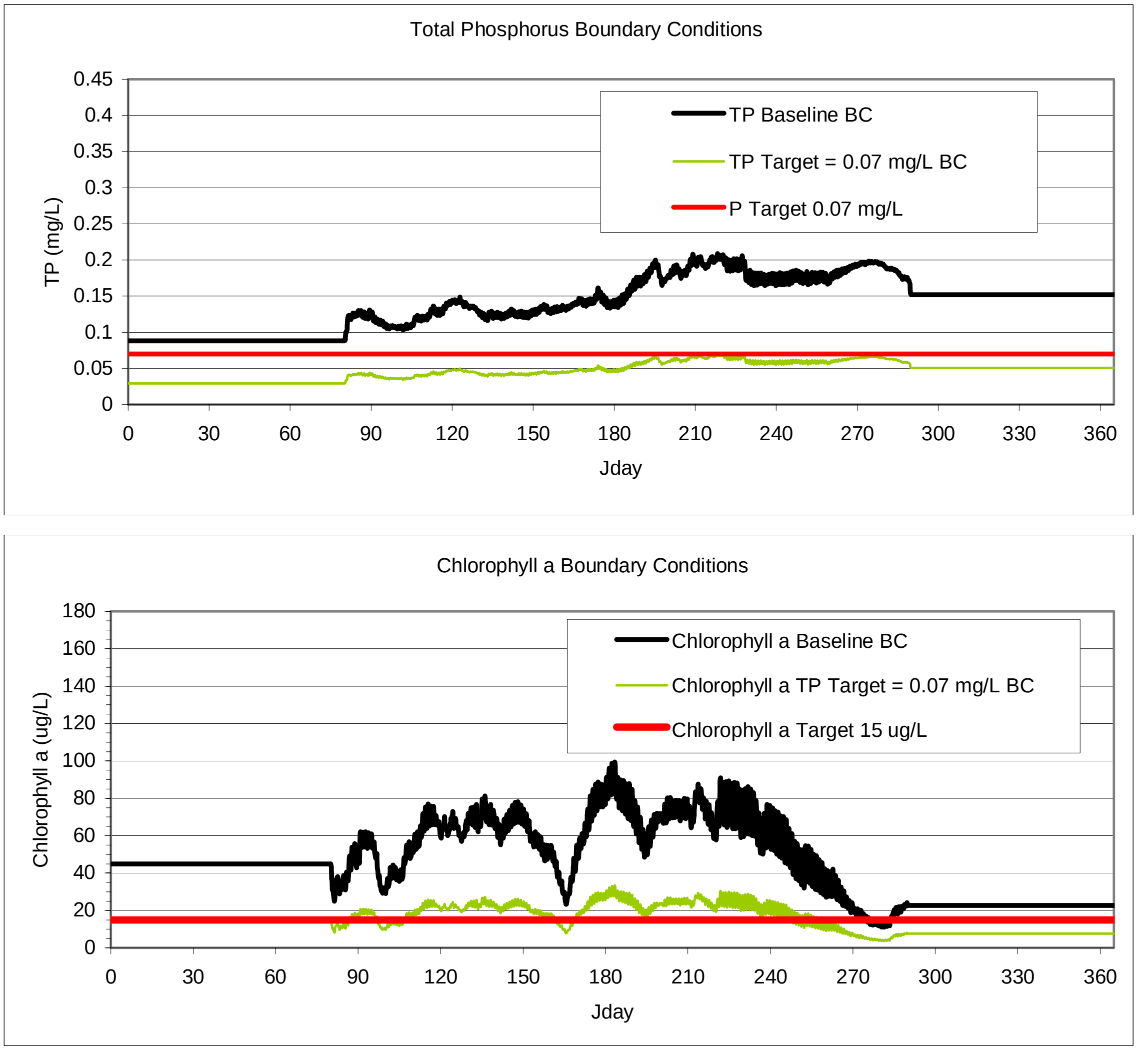

Figure 3.2.14. 1995 Boundary conditions, baseline and modeled total phosphorus target reductions.

of the algal bloom. In general, the dissolved oxygen improvement is greatest in the summer, especially in the metalimnion.

The simulation in Figure 3.2.15 a shows Brownlee Reservoir's initial response to reductions in total phosphorus and organic matter loads based on the total phosphorus target of 0.07 mg/L. When the TMDL is first implemented, sediment oxygen demand will be unchanged from baseline conditions. This limits the initial level of improvement (i.e., increase in dissolved oxygen) in the downstream end of the transition zone and in the lacustrine zone where sediment oxygen demand levels are highest.

The response to these long-term improvements was simulated by reducing sediment oxygen demand to 0.1 gm oxygen m^{-2} day^{-1} throughout the Brownlee Reservoir (Figure 3.2.15 b). This sediment oxygen demand is more typical of naturally occurring sediment oxygen demand levels

(Cole and Wells, 2000). The inflowing boundary conditions are unchanged from the previous simulation.

These simulations show that substantial improvements in water quality in Brownlee Reservoir will occur through implementation of the 0.07 mg/L total phosphorus target proposed for the SR-HC TMDL. While substantial improvements in dissolved oxygen are projected to occur as a result of the attainment of the 0.07 mg/L total phosphorus target, additional improvements are needed to meet dissolved oxygen criteria in Brownlee Reservoir. This is discussed in more detail in Section 3.2.8.7.

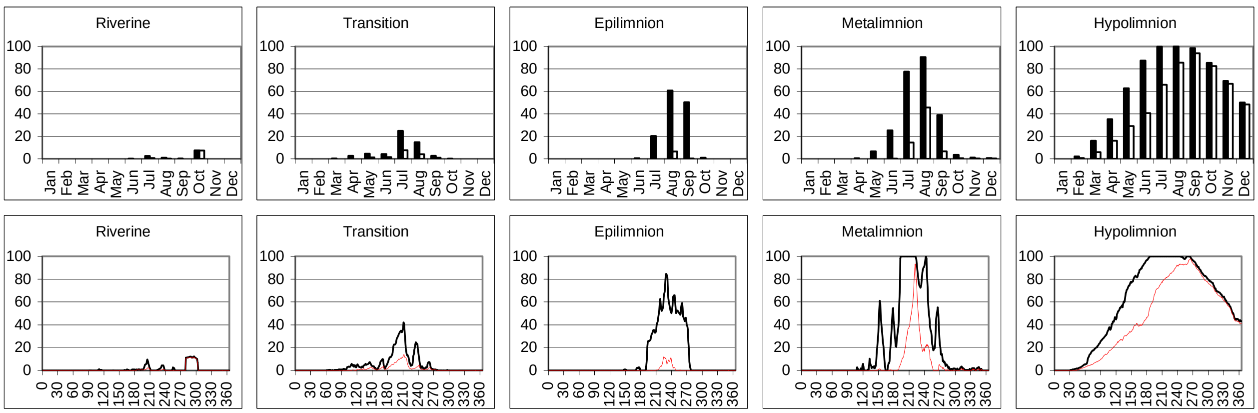

Figure 3.2.15 a. Simulation results showing short-term improvement resulting from implementation of the 0.07 mg/L total phosphorus target. Dark line shows percent dissolved oxygen below criteria (6.5 mg/L) for baseline and light line shows total phosphorus target.

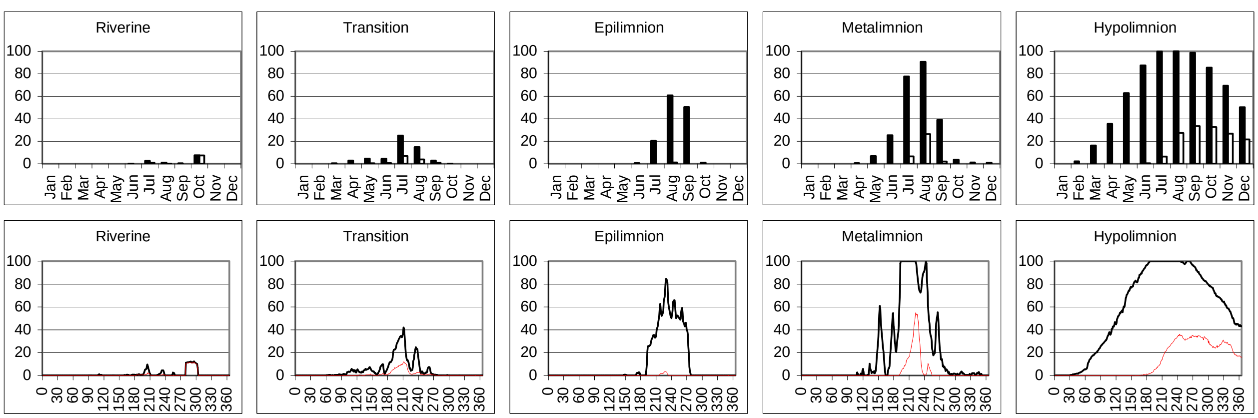

Figure 3.2.15 b. Simulation results showing long-term improvement resulting from implementation of the 0.07 mg/L total phosphorus target and resulting decrease in sediment oxygen demand. Dark line shows percent dissolved oxygen below criteria (6.5 mg/L) for baseline and light line shows total phosphorus target with sediment oxygen demand improvement.

Both calculated and modeled results showed similar increases in water quality through reduced algae (chlorophyll *a*) concentrations and improved dissolved oxygen. Because these evaluations were undertaken using very different methodologies and associated assumptions, the agreement between the two acts to substantiate the predicted outcome.

Other Benefits Projected from Meeting the Total Phosphorus Target.

The reduction in organic matter will also decrease the potential for methylmercury production within the SR-HC TMDL reach. A roughly 44 percent reduction in algae-related organic loading to the SR-HC TMDL reach, and the associated reductions in other aquatic growth through nutrient management will reduce the available organic material and thus reduce the opportunity for of the conversion process. The lack of understanding of the time frame over which it occurs precludes quantification of the actual reduction in methylmercury expected. It is also recognized that this improvement will not be instantaneous as there is already a substantial store of organic material available within the SR-HC TMDL system. However, as incoming loads of organic material decrease over time, and transport and recycling within the system proceeds, the amount of organic material available within the SR-HC TMDL reach will decrease, thus leading to decreased methylmercury concentrations. This in turn will reduce the concerns related to aquatic life and fish consumption by humans and animals.

The reduced growth resulting from a 44 percent reduction in total algal biomass will improve water quality conditions related to domestic water intakes as well, as reduced organic matter will lead to reduced potential for trihalomethane production, fewer filter concerns, and lower corrosive potential as nutrient concentrations decrease.

Finally, the US EPA guidance (US EPA, 2000d) illustrates a water quality continuum where systems exhibiting reference conditions are displayed on the left (lower percentile) of the plotted scale and systems identified as impaired are shifted toward the right (higher percentile) of the plotted scale. Waters in between fall on a continuum that blends gradually from impaired conditions to reference conditions with those on the impaired side of the continuum listed as *at risk*. In attaining this target value, the SR-HC TMDL reach will more closely reflect the most frequently occurring total phosphorus concentrations observed in the Snake River system as a whole, rather than the higher total phosphorus concentrations that currently result in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach being shifted toward the impaired end of the scale.

The target of 0.07 mg/L total phosphorus is slightly higher than that projected statistically for the Snake River upstream of RM 600 (0.065 mg/L total phosphorus), a less impacted system; but represents substantial reductions in total phosphorus loading, nuisance algal growth, and similar reductions in the associated water quality problems identified by this assessment.

As outlined above, the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets are supported by data analysis for the Snake River and the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach. They are also supported by the guidance on determining nutrient criteria recommended by US EPA. The data analysis and modeled reductions show that attainment of the target will result in substantial reduction in algal growth (as determined by chlorophyll *a* data) and improved dissolved oxygen concentrations within the Upstream Snake River segment (RM 409 to 335).

Therefore, it is the opinion of IDEQ and ODEQ that attainment of less than or equal to 14 ug/L mean growing season chlorophyll *a* concentration through attainment of the less than or equal to 0.07 mg/L mainstem total phosphorus target will result in reductions in algal growth sufficient to support aquatic life, domestic water supply, recreational and aesthetic uses within the Upstream Snake River segment of the SR-HC TMDL reach and attainment of the water quality standards for both Oregon and Idaho.

3.2.8.7 Identification of Difference in Assimilative Capacity for The Reservoir Segments.

While targets were evaluated separately for the Upstream Snake River segment (RM 409 to 335) and reservoir segments (RM 335 to 247), the Snake River system operates very much as a complete whole. Water quality within the SR-HC TMDL reach moves as a continuous chain, improvements in water quality in one segment will have a positive effect on downstream segments as degraded water quality in upstream segments will result in poor water quality downstream. This is especially true of the relationship between water quality in Brownlee Reservoir and that in Oxbow and Hells Canyon Reservoirs. Improvements in water quality in Brownlee Reservoir will have an immediate and positive effect on water quality in Oxbow and Hells Canyon Reservoirs. For this reason, the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets were evaluated for water quality improvements primarily in Brownlee Reservoir.

As stated previously, the initial strategy for nutrient target identification in the SR-HC TMDL reach was to establish a target appropriate for the Upstream Snake River segment (RM 409 to 335) which represents the dominant inflow to both the Hells Canyon Complex reservoirs and the Downstream Snake River segment (RM 247 to 188). It was theorized that if the Upstream Snake River segment met water quality standards in river, the water quality in Brownlee Reservoir (and the downstream reservoirs) would be improved. The level of improvement realized in the reservoir complex is a function of (1) the dependence of reservoir water quality on inflowing water quality, and (2) the change in assimilative capacity of the system as it moves through the impoundments. Impairment due to the latter is attributable to the reservoir systems; impairment due to the former is attributable to upstream sources.

The 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets described in the preceding sections are based on the needs of the Upstream Snake River segment (RM 409 to 335). These targets were then applied to the reservoir complex (primarily Brownlee Reservoir as it is located the farthest upstream, has the largest volume, and exhibits the greatest occurrence of water quality degradation of the three and therefore is the most sensitive to inflowing water quality).

The loading analysis (Section 3.2.6) clearly demonstrated that the reservoirs act as a sink for pollutants within the SR-HC TMDL system, removing approximately 44 percent of the total phosphorus and 77 percent of the sediment from the water before it reaches the Downstream Snake River segment (RM 247 to 188).

There are no activities associated directly with the reservoirs that act as phosphorus sources such as those identified in the Upstream Snake River segment (RM 409 to 335). However, the reservoirs do change the way the water moves through the system. This in turn can have an influence on how pollutants are processed and transported within the SR-HC TMDL reach.

The influence of the 0.07 mg/L target was investigated by applying the target phosphorus concentration and the reduced algae load to the inflowing waters of Brownlee Reservoir. For the purposes of this analysis it was assumed that all of the inflowing mainstem met the target concentration and showed the same 44 percent reduction in algae mass calculated to occur in the Upstream Snake River segment (RM 409 to 335).

The same assumptions for algae-related organic material, decay of the labile fraction, and organic matter/O_2 demand coefficients were applied in this evaluation as were applied in the evaluation of the Upstream Snake River segment (Section 3.2.8.6). Oxygen savings in the water column (from reduced algae decomposition) were calculated using 1995 flow data as they represented the most complete set and a reasonably average flow year (90% of the 30-year average). Average monthly flows were calculated, as were average monthly dissolved oxygen concentrations for each of the reservoir sections (RM 335 to 285) using information supplied by IPCo on the size and general volume of the reservoir segments (RM 335 to 247). Daily variations in dissolved oxygen were not tracked. Because they process pollutants differently, have somewhat different flow characteristics during stratification, and represent different levels of priority in designated beneficial use support, the sections of Brownlee Reservoir were evaluated separately for dissolved oxygen influences with the identified 0.07 mg/L total phosphorus target.

Brownlee Reservoir was divided into five separate sections (Figure 3.2.16):

- The riverine section (RM 340 to 325)
- The transition zone (RM 325 to 308)
- The lacustrine zone – epiliminion (RM 308 to 285) from surface elevation to 35 m below the surface.
- The lacustrine zone – metalimnion (RM 308 to 285) from 35 m below the surface to 45 m below the surface.
- The lacustrine zone – hypolimnion (RM 308 to 285) from 45 m below the surface to depth.

The volumes of these sections were calculated using information supplied by IPCo (IPCo, 1999d and personal communication, R. Myers and J. Harrison, IPCo, 2001). The values utilized are shown in Table 3.2.7.

Table 3.2.7. Volume information by section for Brownlee Reservoir. (Data provided by Idaho Power Company.)

Reservoir Section	Section Volume (acre-feet)	% of total reservoir
Riverine	179,382	14%
Transition	341,288	27%
Epilimnion	476,410	37%
Metalimnion	153,565	12%
Hypolimnion	122,696	10%
Total	1,273,341	100%

The influence on water quality was evaluated for the summer months when low dissolved oxygen levels most frequently occur. Each reservoir section was evaluated separately to assess the influence of improved dissolved oxygen and reduced phosphorus and algae loading in the inflowing waters. Each section was evaluated as a whole. It was assumed that the dissolved oxygen improvements within each segment were fully mixed, laterally and vertically. The information generated for the existing conditions (pre-target attainment) is shown in Figure 3.2.17.

Calculated dissolved oxygen curves for the transition zone and epilimnion show dissolved oxygen levels dropping below 6.5 mg/L in July, August and September. Minimum concentration values calculated are approximately 5.25 mg/L and 5.5 mg/L respectively. Calculated dissolved oxygen curves for the metalimnion show a more marked and extensive decrease with dissolved oxygen levels dropping below 6.5 mg/L in June, July, August and September. Minimum concentration values calculated are approximately 2.25 mg/L, occurring during the month of August. Calculated dissolved oxygen curves for the hypolimnion show a substantial decrease in dissolved oxygen concentration starting in June and continuing through the fall. Dissolved oxygen levels calculated dropped well below 3.0 mg/L (a situation lethal to most fish) in July and continue to decrease through the fall. Minimum concentration values calculated are approximately 1.25 mg/L, occurring during the month of September.

The curves shown in Figure 3.2.18 are calculated dissolved oxygen concentrations post-target attainment, showing the response of Brownlee Reservoir waters to improved water quality in the inflowing Snake River at RM 335. In all sections of the reservoir, attainment of water quality targets upstream resulted in a dramatic improvement in dissolved oxygen concentrations in the reservoir waters.

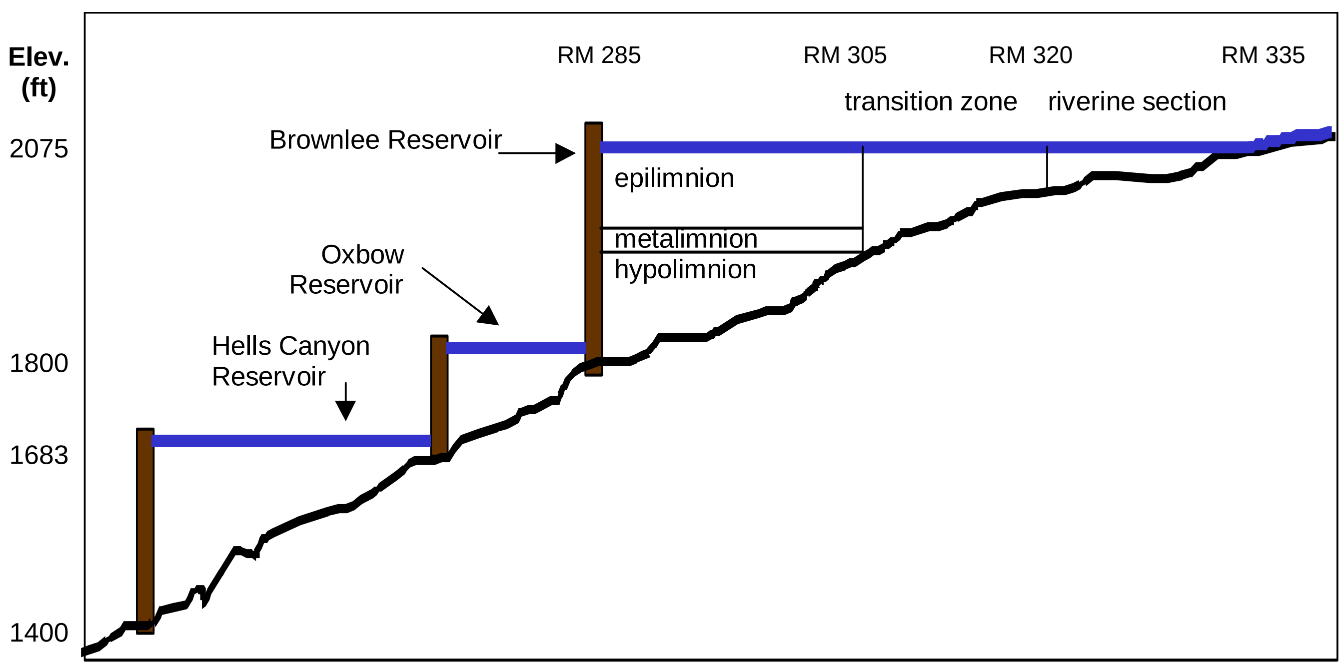

Figure 3.2.16. Diagram of the Hells Canyon Complex showing the dams and the reservoirs and diagramming the separate Brownlee Reservoir sections.

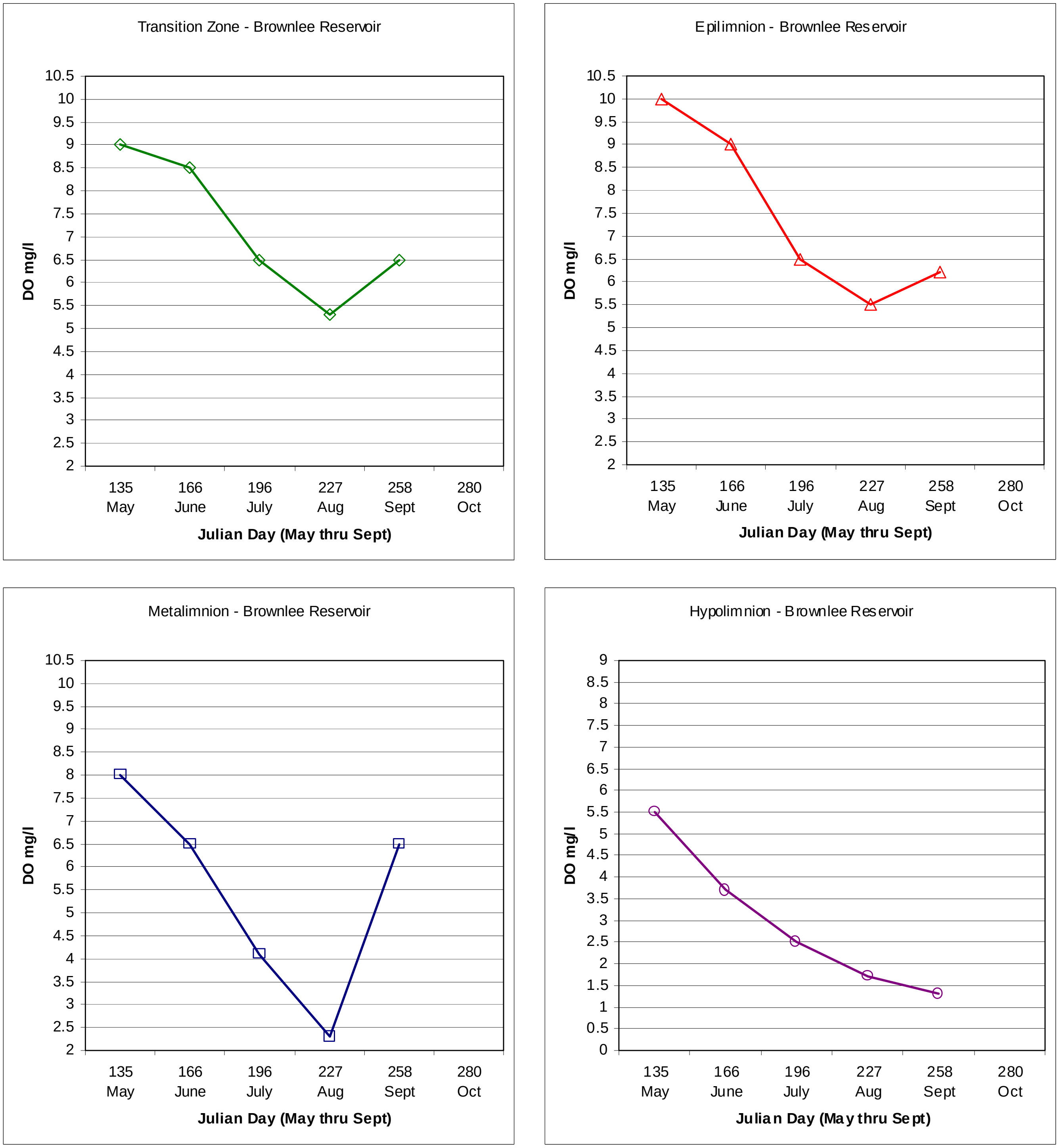

Figure 3.2.17. Calculated dissolved oxygen curves for distinct zones in Brownlee Reservoir (RM 335 to 285) under existing conditions.

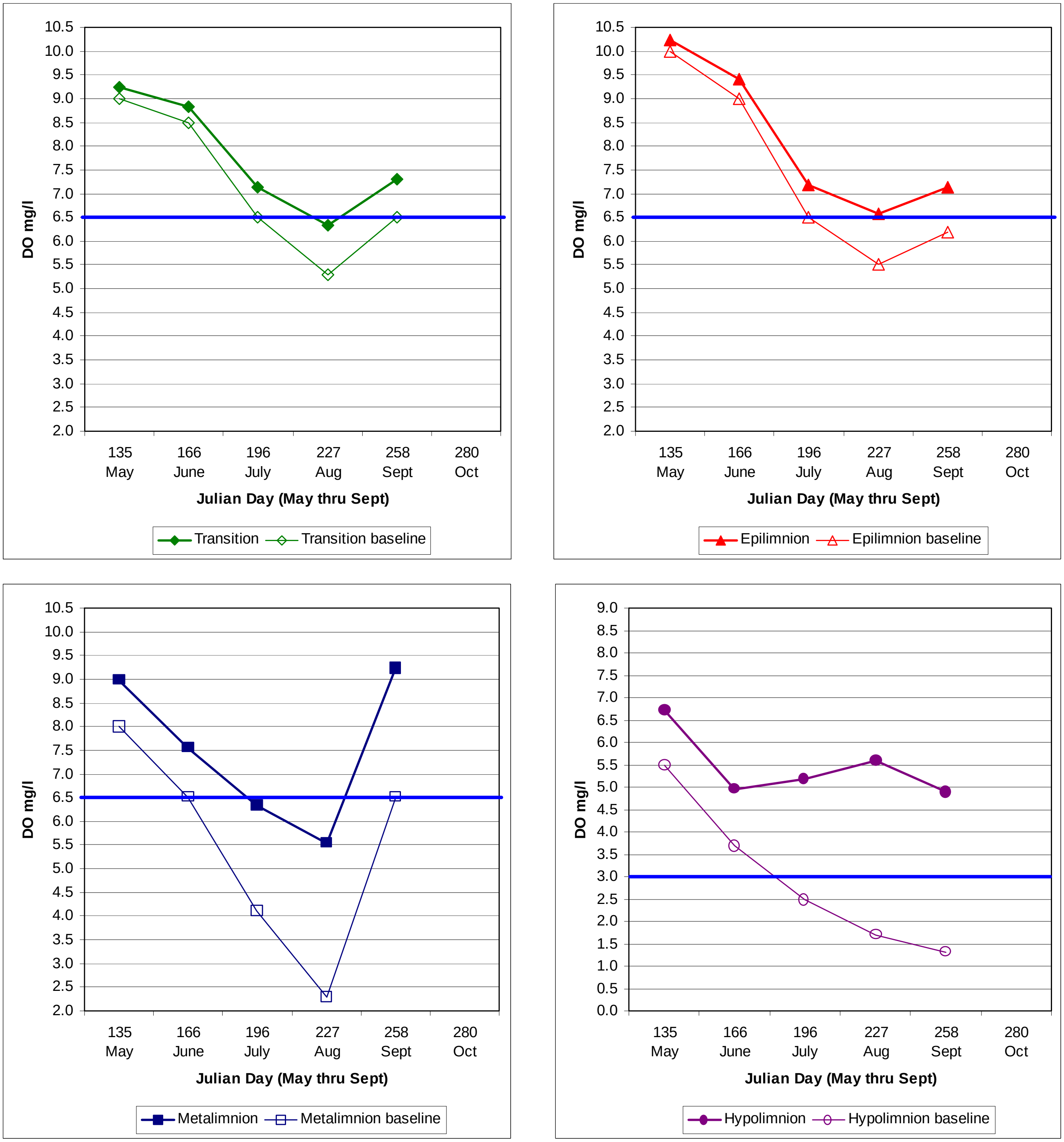

Figure 3.2.18. Calculated effect of improved dissolved oxygen in Brownlee Reservoir (RM 335 to 285) as an effect of attaining the 14 ug/L chlorophyll *a* and 0.07 mg/L total phosphorus concentration targets in the Upstream Snake River segment (RM 409 to 335).

In all cases, low dissolved oxygen conditions were projected to occur to a lesser extent and for a shorter duration under the target conditions than calculated for existing conditions. Dissolved oxygen concentrations were not calculated for the riverine section of Brownlee as the methodology used would result in overestimates due to substantially shorter residence times than those in the transition or lacustrine zones. The curves calculated for existing conditions are also included in the plots for comparison, and are labeled "baseline" conditions for each section.

Calculated post-attainment dissolved oxygen curves for the transition zone show concentrations dropping to or below 6.5 mg/L for approximately 16 days, and *below* 6.5 mg/L for approximately 10 days in early August. Minimum concentration values calculated are approximately 6.3 mg/L. Calculated post-attainment dissolved oxygen curves for the epilimnion show concentrations dropping to but not below 6.5 mg/L for two days in early August. Minimum concentration values calculated are approximately 6.5 mg/L. Calculated dissolved oxygen concentrations for the metalimnion were at or below 6.5 mg/L for approximately 45 days and *below* 6.5 mg/L for approximately 41 days during late July and much of August. Minimum concentration values calculated are approximately 5.5 mg/L, occurring during the month of August.

Calculated dissolved oxygen curves for the hypolimnion show a decrease in dissolved oxygen concentration starting in June and continuing through the fall. Dissolved oxygen levels calculated never dropped below 3.0 mg/L (a situation lethal to most fish). Minimum concentration values calculated are approximately 5.0 mg/L, occurring for approximately two days during the month of June, and approximately 4.9 mg/L, occurring for approximately three days during the month September.

As can be seen from Figure 3.2.18, dissolved oxygen improvements are realized in all sections of the reservoir from application of the 0.07 mg/L total phosphorus target. The improvements calculated for the metalimnion section are the greatest while the increases calculated for the transition zone and epilimnion are the smallest in magnitude. The improvements observed in most cases allow the reservoir sections to meet the water quality target of 6.5 mg/L dissolved oxygen. In those sections and times when dissolved oxygen concentrations are currently very low in Brownlee Reservoir (the metalimnion and hypolimnion in July and August) substantial improvements in dissolved oxygen are realized through the attainment of water quality targets upstream, although the dissolved oxygen target is not attained.

In order to meet water quality targets in Brownlee Reservoir, further implementation of additional mechanisms will have to be employed (in addition to the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets already in place). This difference in assimilative capacity is assumed to be due to the transition from a riverine to a reservoir system. Because this change is anthropogenic in nature, further augmentation of dissolved oxygen in the system will be the responsibility of the impoundments.

Direct calculation of the dissolved oxygen improvements and additional oxygen necessary to meet the water quality target of 6.5 mg/L were completed using the information plotted in Figure 3.2.18 and the reduction in biomass discussed previously. Because of the lack of continuous dissolved oxygen data, linear transitions between dissolved oxygen concentrations were used.

Transitions occurring in the reservoir most certainly do not follow a linear pattern. It is likely that such transitions occurring in the reservoir would describe a more rounded shape with greater temporal variation than described by the calculated curves. The straight-line effects of the calculated dissolved oxygen transitions potentially masks the shoulders of the curves and is a source of error (most probably underestimation) to this analysis. For this reason, an additional margin of safety has been identified.

The identified margin of safety has two purposes in this calculation, to correct for the errors introduced by the linear transitions discussed above, and to be protective over a wide range of water years. Data used in these calculations were from 1995, a relatively average water year (90% of the 30-year average). The identified margin of safety recognizes that dissolved oxygen concentrations in the reservoir will have wider variability than that described by the 1995 data, and seeks to be protective of aquatic life uses.

The calculated time period when post-attainment metalimnetic waters do not meet the 6.5 mg/L target occurs during the months of July and August, a total time period of 45 days where metalimnetic waters are at or below the 6.5 mg/L dissolved oxygen target. Because of the linear transition mechanism used to calculate the change in dissolved oxygen concentration, some exceedences of the target may also occur during the last part of June and the first part of September but are masked by the monthly time step. For this reason, a 65 day period (10 days before and 10 days after the calculated 45 day period of exceedence) was used to calculate the required improvements in dissolved oxygen specific to the metalimnion. This calculation represents a margin of safety of 44 percent. Although it may be an overestimate in some years, this period represents a more protective time frame than the 45 day period calculated directly.

The calculated time period when post-attainment transition zone waters do not meet the 6.5 mg/L target occurs during the months of July and August, a total time period of 16 days where metalimnetic waters are at or below the 6.5 mg/L dissolved oxygen target. Because the same concern regarding the linear transition mechanism used to calculate the change in dissolved oxygen concentration, a 24 day period (4 days before and 4 days after the calculated 16 day period of exceedence) was used to calculate the required improvements in dissolved oxygen specific to the metalimnion. This calculation represents a margin of safety of 50 percent. The time period in which transition zone exceedences occur lies within the exceedence time frame described for the metalimnion. Therefore, while these exceedences will require additional dissolved oxygen be added to the reservoir, they will not necessarily increase the total timeframe over which oxygenation is necessary.

Using the volume of 153,565 acre-feet (Table 3.2.7) and retention times generated for the metalimnion by IPCo, (5 days in July and 8 days in August under full pool (1995) conditions), approximately 1,540 billion liters of water pass through the transition zone and metalimnion during the 65 day period described above.

The total dissolved oxygen mass required to address the loss of assimilative capacity in the metalimnion alone over this time frame is 1,053 tons (957,272 kg). This is equivalent to an even distribution of 16.2 tons/day (14,727 kg/day) over 65 days.

The total dissolved oxygen mass required to address the loss of assimilative capacity in the transition zone alone over this time frame is 72 tons (65,454 kg). This is equivalent to an even distribution of 3.0 tons/day (2,727 kg/day) over 24 days.

Together, these separate loads will require the addition of a calculated 1,125 tons of oxygen (1.02×10^6 kg). When applied in an even distribution, this translates to approximately 17.3 tons/day (15,727 kg/day) for 65 days.

The calculated time period when exceedences occurred in the metalimnion of Brownlee Reservoir is between Julian days 182 and 247 (the first of July through the first week of September) when dissolved oxygen sags are observed to occur to a greater degree than those identified as the result of poor water quality inflowing from the upstream sources. However, this time frame is not a requirement for timing of oxygen addition or other equivalent implementation measures. Timing of oxygen addition or other equivalent implementation measures should be such that it coincides with those real-time periods where dissolved oxygen sags occur and where it will be the most effective in improving aquatic life habitat and support of designated beneficial uses.

To achieve this improvement in dissolved oxygen does not require direct oxygenation of the metalimnetic and transition zone waters. Improvements in dissolved oxygen concentrations can be accomplished through equivalent reductions in total phosphorus or organic matter upstream, or other appropriate mechanism that can be shown to result in the required improvement of dissolved oxygen in the metalimnion and transition zones to the extent required. A reduction of 1.7 million kg total of organic matter/algal biomass would equate to the identified dissolved oxygen mass. This translates to approximately 11,000 kg/day over the critical period (May through September) or 26,000 kg/day over the 65 day period identified in the calculations for reduced assimilative capacity. The total phosphorus load reduction required to achieve this reduction in organic loading is approximately 1,487 kg/day over the critical period (May through September) or 3,500 kg/day over the 65 period identified in the calculations for reduced assimilative capacity. Direct oxygenation is one method by which the additional dissolved oxygen required can be delivered, but it should not be interpreted as the only mechanism available. Cost effectiveness of both reservoir and upstream BMP implementation should be considered in all implementation projects.

Because this requirement for additional dissolved oxygen is specific to Brownlee Reservoir, IPCo (as operator of the Hells Canyon Complex) will be responsible for implementation of these improvements. There are both total phosphorus and dissolved oxygen improvements required within the different segments of the SR-HC TMDL reach. It should be clarified that Upstream Snake River segment (RM 409 to 335) pollutant sources are responsible for those water quality problems occurring in the Upstream Snake River segment (RM 409 to 335). They are not responsible for those water quality problems that are exclusive to the reservoir and that would occur if the waters flowing into Brownlee Reservoir met water quality standards. Similarly, IPCo (as operator of the Hells Canyon Complex) is responsible for those water quality problems related exclusively to impoundment effects that would occur if inflowing water met water quality standards.

Restoring viable concentrations of dissolved oxygen throughout the reservoirs is of highest priority. In the case of the epilimnion and metalimnion, these waters represent primary fish habitat. In the case of the hypolimnion, these waters do not represent the same level of habitat as the metalimnion and epilimnion (IPCo, 2001d). They also represent waters that are more difficult to treat due to low circulation and flushing during stratification. For this reason, the hypolimnetic waters will take longer to meet water quality standards. Sustained reductions over time have been shown to have a positive effect on hypolimnetic waters in other systems and have been projected to occur in Brownlee Reservoir through modeling, but time frames are lengthy, extending many years in some cases (Speece, 1970, 1994, 1996).

In an overall assessment of the immediate benefits, it is obvious that improvements projected to occur in hypolimnetic waters will act to better support designated uses. The dissolved oxygen concentrations, without application of the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets, consistently drop to lethal concentrations, well below 3 mg/L. In all cases with application of the total phosphorus target the dissolved oxygen concentration stayed near or above 3 mg/L. This represents an initial benefit that, combined with the long-term benefits of phosphorus and algae reduction, will result in attainment of non-lethal conditions in the short-term and of water quality standards in the longer-term future.

An additional benefit of the improved dissolved oxygen levels in the transition zone is in the reduced desorption and transformation processes due to the absence of anoxic conditions. The majority of deposition observed in the Hells Canyon Complex occurs in the transition zone of Brownlee Reservoir, which coincides with the area of highest observed sediment-mercury concentrations. By providing sustained dissolved oxygen levels at or above 6.5 mg/L, the pollutant loading associated with this deposition presents a much smaller threat to water quality within the SR-HC TMDL reach and downstream.

Modeled dissolved oxygen improvements provided by IPCo, show a smaller reduction in assimilative capacity than that calculated as discussed above. The total mass of additional dissolved oxygen need projected by the IPCo model was 880 tons total (22 percent difference from the 1,125 tons calculated). The difference may be attributed to the fact that the calculated value (1,125 tons) focuses on annual average chlorophyll *a* and does not account for reductions in other organic matter loads generated instream, or attempt to quantify long-term improvements from reduced loading. The chlorophyll *a* concentrations modeled by IPCo account for reductions in other organic loading to the system and for the reduction in sediment oxygen demand resulting from long-term improvements.

3.2.8.8 Identification of the Critical Period for Target Application.

Because most of the negative effects in the SR-HC TMDL reach associated with elevated nutrient levels stem from excessive algal growth, which is a seasonal occurrence, an evaluation of the critical time period for phosphorus reductions was included as part of the target determination for this TMDL.

Total algal growth and temporal distribution of phosphorus loading was evaluated. Within the mainstem Snake River two general periods of elevated chlorophyll *a* concentration are observed

(Figure 3.2.19). Blooms occur in the mainstem Snake River and in the upstream end of Brownlee Reservoir in the spring (April at RM 385 and May to June at RM 340) and summer (June to July at RM 385 and Aug at RM 340). These periods of growth represent the dominant source of algal biomass to the SR-HC TMDL reach. Other sources of organic material, such as periphyton sloughing, are not well understood. Further investigation of such sources will be carried out as part of the phased implementation process.

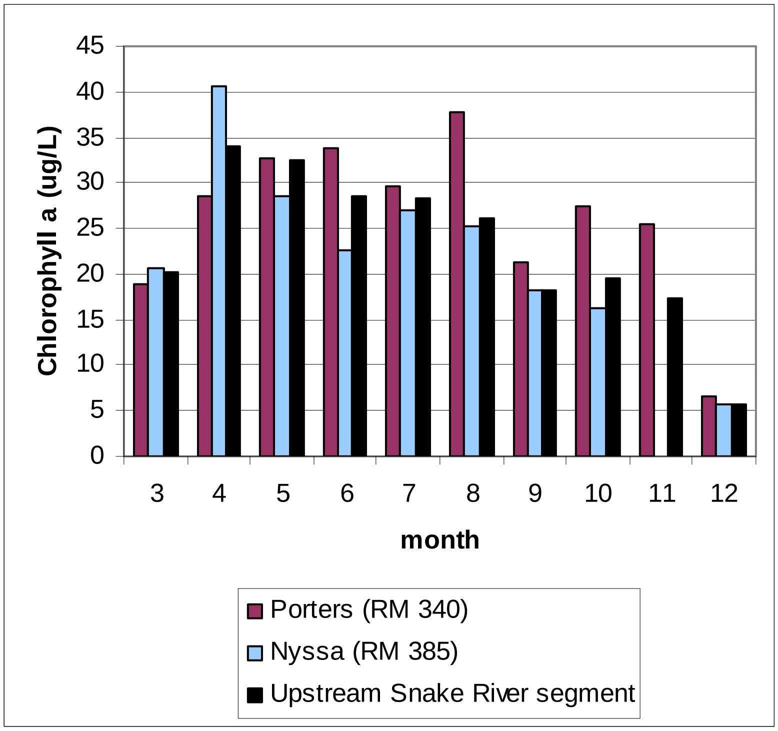

Figure 3.2.19. Temporal distribution of chlorophyll *a* in the Upstream Snake River segment (RM 409 to 335).

Winter conditions do not encourage algal growth as water temperatures are lower and available sunlight is both less intense and of shorter duration. Nuisance level blooms have not been observed to occur during winter months in the SR-HC TMDL reach. Both total phosphorus and chlorophyll *a* concentrations measured in the mainstem Snake River decrease substantially during the late fall and winter months (see Figure 3.2.2 and 3.2.19).

The fact that algae blooms are generally a summer occurrence, and that summer growth appears to be most directly related to the designated use support concerns discussed previously, is an indication that seasonal targets would be appropriate if sufficient reductions could occur during the critical period of algae growth to result in improved water quality and support of designated beneficial uses.

To assess the applicability of a seasonal target, total algal biomass loading was calculated using measured chlorophyll *a* concentrations. The annual distribution of loading was evaluated as shown in Figure 3.2.20.

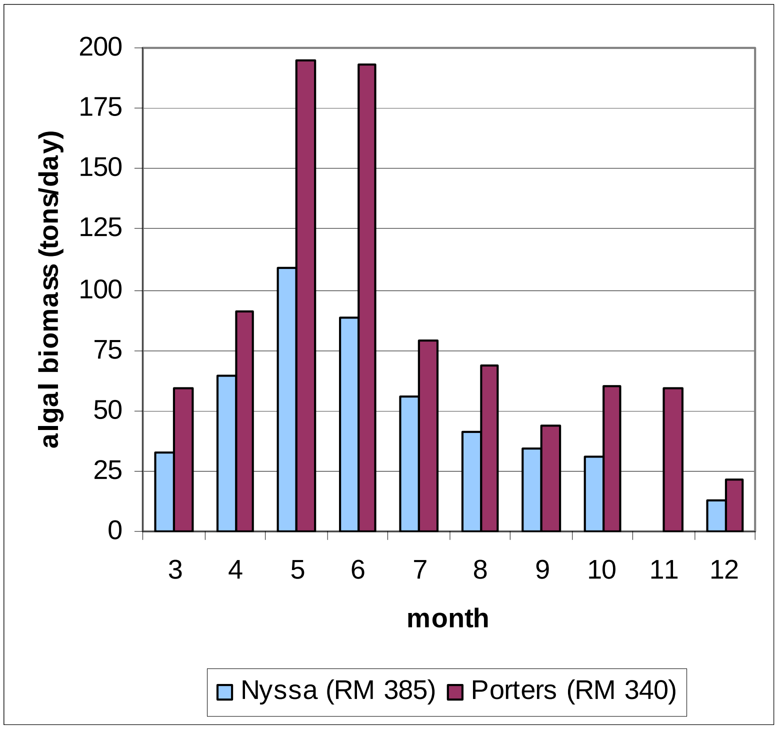

Figure 3.2.20. Temporal distribution of algae biomass loading in the Snake River - Hells Canyon TMDL reach as calculated from measured chlorophyll *a* concentrations.

Several considerations were recognized in the establishment of an appropriate critical period for nutrient reductions.

1. Impairment of the designated recreational and aesthetic use occurred primarily due to algal growth. All complaints received were specific to the summer and early fall months.

2. Concerns related to the potential of non or only partial support of aquatic life uses due to low substrate dissolved oxygen centered primarily on organic matter deposition and decomposition in the river and reservoir headwater areas. This decomposition will occur at a much slower rate in cool water temperatures and is therefore less of a concern in winter and early spring months than in summer and fall months. Nutrient controls will reduce the total amount of algae related growth and deposition overall so that less oxygen depletion occurs as a result of decomposition.

3. Concerns related to increased methylation of mercury due to excessive organic loading are specific to both the organic load and the anoxic conditions documented in Brownlee Reservoir and qualitatively identified in the Upstream Snake River segment (RM 409 to 335). Low dissolved oxygen in these areas is most likely to occur during summer and early fall months. Nutrient controls will reduce the total amount of algae related growth and deposition overall so that less oxygen depletion occurs. Initial calculations show that the areas of greatest

deposition in Brownlee Reservoir and in the Upstream Snake River segment (RM 409 to 335) will benefit from improved dissolved oxygen levels.

4. Domestic water supply concerns regarding trihalomethane production are specific to those time periods when greatest algal biomass is produced (early summer through fall). Filtration concerns are also specific to this time period. Corrosion concerns are specific to time periods with elevated nutrient concentrations. These occur most commonly in the summer and early fall months (Figure 3.2.2).

5. Establishment of critical period should be specific to the needs of the system in supporting designated beneficial uses, but should also recognize naturally occurring exceedences. In the SR-HC TMDL, natural runoff patterns generally occur during the months of March and April. Individual tributary systems may experience earlier or later snowmelt and runoff patterns. BMP-based treatment of snowmelt induced spring flows is not always effective. Both stormwater and agricultural BMPs, if properly installed and operated, will function to reduce this runoff-induced loading, but will function less efficiently in times of substantially increased flow volume, especially if it occurs during a time period when vegetation has not re-established after a winter die-off. Therefore, the highest treatment efficiencies will most likely occur during the summer and fall seasons when vegetation is well established and flows are less than spring runoff volumes.

Given this information, it has been determined that the total phosphorus target identified should be applied in a seasonal fashion that will allow direct management of the water quality concerns associated with nutrient loading. Application of this target over the time frame when conditions favoring algal growth are known to occur (May through September) will result in the reduction of dominant sources of phosphorus in the water shed and system loading in general. With a target application of May through September, it is calculated that approximately 70 percent of the total algal biomass loading can be addressed. The remaining 30 percent of the biomass loading occurs during spring flows, where treatment can occur with stormwater and agricultural BMPs but at reduced efficiency) and during winter months where total loading is minimal and retention within the reservoirs is not slowed by stratification.

This seasonal target will act to reduce both those forms of phosphorus most responsible for algal growth within the system, and algal growth itself. Dissolved phosphorus loading is generally highest during the summer irrigation season in both the mainstem Snake River and the majority of the inflowing tributaries (the Boise River is one exception to this trend as dissolved phosphate concentrations remain relatively steady throughout the year). Thus, application of this target will result in the reduction of the majority of the dissolved phosphate load attributable to anthropogenic sources within the watershed. Dissolved phosphate concentrations throughout the remainder of the year do not pose a substantial concern to water quality as water temperatures are not conducive to excessive growth, and the rapid movement of water through the SR-HC TMDL reach does not result in much retention of this dissolved fraction of the phosphate loading. Additionally, seasonal application of the target will directly address the sediment bound fraction of the total phosphorus loading as it will be in place over the course of the growing and irrigation season.

3.2.9 Reductions Necessary to Meet Nutrient Targets

The specific level of reduction realized by attainment of this target is dependent on the type of water year and the tributary. Setting a concentration-based target means that in high flows, the loading delivered at the target value will be greater than the load delivered at the target value during medium or low flow years. However, the load delivered during high flow years will still be reduced from the load delivered without TMDL-based reductions. Low and average flow years may show a larger relative percentage reduction in nutrient loading by meeting the 14 ug/L mean growing season chlorophyll *a* concentration and 0.07 mg/L total phosphorus targets as loading is based on instream flow (load = flow x concentration). High flow years will also see a reduced nutrient load, but the overall relative magnitude of reduction will be smaller due to the higher flows.

Additionally, research performed by both IPCo and Boise City Public Works (Brown and Caldwell) show that some of the most pronounced water quality problems in Brownlee Reservoir have occurred during the longer retention times resulting from low water years. It is theorized that these longer retention times can allow the development of more severe hypoxic and anoxic conditions. Therefore, both flow and retention time, in correlation with pollutant loads and concentrations have the potential to influence water quality in the SR-HC TMDL reach. All of these factors should therefore be considered in the development of the monitoring plans that will be included in the site specific implementation plans prepared following the approval of this TMDL. They will also be considered in the assessment of progress as implementation proceeds.

3.2.10 Load Allocations

Load allocations are discussed in greater detail in Section 4.0. Total phosphorus allocation mechanisms were determined as a result of discussions within the public process and PAT work group products (Appendix I).

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3.3 Pesticide Loading Analysis

3.3.1 Water Quality Targets and Guidelines

The purpose of TMDL development is to meet applicable water quality standards. Because the SRHC TMDL is a bi-state effort, the most stringent of each state's water quality standards have been identified as the targets for this TMDL. In this way the attainment of these targets will ensure that the water quality requirements of both states will be met.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for pesticides. An evaluation of available data has shown the pesticides of concern specific to the SR-HC TMDL effort to be DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane, CAS #50-29-3), and its metabolites DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethane, CAS #72-54-8) and DDE (1,1-dichloro-2,2-bis(chlorophenyl) ethylene, CAS #72-55-9) and dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,exo-1,4:5,8-dimethanonaphthalene, CAS #60-57-1). The water quality standards and guidance values appropriate to pesticides in the SR-HC TMDL are those that apply to DDT and its metabolites and dieldrin. The water quality targets established for the SR-HC TMDL are based on standards from both Idaho and Oregon. The standards adopted by both states are based on US EPA guidance values (National Toxics Rule and Table 20) (EPA FRL-OW-6186-6a).

DDT: less than 0.024 ng/L water column concentration
DDD: less than 0.83 ng/L water column concentration
DDE: less than 0.59 ng/L water column concentration
Dieldrin: less than 0.07 ng/L water column concentration

These represent the applicable targets for pesticides for the SR-HC TMDL.

3.3.2 Designated Beneficial Use Impairment

There are no data available documenting pesticide concentrations in water, fish tissue or sediment in Oxbow Reservoir. There are no indications of impairment of the designated beneficial uses due to pesticide concentrations in Oxbow Reservoir. No fish consumption advisories for pesticides are currently in place. However, over 95% of the inflow to Oxbow Reservoir is from Brownlee Reservoir, therefore, available data from upstream segments (Upstream Snake River and Brownlee Reservoir) were evaluated. These data show elevated concentrations of fish tissue t-DDT and dieldrin. The US EPA action level for fish tissue DDT was established to address the combination of DDT and its metabolites (known as total or t-DDT). This action level, set at 1.0 mg/kg, was exceeded in 44% of the data. None of the available data showed exceedences of the US EPA action levels for fish tissue concentrations of dieldrin (1.0 mg/kg).

Fish containing high concentrations of pesticides pose a health threat to humans and predatory wildlife that ingest fish tissue. Predatory wildlife most at risk are those predators of older, larger fish such as bald and golden eagles, both of which inhabit areas of the SR-HC TMDL reach.

Water column data from upstream segments is very limited. Only a very small data set was available for water column concentration. All water column samples exceeded the SR-HC TMDL water column targets for DDT and dieldrin. All fish tissue samples exhibited concentrations of DDT and dieldrin above the US EPA screening level. None of the samples exceeded the US FDA action level for DDT and dieldrin in edible fish (Clark and Maret, 1998; Rinella *et al.*, 1994). Only t-DDT (four Snake River sites and five samples in Brownlee Reservoir), and Dieldrin (one sample in Brownlee Reservoir) showed fish tissue concentrations that exceeded the National Academy of Science, National Academy of Engineering (NAS/NAE) criteria. All fish tissue samples collected in this reach were positive for t-DDT. These data do not yield a clear answer on the support status of designated beneficial uses but do indicate that sufficient concern exists to justify the collection of additional water column data in both the Oxbow Reservoir segment (RM 285 to 272.5) and the segments upstream.

3.3.3 Pesticides in Surface Waters

3.3.3.1 DDT.

DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane) is a man-made chemical that was widely used historically to control both insects that could damage agricultural crops and those that carry diseases like malaria and typhus. DDT was discovered in 1873, but was not identified as an insecticide until 1939 when Paul Muller of Geigy Pharmaceutical in Switzerland discovered its effectiveness. He was awarded the Nobel Prize in medicine and physiology in 1948 for this discovery.

The use of DDT increased substantially on a global scale after World War II. It was particularly effective against the mosquito that spreads malaria and lice that carry typhus. The World Health Organization (WHO) estimates that during the period of its use approximately 25 million lives were saved by reducing the spread of these diseases. DDT seemed to be the ideal insecticide as it was cheap and of relatively low toxicity to mammals (oral LD50 is 300 to 500 mg/kg). However, concern over environmental effects began to appear in the late 1940s. Many species of insects were able to develop a resistance to DDT so it was no longer as efficacious a control mechanism. In addition, DDT was also discovered to be highly toxic to fish (ATSDR, 1994b, 2001; Harrison, 2001), and was linked to eggshell thinning in several families of birds (NAS/NAE, 1973; US EPA, 1992c).

Because of the risk it presented to wildlife and the potential human health concerns being raised, the use of DDT was banned (except for public health emergencies), in the United States in 1972 (USFWS, 2002). DDT is however still used in some other countries.

The remarkable chemical stability of DDT and its tendency to bio-concentrate in fatty tissues add to the complexity of the problem of legacy application and current water quality concerns. DDT is not metabolized rapidly; rather, it is stored in fatty tissues within the body. As an average, about eight years are required for an animal to metabolize half of the DDT it assimilates (this eight years is known as the biological half-life). Therefore, if an animal continues to ingest DDT at a steady rate, it will build up over time (Harrison, 2001). The buildup of DDT in natural waters is however, a reversible process. The US EPA reported a 90% reduction of DDT in Lake Michigan fish by 1978 as a result of the ban (Harrison, 2001).

Two similar chemicals (breakdown products of DDT) that are often associated with the presence of DDT in environmental systems are DDE (1,1-dichloro-2,2-bis(chlorophenyl) ethylene) and DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethane). While these compounds are breakdown products or metabolites of DDT, DDD was also manufactured to kill pests. Its use has also been banned. DDE has no known commercial use (Harrison, 2001).

3.3.3.2 Dieldrin.

Dieldrin is also a man-made, chlorinated insecticide; popular for crops like corn and cotton from 1950 to 1970. Dieldrin does not occur naturally in the environment. Because of concerns about damage to the environment and the potential harm to human health, US EPA banned all uses of dieldrin except to control termites in 1974. In 1987, US EPA banned all uses of dieldrin (ATSDR, 2001; NTP, 2001).

In the environment, dieldrin binds tightly to soil. The disappearance of 95% of the original insecticide after application has been shown to require from 5 to 25 years (from references in PMEP, 2001). Volatilization or evaporation to the air is responsible for most of the dieldrin lost from the soil surface. The persistence of dieldrin in the soil is influenced by soil type, where soils with a high organic matter content show higher dieldrin persistence than sandy soils (from references in PMEP, 2001).

Plants take in and store dieldrin from the soil. As with DDT, dieldrin is a very stable chemical and tends to bio-concentrate in fatty tissues. Dieldrin is not metabolized very rapidly and leaves the body very slowly (ATSDR, 2001). Because dieldrin is bioaccumulative, it does not break down easily in the environment and becomes more concentrated as it moves up the food chain to humans and other wildlife (US EPA, 2001f). Dieldrin is a persistent, bioaccumulative, and toxic (PBT) pollutant targeted by US EPA.

As stated above, the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for pesticides. No data is available to support this listing. However, pesticide data is available for some sites upstream of Oxbow Reservoir, including Brownlee Reservoir, which represents the largest source of inflow to Oxbow Reservoir.

Therefore, existing pesticide data for the SR-HC TMDL reach in total was evaluated. Although several pesticides have been identified in the SR-HC TMDL reach, those pesticides observed to occur at elevated concentrations within this data set were the organochlorine insecticides DDT (and its metabolites), and dieldrin. These compounds were identified as pesticides that should be evaluated within the SR-HC TMDL.

While a state standard-based fish tissue target is not available to this TMDL effort, data collected show these compounds occur in concentrations exceeding the established US EPA screening level for contaminants in edible fish (t-DDT). Concentrations of DDT and dieldrin were also observed to exceed the NAS/NAE criteria to protect fish and wildlife that consume fish within the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir segment (RM 335 to 285) of the SR-HC TMDL reach. However, none of the data collected show pesticide concentrations in fish tissue that exceed the US FDA action level for contaminants in edible fish.

Neither t-DDT nor dieldrin is highly water-soluble. However, these compounds commonly adsorb onto suspended particles within the water system where they can be deposited on stream, lake and reservoir bottoms and then become re-suspended and transported in a cyclic fashion dependant on flow volume and velocity. Aquatic organisms, especially bottom-feeding species such as suckers, are vulnerable to the bioaccumulation of these compounds.

Both t-DDT and dieldrin are persistent, long lived contaminants. The half-lives (the time it takes for one half of the total mass to degrade) for these compounds have been estimated in the range of hundreds of years. Therefore, even though their use has been discontinued, they are expected to remain in the environment for the foreseeable future (US EPA, 1992a, 1992b and 1992c). This problem is evident throughout the United States. In a national US EPA study (US EPA, 1992a, 1992b and 1992c), over 90 percent of 388 sites sampled nationwide in 1986 and 1989 showed concentrations of DDE (a metabolite of DDT) and PCBs.

3.3.4 Sources

Neither DDT nor dieldrin occur naturally to any appreciable extent in the environment (Harrison, 2001). All sources of these compounds are therefore anthropogenic. Both DDT and dieldrin were used extensively in the United States prior to the 1970's. Their use was discontinued due to their potential negative effects on humans and wildlife. DDT and dieldrin are considered probable carcinogens in humans (US EPA, 1991a, 1992c, 1994c). The use of DDT in the US has been banned since 1972, and the use of dieldrin was phased out between 1974 and 1987 (US EPA, 1992c).

These compounds entered surface water systems primarily from agricultural nonpoint source runoff and atmospheric deposition. Currently, the primary sources of these compounds in surface waters are legacy deposition and continued agricultural runoff from previously treated areas.

3.3.5 Transport and Delivery

Organochlorine pesticide transport and deposition are, in most cases, directly correlated with the transport and deposition of sediment and organic matter (Clark and Maret, 1998; Maret, 1995a and 1995b; Maret and Ott, 1997; Rinella *et al.*, 1994). As these compounds are no longer in use today, the transport and delivery of pesticides adsorbed to entrained sediment and organic material in the SR-HC drainage is the most likely source of continued loading to the mainstem Snake River within the SR-HC TMDL reach.

3.3.6 Data Available for the Snake River - Hells Canyon TMDL Reach

A pesticide monitoring effort by the USGS from 1992 through 1997 (Clark and Maret, 1998) identified t-DDT and dieldrin concentrations in fish tissues throughout the Snake River and several major tributaries in Idaho. The data showed that concentrations of both t-DDT and organochlorine compounds increased with distance downstream. Reservoir concentrations were somewhat higher overall than tributary concentrations, but the trend was evident in both types of surface waters (Table 3.3.1). Only a very small data set was available for water column concentrations. All eight water column samples, four each for DDT and dieldrin, located in the Upstream Snake River segment (RM 409 to 335) exceeded the SR-HC TMDL water column targets. Over 44% of the fish tissue samples exhibited concentrations of t-DDT above the US EPA screening level. None of the fish tissue samples exhibited concentrations of dieldrin above the US EPA screening level. None of the samples exceeded the US FDA action level for DDT and dieldrin in edible fish (Clark and Maret, 1998; Rinella *et al.*, 1994). Only t-DDT (four Snake River sites and five samples in Brownlee Reservoir), and Dieldrin (one sample in Brownlee Reservoir) showed fish tissue concentrations that exceeded the NAS/NAE criteria. All fish tissue data available in this reach (RM 409 to 285, and 247 to 188) were positive for t-DDT (where t-DDT was calculated as the sum of DDT and all metabolite and degradation compounds if not directly measured.

The available t-DDT data show that total concentrations are highest in fish tissue taken from Brownlee Reservoir, followed by samples taken from the Snake River at Jump Creek (upstream of RM 409). Fish tissue samples taken from the Snake River near the Weiser and Malheur river inflows show concentrations slightly higher than those observed in fish tissue samples taken from the Snake River near the Boise and Owyhee river inflows upstream. A general comparison of the Upstream Snake River segment (RM 409 to 335) data (riverine) to the Brownlee Reservoir segment (RM 308 to 285) (lacustrine) data show an increase in observed t-DDT concentrations in reservoir samples. The mean fish tissue concentration in the Upstream Snake River segment was 990 ug/kg (range = 230 ug/kg to 1,700 ug/kg, median = 964 ug/kg). The mean for the Brownlee Reservoir segment samples was 1,261 ug/kg (range = 96 ug/kg to 3,633 ug/kg, median = 1,099 ug/kg). The Brownlee Reservoir samples showed much greater variation than the Upstream Snake River samples.

Rigorous interpretation of these data for site-specific concentration assessment is not possible, however, as fish tissue data are not necessarily indicative of the conditions of the waters in which they were harvested. Additionally, fish tissue concentrations are dependent on size, age, species, habitat conditions and other factors. Fish often move repeatedly between mainstem and tributary sites. The amount of time spent in any one location, and the life stage and season during which this time was spent, can influence the level of pesticide accumulation dramatically.

Data evaluated show that fish tissue t-DDT concentrations are generally higher in the reservoir system than in the Upstream Snake River segment (RM 409 to 335). These same data show that all of the tributary drainages monitored exhibited some level of fish tissue t-DDT contamination. All sites monitored also showed relatively low concentrations of sediment and water t-DDT concentrations as compared to the observed fish tissue concentrations, indicating the occurrence of bioaccumulation within the aquatic species sampled.

Based on the small data set available, water column t-DDT concentration data exhibit only moderate variation within the Upstream Snake River segment (RM 409 to 335). No water column data are available for the Brownlee Reservoir segment (RM 335 to 285). However, all

Table 3.3.1. Data available showing detectable t-DDT distribution in fish tissue, water and sediment in the Lower Snake River Basin.

Location	Species/ Sample	Pesticide	Conc. (ug/kg)*	Action Level Exceeded?		
				US EPA	SRHC TMDL	US FDA
Snake River at Swan Falls	sucker	t-DDT	230	No	NA	No
Snake River at Jump Creek	catfish	t-DDT	1700	Yes	NA	No
Owyhee River mouth	catfish	t-DDT	1040	Yes	NA	No
Owyhee River mouth	sediment	DDE	10.5	NA	NA	NA
Boise River at Parma	sucker	t-DDT	888	No	NA	No
Boise River at Parma	water	t-DDT	0.003	Yes	Yes	NA
Boise River at Parma	sediment	t-DDT	1.4	NA	NA	NA
Snake River at Nyssa	catfish	t-DDT	776	No	NA	No
Snake River at Nyssa	sucker	t-DDT	593	No	NA	No
Payette River 10 km upstream of mouth	bullhead	t-DDT	120	No	NA	No
Malheur River mouth	catfish	t-DDT	1270	Yes	NA	No
Malheur River mouth	water	t-DDT	0.012	Yes	Yes	NA
Malheur River mouth	sediment	t-DDT	42.3	NA	NA	NA
Malheur River mouth	sediment	DDE	5.8	NA	NA	NA
Payette River mouth	water	t-DDT	0.007	Yes	Yes	NA
Payette River mouth	sediment	t-DDT	23.1	NA	NA	NA
Snake River at Weiser	catfish	t-DDT	1420	Yes	NA	No
Snake River at Weiser	water	t-DDT	0.003	Yes	Yes	NA
Snake River at Weiser	sediment	t-DDT	8.9		NA	NA
Brownlee Reservoir	carp	t-DDT	3633	Yes	NA	No
Brownlee Reservoir	sucker	t-DDT	1505	Yes	NA	No
Brownlee Reservoir	catfish	t-DDT	1099	Yes	NA	No
Brownlee Reservoir	catfish	t-DDT	1080	Yes	NA	No
Brownlee Reservoir	catfish	t-DDT	1300	Yes	NA	No
Brownlee Reservoir	bass	t-DDT	113	No	NA	No
Brownlee Reservoir	crappie	t-DDT	96	No	NA	No
Brownlee at Burnt River	sediment	t-DDT	24	NA	NA	NA
Brownlee at Mountain Man Lodge	sediment	t-DDT	7.5	NA	NA	NA
Downstream Snake River at Pittsburgh Landing	sucker	t-DDT	191.1	No	NA	No
Downstream Snake River at Pittsburgh Landing	sucker	t-DDT	95.2	No	NA	No

* Water samples are whole water reported in ug/L

(Data presented is from Clark and Maret, 1998, Rinella *et al.*, 1994; IPCo, 200d).

US EPA = US Environmental Protection Agency screening level of 10^{-6} for contaminants in edible fish (Nowell and Resek, 1994) for fish tissue samples and 0.001 ug/L DDT water column concentration for chronic exposure (EPA FRL-OW-6186-6a).

SR-HC TMDL = Snake River – Hells Canyon DDT target of 0.000024 ug/L.

US FDA = US Food and Drug Administration action level for contaminants in edible fish (Nowell and Resek, 1994).

water column concentrations measured in the Upstream Snake River segment (n = 4) exceeded the SR-HC TMDL target value for DDT (0.024 ng/L).

Sediment t-DDT data however show greater variation and moderately higher concentrations overall in the Upstream Snake River segment (mean = 19 ug/kg, range = 1.4 ug/kg to 42.3 ug/kg, n = 6) as compared to those observed in the Brownlee Reservoir segment (mean = 16 ug/kg, range = 7.5 ug/kg to 24 ug/kg, n = 2). Bed sediment from Brownlee Reservoir at the Burnt River inflow contained the largest concentrations of organochlorine compounds in the Snake River Basin (Clark and Maret, 1998). The data set for sediment t-DDT concentrations is very small however, and may not be representative of the overall distribution of t-DDT within the SR-HC TMDL reach.

The US Department of the Interior (US DOI) conducted a study in 1990 (Rinella *et al.*, 1994) that included bed sediment data from 14 sites in the Owyhee and Malheur drainages and the Snake River from approximately RM 425 to Brownlee Reservoir. Measurable concentrations of DDE were detected at all 14 sites, and dieldrin was detected at 13 sites. Those sites appropriate to this TMDL effort and the concentrations measured are listed in Table 3.3.1 and Table 3.3.2.

A more recent sediment study (IPCo, 200d) included 42 samples taken from the mainstem Snake River from RM 397 downstream to Brownlee Dam (RM 285). Samples were collected from December 1998 to January 2000. In Brownlee Reservoir, samples were taken approximately every five miles from RM 340 to RM 285. Snake River samples included the mouth of the Owyhee, Boise, Malheur, Payette, Weiser, Burnt and Powder rivers.

This sampling effort detected only one organochlorine compound, DDE. Two Snake River samples, one at the mouth of the Owyhee River and one at the mouth of the Malheur River, exhibited measurable sediment concentrations, 10.5 ug/kg and 5.8 ug/kg DDE respectively. None of the mainstem river samples, in Brownlee Reservoir or the upstream channel, showed detectable concentrations of dieldrin. This study, based on sampling and analytical techniques very similar to those used by Rinella (Rinella *et al.*, 1994), contained a much larger sample set than the 1990 work, but showed dramatically different concentration distributions although detection limits, particle distributions and total organic carbon concentrations were similar in both studies (IPCo, 200d). Additional, long-term data collection is necessary to determine if the lower concentrations observed in the 2000 study are an indication of water quality trends in the SR-HC TMDL reach. If these values were indicative of a trend in water quality, fish tissue concentrations would also be expected to decline over time.

The available dieldrin data from the 1990 study show that fish tissue concentrations were relatively similar throughout the Upstream Snake River segment (RM 409 to 335), increasing slightly within the Brownlee Reservoir samples. A comparison of mean values from the Upstream Snake River segment (riverine) with the Brownlee Reservoir segment (lacustrine) shows only a relatively moderate difference. The mean fish tissue concentration in the Upstream Snake River segment was 32.4 ug/kg (range = 12 ug/kg to 50 ug/kg, median = 30 ug/kg). The mean for the Brownlee Reservoir segment samples was 45 ug/kg (range = 19 ug/kg to 100 ug/kg, median = 37 ug/kg). The Brownlee Reservoir samples showed much greater variation than the

Table 3.3.2. Data available on Dieldrin distribution in fish tissue, water and sediment in the Lower Snake River Basin.

Location	Species/ Sample	Pesticide	Conc. (ug/kg)*	Action Level Exceeded?		
				US EPA	SRHC TMDL	US FDA
Snake River at Jump Creek	catfish	Dieldrin	30	No	NA	No
Owyhee River mouth	catfish	Dieldrin	50	No	NA	No
Boise River at Parma	water	Dieldrin	0.002	No	Yes	NA
Boise River at Parma	sediment	Dieldrin	0.1	NA	NA	NA
Snake River at Nyssa	catfish	Dieldrin	12	No	NA	No
Snake River at Nyssa	sucker	Dieldrin	< 5.0	-	-	-
Malheur River mouth	catfish	Dieldrin	50	No	NA	No
Malheur River mouth	water	Dieldrin	0.007	No	Yes	NA
Malheur River mouth	sediment	Dieldrin	4.1	NA	NA	NA
Payette River mouth	water	Dieldrin	0.001	No	Yes	NA
Payette River mouth	sediment	Dieldrin	0.4	NA	NA	NA
Snake River at Weiser	catfish	Dieldrin	20	No	NA	No
Snake River at Weiser	water	Dieldrin	0.002	No	Yes	NA
Snake River at Weiser	sediment	Dieldrin	0.2	NA	NA	NA
Brownlee Reservoir	sucker	Dieldrin	19	No	NA	No
Brownlee Reservoir	carp	Dieldrin	37	No	NA	No
Brownlee Reservoir	catfish	Dieldrin	20	No	NA	No
Brownlee Reservoir	catfish	Dieldrin	100	No	NA	No
Brownlee Reservoir	catfish	Dieldrin	50	No	NA	No
Brownlee Reservoir	sm bass	Dieldrin	< 5.0	-	-	-
Brownlee Reservoir	white crappie	Dieldrin	< 5.0	-	-	-
Brownlee at Burnt River	sediment	Dieldrin	7	NA	NA	NA
Downstream Snake River at Pittsburgh Landing	sucker	Dieldrin	< 5.0	-	-	-
Downstream Snake River at Pittsburgh Landing	sucker	Dieldrin	3.8	No	NA	No

* Water samples are whole water reported in ug/L
(Data presented is from Clark and Maret, 1998, Rinella *et al.*, 1994; IPCo, 200d).
US EPA = US Environmental Protection Agency screening level of 10^{-6} for contaminants in edible fish (Nowell and Resek, 1994) for fish tissue data and 0.056 ug/L water column concentration for chronic exposure (EPA FRL-OW-6186-6a).
SR-HC TMDL = Snake River – Hells Canyon dieldrin target of 0.00007 ug/L.
US FDA = US Food and Drug Administration action level for contaminants in edible fish (Nowell and Resek, 1994).

Upstream Snake River samples. In the small data set available for dieldrin, over 73% of the fish tissue data points (n = 16) showed concentrations of dieldrin that were above the detection limits.

As with t-DDT data discussed above, it should be kept in mind that fish tissue data are not necessarily indicative of the conditions of the waters in which they were harvested as move back and forth between mainstem and tributary sites. The size, type and age of the fish, environmental conditions, the amount of time spent in any one location, and the life stage and season during which this time was spent, can influence the level of pesticide accumulation dramatically.

Data available show that fish tissue dieldrin concentrations in the 1990 study were generally higher in the reservoir system than in the Upstream Snake River segment (RM 409 to 335). These same data show that all of the tributary drainages monitored exhibited some level of fish tissue dieldrin contamination. All also showed relatively low concentrations of sediment and water column dieldrin concentrations as compared to the observed fish tissue concentrations, indicating substantial bioaccumulation within the aquatic species sampled.

No water column dieldrin data is available for the Brownlee Reservoir segment (RM 335 to 285), and only a single sediment dieldrin data point is available for Brownlee Reservoir. Therefore, a comparison of upstream to reservoir segments is not possible. However, all water column concentrations measured in the Upstream Snake River segment (n = 4) exceeded the SR-HC TMDL target value for dieldrin (0.07 ng/L).

The relative amount of t-DDT in fish tissue within the SR-HC TMDL reach is over 30 times that of dieldrin in the Upstream Snake River segment (RM 409 to 335) and over 28 times that of dieldrin in the Brownlee Reservoir segment (RM 335 to 285) for the 1990 study data. This is influenced by the difference in water column and lipid solubility of these compounds and the relative efficiency of uptake and excretion processes within aquatic species. It may also be influenced to a small extent by the relative differences in sediment concentration observed. (The mean t-DDT concentration in sediments is nearly 8 times that of dieldrin.)

From the data in the tables and studies discussed above it is evident that t-DDT and dieldrin are present in the Upstream Snake River and Brownlee Reservoir segments of the SR-HC TMDL, although it is not clear to what extent they still occur, as detectable sediment concentrations were generally observed only in the 1990 study, not the more extensive 2000 study.

It was also observed that tributary drainages to the SR-HC system exhibit similar pesticide pollutant loading concerns. Given the fact that the vast majority of water entering Oxbow Reservoir (greater than 99%) comes directly from Brownlee Reservoir, it is assumed that a portion of the organochlorine insecticide load in Brownlee Reservoir is transferred to Oxbow Reservoir. The relative proportion of this loading however, is unknown. It is assumed that the sediment trapping characteristics of Brownlee Reservoir act to inhibit the direct transport of sediment bound organochlorine insecticides between the two reservoirs. The validity of the pesticide listing in Oxbow cannot be directly assessed without further data collection. The presence of a general concern associated with t-DDT and dieldrin in the Upstream Snake River and Brownlee Reservoir segments however, is clearly demonstrated by the available data.

3.3.7 Determination of Pesticide Loading

Given the available data set, a rough approximation of pesticide loading to the SR-HC TMDL reach has been calculated. Since data are available for the Upstream Snake River segment (RM 409 to 335) only, loading at the USGS gage at Weiser (mainstem Snake River) is calculated to be approximately 42 kg/year (mean) for t-DDT and approximately 28 kg/year for dieldrin for an average water year. The calculated load capacity of the SR-HC TMDL reach at RM 351 (Weiser, Idaho) is approximately 0.34 kg/year t-DDT and 0.98 kg/year for dieldrin. Assuming that the data collected were representative of the average annual concentrations in the water column, this shows that the current pesticide loading is between 30 and 100 times greater in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach than the targets would allow.

All of this loading is the result of legacy application and transport. None of the load is from natural sources. None of the load is assumed to be from current application as both of these compounds are no longer in use.

While this serves to determine a relative loading value, these calculations are very approximate due to the small data set, and cannot be used to specify localized loading to an appropriate level of accuracy. Concentrations were measured only one time, and do not cover the variability of flow or transport conditions that occur over the course of the year. Additionally, load allocations for t-DDT and dieldrin are already established at zero levels within the basin by previous bans on usage (US EPA, 1992c). Therefore, even if sufficient data were available to calculate loading, no allocation mechanism exists to more stringently address the reduction of t-DDT and dieldrin.

The majority of the pesticide load associated with these compounds is accepted to be associated with sediment transport from areas of legacy application. While some legacy application undoubtedly occurred within the direct drainage of the SR-HC TMDL reach, it is most probable that the majority of the application occurred in the tributary and upstream drainages as they represent a larger proportion of the overall agricultural land surface than the direct drainage. Indirect mechanisms will therefore be the primary means for reducing the loading of these pollutants within the SR-HC TMDL reach.

Determination of pollutant loading to a surface water system is generally accomplished through an association of concentration and flow values. Without sufficient water column concentration data for the SR-HC system, calculated loading can only be used as a general indicator of level of concern. Therefore, alternative methods of assessing pesticide loading have been investigated.

3.3.8 Load Allocations and Other Appropriate Actions

Load allocations for t-DDT and dieldrin are discussed in Section 4.0 of this document. All current loading of these pesticides is considered background from legacy sources.

3.3.8.1 DATA COLLECTION

Additional data will be collected as part of the phased implementation process to assess the extent of pesticide pollutant loading to Oxbow Reservoir. The data collected during the first phases of the Implementation Plan will be assessed using the current water quality parameters, and the approach and implementation measures outlined here (and in greater detail in the source specific implementation plans) and will be assessed for appropriateness and applicability. In correlation with this effort, reasonable and prudent measures will be identified and implemented to reduce the loading to the Upstream Snake River and Brownlee Reservoir segments, therefore reducing the loading to Oxbow Reservoir. If measures identified herein are determined to be adequate to meet the target criteria, implementation efforts will continue as outlined. If new information identifies additional measures that need to be taken, these will be incorporated into the TMDL and Implementation Plan outline.

3.3.8.2 Pesticide Reduction through Direct Sediment Removal.

Direct removal of pesticides deposited in sediments is not feasible in most areas of the SR-HC TMDL reach. Most sources of legacy pesticides in the area are diffuse in nature and do not stem from a discreet source, but rather from historical application on agricultural lands or deposition from surface water transport. Removal of the sediments and organic material associated with these compounds would potentially result in degradation of other habitat parameters.

3.3.8.3 Pesticide Reduction through Sediment Control/Reduction.

While direct removal of pesticide pollutants is not feasible in the SR-HC TMDL reach, management practices can be targeted to reduce further transport to surface water systems. As identified previously, pesticide transport and deposition are, in most cases, directly correlated with the transport and deposition of sediment and organic matter (Clark and Maret, 1998; Maret, 1995a and 1995b; Maret and Ott, 1997; Rinella *et al.*, 1994). Reductions in the amount of these materials entering the SR-HC system will therefore result in reduction of pesticide pollutant transport and loading to the system. Reduction of such transport will be directly linked to the sediment reduction measures identified within this and other, related TMDLs in the Snake River Basin.

It should be clearly stated that this strategy of legacy pesticide management in no way is intended to require direct monitoring of loading or load reductions. Such monitoring for nonpoint source loading is not feasible and will therefore not be required as part of this TMDL process. Rather, appropriate management techniques specific to proper stewardship will be employed as part of the overall TMDL implementation process. These management techniques are projected to result in reduction of overall DDT and dieldrin loading related to nonpoint source discharge to the mainstem Snake River.

3.3.8.4 Pesticide and Sediment TMDLs in Tributary Systems.

TMDLs directly addressing pesticides will be written for the Owyhee and Malheur rivers by the State of Oregon in 2006 and 2003 respectively. The efforts associated with implementation of these TMDLs will also help to reduce the amount of t-DDT and dieldrin loading to the system by addressing erosive processes.

Indirect reductions in pesticide loading to the SR-HC TMDL reach will also be realized from sediment control measures on inflowing drainages as much of the pesticide loading to the system is thought to occur from pesticides bound to sediment and organic material (Maret, 1995a and 1995b; Maret and Ott, 1997; Clark and Maret, 1998; Rinella *et al.*, 1994). Sediment TMDLs will be written for tributaries to the Owyhee River, Burnt River and tributaries and Powder River and tributaries in 2005 and 2006 by the State of Oregon. Sediment TMDLs have been written for the Mid-Snake and Lower Boise rivers and will be written for the Weiser River and the tributaries to the Weiser and Payette Rivers in 2003 and 2006 by the State of Idaho. The efforts associated with implementation of these TMDLs will also help to reduce the amount of t-DDT and dieldrin loading the system by addressing erosive processes.

3.3.8.5 Reductions Due to Discontinued Use.

Maret (1995a and 1995b), in an intensive study of available data on pesticides in fish tissues observed DDT and its metabolites and PCBs in most of the fish tissue sampled from the Upper

Snake River Basin between 1970 and 1990. His analysis identified a general trend of decreasing concentrations for DDT, its metabolites and dieldrin in the Upper Snake River Basin over time during this period. This decline is assumed to be the result of a combination of discontinued use, improved land management practices, and, to a smaller extent, degradation of existing loads. A similar decline is expected to be occurring in the Lower Snake River Basin. This decline will be enhanced by the implementation of appropriate sediment control measures within this and other TMDLs in the Lower Snake River Basin.

3.3.8.6 Other Protective Measures.

In addition to the sediment control measures implemented through the TMDL processes in the Snake River Basin, existing fish consumption advisories for mercury in the SR-HC TMDL reach target the same populations that would be at risk from bioaccumulation of pesticides in fish tissue. These advisories will act, in an indirect fashion, to protect the designated beneficial use of fishing.

3.4 Bacteria and pH Loading Analyses

3.4.1 Bacteria Loading Analysis

The Upstream Snake River segment (RM 409 to RM 335) is listed for bacteria. Previously, both Oregon and Idaho bacteria criteria were based on fecal coliform bacteria levels. Currently, criteria of both Oregon and Idaho require waterbodies where primary contact recreation occurs to contain less than 126 *E. coli* organisms/100 mL water, and less than 406 *E. coli* organisms/100 mL of water in areas where secondary contact recreation occurs (Table 2.2.1 and Table 2.2.2).

Elevated concentrations of bacteria in surface waters can result in health risks to individuals who are swimming, water skiing or skin diving (primary contact recreation) or other activities that carry the risk of ingestion of small quantities of water. This is of particular concern to the SR-HC TMDL reach as recreation is a significant use of the waterbody.

Common sources of bacteria in surface water include improperly treated sewage and septic systems as well as wastes from warm-blooded animals.

A more detailed discussion of concerns and sources of bacterial loading is available in Section 2.3.1.2.

3.4.1.1 DATA ANALYSIS.

Both *E. coli* and fecal coliform data have been used in the assessment of current and historical bacteria violations in the SR-HC TMDL reach. Current data collection allowed *E. coli* levels to be evaluated in the Upstream Snake River segment (RM 409 to 285) of the SR-HC TMDL reach. More detailed information including monitoring dates and sources is available in Section 2.3.1.2.

This listing has been evaluated using available data collected from within this segment from 1978 until present, particularly with available recent data correlated with areas and periods of recreation use. The data show that bacteria counts (*E. coli* and fecal coliform) have not exceeded water quality criteria for primary or secondary contact recreation within the Upstream Snake River segment (RM 409 to 285) of the SR-HC TMDL reach over this time period.

Table 3.4.1 shows summary bacteria data for the 1999 season. These data were collected in an appropriate fashion for evaluation of the 30-day log mean, with a minimum of 5 samples over an appropriate time period collected at most sampling locations. This monitoring was undertaken during the summer season and correlates well not only with the period of time that conditions in the river would be conducive to bacterial growth, but also to the season of greatest primary contact recreation use. Thus, they represent the critical time period for violations within the segment.

3.4.1.2 APPROPRIATE ACTIONS.

Based on these data, the SR-HC TMDL process recommends that the mainstem Snake River (RM 409 to RM 347, OR/ID border to Scott Creek inflow) be delisted for bacteria by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL (Table 3.4.2). The SR-HC TMDL process further recommends that

Table 3.4.1. Summary bacteria data for the 1999 season in the Upstream Snake River segment (RM 409 to 285) of the Snake River - Hells Canyon TMDL reach.

RM	Number of Samples	E. coli (#/100 mL)	
		Mean	Maximum
335	3	13	22
340	15	11	53
385	7	18	37
403	8	19	91

Table 3.4.2. Appropriate actions for bacteria in the Snake River - Hells Canyon TMDL reach.

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River (RM 409 to 335)	data support delisting recommend delisting	data support delisting recommend delisting
Brownlee Reservoir (RM 335 to 285)	not listed	not listed
Oxbow Reservoir (RM 285 to 272.5)	not listed	not listed
Hells Canyon Reservoir (RM 272.5 to 247)	not listed	not listed
Downstream Snake River (RM 247 to 188)	not listed	not listed

monitoring of bacteria levels (*E. coli*), especially in those areas of the SR-HC TMDL reach where recreational use consistently occurs, continue to be an integral part of the water quality monitoring of the Upstream Snake River segment (RM 409 to 285).

It should be noted that this recommended delisting is based only upon the assessment of what is required to attain water quality standards in the mainstem Snake River. No assessment of tributary water quality has been attempted in this TMDL, and conditions specific to bacteria occurring in the mainstem may not reflect conditions occurring in the tributaries. Thus, it is possible that bacteria concentrations in the tributaries to the mainstem Snake River exceed state water quality criteria. Tributary TMDLs could require reductions and could find conditions different from those assumed herein.

In addition, this TMDL does not address bacterial reductions currently required in the Lower Payette River TMDL (IDEQ, 1999b) to meet water quality standards in that tributary.

3.4.2 pH Exceedence Analysis

pH is an indicator of the acidity or alkalinity of a system. Extreme levels of pH can be directly toxic to aquatic life. Even at less extreme levels either acid or alkaline conditions can cause chemical shifts in a system that can result in the release of metallic compounds from sediments in acid conditions or increased ammonia toxicity and release of sorbed phosphorus at high pH levels.

In order to meet the water quality criteria of both states, a pH range of 7 to 9 units has been established as a target for the SR-HC TMDL process to support designated aquatic life beneficial uses within the SR-HC reach. This target has been identified to provide appropriate habitat for fish (including salmonids) and other aquatic life.

Sources of possible pH modification include discharge of acidic or alkaline industrial or municipal wastes, ammonia production during organic matter decomposition, agricultural runoff, and excessive algal growth. However, in this reach, pH is buffered by naturally occurring mineral salts so changes, when they occur, are usually small.

A more detailed discussion of concerns related to and sources of pH modifications is available in Section 2.3.1.2.

3.4.2.1 Data Analysis.

Upstream Snake River Segment (RM 409 to 285). Data collected from 1968 to 1974 in the Upstream Snake River segment show pH values ranging from 7.5 to 9.0 at RM 361 (near Weiser, Idaho) and between 7.7 and 8.5 slightly upstream from RM 409 (near Marsing, Idaho). These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974 and 1975). Data collected from 1975 to 1991 show pH values ranging from 7.5 to 9.1 at RM 361 (near Weiser, Idaho). Exceedences of the pH target for the SR-HC TMDL occurred less than 1% of the time. A study over a similar time period but with less frequent sampling slightly upstream from RM 409 (near Marsing, Idaho) showed a range of pH values from 7.5 to 8.9. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974 and 1975). Data collected by IPCo during 1995 at three locations in the Upstream Snake River segment of the SR-HC TMDL reach show pH levels that range from 8.2 to 8.9 near RM 409, Adrian, Oregon; from 7.1 to 8.9 near RM 385, Nyssa, Oregon; and from 8.3 to 9.0 at RM 340, near Weiser, Idaho. An evaluation of all available pH data for the Upstream Snake River segment of the SR-HC TMDL reach shows less than 1% exceedence of the 7.0 to 9.0 pH target (greater than 300 data points). Data ranges for the Upstream Snake River segment are shown in Figure 2.3.9.

Brownlee Reservoir. Data collected from 1968 to 1974 near Brownlee Dam show pH values that average 8.0. No depth information is available with these data so location and water column variations are not known. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring (US EPA, 1974 and 1975). An evaluation of all recent (1992, 1995, 1997) inflowing and mainstem pH data showed the lowest pH observed in the Brownlee Reservoir to be 7.4. The highest pH observed was 9.6 (IPCo, 1999d, 2000a, 2000c). Less than 5 % of the data were outside of the pH target established for this TMDL process (out of 529 data points, 25 data points showed exceedences, 4.7%). Figure 2.3.17 shows a summary of pH data for 1992, 1995, and 1997.

A more detailed discussion of data available is included in Section 2.3.1.2 and Section 2.3.2.2.

3.4.2.2 Appropriate Actions.

Based on these data, the SR-HC TMDL process recommends that the mainstem Snake River from RM 409 to RM 347 (OR/ID border to Scott Creek inflow) and from RM 335 to RM 285 (Brownlee Reservoir) be delisted for pH by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL (Table 3.4.3). The SR-HC TMDL process further recommends that monitoring of pH continue to be an integral part of the water quality monitoring of the Upstream Snake River segment (RM 409 to 285).

Table 3.4.3. Appropriate actions for pH in the Snake River - Hells Canyon TMDL reach.

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River (RM 409 to 335)	data support delisting recommend delisting	data support delisting recommend delisting
Brownlee Reservoir (RM 335 to 285)	data support delisting recommend delisting	data support delisting recommend delisting
Oxbow Reservoir (RM 285 to 272.5)	not listed	not listed
Hells Canyon Reservoir (RM 272.5 to 247)	not listed	not listed
Downstream Snake River (RM 247 to 188)	not listed	not listed

It should be noted that this recommended delisting is based only upon an assessment of what is required to attain water quality standards in the mainstem Snake River. No assessment of tributary water quality has been attempted in this TMDL, and conditions specific to pH occurring in the mainstem may not reflect conditions occurring in the tributaries. Thus, it is possible that pH levels in the tributaries to the mainstem Snake River exceed state water quality criteria. Tributary TMDLs could require implementation and could find conditions different from those assumed herein.

3.5 Sediment Loading Analysis

3.5.1 Water Quality Targets and Guidelines

The purpose of TMDL development is to meet applicable water quality standards. Because the SR-HC TMDL is a bi-state effort, the most stringent of each state's water quality standards have been identified as the targets for this TMDL. In this way the attainment of these targets will ensure that the water quality requirements of both states will be met.

The Upstream Snake River segment (RM 409 to 335), the Brownlee Reservoir segment (RM 335 to 285) and the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach are listed for sediment on the state 303(d) lists for this TMDL. The water quality standards and guidance values identified for sediment by the states are narrative criteria that require that sediment shall not exceed quantities that impair designated beneficial uses. These criteria are linked to turbidity and state that turbidity should be less than 50 nephelometric turbidity units (NTU) above background for any given sample and less than 25 NTU for any ten consecutive days. This latter discussion was originally developed to address point sources and incorporates mixing zones in the evaluation of violations.

A narrative standard for sediment is appropriate given that wide ranges of sediment concentration and duration occur in surface waters. Interpretation of the narrative standard on a site-specific basis is necessary to identify targets that will protect designated beneficial uses within the listed segment. The designated beneficial uses within the SR-HC TMDL reach determined to be most at risk from excess sediment were those associated with aquatic life. Because sediment includes both organic and inorganic materials, direct and indirect impacts to aquatic life are possible.

Direct effects such as scale erosion, sight impairment and gill clogging are commonly associated with the duration of occurrence of a specified sediment concentration. Newcombe and Jensen (1996), in a review of 80 published reports on suspended sediment in streams and estuaries reported that lethal effects in rainbow trout begin to be observed at concentrations of 50 mg/L to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species (CH2MHill, 1998).

Indirect impacts associated with sediment in the SR-HC TMDL reach include low dissolved oxygen concentrations due to the decomposition of organic sediment materials, and water column enrichment by adsorbed pollutants. A more detailed discussion of these concerns is included in the Subbasin Assessment for the SR-HC TMDL.

Therefore, sediment loading within the SR-HC TMDL reach is of concern for aquatic life designated beneficial use support, and also because of the attached pollutant loads (nutrients, pesticides and mercury) that the sediment carries. In the SR-HC TMDL, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

3.5.1.1 Snake River - Hells Canyon TMDL Water Quality Sediment Targets.

Specific to direct negative effects on aquatic life, and indirect negative effects to the system linked to the transport of adsorbed pollutants, the sediment target for the SR-HC TMDL has been set at less than or equal to 80 mg total suspended solids/L for acute events lasting no more than 14 days, and less than or equal to 50 mg total suspended solids/L as a monthly average. Available information utilized in the determination of this target included both site-specific data and literature values. A more detailed discussion of the reasoning behind this target is outlined in the following sections of this document.

It is the professional opinion of IDEQ and ODEQ that these targets will be protective of both aquatic life (EIFAC, 1964; NAS/NAE, 1973; IDEQ, 1991; CH2MHill, 1998; Newcombe and Jensen, 1996) and water quality, and will meet the requirements of the CWA. The identification of the short term 80 mg/L target will allow natural runoff and storm events (for which aquatic life in the SR-HC TMDL reach are adapted) to be accommodated for by the TMDL. It is the professional opinion of IDEQ and ODEQ that attainment of these targets represent a valid interpretation of narrative standards and will result in support of the designated beneficial uses within the system.

3.5.2 Designated Beneficial Use Impairment

Duration data is critical in determining direct effects to aquatic life within the SR-HC TMDL reach. No such duration data is available to this TMDL effort. It will be collected as appropriate as part of the monitoring undertaken in the first phase of implementation following approval of this TMDL. The data collected will be assessed to determine effects on aquatic life within the SR-HC. This information will be incorporated into the TMDL as part of the iterative process.

Data is available that show indirect negative effects on aquatic life in the form of low dissolved oxygen (in the reservoir complex) and high productivity levels (in both the Upstream Snake River segment (RM 409 to 335) and Brownlee Reservoir). (This data is discussed in more detail in the Subbasin Assessment for the SR-HC TMDL and in Section 3.2.) High suspended sediment concentrations have been observed in many of the agricultural drains and several tributaries where they enter the Snake River (US EPA, 1974 and 1975; personal observations, Upstream Snake River segment (RM 409 to 335), July 1999, July and August 2000, June 2001). A substantial increase in turbidity is visually obvious as an observer moves downstream from the Marsing Bridge to the Weiser Bridge during spring and summer months. This visual trend is supported by data available for the Upstream Snake River segment (RM 409 to 335).

3.5.2.1 Endangered and Threatened Species.

The SR-HC TMDL reach provides habitat for the Idaho spring snail (*Pyrgulopsis idahoensis*, formerly *Fontelicella idahoensis* (Frest and Johannes, 2001)). The identified distribution in the mainstem Snake River is from RM 422 to 393 and from RM 372 to 40 (IPCo, 2001a). This snail species is listed as threatened under the Federal Endangered Species Act (ESA), and requires cold, clear, well-oxygenated water for full support.

3.5.3 Sources

Both natural and anthropogenic sources of sediment are known to occur in the SR-HC TMDL drainage. Sources of sediment loading to this reach include natural loading and anthropogenic loading from both point and nonpoint sources. A brief overview of sediment sources is available below. A more detailed description is available in the Subbasin Assessment for the SR-HC TMDL (Section 2.2.4.5).

3.5.3.1 Natural Sources.

Natural sources of sediment include erosion of rock and soils through wind, precipitation, temperature extremes and other weathering events. Erosion from surface water flow is substantial under average conditions, and erosion from high flow events such as flash floods and snowmelt events can result in greater sediment transport and deposition in a single large event than occurs all year from average flows. Additionally, landslides and debris flows can contribute sediment to surface water systems.

The Bonneville Flood, a catastrophic flood event that occurred approximately 14,500 years ago as the result of the failure of one of the natural dams at Red Rock Pass of Pleistocene Lake Bonneville, deposited fine-grained silty soils over much of the region. The results of this event and the associated erosive processes are visible today in the large bar complexes, fine-grained, easily re-suspended slack water deposits, scoured and eroded basalt and scabland topography in the SR-HC TMDL reach (Link *et al.*, 1999).

As there are no undeveloped watersheds in the SR-HC TMDL reach to use as a reference system for determining natural loading, a rough estimate was derived using the data available for spring runoff in the SR-HC TMDL reach. It was assumed that the majority of the natural sediment loading is delivered during spring runoff-induced flows primarily within the tributary systems. The hydrographs for all major tributaries to the SR-HC TMDL reach were evaluated, peak monthly average flows were identified and available water column concentrations used to calculate total load during spring runoff. Nearly all tributaries to the Snake had the highest flows in April. The exceptions were the Payette River, which had a broader peak of high flows (April and May loading) and the Weiser, which had the highest flow in February. The average relative loading delivered during the high flow month was 23 percent (range = 15% to 36%). This figure was applied as an estimate of natural loading to the mainstem Snake River in the SR-HC TMDL reach.

A necessary set of data for the tributary streams is not currently available. Therefore, natural background concentrations for all tributaries will be determined as part of upcoming TMDL development on the Weiser, Owyhee, and Malheur Rivers, and tributary implementation plans for the Payette and Boise Rivers.

3.5.3.2 Anthropogenic Sources.

All permitted point sources discharging to the mainstem Snake River within the SR-HC TMDL reach (Section 3.0) include maximum total suspended solids discharge limits in their NPDES permits. Most measured total suspended solids concentrations from these point sources are well below the maximum allowable concentrations identified by their NPDES permits. These permit requirements meet or exceed the SR-HC TMDL targets.

Anthropogenic nonpoint sources of sediment in the SR-HC area include agricultural sources such as plowing and flood and furrow irrigation; forestry sources such as logging and streambank disturbance; and urban/suburban sources including construction, stormwater runoff and irrigation.

3.5.4 Transport and Delivery

The primary mechanism of sediment transport in the SR-HC TMDL reach is surface water flow. High flows can transport large amounts of sediment in a wide range of particle sizes and weights. Lower flows preferentially transport lighter, smaller particle fractions. Sediment particles are deposited in areas of streams and rivers where flows decrease and sediments fall out proportionately with size and weight distributions. Sediments deposited in this manner accumulate in areas of the channel where flows are reduced. They can be re-suspended due to increasing flow and carried further downstream. This deposition and transport pattern is evident in the evaluation of suspended sediment data from 1995, an average flow year following a series of lower flow years (Appendix E). In the months of May and June, spring flows transported nearly 200 million kilograms of sediment in the Upstream Snake River segment (RM 409 to 335); the result of several years of in-channel deposition. This mass of transport was nearly three times as large as any other monthly loading that year. Sparse vegetation and timing of snowmelt in areas of the SR-HC TMDL reach and many of the tributary drainages produce conditions favoring high surface runoff and sediment transport.

Additionally, land use patterns may influence sediment transport and delivery within the watershed. Flood and furrow irrigation ditches, if they are aligned and sloped toward streams and rivers, act to direct snowmelt runoff to surface water systems. In contrast, sediment basins and settling ponds or other treatment mechanisms on agricultural lands can help to contain snowmelt and stormwater runoff and reduce or remove suspended sediments from both agricultural flows and precipitation events. Similarly, a high density of impervious surface (commonly associated with urban development) increases the volume of runoff from storm events. If properly managed, this stormwater can be diverted to catchbasins or other mechanisms where velocity is decreased and entrained materials are allowed to settle out before water enters surface or ground water systems. Unfortunately, the relative impact of land use practices is not quantifiable with the available data for the SR-HC system.

3.5.5 Data Available for the Snake River - Hells Canyon TMDL Reach

As discussed in the general loading assessment, a fairly robust data set for sediment was available to the SR-HC TMDL effort. Sediment data has been collected over the time period from 1975 to current for both the mainstem Snake River and tributary sites. Data has been collected in the form of suspended sediment concentration (SSC) measurements (n = 344), total residue measurements (equivalent to total suspended solids measurement)(n = 1,754) and turbidity measured by a Hach turbidimeter (n = 1,099). The most robust data set available was the total residue measurement data. As the total residue and total suspended solids methods are considered essentially equivalent, this data will be referred to as total suspended solids (TSS) throughout the remainder of this document. To preserve consistency in the analysis, this data set was compared with the other available data sets in an effort to determine if it was representative of the other data collected and could therefore stand alone. The largest possible number of paired data sets available for each method were compared, and the total suspended solids measurements were found to be well correlated with the turbidity measurements and moderately correlated with the suspended sediment concentration values. The lower level of correlation with the suspended sediment concentration data is not unexpected as the suspended sediment concentration data represented a much smaller and somewhat spatially limited data set (there were much fewer correlated pairs); and studies on a variety of other systems have shown that suspended sediment concentrations often are not well correlated with total suspended solids measurements (Gray *et al.*, 2000; WDOE, 1997). Table 3.5.1 and Figure 3.5.1 show the correlation observed between total suspended solids measurements and the other data sets available.

Table 3.5.1. Comparison of total suspended solids (total residue analysis) data to other sediment data available for the Snake River - Hells Canyon TMDL reach.

Method compared	Correlation coefficient (R^2)	Y-Intercept	Number of data pairs
Turbidity (Hach)	0.825	5.4	705
SSC	0.671	8.3	14

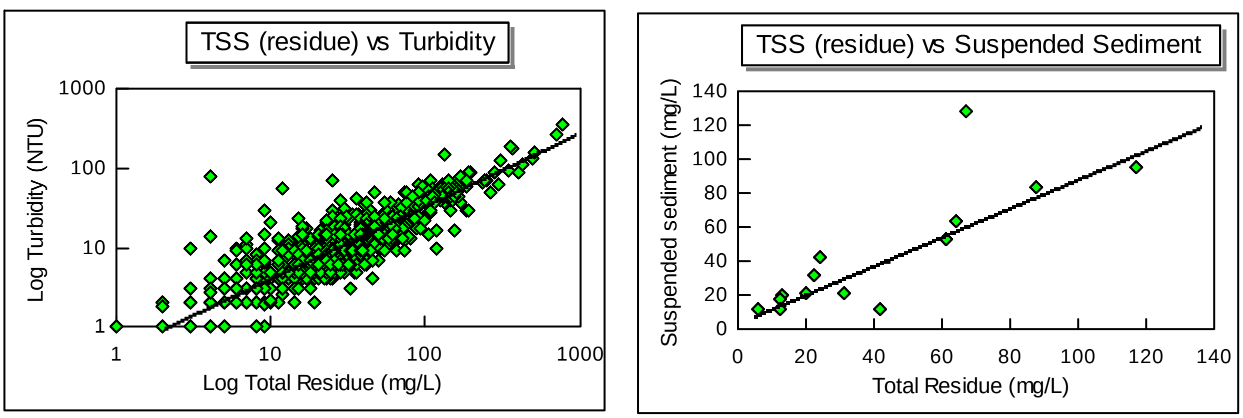


Figure 3.5.1. Linear correlation plots of total suspended solids (TSS (residue)) vs. turbidity measurements and TSS (residue) vs. suspended sediment concentrations (SSC) in the Snake River - Hells Canyon TMDL data set.

There has been a substantial amount of discussion within this TMDL process regarding the appropriateness and inherent biases of total suspended solids and suspended sediment concentration data. Both methods measure organic and inorganic sediment fractions. The analytical method used to determine total suspended solids involves filtration of an aliquot of a water sample that has been swirled to re-suspend sediment particles that may have settled to the bottom of the container. Because the entire sample is not filtered, total suspended solids data carries a slight bias toward the lighter sediment particles. The total suspended solids measurement is therefore somewhat more conservative in estimating algae, silt and clay particles, but would underestimate sand and larger, denser particles to a degree. The analytical method used to determine suspended sediment concentration filters the entire water sample and is therefore not biased toward a particular weight or density class.

While the analytical methods used are similar for both methods, the procedures used to obtain sample aliquots differ and can produce results that differ considerably when larger particle sizes (sand) represents a substantial portion of the suspended material. When fine or very fine particles make up a substantial portion of the suspended material, a higher correlation can be achieved between the two methods (WDOE, 1997).

In the SR-HC TMDL reach, the organic, clay and silt fractions of the suspended sediment are commonly observed to carry the majority of the adsorbed pollutants of concern. In addition, the effect of the organic sediments on dissolved oxygen concentrations within the water column is of concern. As total suspended solids data offers a reasonable correlation with other data sets, and represents a conservative mechanism to assess the sediment load of greatest concern, total suspended solids data were selected as the measure for sediment within this system. In addition, total suspended solids values were found to correlate well with turbidity measurements taken at the same time and place (R2 = 0.825, n = 705). This indicates that total suspended solids measurements will allow a fairly straightforward correlation of TMDL targets and point, nonpoint and direct water column measurement techniques.

Adequate data were available to calculate loading for the SR-HC TMDL reach and inflowing tributaries. Data were also available to calculate point source loading to the SR-HC TMDL reach. Flow and concentration data, average and maximum allowable, were used to determine point source loads. Nonpoint source loading data were not available to this effort.

Duration data to determine direct sediment impacts on aquatic life were not available to this effort. Distribution of the total suspended solids data utilized is shown in Table 3.5.2. A total data set is available in the Appendix E.

It should be noted that often the terms total suspended solids (TSS) and suspended sediment concentration (SSC) are used interchangeably in the literature (usually under the acronym TSS) to indicate the measurement of solids suspended in a water matrix (Gray *et al.*, 2000). This has been the case in the literature review of sediment studies for this TMDL effort. Every attempt has been made to determine the specific analytical method utilized by each study and the acronyms applied in this document are, to the extent possible, consistent with those identified previously.

3.5.6 Determination of Sediment Loading

The available data show that sediment loading to the SR-HC TMDL reach originates almost exclusively from the Upstream Snake River segment (RM 409 to 335). Point source loading represents less than 1 percent of the total sediment loading to the SR-HC TMDL reach. Measured tributary loading to this segment accounts for the majority of the sediment loading to the entire SR-HC TMDL reach, 76 percent, with ungaged (estimated) drain flows accounting for 10 percent of the total system load and unmeasured sources accounting for approximately 12 percent of the total. Sources of this unmeasured load include nonpoint source runoff from both

Table 3.5.2. Distribution of sediment data available for the Snake River - Hells Canyon TMDL reach (1970 through 1997).

Sample Site	Number of Samples	Mean TSS concentration (mg/L)	Maximum (mg/L)	Minimum (mg/L)
Snake River at Marsing	44	21.2	42	2
Tributary Mouths				
Owyhee	169	65.2	562	7
Boise	144	41.1	295	1
Malheur	93	109.2	787	2
Payette	98	36.5	406	3
Weiser	59	27.5	117	2
Drains	194	151.4	1,320	2
Upstream Snake River Mainstem	304	38.3	685	1
Brownlee Reservoir	147	21.1	411	1
Oxbow Reservoir	113	7.8	215	1
Hells Canyon Reservoir	58	9.4	116	1
Downstream Snake River Segment	69	6.9	24	1

Data in this table are from US EPA STORET, 1998a; IPCo, 1999d, 2000a, 2000c, 2000d and USGS, 1999.

anthropogenic sources and precipitation events, unidentified small tributaries and drains, error in gauged flow measurements and in-channel erosion sources.

Sediment loading to the SR-HC system shows a marked increase starting in the month of March and continuing through July and August. The months of April, May and June show the highest overall sediment loading to the system (Figure 2-29 in Appendix G), averaging over 1.5 million kg/day. July through October flow volumes and associated sediment loads are much reduced from the peaks in the previous months. These loads are smaller and relatively steady, averaging about 500,000 kg/day. Because of their direct association to irrigation and summer stormwater runoff activities, these loads are expected to carry the highest fraction of adsorbed nutrient and pesticide loading. Winter loads (November through January) average approximately 300,000 kg/day. Total suspended solids data collected by Boise City Public Works during the year 2000 show a similar trend in temporal distribution (BCPW, 2001). The relative percent sediment loading contribution for each of the SR-HC segments and inflowing tributaries for an average water year is shown in Tables 3.5.3 a and b.

Sediment loads from agricultural drains discharging to the SR-HC TMDL reach were determined using available concentration data and flow data where available. Flow data were not plentiful however, and most flows were estimated using general descriptions and the calculated return flow information by area supplied by the USBR (USBR, 2001). Concentrations were calculated averages where data were not available. These values should be viewed as best estimates. If drain specific data become available during the implementation of this TMDL it should be used

Table 3.5.3 a. Sediment (total suspended solids) loads calculated for point sources discharging directly to the Snake River - Hells Canyon TMDL reach (based on concentration data from 1995, 2000 and design flows).

Point Source	NPDES Permit Number	Location (RM)	Current Design-flow Load (kg/day)
City of Nyssa	101943 OR0022411	385	32 kg/day
Amalgamated Sugar	101174 OR2002526	385	Negligible
City of Fruitland	ID0020907	373	62 kg/day
Heinz Frozen Foods	63810 OR0002402	370	396 kg/day
City of Ontario	63631 OR0020621	369	209 kg/day
City of Weiser (WWTP)	ID0020290	352	213 kg/day
City of Weiser (WTP)	ID0001155	352	Negligible
Brownlee Dam (IPCo)	ID0020907	285	Negligible
Oxbow Dam (IPCo)	101275 OR0027286	272.5	Negligible
Hells Canyon Dam (IPCo)	101287 OR0027278	247	Negligible

in place of these estimates. Land area associated with the drains was calculated at 249,100 acres total (USBR, 2001).

Point source loads were calculated using total suspended solids values specified in NPDES permits specific to permitted facilities and the reported values supplied to the State of Oregon (permitted discharges in Oregon) and the US EPA (permitted discharges in Idaho). Constant concentrations from preceding months were assumed for months where discharge concentrations were not reported. For facilities discharging part time, only that time when discharge occurred was assessed. The total loading value for point sources in Tables 3.5.3 a and b reflects both part time discharges and seasonal discharge requirements for some facilities.

3.5.7 Total Suspended Solids - Relative Organic Content Determination

The relative distribution of inorganic and organic constituents within the total suspended solids measurement is helpful in determining source and treatment alternatives as well as in correlating this effort with that of total phosphorus reduction in Section 3.2. One method of identifying a good portion of the organic material in a sediment sample is to determine the volatile suspended solids (VSS) component. This analytical procedure uses high temperatures to “burn off” the organic content in a total suspended solids sample. The sample is weighed before and after the

Table 3.5.3 b. Sediment (total suspended solids) loads calculated for nonpoint sources discharging to the Snake River - Hells Canyon TMDL reach (based on concentration data from 1995 to 2000 and average flows).

Nonpoint Source	Location	Load (kg/day)
Snake River Inflow	RM 409: Upstream Snake River Segment	677,785
Owyhee River	RM 396.7: Upstream Snake River Segment	66,152
Boise River	RM 396.4: Upstream Snake River Segment	130,466
Malheur River	RM 368.5: Upstream Snake River Segment	92,870
Payette River	RM 365.6: Upstream Snake River Segment	137,887
Weiser River	RM 351.6: Upstream Snake River Segment	53,617
Drains	Upstream Snake River segment (RM 409 to 335)	143,430
Ungaged flows	Upstream Snake River segment (RM 409 to 335)	181,484
Agriculture, Stormwater and Forestry	Upstream Snake River segment (RM 409 to 335)	Included in the ungaged flow loading
Upstream Snake River Segment Total Loading	RM 409 to 335	1,483,691
Burnt River	RM 296: Brownlee Reservoir Segment	13,274
Powder River	RM 327.5: Brownlee Reservoir Segment	14,857
Agriculture, Stormwater and Forestry	Brownlee Reservoir segment (RM 335 to 285)	Cannot be calculated, assumed small
Agriculture, Stormwater and Forestry	Oxbow Reservoir segment (RM 285 to 272.5)	Cannot be calculated, assumed small

Data in this table are from US EPA STORET, 1998a; IPCo, 1999d, 2000a, 2000c, 2000d and USGS, 1999.

procedure and the volatile fraction is determined by difference. A limited data set was obtained from IPCo and Boise City Public Works (BCPW, 2001) monitoring efforts. This information included both the mainstem Snake River and some tributary sites. Total suspended solids and volatile suspended solids data collected from the Snake River are shown in Table 3.5.4 a. This data is plotted in Figure 3.5.2.

The plotted data show that the relative percent of total suspended solids that is volatile (organic) fluctuates over time from ~5 percent to ~ 35 percent. The extremes occur during the months of the year when algae growth would be expected to be at its lowest levels. During the spring and summer months (May through August), a gradual increase in the organic fraction is observed which correlates well with the algae growth observed within the SR-HC TMDL reach. The plot also shows that while there is a substantial change in overall concentration, there is much less fluctuation in the relative amount of organic material associated with the sediment measurements. Throughout the growing season, organic matter represents approximately 15 to 25 percent (~20% average) of the total sediment load within the mainstem Snake River in the vicinity of the SR-HC TMDL reach (RM 441.9 to 340).

Table 3.5.4 a. Monthly mean total suspended solids (TSS) and volatile suspended solids (VSS) data from the mainstem Snake River.

Month	Avg. TSS	Avg. VSS	% VSS
January	6.20	1.80	29.03
February	27.70	2.08	7.49
March	58.40	7.70	13.18
April	31.48	6.68	21.21
May	35.47	5.87	16.54
June	41.07	8.50	20.70
July	33.88	7.82	23.07
August	27.64	7.21	26.10
September	20.87	4.63	22.20
October	13.35	3.43	25.72
November	9.95	3.28	32.91
December	8.02	1.92	23.94

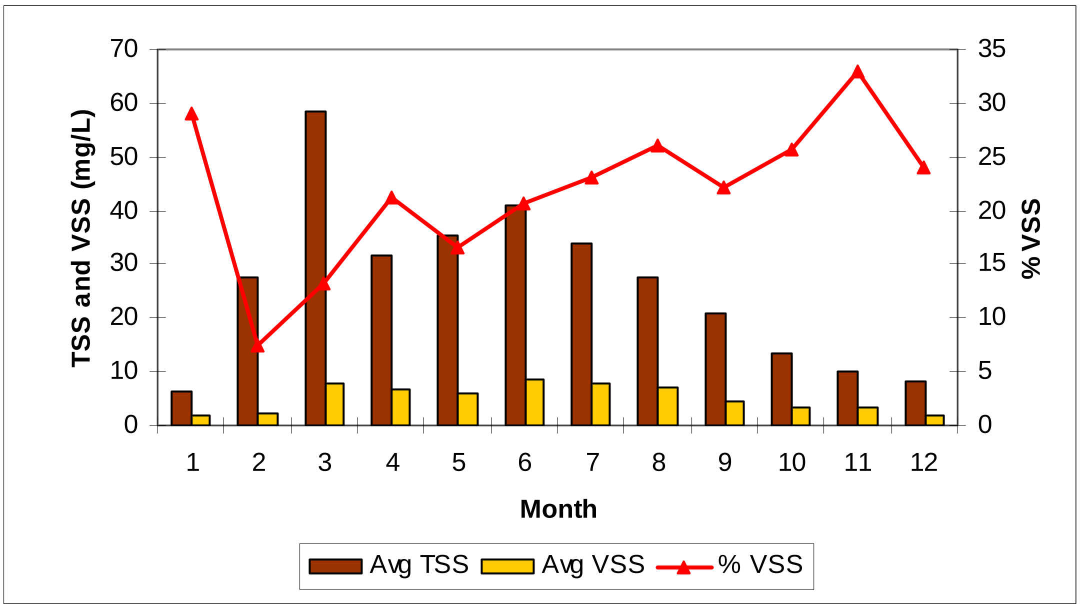


Figure 3.5.2. Total suspended solids (TSS) and volatile suspended solids (VSS) data plotted as monthly means for the mainstem Snake River.

A small data set was also available from IPCo and Boise City Public Works (BCPW, 2001) that allowed a comparison of relative percent organic content between the Snake River mainstem and some inflowing tributaries. This data is shown in Table 3.5.4 b; data is plotted in Figure 3.5.3. The plotted data show that the relative percent volatile suspended solids is reasonably stable within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach and the inflowing tributaries (Boise and Payette Rivers). The relative percent volatile suspended solids is ~20 percent. This value increases steeply within the reservoir as larger, mostly inorganic sediments drop out and smaller, suspended matter dominates. Again, while the overall concentration of total suspended solids and volatile suspended solids fluctuate fairly widely, the

Table 3.5.4 b. Comparison data for mean total suspended solids (TSS) and volatile suspended solids (VSS) data from the mainstem Snake River, the Lower Boise River and the Lower Payette River.

Location	Mean TSS	Mean VSS	% VSS
Payette River	19.08	2.63	13.81
Boise River	26.65	3.99	14.97
284.4	3.31	1.07	32.40
340	25.29	4.60	18.19
351	42.93	8.87	20.67
403	22.16	4.78	21.59
441.9	16.10	4.89	30.35

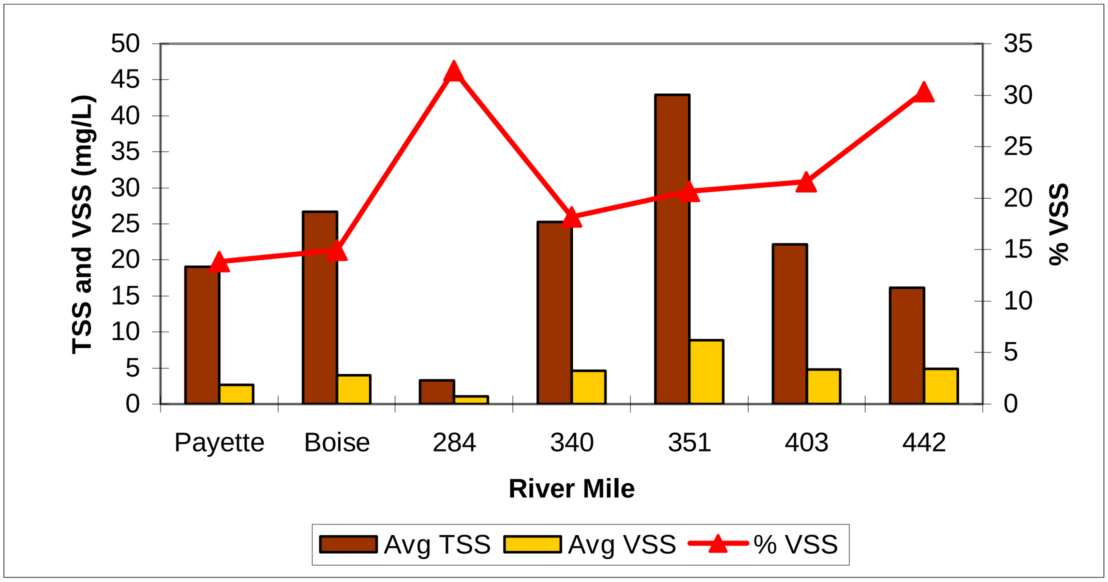


Figure 3.5.3. Total suspended solids (TSS) and volatile suspended solids (VSS) data plotted for the mainstem Snake River and some tributary inflows.

general correlation of total suspended solids and volatile suspended solids remains reasonably constant.

This reasonably stable ratio over the summer growing season indicates that reductions in algae growth within the Snake River will result in a consistent reduction of sediment concentrations in the SR-HC TMDL reach. It also indicates however, that the majority of sediment in the SR-HC TMDL reached, based on these data, is inorganic. Therefore, sediment reductions, while they will be assisted by the measures implemented to attain nutrient reductions, will still need to be addressed separately to attain the identified targets in some places and at some times.

3.5.8 TMDL Determination

Given the water quality concerns associated with sediment in the SR-HC TMDL reach, available information (both site-specific and literature values) was considered in the determination of an appropriate sediment target and TMDL for the SR-HC TMDL reach. Specific to direct negative effects on aquatic life, current targets recognized in other sediment TMDL efforts are reasonably correlated.

Recommendations of less than or equal to 80 mg/L total suspended solids concentration as a daily maximum, and less than or equal to 52 mg/L total suspended solids concentration as a monthly average have been proposed in the upstream Snake River (IDEQ 2000d). Concentrations of less than or equal to 80 mg/L suspended sediment concentration for acute events lasting less than 14 days, and less than or equal to 50 mg/L suspended sediment concentration for acute events lasting less than 60 days have been identified for the Lower Boise River (IDEQ, 1998a). Targets of less than or equal to 56 mg/L suspended sediment concentration have been identified in the Yakima TMDL for both sediment and DDT concerns (WDOE, 1997).

In addition to the protection of designated beneficial uses, the transport of adsorbed nutrients, mercury and organochlorine pesticides through sediment transport and delivery within the SR-HC TMDL reach is of concern. These compounds adsorb to entrained organic matter and fine particles with high surface areas. It is estimated that over 90 percent of adsorbed pollutant loading is carried by the silt/clay and fine to very fine particle fractions of sediment. The majority of the remaining adsorbed load is carried by entrained organic material (Baird, 1995; Clark and Maret, 1998; Rinella *et al.*, 1994).

Sediments in the bed of the Snake River in the Upstream Snake River segment (RM 409 to 335) average approximately 1 percent total organic carbon, 12 percent silt and clay, and 38 percent fine or very fine particles. Sediments in the Brownlee Reservoir segment (RM 335 to 285) average approximately 1.3 percent total organic carbon, 83 percent silt and clay, and 12 percent fine or very fine particles (IPCo, 2000d; Clark and Maret, 1998). As smaller particle sizes tend to travel farther before settling out, the majority of these sediment fractions in the reservoir most likely originated in the Upstream Snake River segment. A reduction in sediment in the SR-HC TMDL reach, and specifically these fractions, will result in a corresponding reduction in pollutant loading for nutrients, mercury and pesticides.

To specifically target that fraction of the entrained sediment that carries the largest pollutant load, total suspended solids-based targets were selected. To target that fraction of annual runoff most likely to contain the adsorbed pollutant load, the temporal distribution of sediment delivery to the SR-HC system was evaluated.

It was observed that the majority of total suspended solids loading to the SR-HC TMDL reach occurred over the summer growing season (April to October). Roughly 70 percent of the total sediment load is delivered during this time period (Table 3.5.5) even though the highest flows in the SR-HC TMDL reach generally occur during the spring season (February, March and April).

Figure 3.5.4, plots A through J (multiple pages) shows total suspended solids concentrations measured at points within the SR-HC TMDL reach and at the mouths of inflowing tributaries. The data sets displayed do not contain equal numbers of data points for the 1975 to 1980 and 1990 to 2000 time periods. In most cases, more data was available in the 1990 to 2000 time

Table 3.5.5. Mean and range of % total suspended solids (TSS) delivered seasonally to the Snake River - Hells Canyon TMDL reach. (Summer is defined as late April through October, spring is defined as February through early April, and winter is defined as November through January.)

	Summer Season	Spring Season	Winter Season
Average Water Year			
Mean % of TSS delivered	72%	19%	8%
Range of %TSS delivered	64% to 86%	27% to 22%	14% to 5%
High Water Year			
Mean % of TSS delivered	69%	29%	12%
Range of %TSS delivered	60% to 85%	20% to 30%	8% to 16%
Low Water Year			
Mean % of TSS delivered	73%	14%	16%
Range of %TSS delivered	55% to 87%	12% to 17%	11% to 28%

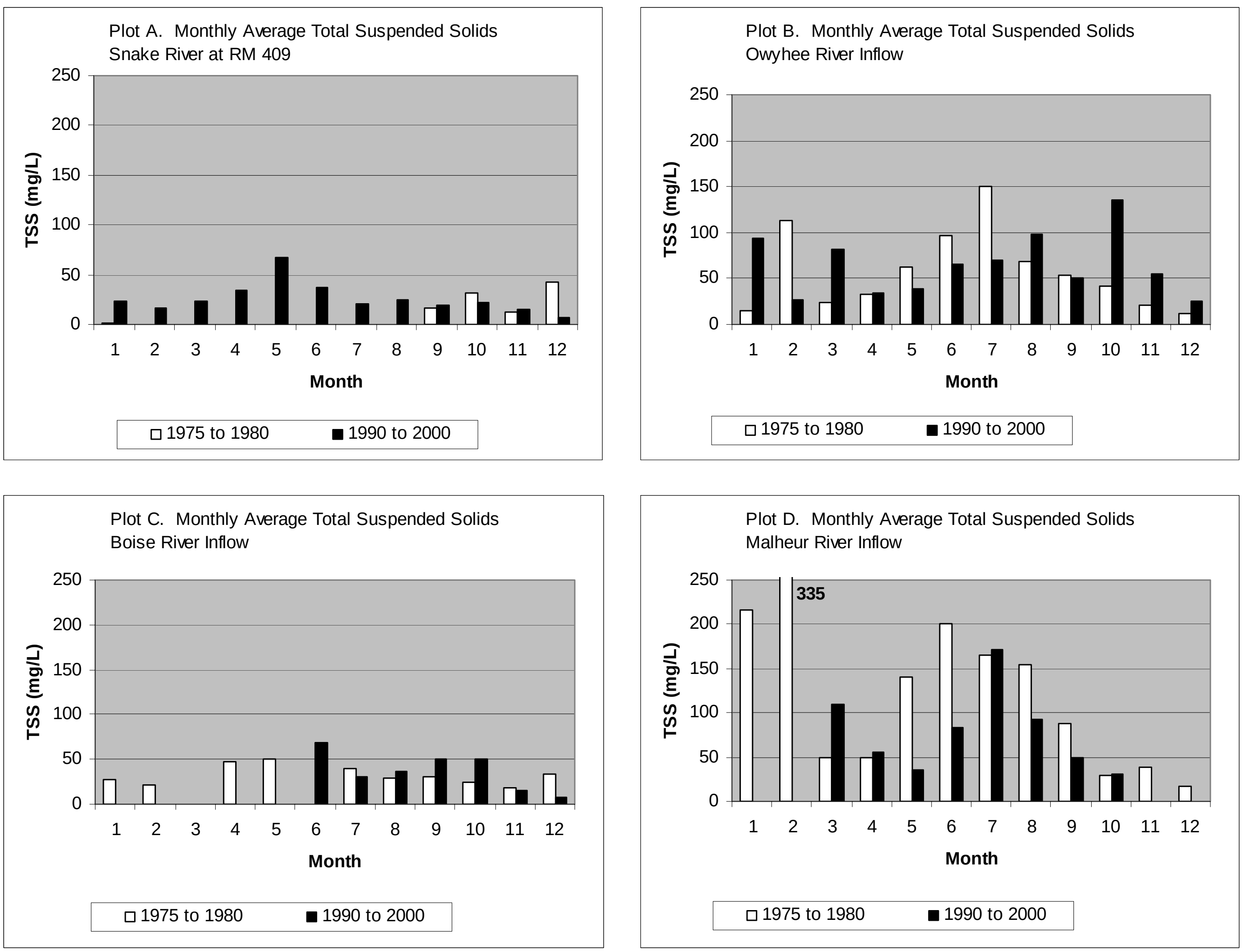


Figure 3.5.4. Mean monthly total suspended solids (TSS) concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

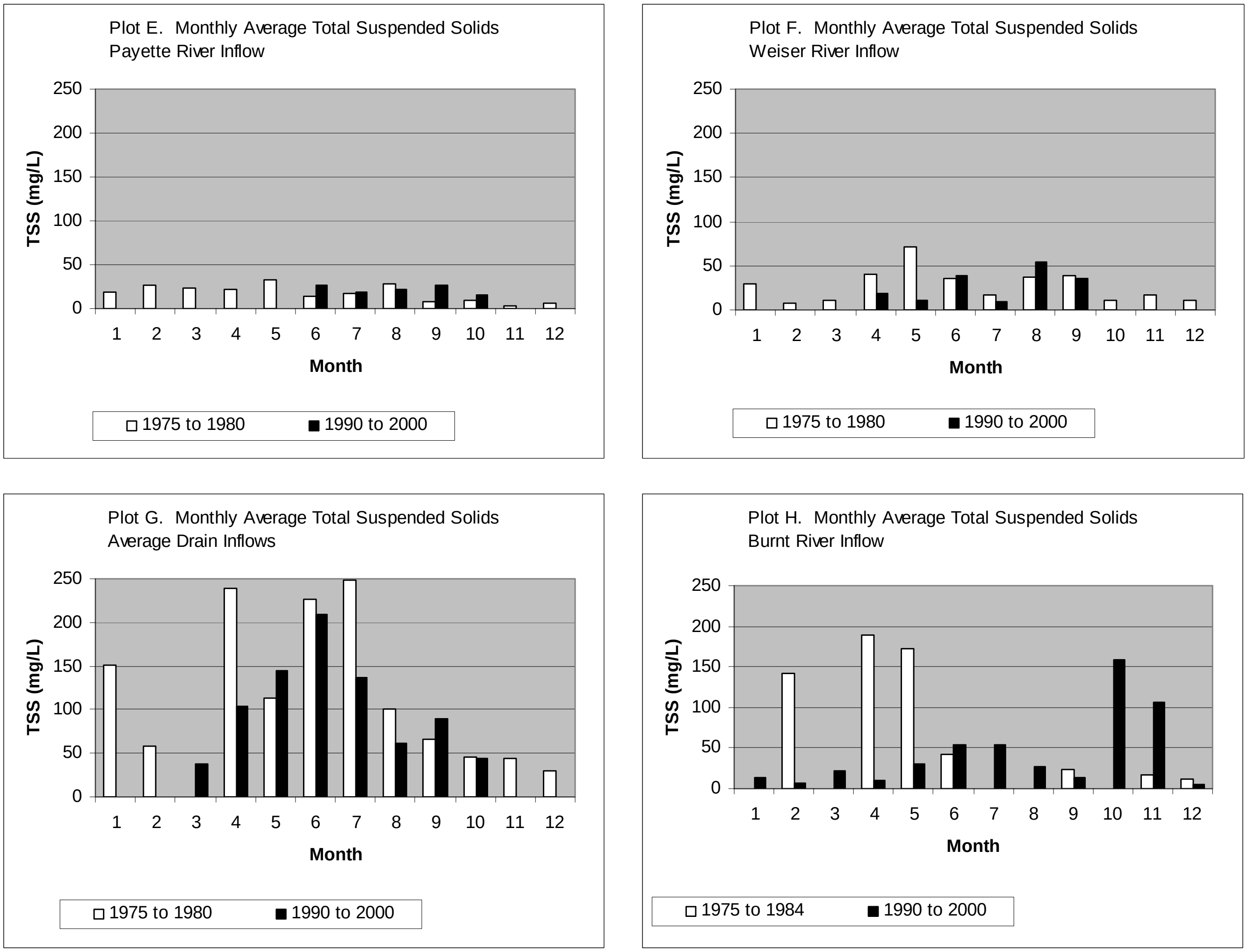
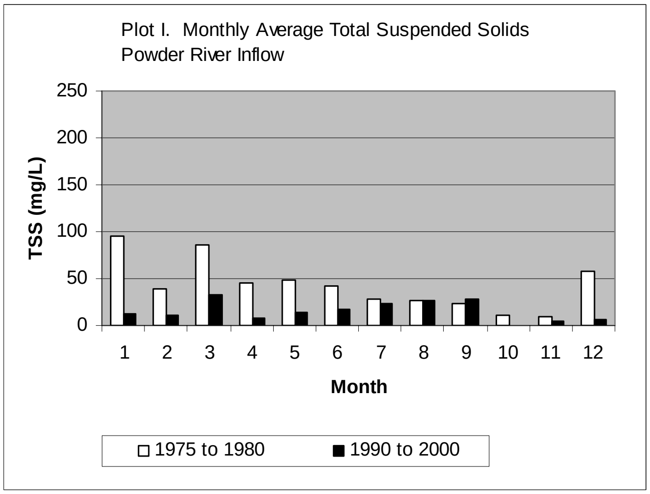


Figure 3.5.4. (cont.) Mean monthly total suspended solids (TSS) concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

period than in the 1975 to 1980 time period. Data is presented as available. Lack of data or smaller than average data sets occurred in some years and locations. Therefore, these limited data may not be representative of average conditions. Scales on all plots were normalized to allow for an easier comparison of relative concentration differences.

The Malheur River (plot D), the Burnt River (plot H) and the Powder River (plot I) show reductions in total suspended solids concentrations from the 1975 to 1980 data as compared to the 1990 to 2000 data.

Total suspended solids concentrations at the mouth of inflowing tributaries do not exceed the average monthly target value of 50 mg/L until late April when they increase sharply. Concentrations continue to increase through July and then decline, dropping below the 50 mg/L monthly average in September. The months in which sediment reduction measures would be the most effective (based on this data) would therefore be from April through August. Winter total



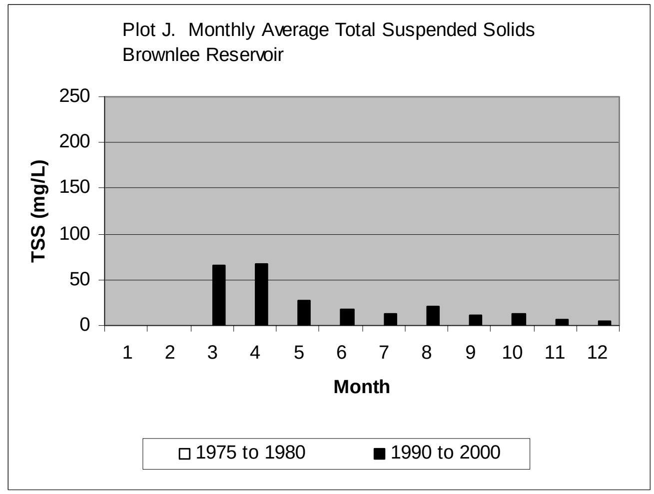


Figure 3.5.4. (cont.)   Mean monthly total suspended solids (TSS) concentrations for locations on the mainstem Snake River and at the mouths of the major tributary inflows within the Snake River - Hells Canyon TMDL reach. The data sets displayed do not necessarily contain equal numbers of data points.

suspended solids concentrations in most inflows are rarely observed above 50 mg/L as a daily average and higher, snowmelt induced total suspended solids concentrations do not commonly last more than 14 consecutive days.

Therefore, setting targets that would address the loading occurring this critical time period would encompass the largest portion of the delivered load, while minimizing concerns associated with that time period where natural processes such as snow melt and precipitation result in high flows that are difficult to treat effectively. In the SR-HC TMDL, natural runoff patterns generally show the occurrence of high flow volumes during the months of March and April. Individual tributary systems may experience earlier or later snowmelt and runoff patterns. BMP-based treatment of snowmelt induced spring flows is not always effective. Both stormwater and agricultural BMPs, if properly installed and operated, will function to reduce this runoff-induced loading, but will function less efficiently in times of substantially increased flow volume, especially if it occurs during a time period when vegetation has not re-established after a winter die-off. Therefore, the highest treatment efficiencies will most likely occur during the summer and fall seasons when vegetation is well established and flows are less than spring runoff volumes.

Summer growing season flows are also the most likely sources of legacy pesticide and legacy seed-treatment based mercury transport, as this is when agricultural irrigation use and surface return flows are highest. Soil particles and organic material transported through erosive processes associated with irrigation and stormwater runoff are also likely to contain adsorbed phosphorus. Algae blooms observed in the Upstream Snake River in the late spring and early summer are well correlated with the irrigation season.

In investigating appropriate total suspended solids targets for the SR-HC TMDL reach, several factors were considered, including fish species present, land use distribution (for determining potential for adsorbed pollutant loads), flow and loading distribution, and data available.

At minimum, full support of designated beneficial uses can occur in an environment where sediment and other habitat conditions result in a “none-to-slightly reduced” fishery. An in-depth evaluation of sediment requirements was completed on the Lower Boise River to determine the fishery needs. This work resulted in the identification of a sediment target of less than or equal to 50 mg/L suspended sediment concentration for acute events lasting less than 60 days. This determination was specific to fishery support. In the Mid-Snake TMDL process, a similar evaluation was completed that resulted in the identification of a target of less than or equal to 52 mg/L suspended sediment concentration as a monthly average.

The range of 50 mg/L to 100 mg/L total suspended solids identified by Newcombe and Jensen (1996) was carefully evaluated for application to the SR-HC TMDL reach. The research is specific to rainbow trout, a species known to exist in the SR-HC TMDL reach and while all of the research is not specific to the SR-HC drainage, it represents the current understanding of sediment effects on aquatic life.

Also carefully reviewed was the caution that in order to protect against lethal or paralethal effects on fisheries, sediment concentrations at or above 80 mg/L total suspended solids cannot be sustained for more than 30 days.

The targets evaluated were established based on work that included a broad range of locations and fish species. The fish populations identified within the Mid-Snake and Boise River systems are very similar to those identified within the SR-HC TMDL reach. Therefore, these targets should also be protective of the fish species in the SR-HC TMDL reach.

In light of this information, a two part sediment target for the SR-HC TMDL reach was identified: a conservative target of less than or equal to 80 mg total suspended solids/L for acute events lasting no more than 14 days, and less than or equal to 50 mg total suspended solids/L monthly average. This target will be applied year round. The less than or equal to 50 mg/L total suspended solids monthly average will serve as the load capacity for the SR-HC TMDL. It is the professional opinion of IDEQ and ODEQ that attainment of these targets represent a valid interpretation of narrative standards and will result in support of the designated beneficial uses within the system. This two part target protects the fishery, results in reduction of that specific fraction of the sediment most likely to carry adsorbed pollutants into the SR-HC TMDL reach, and allows an off-ramp for naturally occurring events over which landowners and managers have little control.   This target is applied to the SR-HC TMDL reach in the Upstream Snake River, Brownlee Reservoir and Oxbow Reservoir segments (RM 409 to 272.5) as they are listed for sediment in the SR-HC TMDL reach.

The type of sediments identified and the potential for pollutant transport are very similar between the Mid-Snake TMDL reach and the SR-HC TMDL reach. The target selected is conservative in nature (the lower end of the range identified as resulting in no-effect to slightly-reduced fisheries and should therefore ensure minimal negative impacts to the aquatic life in the SR-HC TMDL reach (EIFAC, 1964; NAS/NAE, 1973; IDEQ, 1991; Newcombe and Jensen, 1996, WDOE, 1997).

In absence of duration-specific data that would allow direct interpretation of how sediment transport occurs within the SR-HC TMDL reach; this target was selected as being protective of the system in general. Site-specific data will be collected during the first phase of implementation to refine this target if necessary.

The short term target of less than or equal to 80 mg/L total suspended solids for acute events of less than 14 day duration was derived from the recommendation that sediment concentrations of greater than 80 mg/L total suspended solids for more than 30 days could result in lethal or paralethal effects on fisheries. Given the concern that two, 30 day periods may occur in close proximity and result in a detrimental effect on the fishery, it was decided that a 14 day duration would provide appropriate salmonid rearing/cold water aquatic life support. If two 14-day events were to occur in close proximity (for example one day apart, worst case scenario) the collective effects would still be within the recommended duration for protection of fisheries. Most fish have adapted to survive short duration high intensity events, and most naturally occurring events, while they may result in sustained high flows, do not result in sustained high concentrations of sediment for long duration.

Due to the observed concentration and flow trends within the SR-HC TMDL reach and inflowing tributary systems, the critical period for this target will focus on the summer growing months as that is where the available data show the greatest number of total suspended solids concentrations above 50 mg/L (monthly average) occur. An example of this distribution is seen in the total suspended solids concentrations measured at points within the SR-HC TMDL reach and at the mouths of inflowing tributaries, as shown in Figure 3.5.4

The specific level of reduction realized by attainment of this target is dependent on the type of water year and the hydrology of the surface water system to which it is applied. Setting a concentration-based target means that in high flows, the loading delivered at the target value will be greater than the load delivered at the target value during medium or low flow years.

However, the concentration of total suspended sediment in the water column is a primary factor affecting aquatic life support, so a concentration-based target is reasonable. Additionally, the load delivered during high flow years will still be reduced from the load delivered without TMDL-based reductions. Low and average flow years may show a larger relative percentage reduction in sediment loading by meeting the monthly average 50 mg/L total suspended solids target as loading is based on instream flow (load = flow x concentration). High flow years will also see a reduced sediment load, but the overall relative magnitude of mass realized by the reduction will be smaller because of the higher flows.

Table 3.5.6 shows the calculated loading at current conditions. Calculated loading at the 50 mg/L target level is also shown that incorporates a 10 percent margin of safety. Under these conditions it can be observed that the inflow from the Snake River (at RM 409) and the Boise, Payette and Weiser Rivers does not exceed the target, while the inflow from the Owyhee and Malheur Rivers, and that of the drains exceeds the target and would need to reduce total suspended solids by between 27 percent and 60 percent in order to meet the target criteria at the mouth of the inflow to the Snake River.

3.5.9 Load Allocations

Specific information is presented in Section 4.0. Reductions identified in Table 3.5.6 are specific to the mouth of those tributaries where discharged total suspended solids concentrations are greater than 50 mg/L monthly average. These reductions are expected to minimize site-specific degradation of habitat and impairment of designated uses at the inflow point within the mainstem Snake River.

Table 3.5.6. Current sediment loads, projected loading based on 50 mg/L total suspended solids (TSS), and percent reduction realized (based on concentration data from 1995, 1996 and 2000, and average flow values).

Sample Site	Current Load (TSS) (kg/day)	Projected Loading at 50 mg/L (TSS) (kg/day)	% Reduction
Snake River at Marsing	677,785	1,054,463	
Tributary Mouths			
Owyhee	66,152	48,007	27
Boise	130,466	148,569	
Malheur	92,870	42,062	55
Payette	137,887	296,530	
Weiser	53,617	121,144	
Drains	143,430	57,628	60
Ungaged flows	181,484	118,178	35
Upstream Snake River Mainstem	1,483,691	1,886,581	
Burnt	13,274	9,713	27
Powder	14,857	26,348	
Brownlee Reservoir	193,093	1,888,952	
Oxbow Reservoir	275,470	1,904,434	

3.6 Temperature Loading Analysis

3.6.1 Water Quality Targets and Guidelines

The purpose of TMDL development is to meet applicable water quality standards. The SR-HC TMDL is a bi-state effort; therefore the most stringent of each state's water quality standards have been identified as targets for this TMDL. In this way the attainment of these targets will ensure that the water quality requirements of both states will be met.

The entire SR-HC TMDL reach (from RM 409 to RM 188) is listed for temperature on the state 303(d) lists. The water quality standards and guidance values identified for temperature in the SR-HC TMDL are numeric criteria specific to the designated beneficial uses of *cold water aquatic life* and *salmonid spawning and rearing* when and where these uses occur.

The entire SR-HC TMDL reach (from RM 409 to RM 188) has been designated for cold water aquatic life by the State of Idaho. This same segment has been designated for salmonid spawning and rearing by the State of Oregon. Within the beneficial use designation of salmonid spawning and rearing, the State of Oregon can differentiate separately between those areas where salmonid spawning occurs and those areas where salmonid rearing occurs within a watershed. The water quality targets applied to these areas are then determined by this localized designation of use with salmonid rearing targets applied to those areas designated for salmonid rearing and salmonid spawning targets applied to those areas designated for salmonid rearing.

Specific designation of the salmonid spawning and salmonid rearing beneficial uses in the SR-HC TMDL reach are as follows:

Salmonid Spawning. The states of Oregon and Idaho have designated the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach for salmonid spawning. Both the State of Idaho and the State of Oregon have designated tributaries to the SR-HC TMDL reach for salmonid spawning based on the available data and the current level of understanding of fish species present. Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Salmonid spawning is not observed to occur in the Upstream Snake River (RM 409 to 335), Brownlee Reservoir (RM 335 to 285), Oxbow Reservoir (RM 285 to 272.5) or Hells Canyon Reservoir (RM 272.5 to 247) segments of the SR-HC TMDL. The salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries to the SR-HC TMDL reach so designated, when and where that designated use occurs. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

This localized designation of salmonid spawning areas is integral to the approach outlined in the initial sections of this document regarding the open acknowledgement by this TMDL effort that there are distinct spatial and temporal use patterns within the specific segments designated for specific beneficial uses within the SR-HC TMDL reach. Targets must be set to recognize those spatial/temporal use patterns that exist, as well as the needed connectivity within the mosaic of designated beneficial uses (including critical habitat for sensitive species) throughout the waterbody. This approach provides for full support of existing uses and the restoration of impaired designated uses within that mosaic. In setting specific salmonid rearing and salmonid spawning designations, the SR-HC TMDL also recognizes that this ecosystem is comprised of a variety of aquatic environments that include lentic (still water), lotic (flowing water) and transition areas, each with their own characteristic attributes, habitat types and beneficial uses. In this way the proposed approach can result in a TMDL that is achievable, that will meet criteria, and that will support designated beneficial uses without imposing inappropriate and unreachable water quality targets and implementation expectations.

Salmonid Rearing. The State of Oregon has designated the mainstem Snake River in the SR-HC TMDL reach for salmonid rearing (the State of Idaho designated beneficial use equivalent to *salmonid rearing* is *cold water aquatic life*). The State of Idaho has designated the entire reach for cold water aquatic life. The salmonid rearing/cold water aquatic life beneficial use designation, and the accompanying water quality targets apply to the mainstem Snake River within the SR-HC TMDL reach. As the mainstem SR-HC TMDL reach of the Snake River is an interstate waterway, the more stringent of the two states' standards applies and has been identified as the salmonid rearing/cold water aquatic life target for this TMDL. Temperature targets for the SR-HC TMDL were established based on a comparison between the temperature standards for Idaho and Oregon. A detailed description of the comparison methodology is contained in Appendix C.

The State of Idaho designation of salmonid spawning as a beneficial use for Brownlee Reservoir, Oxbow Reservoir and Hells Canyon Reservoir has been formally removed by state legislative action finalized on March 30, 2001. For the purposes of this TMDL, the current use designations identified by the states have been applied.

3.6.1.1 SALMONID REARING/ COLD WATER AQUATIC LIFE.

The temperature target identified for the protection of salmonid rearing/cold water aquatic life when aquatic species listed under the Federal Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: 17.8 ^{o}C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^{o}C. If and when the site potential is greater than 17.8 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources (0.14 ^{o}C is considered less than measurable by ODEQ).

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

This target is based on Oregon temperature standards, which were found to be more stringent that Idaho cold water aquatic life temperature standards. It includes narrative criteria that acknowledges that "natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions" (OAR 340-41-120 (11)(c)).

Language regarding standard exceedences from naturally occurring sources, similar to that outlined for Oregon State standards above is also contained in the Idaho State Water Quality Standards. At the start of this TMDL process, existing Idaho standards stated that "where natural background conditions from natural surface or ground water sources exceed any applicable water quality criteria...that background level shall become the applicable site-specific water quality criteria" (IDAPA 58.01.02.07.06). A clarification to this statement was added through legislative action during this TMDL process (effective March 15, 2002). Current Idaho State Water Quality Standards state "when natural background conditions exceed any applicable water quality criteria...the applicable water quality criteria shall not apply, instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401" (IDAPA 58.01.02.200.09). While the current Idaho State language represents a clarification of the original statement, both recognize the existence of conditions where the presence of natural sources can result in conditions that exceed applicable water quality standards.

Therefore, this approach is supported by both the current Idaho State Water Quality Standards, the Idaho State Water Quality Standards existing at the start of the SR-HC TMDL process, and Oregon State Water Quality Standards.

Although the salmonid rearing/cold water aquatic life designation and the associated targets are applied year-round, the critical time period for salmonid rearing/cold water aquatic life in the SR-HC TMDL reach is from June through September, when elevated water temperatures are most likely to occur. Water temperatures throughout the remainder of the year generally meet the target criteria.

3.6.1.2 Salmonid Spawning.

The temperature target identified for the protection of salmonid spawning when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is less than or equal to a maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C (temporary rule, effective by action of the IDEQ board 11-14-03, pending approval by Idaho Legislature 2005, subject to US EPA action). If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. (The State of Oregon definition of no measurable increase (0.14 ^{o}C) was used as it is more stringent than the State of Idaho definition of 0.3 ^{o}C.)

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

The temperature target for salmonid spawning is applicable only when and where salmonid spawning occurs within the SR-HC TMDL reach. This target applies to the Downstream Snake River segment (RM 247 to 188) only, and is specific to those salmonids identified to spawn in this area, namely fall chinook and mountain whitefish. This target is based on Idaho temperature

standards, which were found to be more stringent that Oregon salmonid spawning temperature standards.
Temperature targets for salmonid spawning in the SR-HC TMDL reach apply during critical time periods for salmonid spawning. These targets apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188). Critical time periods for salmonid spawning in the Downstream Snake River segment of the SR-HC TMDL reach are from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.

Critical time periods for fall chinook spawning were identified through site-specific data collected by IPCo and USFWS from 1991 through 2001. Fall chinook redds have been identified below Hells Canyon Dam as early as October 9th (IPCo, 2001c, 2001e). However, these early spawners represent less than 1.2 percent of the total number of fall chinook redds documented (Figure 3.6.0). The majority of fall chinook redds created were identified after October 23rd in all years. Of the total number of fall chinook redds counted, approximately 8 percent were present during the week of October 23rd, and approximately 30 percent were present during the week of October 30th. The remaining 70 percent were identified in the following weeks.

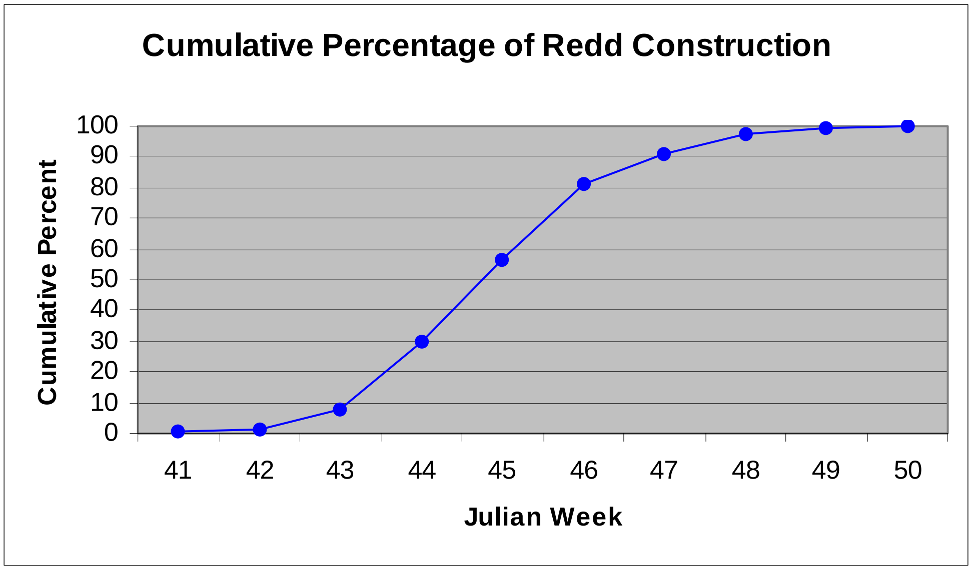


Figure 3.6.0. Cumulative percentage of redd construction for fall chinook observed in the Snake River below Hells Canyon Dam (RM 247) 1991 through 2001. Data collected by IPCo and USFWS (IPCo, 2002).

Given the fact that less than 1.2 percent of the identified fall chinook redds were in place prior to the week of October 23rd, it is the opinion of the DEQs that this week (October 23) represents a valid threshold for the initiation of fall chinook spawning below the Hells Canyon Dam. The fall chinook spawning period, based on this site-specific data, is therefore determined to extend from October 23rd to April 15th. This time period is also protective of the mountain whitefish spawning period (starting 01 November). Chinook spawning does not occur above Hells Canyon Dam, as the dam acts as a barrier to upstream migration.

The spawning and incubation times referenced in this document are based on existing site-specific data. If additional site-specific data on spawning and incubation times or a more complete understanding of critical water temperatures become available following the submission and approval of this TMDL, these data will be evaluated in the context of the iterative TMDL process. If it is determined that the additional data are appropriate to this TMDL, the time frames and/or temperatures identified for spawning and incubation will be updated as necessary to reflect the expanded data set and improved understanding of the SR-HC TMDL reach and related habitat and use-support needs; or a change in state standards for salmonid spawning.

3.6.1.3 SUMMARY OF SNAKE RIVER - HELLS CANYON TMDL WATER QUALITY TEMPERATURE TARGETS AND USE DESIGNATION.

The salmonid rearing/cold water aquatic life temperature target identified for the SR-HC TMDL reach applies to RM 409 to 188. This target is 17.8 ^{o}C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^{o}C. If and when the site potential is greater than 17.8 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. The critical time period for this target is from June through September.

The salmonid spawning temperature target identified for the SR-HC TMDL reach applies to RM 247 to 188. The target is a maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. This target applies only when and where salmonid spawning occurs and is specific to those salmonids identified to spawn in the designated segment (RM 247 to 188), namely fall chinook October 23rd through April 15th and mountain whitefish (November 1st through March 30th).

These targets apply when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

Note: The temperature analysis set forth in this TMDL does not specifically address attainment of Oregon's criterion for protection of Threatened and Endangered Species. Oregon will address this in the Section 401 certification analysis for the Hells Canyon Complex.

3.6.1.4 CHANGES TO STATE OF IDAHO WATER QUALITY STANDARDS.

As stated above, language regarding standard exceedences from naturally occurring sources is contained in the Idaho State Standards. Previously, Idaho standards stated that "where natural background conditions from natural surface or ground water sources exceed any applicable water quality criteria...that background level shall become the applicable site-specific water quality criteria" (IDAPA 58.01.02.07.06 (2000)). This language has been interpreted to require a rule-making change to establish natural background as a site-specific standard. A change to this language has been completed by the State of Idaho to clarify that "when natural background conditions exceed any applicable water quality criteria...the applicable water quality criteria shall not apply, instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401" (IDAPA 58.01.02.200.09 (2002)). This change was approved by the IDEQ Board and the Idaho State Legislature, effective 15 March 2002.

3.6.1.5 Pacific Northwest Temperature Criteria Guidance Project.

In addition to the proposed change to the Idaho standards, a much broader effort is currently underway to formulate regional temperature guidance for the Pacific Northwest. This effort, with participation from US EPA, USFWS, NMFS, the states of Idaho, Oregon and Washington, and Tribes, had been initiated to recognize and incorporate some of the natural variations in water temperature occurring throughout the region in temperature standards for the Pacific Northwest.

The goal of this project is to develop regional temperature criteria guidance that meets the biological requirements of native salmonid species for survival and recovery pursuant to ESA, provides for the restoration and maintenance of surface water temperature to support and protect native salmonids pursuant to the CWA, and meets the salmon rebuilding needs of federal trust responsibilities with treaty tribes. It is also a goal of this project that the guidance produced will recognize the natural temperature potential and limitations of water bodies. This guidance is also expected to be fashioned in a manner that will allow it to be effectively incorporated by states and tribes in water quality standards programs (US EPA, 2002).

Once this guidance is finalized, it is expected that the States and Tribes in the Pacific Northwest will use the new criteria guidance to revise their temperature standards, if necessary, and that US EPA, USFWS and NMFS will use the new criteria guidance to evaluate state and tribal standard revisions (US EPA, 2002).

These ongoing processes to effect changes to water temperature standards in the SR-HC TMDL reach will be monitored throughout this TMDL effort. If these processes result in changes to state or federal water quality criteria, such changes may be incorporated as appropriate into the SR-HC TMDL through the long-term, iterative nature of the TMDL process.

3.6.2 Designated Beneficial Use Impairment

The designated beneficial uses within the SR-HC TMDL reach determined to be most at risk from elevated water temperature were those associated with aquatic life. Both direct and indirect impacts to aquatic life are possible due to elevated water temperatures.

Direct negative effects of elevated water temperature include lower body weight, poor oxygen exchange and reduced reproductive capacity in aquatic species. Extreme high water temperatures can result in death if they persist for an extended length of time. Juvenile fish are more sensitive to temperature variations and duration than adult fish, and can experience negative impacts at lower water temperatures than adult fish.

Indirect effects associated with elevated water temperature include low dissolved oxygen concentrations due to the growth of algae in the upper water column (diurnal), and increased decomposition rate for organic materials in the lower water column. Elevated water temperatures can also lead to improved growth and decomposition conditions for aquatic nuisance growth such as algae. Appendix C contains more detailed information specific to temperature tolerances of fish species found in the SR-HC TMDL reach.

No specific data is available showing direct effects to fish or other aquatic life due to elevated water temperature in the SR-HC TMDL reach. However, information is available that show differences in fish populations relative to the availability of cool water refugia within the SR-HC TMDL system. These data, collected by IPCo fish biologists (IPCo, 2001g) show a convincing trend in population support where cold water refugia are available during periods of elevated water temperature within the mainstem Snake River. A more detailed discussion of this information is included in the following sections of this document.

Given this understanding, impairment of the salmonid rearing/cold water aquatic life designated beneficial use occurs in the Upstream Snake River segment (RM 409 to 335) where population and species diversity are limited. The salmonid rearing/cold water aquatic life designated beneficial use is supported in the other segments due to the availability of cold water refugia.

Data collected by IPCo and USFWS indicate that fall chinook spawning is occurring under existing conditions throughout the 100-mile reach of the Snake River from below Hells Canyon Dam (RM 245) downstream to Asotin WA (RM 145). While the SR-HC TMDL extends only to the confluence of the Salmon River, the entire 100 miles of the Snake River from Hells Canyon Dam downstream to Asotin, WA currently supports (to some extent) salmonid spawning activity.

Data available for the Downstream Snake River segment (RM 247 to 188) show that the salmonid spawning temperature targets are exceeded in the late fall of some years. Fall chinook have been documented to spawn in the Snake River between Hells Canyon Dam and Asotin, WA as discussed above. The majority of spawning activity occurs from mid-October through the first week of December. Currently, the peak of spawning in the river downstream of Hells Canyon Dam occurs when daily mean and maximum water temperatures are between 12 ^{o}C and l6 ^{o}C.

Data currently available on fall chinook spawning (IPCo, 2002, attachment 13 and 14) does not show impairment due to elevated water temperatures occurring in the late fall. Additionally, studies undertaken by IPCo suggest that warmer fall and winter water temperatures can cause accelerated hatching and fry development. The accelerated hatching and fry development may provide a survival benefit to out-migrating juvenile fall chinook. However, these data, and their interpretation, are preliminary and further study will help to further clarify the support status of fall chinook in this section of the SR-HC TMDL reach. Water temperature data (IPCo, 2002) collected downstream of the SR-HC TMDL reach show that the Snake River downstream of river mile 188 meets the SR-HC TMDL salmonid spawning targets during this time period (October/November).

It is recognized that water temperature is only one component of salmonid spawning habitat requirements. The ability to maintain stable flows during the spawning period provides benefits to salmonid spawning. Stable flows provide redd protection and minimize de-watering during the incubation period.

3.6.3 Sources

Elevated water temperature increases in the SR-HC TMDL reach are the result of a combination of sources. Both natural and anthropogenic sources of temperature are present in the SR-HC TMDL drainage. Anthropogenic sources of temperature loading to this reach include both point and nonpoint sources in the form of point source discharges, agricultural and stormwater drains, and tributary inflows.

3.6.3.1 Natural Sources.

Natural heat exchange through elevated air temperatures and direct solar radiation on the water surface play a major role in summer water temperatures. Both the mainstem Snake River and the inflowing tributaries drain basins located in hot, dry climates (See Figure 2.3 for average daily air temperatures in the SR-HC TMDL reach). These river systems are characteristically wide and relatively slow moving in the lower portions of their respective watersheds as compared to the upper watersheds. Native vegetation in all but the headwaters of most drainages is relatively low growing and sparse and therefore provides little shading on the wider, downstream sections of these river systems. These environmental factors play a dominant role in water temperatures in the SR-HC TMDL reach.

Aerial photos taken of the mainstem Snake River in 1909 from a hot air balloon show relatively little vegetative cover on the banks of the Snake River or the tributaries (See Photo 3.6.0). One of these photos has been included on the following pages; others are available through the Oregon Historical Society (Portland, Oregon). All the photos show approximately the same low, rolling, sparsely vegetated terrain extending down to the Snake River. All show that what trees are present (mostly what appear to be juniper) are small and somewhat limited in distribution. A few, more leafy trees are visible along some of the river and tributary banks, but they are all very small in comparison to the size of the mainstem river channel. The photos clearly show the lack of ability of this vegetation to shade the mainstem Snake River, or the tributaries. They also serve to demonstrate the open nature of the river system to solar radiation and atmospheric temperature influences. These photos were obviously not taken prior to the advent of white settlers in the basin, and are not intended to represent the pre-anthropogenic condition of the Snake River, but they do help to establish an understanding of historic site vegetation in the early 1900's, prior to extensive settlement of the area or substantial impoundment of the Snake River itself. It is recognized that migration west along the Oregon Trail, starting in the 1840's, and settlement, ranching and farming along the Snake River in the late 1800's had a substantial impact on the original vegetation bordering the Snake River and its tributaries. By 1909 the Snake River area had been grazed for a period of anywhere from decades to over half a century.

3.6.3.2 Anthropogenic Sources.

As discussed in detail in previous sections, the Snake River is a highly regulated river. Estimates indicate that nearly half the annual discharge is stored and diverted for irrigation upstream of the

Hells Canyon Complex of dams (usable storage capacity above Hells Canyon is ~10 million acre-feet, average annual runoff at Weiser, ID of 13.25 million acre-feet). With such a highly regulated system it is difficult to determine what are natural conditions for temperature, or precisely how altered current conditions are from natural conditions.

Photo 3.6.0 Aerial photograph (taken from a hot air balloon) of the Snake River near Vale, Oregon showing local vegetation in 1909. Photo courtesy of the Oregon Historical Society.

Photo 3.6.0 (cont.) Aerial photograph (taken from a hot air balloon) of the Snake River near Vale, Oregon showing local vegetation in 1909. Photo courtesy of the Oregon Historical Society.

Because of its length, temperature changes in the headwaters of the Snake River cause little if any detectable change in temperature downstream, yet flow alteration due to extensive flow regulation within the Snake River system has resulted in spring flows at Weiser, Idaho that are from 20 to 30 percent lower, and late summer/early fall flows that are typically 40 percent greater than before flow regulation began (Table 2.1.0). This increase in summer flows potentially acts to decrease naturally induced heating due to meteorological effects.

Additionally, nearly all the water in the Snake River is diverted for irrigation above Milner Dam (RM 639) from July through September, often longer. Below Milner Dam the Snake River is replenished by springs fed by subsurface recharge and ground water, rapidly gaining 5,000 to 6,000 cfs in water averaging 11 ^{o}C to 13 °C, and from extensive surface water return flows with water temperatures that are potentially higher than those of the groundwater springs. During summer months the water warms rapidly as it traverses the desert canyon it has cut through Idaho's Snake River Plain. Water temperatures between 22°C and 25°C are commonly observed at RM 345, ten miles above the headwaters of Brownlee Reservoir. These water temperatures are not much different than those currently found in the Salmon River near its mouth, as shown in Figure 3.6.1.

Unlike the Snake River, discharge of the Salmon River is effectively unregulated. (While there are a few small dams in some headwater tributaries, total storage capacity is less than 0.1 percent of the Salmon's average annual runoff). Large portions of its watershed are in wilderness or roadless areas and the watershed is very sparsely populated. These factors combine to make the Salmon River, while not pristine, the most natural river of its size anywhere in the lower 48 states. It follows that its existing water temperatures are close to natural as well.

Figure 3.6.1 a shows water temperatures observed in the Salmon River just above its confluence with the Snake River for 1991 through 1999. Long-term average summer water-temperatures in the Snake River above the Salmon River, and in the Salmon River itself, show differences of less than one degree, as illustrated in Figure 3.6.1 b. The July average water temperature over a decade of monitoring was 20.0 °C in the Snake River above the Salmon River inflow (RM 188) and 19.5 °C in the Salmon River. The August average water temperature for this same time period was 21.7°C in the Snake River above the Salmon River inflow and 21.1°C in the Salmon River (personal communication, Ralph Myers, Idaho Power Company, August 2002). Snake River water temperatures below Hells Canyon Dam are closer to those measured in the Salmon River than those measured upstream of Brownlee Dam (at RM 345) from January through September.

Permitted point source discharges to the SR-HC TMDL reach include four municipal and two industrial discharges to the Upstream Snake River segment (RM 409 to 335). The combined flow from all six of these point sources averages 10.5 cfs annually (less than 1/1000 of the total mainstem flow). This flow is further reduced during the summer growing season, as the City of Ontario discharge is land applied during that time period. Three additional permitted point sources discharge to the remaining downstream segments below Brownlee Reservoir. They are all related to the operation of the Hells Canyon Complex dams and have relatively minor flow contributions (54 cfs maximum permitted flow combined, approximately 0.3 percent than of the total mainstem flow).

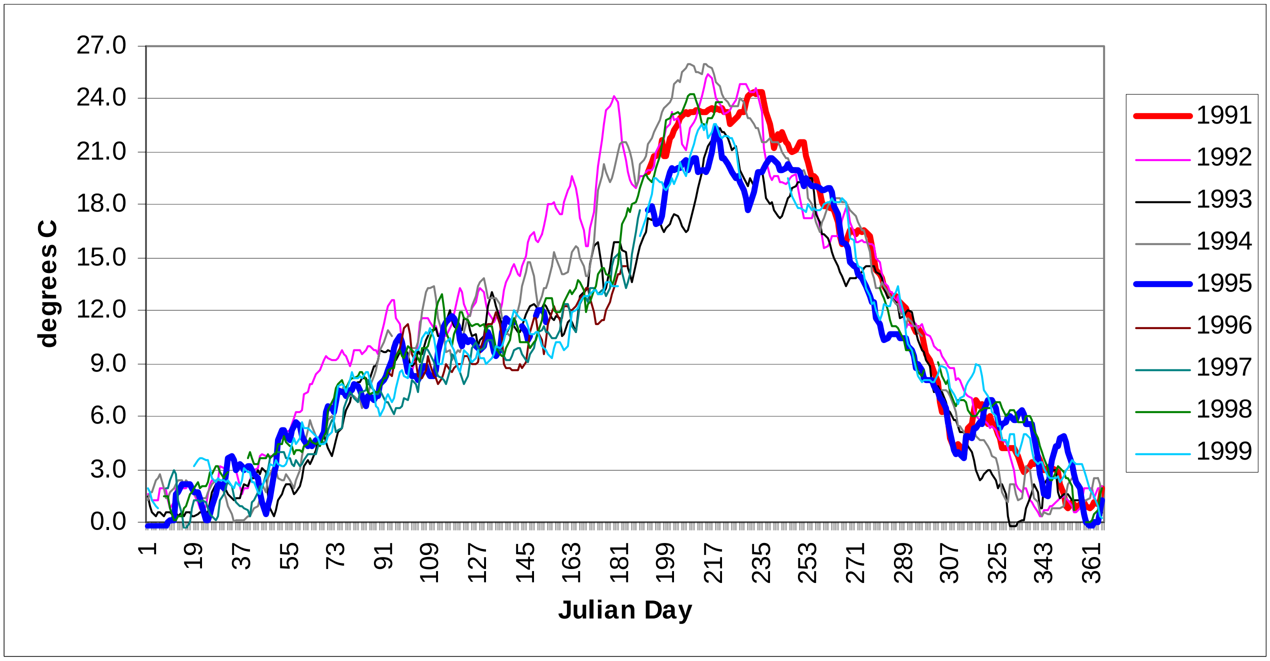


Figure 3.6.1 a. Water temperatures observed in the Salmon River near the confluence with the Snake River at Snake River mile 188. (1991 represents a low water year, 1995 represents a medium water year.)

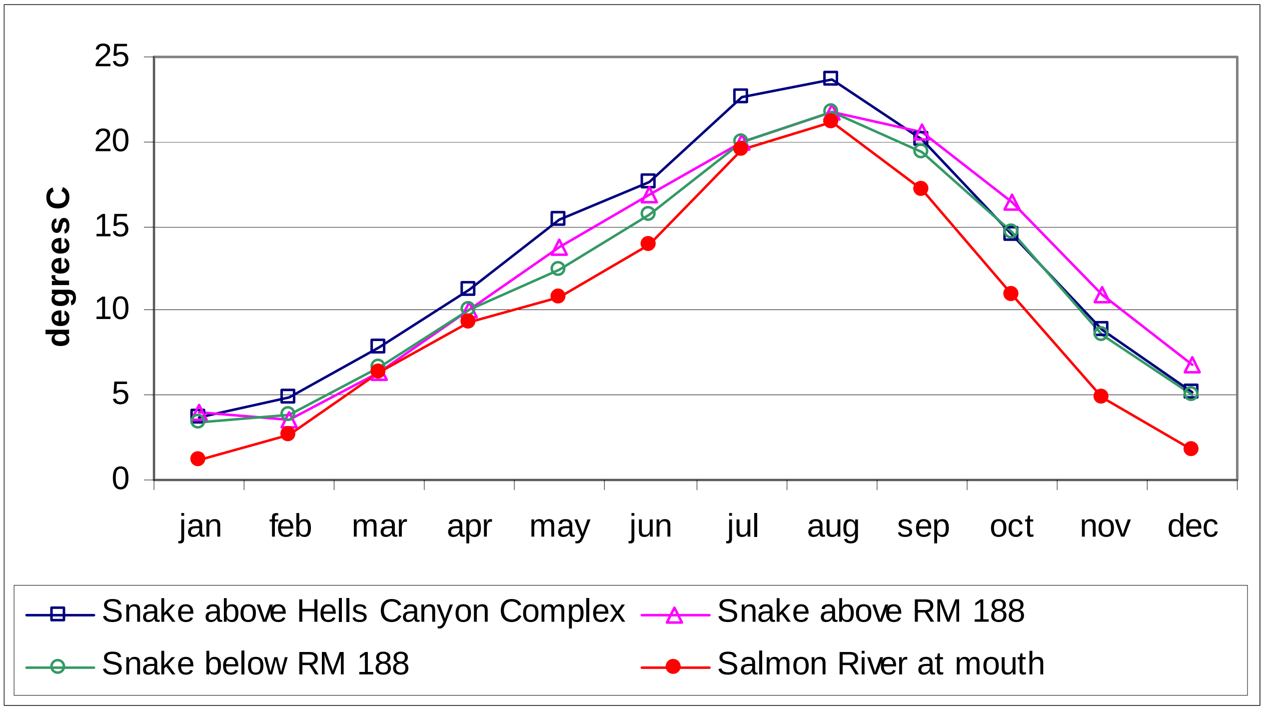


Figure 3.6.1 b. Long-term monthly mean water temperatures observed in the Snake and Salmon Rivers. (The Salmon River flows into the Snake at RM 188.)

Nonpoint sources of anthropogenic temperature increase include agricultural and stormwater drains, and tributary inflows. Agricultural, stormwater and other ungaged drains that discharge directly to the Snake River are estimated to contribute a combined flow of approximately 1,200 cfs annually (less than 8% of the total mainstem flow). Agricultural drain flows are highly seasonal in nature with the highest flow values occurring during the growing season (April to October) when irrigation is in use and very low flows, predominantly driven by precipitation or melt-off, occurring in the winter. The one exception to this trend is the conveyance of snowmelt flows in some drainages in the early spring when flows may exceed those observed during the irrigation season for short periods of time. Calculated agricultural return flows in the Upstream Snake River segment (RM 409 to 335) in the form of surface water range from 635 cfs to 764 cfs during June, July, August and September (USBR, 2001).

Tributary inflows to the SR-HC TMDL reach (including the mainstem Snake River above RM 409) total approximately 16,000 cfs annually, and approximately 14,000 cfs during the months of June, July, August and September (median water year). The tributaries to the SR-HC TMDL reach (including the mainstem Snake River above RM 409) represent the majority of the total mainstem flow. Tributary inflows are also seasonal in nature, as shown in Figure 2.8. The temperature of inflowing tributary waters is a combination of natural and anthropogenic temperature sources within the separate tributary drainages. Tributary water temperatures are seasonal in nature and generally do not deviate substantially from mainstem water temperatures during the critical months of June, July, August and September.

In addition to the above sources, ungaged flows, both ground and surface water, also represent temperature sources to the SR-HC TMDL. The annual water balance in median water years shows an average 6 percent difference (overall difference ranged from 1% to 12% depending on the specific water year) between the measured and estimated inflow and the measured instream flow. The water balance for June, July, August and September in median water years shows an average 9.7 percent difference (overall difference ranged from 5% to 14% depending on the specific month and water year) between the measured inflow and the measured instream flow. This ungaged gain/loss is due to a combination of ungaged inflows and diversions, ungaged overland runoff, ground water inflows, seepage losses, and gauge and estimation error.

3.6.3.3 Additional Considerations

It is recognized by this TMDL that temperature is a highly variable pollutant and therefore needs to be addressed differently from other, conservative pollutants. These considerations and the approaches taken to identify and address these issues are discussed in the following sections.

3.6.4 Data Available for the Snake River - Hells Canyon TMDL Reach

A fairly robust data set for water temperature was available to the SR-HC TMDL effort. Temperature data has been collected over the time period from 1954 to current for both mainstem Snake River and tributary sites. Historic data gathered prior to the construction and completion of the Hells Canyon Complex have been utilized to identify pre-impoundment (Hells Canyon Complex) water temperatures. They do not represent an unregulated or un-impounded system as diversions and upstream and tributary impoundments were in place in many areas when these data were collected. They do, however, lend a better understanding of the conditions that existed in the SR-HC TMDL reach prior to the completion of the Hells Canyon Complex of dams. These data are displayed in Tables 2.3.22 and 2.3.30 and in Figures 2.3.19 and 2.3.24 in the preceding sections of this document.

Current data, collected from 1991 through 2000 is also available. Although the available data sets are not consistent in coverage, and do not always include co-monitored flow values, they are helpful in an evaluation of water temperature trends within the system. Distribution of the recent water temperature data available is shown in Table 3.6.1. A total data set is available in Appendix E.

Table 3.6.1. Distribution of recent water temperature data available for the Snake River - Hells Canyon TMDL (1990 through 2000).

Sample Site	Distribution and Duration of Temperature data available
Snake River near Murphy (RM 460 to 450)	Daily min, max, mean 03/1996 to 04/1997 06/1997 to 02/1998 04/1998 to 04/1999 10/1999 to 01/2000 04/2000 to 09/2000 11/2000 to 12/2000
Owyhee River Mouth (RM 396.7)	Daily min, max, mean 07/1996 to 08/1999 07/2000 to 08/2000 (From hourly temperature readings)
Boise River Mouth (RM 396.4)	Daily min, max, mean 11/1995 to 07/1996 05/1997 to 09/1997 11/1998 to 12/1998 01/1999 to 09/1999
Snake River at Nyssa (RM 385)	Daily mean – 04/1990 to 04/1991 Daily min, max, mean 03/1996 to 04/1999 01/2000 to 09/2000 12/2000
Malheur River Mouth (RM 368.5)	Daily min, max, mean 07/1996 to 08/1999 07/2000 to 08/2000 (From hourly temperature readings)
Payette River Mouth (RM 365.6)	Daily min, max, mean 08/1997 to 09/1997 07/1998 to 08/1998 05/1999 to 09/1999
Snake River near Weiser (RM 351 to 355)	Daily min, max, mean 03/1996 to 09/1999 01/2000 to 07/2000 10/2000 to 12/2000 RM 345, daily max, mean, min 01/1991 to 12/2001
Weiser River Mouth (RM 351.6)	Daily min, max, mean 08/1997 to 09/1997 06/1998 to 09/1998 05/2000 to 09/2000
Snake River at Porters Island (RM 340)	Daily mean – 04/1990 to 04/1991
Drains	Instantaneous measurements

Sample Site	Distribution and Duration of Temperature data available
	01/1975 to 12/1975 08/1977 05/1978 to 12/1978 01/1979 to 11/1979 01/1980 to 09/1980 (all dates not available for all drains, flow not available for all dates or drains)
Brownlee Reservoir (RM 335 to 285)	Mixed – depth and surface, not daily 03/1992 to 12/1992 03/1995 to 12/1995 03/1997 to 12/1997 03/1999 to 12/1999 Brownlee Dam outflow, daily max, mean, min 01/1991 to 12/2001
Oxbow Reservoir (RM 285 to 272.5)	Mixed – depth and surface, not daily 03/1995 to 11/1995 03/1997 to 11/1997 Oxbow Dam outflow, daily max, mean, min 01/1991 to 12/2001
Hells Canyon Reservoir (RM 272.5 to 247)	Mixed – depth and surface, not daily 01/1995 to 12/1975 01/1997 to 12/1979 Hells Canyon Dam outflow, daily max, mean, min 01/1991 to 12/2001
Downstream Snake River Segment (RM 247 to 188)	Mixed 01 to 12/1975 to 1989, not daily (all dates not available for all years) RM 239 to 192, daily max, mean, min 01/1991 to 12/2001

Data in this table are from US EPA STORET, 1998a; IPCo, 1999a, 2000a, 2000c and USGS, 1999.

3.6.5 Existing Conditions and Observed Water Temperatures

Figure 3.6.2 a shows the daily maximum water temperatures at several locations in the SR-HC TMDL reach. Data displayed is from 1999 and 2000 (relatively average water years). For the sake of comparison, similar data from 1990 and 1991 (relatively low water years) has been plotted for those locations for which it is available. As evidenced by the following plots, the absolute magnitude of change is specific to the data plotted, but the overall trends are consistent from year to year. The temperature of water inflowing from the upstream Snake River at RM 409, and the water temperature at all monitored locations within the SR-HC TMDL reach is often substantially warmer than the salmonid rearing/cold water aquatic life criterion during the summer months, especially July and August. By contrast, the water released from Brownlee, Oxbow and Hells Canyon dams is substantially cooler and does not show as great or extensive a level of exceedence.

3.6.5.1 UPSTREAM SNAKE RIVER SEGMENT.

As water moves downstream within the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach, it gradually becomes warmer, and its temperature fluctuates more widely over time. Direct measurement of water temperature in the Snake River inflowing at RM 409 is not available. Measurements taken at Murphy, Idaho (RM 453.5) located upstream of the

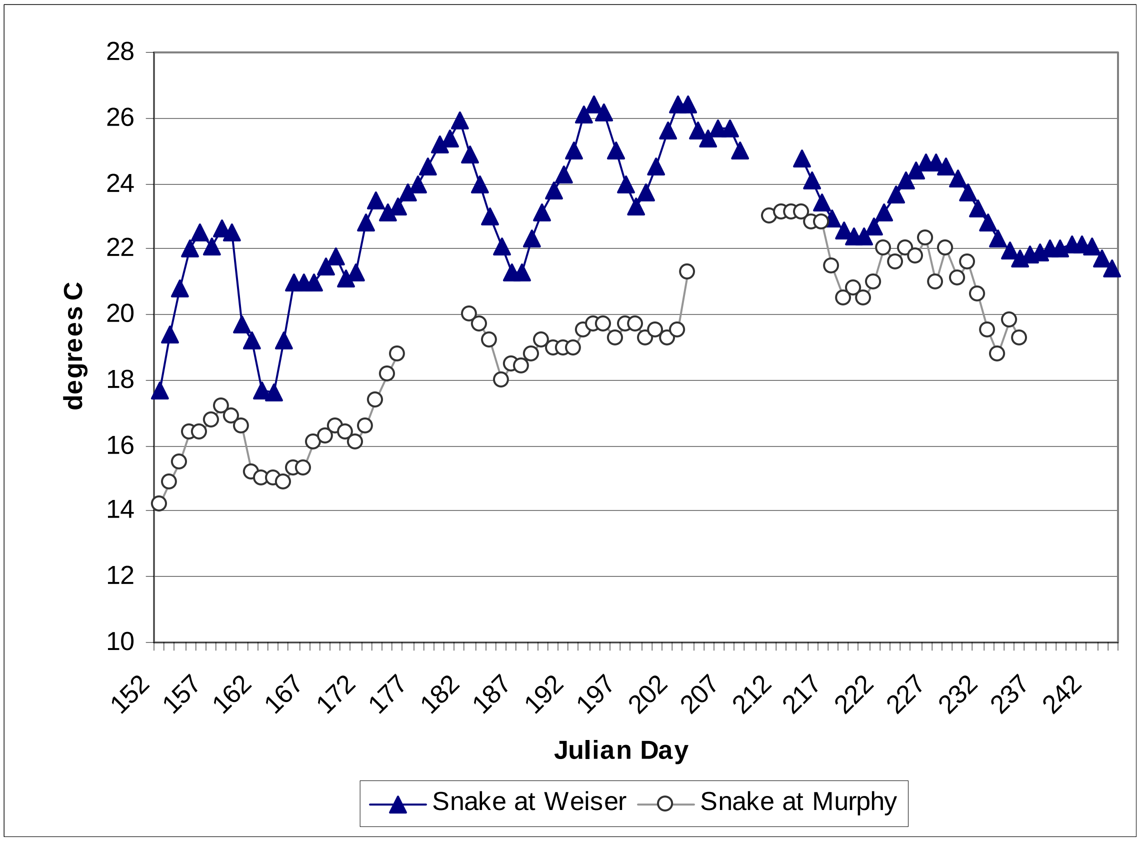


Figure 3.6.2 a – average water year. Daily maximum water temperatures observed in the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL reach, June 01 through August 30 1999-2000. (Precipitation in 1999 and 2000 was approximately 118% of the 30-year average.)

Idaho/Oregon border, show that the mainstem Snake River meets water quality criteria established for the support of salmonid rearing/cold water aquatic life from the first of September through the middle of June. Water temperatures at this site are above 17.8 ^{o}C from late June through late September (Julian days 177 to 265) in an average water year. In a dry water year this time period increases to include nearly the entire month of June.

Water temperatures rise gradually through the months of May and June, commonly peaking near 23 ^{o}C at the beginning of August and then decrease steadily through the month, reaching temperatures below the target by early September. Figure 3.6.2 a shows water temperatures throughout the summer for an average and a dry year in the Upstream Snake River segment (RM 409 to 335). Water temperatures above the 17.8 ^{o}C occur from early July through the end of August (Julian days 182 to 243). Given the above information, the critical time period for salmonid rearing/cold water aquatic life in the SR-HC TMDL reach includes the months of June, July, August and September. These values are tabulated in Table 3.6.2.

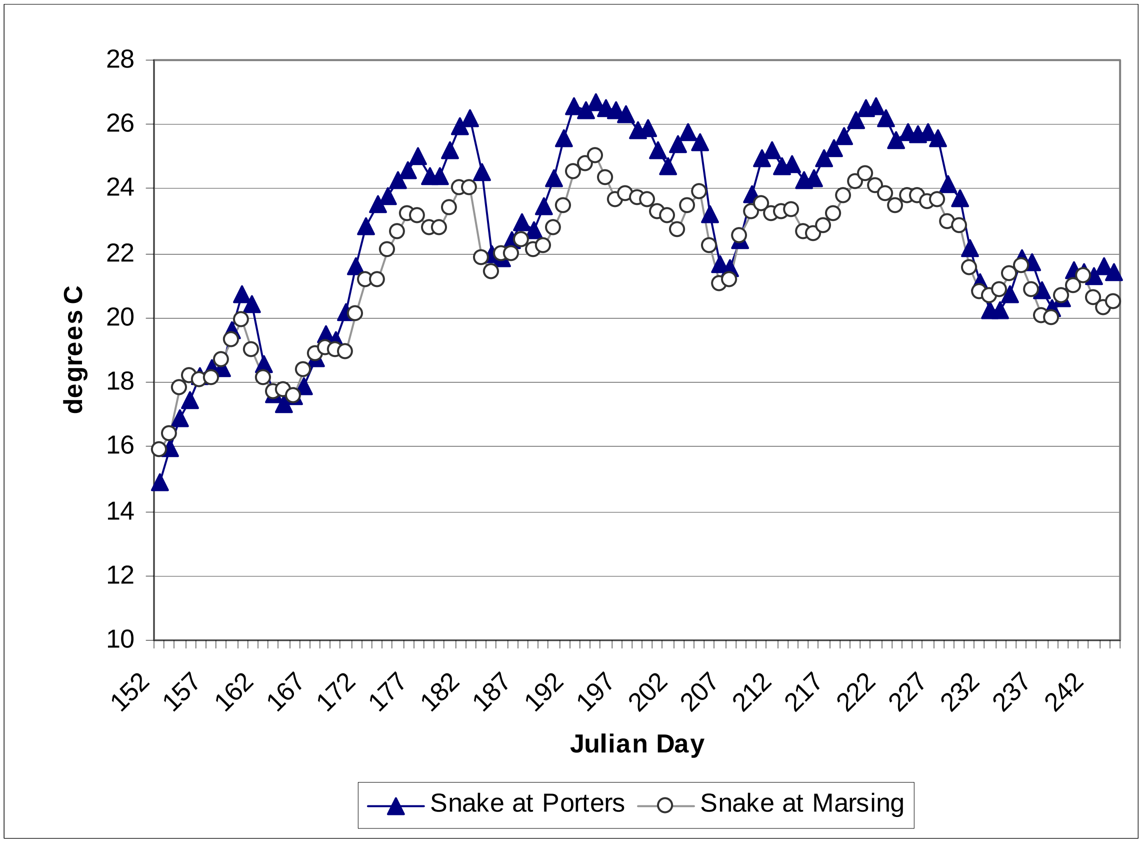


Figure 3.6.2 a – low water year. Daily maximum water temperatures observed in the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL reach, June 01 through August 30 1990 to 1991. (Precipitation in 1990 and 1991 was approximately 54% of the 30-year average.)

The trend observed in the mainstem Snake River near Murphy, Idaho (RM 453.5) is repeated in data collected downstream near Weiser, Idaho (RM 351). Temperatures observed in the mainstem Snake River near Weiser, Idaho (RM 351) show that the mainstem Snake River meets the water quality targets established for the support of salmonid rearing/cold water aquatic life from the first of October through the end of May. Routine, nearly continuous exceedences of the 17.8 °C target value are observed in the months of June, July, and August (Julian days 152 to 242) in both average and dry water years. Consistent daily maximum water temperature data is not available for September but the trend in water temperature evident at the end of August would project that exceedences would potentially occur through most of September (Julian days 243 to 274). Water temperatures in this section of the river rise gradually through the month of May, commonly peaking near 26 °C near the middle of July and then decrease through August and September, reaching temperatures below the 17.8 °C target in October.

In general, in an average water year, water temperatures measured in the mainstem Snake River near Weiser are approximately 5 °C higher than those observed near Murphy during early to mid-summer (4.8 °C in June, 4.9 °C in July). During the month of August, this difference narrows to approximately 2.2 °C as mainstem water temperatures begin to decrease within the Snake River system.

Table 3.6.2. Time periods of temperature target and standard exceedence for the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL reach.

	Target or standard value	Days at or below the target value	Days consistently greater than target value
Snake River at Murphy			
SR-HC TMDL salmonid rearing/cold water aquatic life target (State of Oregon salmonid rearing standard)	17.8 °C 7-day daily maximum average water temperature	01 Sept to 22 June (244 to 173)	23 June to 31 Aug (174 to 243)
State of Idaho cold water aquatic life temperature standard	22 °C instantaneous temperature	17 Aug to 29 July (229 to 210) 05 Aug to 09 Aug (217 to 221)	30 July to 04 Aug (211 to 216) 10 Aug to 16 Aug (222 to 228)
State of Idaho cold water aquatic life temperature standard	19 °C maximum daily average water temperature	01 Sept to 30 June (244 to 181)	01 July to 31 Aug (182 to 243)
Snake River at Weiser			
SR-HC TMDL salmonid rearing/cold water aquatic life target (State of Oregon salmonid rearing standard)	17.8 °C 7-day daily maximum average water temperature	02 Oct to 31 May est. (275 to 151)	01 June to 01 Oct est. (152 to 274)
State of Idaho cold water aquatic life temperature standard	22 °C instantaneous temperature	31 Aug to 03 June (243 to 154) 09 June to 20 June (160 to 171) 05 July to 06 July (186 to 187) 23 Aug to 25 Aug (235 to 237)	04 June to 08 June (155 to 159) 21 June to 04 July (172 to 185) 07 July to 22 Aug (188 to 234) 26 Aug to 30 Aug (238 to 242)
State of Idaho cold water aquatic life temperature standard	19 °C maximum daily average water temperature	11 June to 12 June (162 to 163) 16 Sept to 01 June (259 to 152)	02 June to 10 June (153 to 162) 13 June to 15 Sept est. (164 to 258)

Julian days are given in parentheses below the calendar dates

In general, in a dry water year, much smaller differences upstream to downstream are observed in water temperatures measured in the mainstem Snake River. Water temperatures measured near Porters Island (downstream of Weiser) are approximately 1 °C higher than those observed near Marsing (downstream of Murphy) during the early to mid-summer (0.8 °C in June, 1.5 °C in July). During the month of August, this difference narrows to approximately 1.1 °C as mainstem water temperatures begin to decrease within the Snake River system.

3.6.5.2 Brownlee Reservoir Segment.

Temperatures recorded historically (1957) at the Brownlee Dam-site prior to construction show that the average daily maximum water temperature in the river was 18.6 °C during June, 22.1 °C during July, 21.2 °C during August and 18.3 °C during September. Mean daily average water temperatures for this year showed that the water temperature exceeded 17.8 °C for the June through September time period and exceeded 19 °C during the months of July and August. During the month of July, daily maximum water temperatures averaged greater than 22 °C

(Table 2.3.21 and Figure 2.3.23). While these data do not represent pristine conditions (there were impoundments upstream at this time), they demonstrate quite conclusively that elevated water temperatures (above target values) do not occur solely as the result of the Hells Canyon Complex of impoundments within the SR-HC TMDL reach.

As identified in the previous discussion, water flowing into Brownlee Reservoir from the Upstream Snake River segment (RM 409 to 335) is often warmer than the salmonid rearing/cold water aquatic life maximum criterion during the summer months. Within the reservoir, the surface waters continue to warm as they move downstream, while deeper waters cool. A report on Brownlee Reservoir authored by IPCo in 1999 (IPCo, 1999d) states that Brownlee Reservoir consistently experiences thermal stratification during summer months, with the thermocline forming near the elevation of approximately 1948 ft (~37 m below the surface elevation at full pool) and extending approximately 25 miles upstream of the dam (Figure 3.6.2 b). The reservoir is typically stratified from March until November.

Surface waters in the reservoir are often warmer than the salmonid rearing/cold water aquatic life maximum criterion during the summer months. The temperature of hypolimnion waters is generally less than 10 ^{o}C, while surface water temperatures can reach above 26 ^{o}C. The strongest thermal stratification occurs during the months of July and August. Cooling starts to occur in surface waters in September, leading to a gradual breakdown of stratification in November.

Data collected by IPCo in 1992, 1995 and 1997 (Figure 3.6.2 b) show that maximum surface water temperatures generally range from 20 ^{o}C to 23 ^{o}C in early July to 23 ^{o}C to 26 ^{o}C in August. The Brownlee Reservoir Model Report (IPCo, 1999d) states that a maximum surface water temperature of 29 ^{o}C was recorded near Brownlee Dam. Minimum surface water temperatures observed in the report (surface to a depth of 50 feet) ranged from 18 ^{o}C to 20 ^{o}C in early July and 20 ^{o}C to 22 ^{o}C in August in 1992 and 1995. Surface waters exceeded 24 ^{o}C in August.

In 1995, a reasonably average year, instantaneous measurements of surface water temperature (<1 m below the surface) averaged 13.5 ^{o}C during May, 18.4 ^{o}C during June, 24.0 ^{o}C during July, 23.7 ^{o}C during August, 20.3 ^{o}C during September and 17.1 ^{o}C during October. Instantaneous water temperature data collected at a depth of 15 m (45 feet) averaged 12.2 ^{o}C during May, 17.3 ^{o}C during June, 20.5 ^{o}C during July, 21.7 ^{o}C during August, 20.6 ^{o}C during September and 16.3 ^{o}C during October. Similar data, collected by the Boise City Public Works in 1999 (BCPW, 2001), show surface water temperatures that ranged from 19 ^{o}C to 25 ^{o}C in July, and 22 ^{o}C to 26 ^{o}C in August. Temperatures near the metalimnion ranged from 19 ^{o}C to 23 ^{o}C in July and from 22 ^{o}C to 23 ^{o}C in August. Deep (hypolimnetic) water temperatures ranged from 12 ^{o}C to 15 ^{o}C in July and from 12 ^{o}C to 14 ^{o}C in August over the same time period.

The stratification of the reservoir and the resulting water temperature ranges are dependent on the operation of the reservoir as a mechanism for flood control. The Brownlee Reservoir Model Report (IPCo, 1999d) compares 1992 data to 1997 data to illustrate this difference (Figure 3.6.2, 1992 and 1997). In 1992, relatively low precipitation levels necessitated little drawdown for flood control purposes, while above average precipitation levels in 1997 necessitated substantial drawdowns. During the summer of 1997, the report states that the volume of water in the reservoir below 10 ^{o}C was nearly nonexistent due to heating from shallow depths and delayed

Figure 3.6.2 b – 1992 Temperature isopleths for Brownlee Reservoir for June, July and August of 1992 (a dry water year). (Data collected and plotted by Idaho Power Company.)

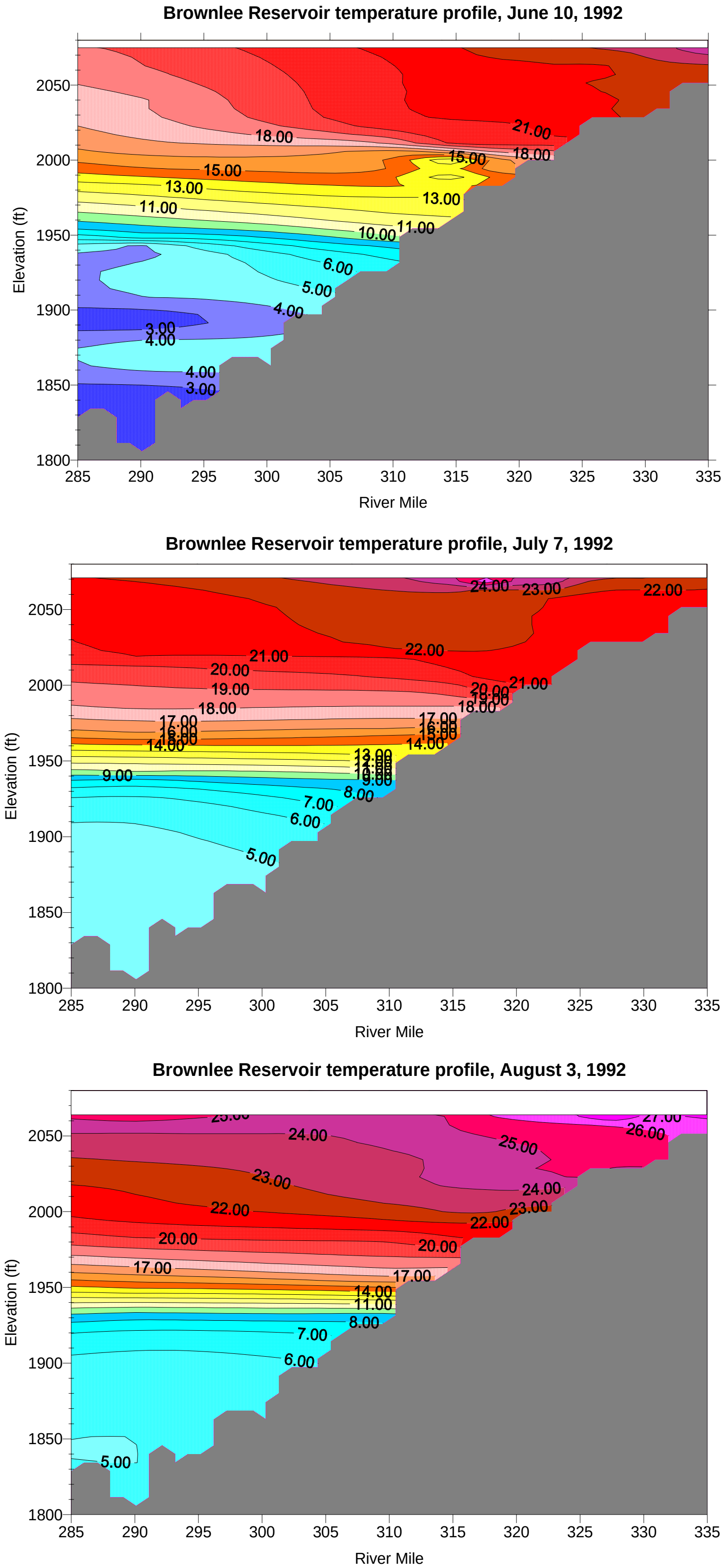
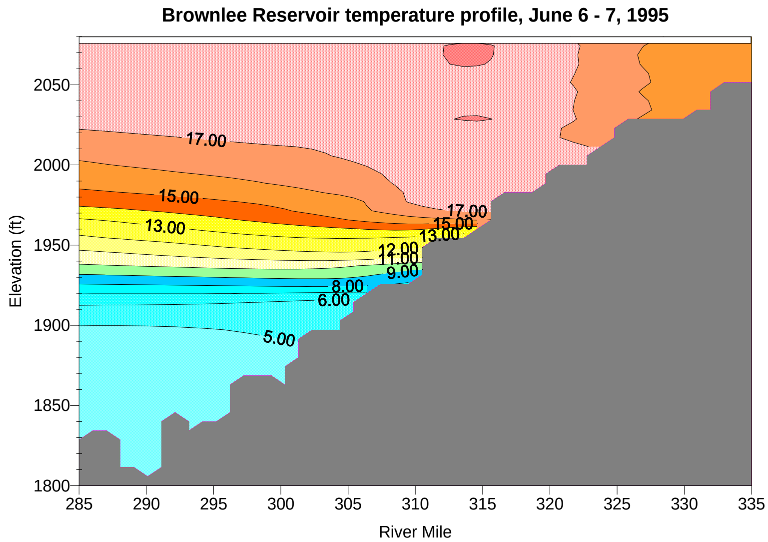
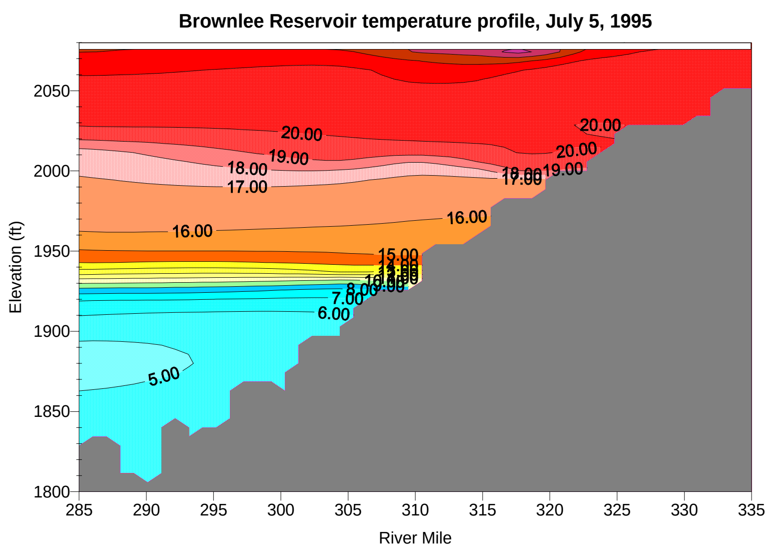


Figure 3.6.2 b – 1995 Temperature isopleths for Brownlee Reservoir for June, July and August of 1992 (an average water year). (Data collected and plotted by Idaho Power Company.)





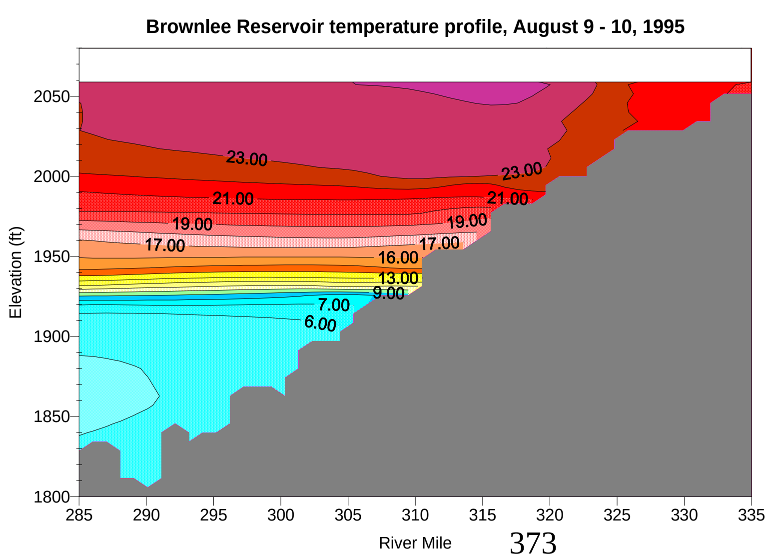
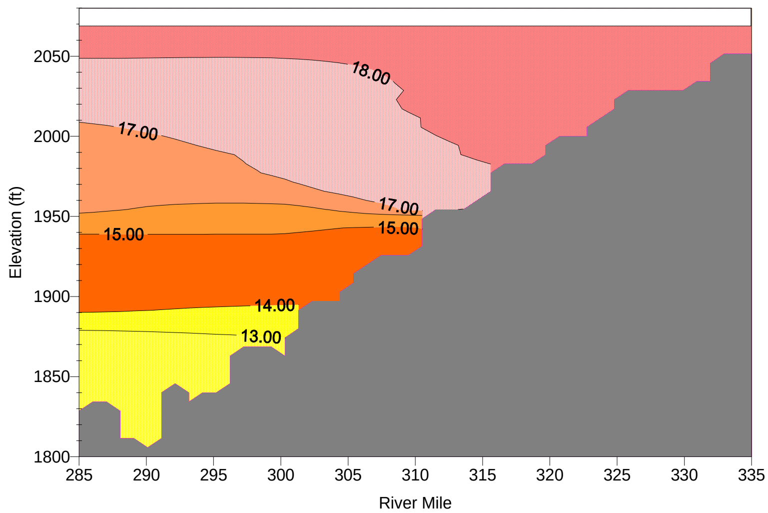
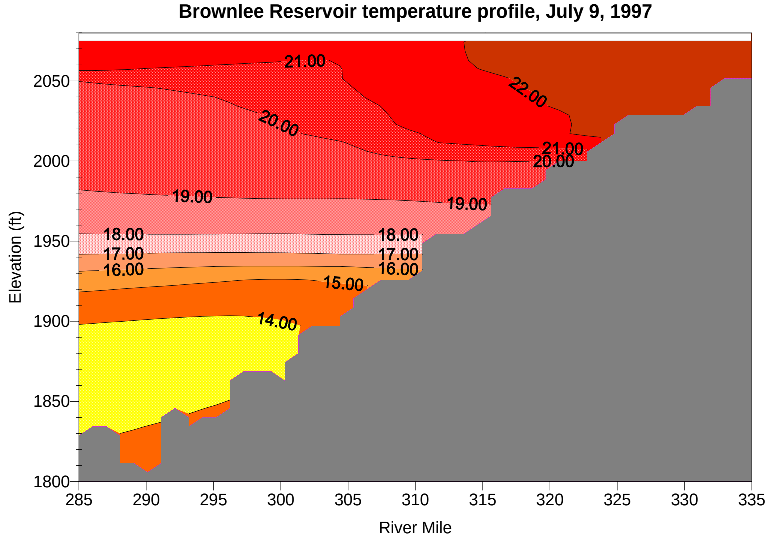


Figure 3.6.2 b – 1997 Temperature isopleths for Brownlee Reservoir for June, July and August of 1992 (a high water year). (Data collected and plotted by Idaho Power Company.)

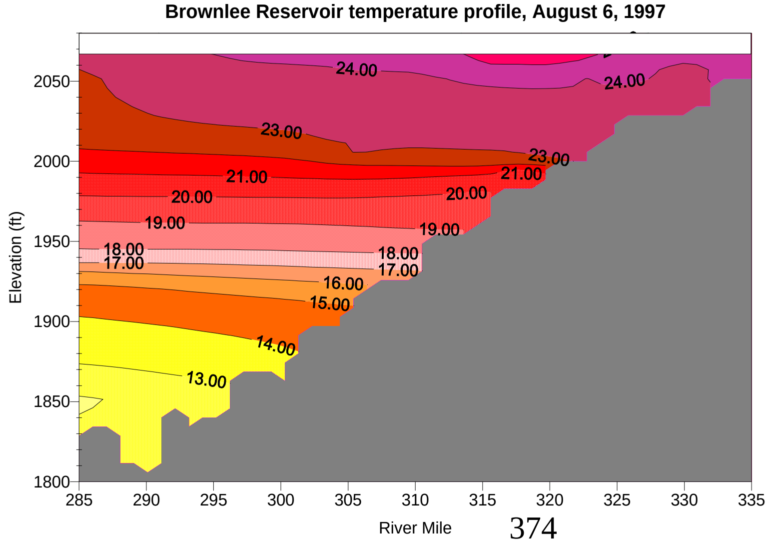
Brownlee Reservoir temperature profile, June 11, 1997



Brownlee Reservoir temperature profile, July 9, 1997



Brownlee Reservoir temperature profile, August 6, 1997



storage. Water temperatures at the thermocline in July of 1992 were approximately 11 ^{o}C, in July of 1997 the temperature was approximately 17 ^{o}C. Similarly, hypolimnion temperatures for the two years were 5 ^{o}C and 13 ^{o}C, respectively. Substantial drawdown within the reservoir system results in higher overall water temperatures due to more effective heating within the shallower reservoir depths, and less storage of cold, snow-melt runoff water. Figure 3.6.2 b, from the Brownlee Reservoir Water Quality and Model Development Report (IPCo, 1999d) illustrates the temperature variability within the reservoir and the influence of drawdown timing and magnitude on water temperatures during the summer months.

The greater surface area of Brownlee Reservoir allows more solar and atmospheric influence on temperature within the surface water layers. However, increasing depth and channel width act to cool the majority of the water volume below the inflow temperature. While water at the surface in Brownlee Reservoir is observed to exceed the salmonid rearing/cold water aquatic life maximum criterion during the summer months, water in deeper layers of the reservoir is substantially cooler and does not show as great or extensive a level of exceedence.

3.6.5.3 Oxbow Reservoir Segment.

Temperatures recorded historically (1954 to 1957) at the Oxbow Dam-site prior to construction (Table 2.3.30) show that the average daily maximum water temperature in the river was greater than 17.8 ^{o}C from June through September for all four years. The trend observed here shows a pattern very similar to that observed at the Brownlee Reservoir Dam-site prior to construction. While these data do not represent pristine conditions (there were impoundments upstream at this time), they demonstrate quite conclusively that the elevated water temperatures (above target values) currently observed do not occur solely as the result of the Hells Canyon Complex of impoundments within the SR-HC TMDL reach.

Oxbow Reservoir is a moderately sized, run-of-river reservoir, and water passes through very quickly (approximately 1.4 days). As shown by the temperatures in the metalimnetic waters of Brownlee Reservoir, water flowing into Oxbow Reservoir is often cooler than the river inflow to Brownlee Reservoir. The majority of the water flowing into Oxbow Reservoir is released from the outlet of Brownlee Dam. Water released from the outlet of the dam is from the lower water column of Brownlee Reservoir and therefore remains cooler during summer months than surface water layers. Water temperature data available to this TMDL effort for the downstream portion of Oxbow Reservoir are very limited, and most were collected in the mid to late 1970's.

In the absence of a complete, reservoir-wide data set, this TMDL effort recognizes that most of the water entering Oxbow Reservoir is from the outlet of Brownlee Dam (Figure 3.6.2 c). The temperature of water introduced into Oxbow is generally cooler than that of the surface waters upstream of Brownlee Dam. Temperature ranges and depth related trends are expected to mimic those observed in Brownlee Reservoir. As Oxbow is a small, run-of-river reservoir, water passes through very quickly, and an increase in water temperature is more likely to be observed at the downstream end of the reservoir as a result of atmospheric conditions than at the immediate outlet of the dam.

The small data set available for downstream portions of Oxbow Reservoir contains only instantaneous measurements of surface water temperature, not daily maximum temperatures and

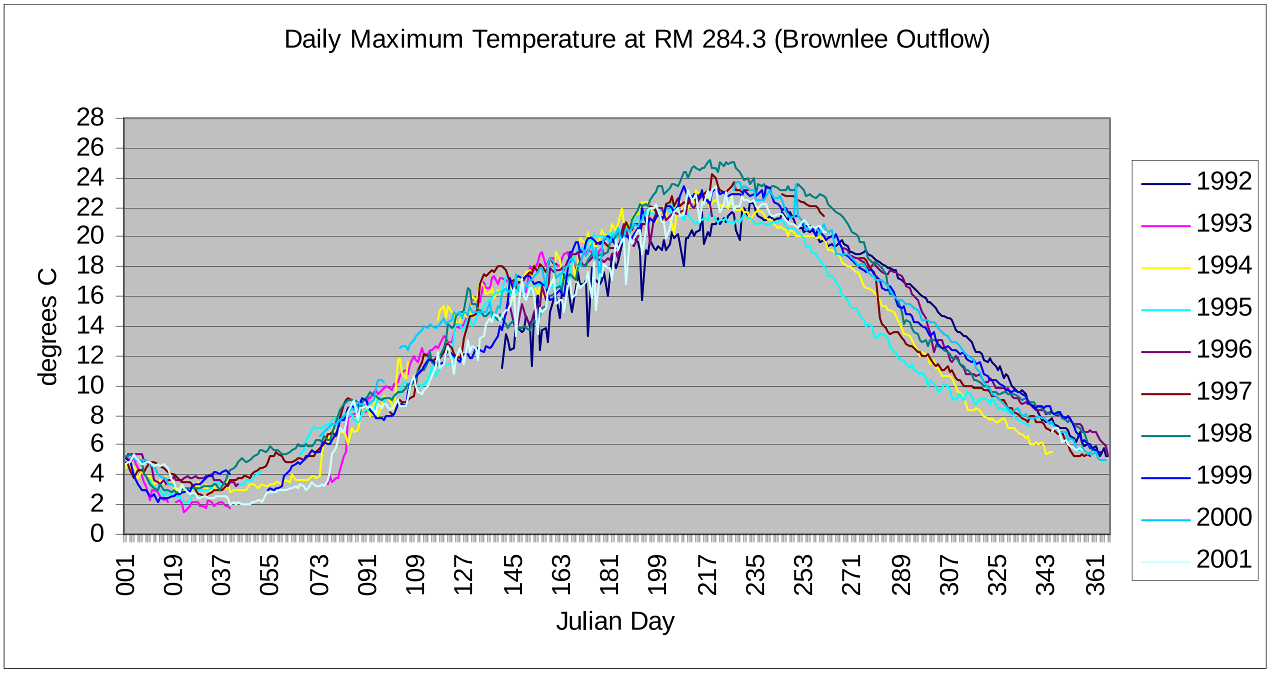


Figure 3.6.2 c Water temperatures observed at the outflow of Brownlee Reservoir in the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

therefore cannot be used to determine whether or not an exceedence of water quality standards or target values has occurred. However, the limited data available show that surface water near the dam (at RM 272.3) in Oxbow Reservoir is at slightly warmer temperatures than those measured at the outlet of Brownlee Dam in the early summer (approximately 2 ^{o}C during the month of June). This difference decreases later in the summer when the water entering Oxbow from Brownlee Reservoir upstream is warmer (0.5 ^{o}C increase). Water temperature overall increases during summer months. Instantaneous surface water temperature data collected at RM 284.3 are routinely above 17.8 ^{o}C from July through September (Julian days 182 through 273). The fact that the majority of water discharging into Oxbow Reservoir exhibited water temperatures above 17.8 ^{o}C indicate that surface water temperatures in downstream portions of Oxbow Reservoir were, most likely, also above 17.8 ^{o}C during this same time frame.

Similar to the trends observed in Brownlee Reservoir, increasing depth and channel width in Oxbow Reservoir act to minimize the effect of natural sources of warming in the majority of the water volume.

3.6.5.4 HELLS CANYON RESERVOIR SEGMENT.

Surface water temperature data is not available for downstream portions of Hells Canyon Reservoir. The majority of the water entering Hells Canyon Reservoir is from the outlet of Oxbow Dam (Figure 3.6.2 d), and is somewhat cooler than that of surface waters upstream of Oxbow Dam.

Hells Canyon Reservoir is a moderately sized, run-of-river reservoir, and water passes through very quickly (approximately 4 days). An increase in surface water temperature is more likely to

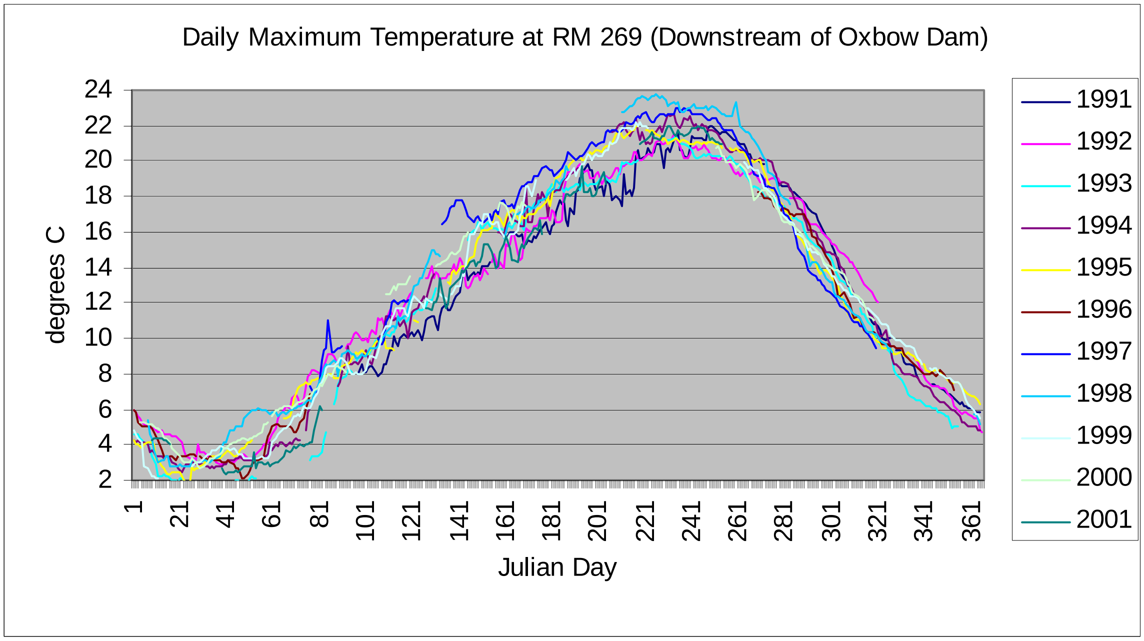


Figure 3.6.2 d. Water temperatures observed downstream of the outflow of Oxbow Reservoir (RM 269) in the Hells Canyon Reservoir segment (RM 272.5 to 247) of the Snake River - Hells Canyon TMDL reach.

be observed at the downstream end of the reservoir as a result of atmospheric conditions than at the immediate outlet of the dam. Data collected from downstream of the outlet of Oxbow Dam (RM 269) between 1991 and 2001 show water temperatures above 17.8 °C during the months of July, August and September (Julian days 182 through 273). The fact that the majority of water discharging into Hells Canyon Reservoir exhibited water temperatures above 17.8 °C indicate that surface water temperatures in downstream portions of Hells Canyon Reservoir were, most likely, also above 17.8 °C during this same time frame.

Similar to the trends observed in the upstream reservoirs (Brownlee and Oxbow), increasing depth and channel width in Hells Canyon Reservoir act to minimize the effect of natural sources of warming in the majority of the water volume.

3.6.5.5 DOWNSTREAM SNAKE RIVER SEGMENT.

Water moving through the outlet of Hells Canyon Dam represents the dominant source of flow to the Downstream Snake River segment (RM 247 to 188). Water temperature data available for the Downstream Snake River segment includes three years of monthly average temperatures from June 1955 through June 1958 at RM 203 below the Hells Canyon dam, and 10 years (1991 through 2001) of daily minimum, mean and maximum water temperature data provided by IPCo for various sites within the Downstream Snake River segment (RM 247 to 188). Water temperatures measured immediately downstream from the outlet to Hells Canyon Dam (Figure 3.6.2 e) show exceedences of the 17.8 °C target in July, August, and September (Julian days 182 through 273). Water temperatures further downstream of the outlet of Hells Canyon Dam (Figure 3.6.2 f), show summer high temperatures above 17.8 °C for most of June, July, August and September (Julian days 152 through 273).

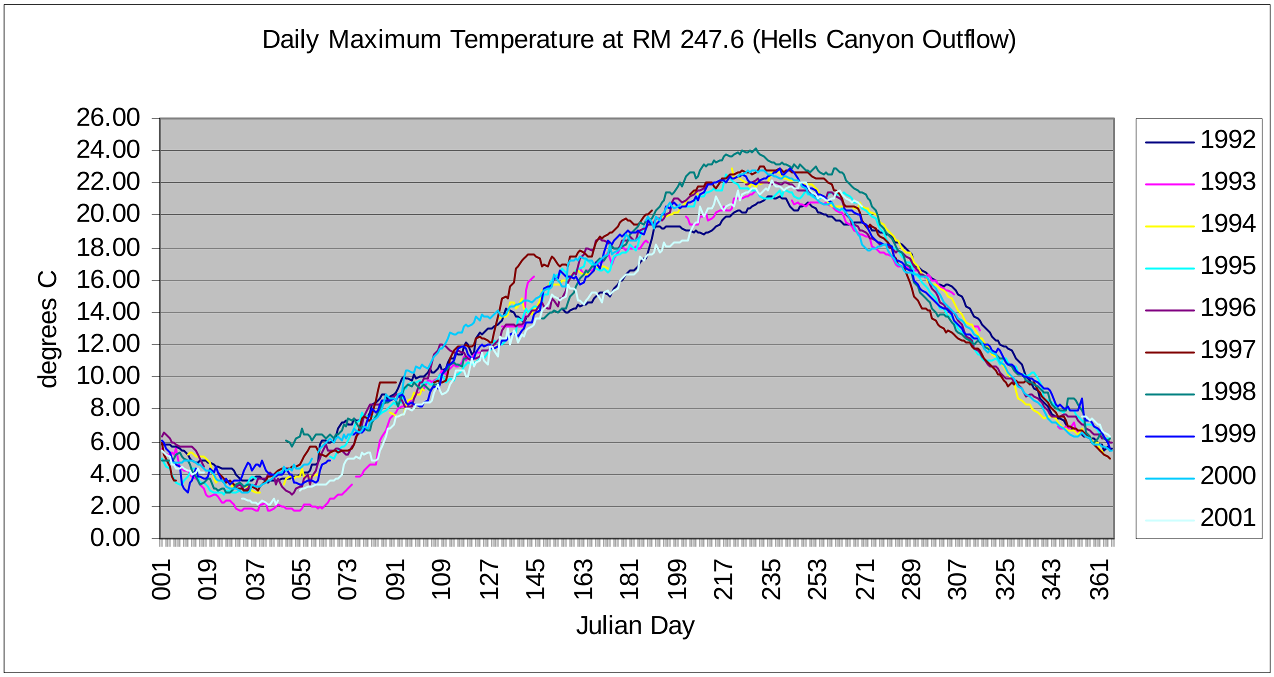


Figure 3.6.2 e. Water temperatures for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach near Hells Canyon Dam.

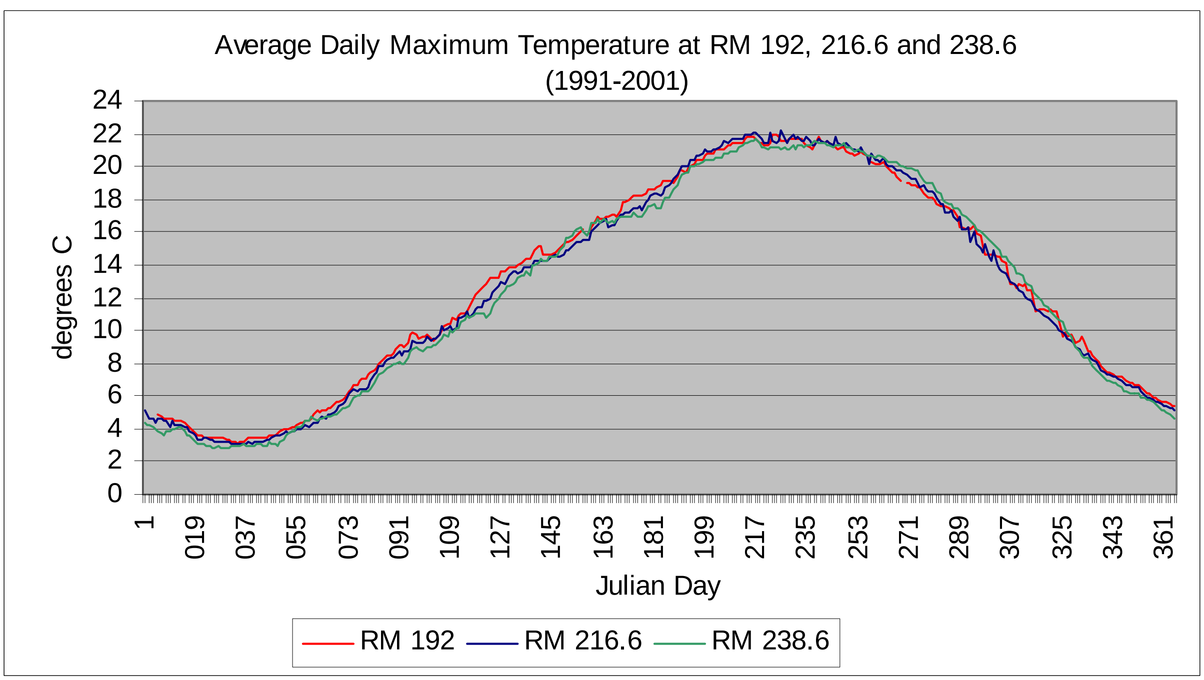


Figure 3.6.2 f. Water temperatures for the Downstream Snake River segment (RM 247 to 188) of the Snake River - Hells Canyon TMDL reach.

Average conditions over the 10 year time period available, as plotted in Figure 3.6.2 f, show only minor temperature change occurring between the outlet of Hells Canyon Dam (RM 247) and the inflow of the Salmon River (RM 188). A more discernable, general trend in water temperature can be observed over the course of a single year as in Figure 3.6.2 g, where fall water temperatures leaving Hells Canyon Dam are slightly warmer than those downstream.

During the early summer months (20 June to 03 August, Julian day 170 to 215), as water moves downstream, temperatures at RM 192 are observed to be slightly warmer (by approximately 0.4 ^{o}C maximum in 1995) or very similar to water temperatures near the outlet of Hells Canyon Dam (RM 239). The opposite trend is observed in the later summer months (08 August to 01 October, Julian day 220 to 274) when temperatures at RM 192 are slightly cooler than water temperatures near the outlet of Hells Canyon Dam (RM 239) (by approximately 0.7 ^{o}C maximum in 1995). Water temperatures observed at RM 192 are essentially the same as those observed at RM 239 during the mid-summer months (Julian days 194 to 220). However, the magnitude of the observed changes is very small and may represent less of an overall temperature change than the diurnal variations observed for this reach of the river.

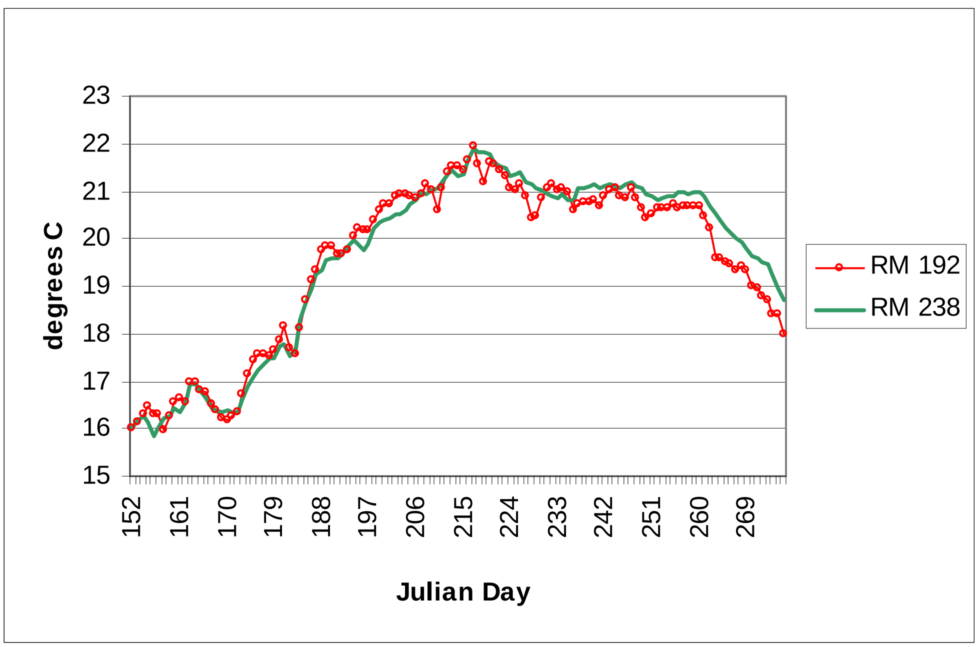


Figure 3.6.2 g. Water temperatures near the outflow of Hells Canyon Dam (RM 238) and above the inflow of the Salmon River (RM 192) measured June through September of 1995.

Water temperatures in the Downstream Snake River segment (RM 247 to 188) are shown in Figure 3.6.2 h for the 1950s, pre-construction of the Hells Canyon Complex and the 1990s, post-construction. Pre-construction water temperature data is available for RM 203, (approximately 44 miles downstream of the Hells Canyon Dam-site) for water years 1955 through 1958 as monthly averages. Water years 1955 and 1959 are slightly below average (75% and 73% of the 50-year average respectively), 1958 is close to an average water year (102% of the 50-year average), and 1956 and 1957 are slightly above average water years (116% and 113% of the 50-year average respectively). These data are not intended to represent natural temperature

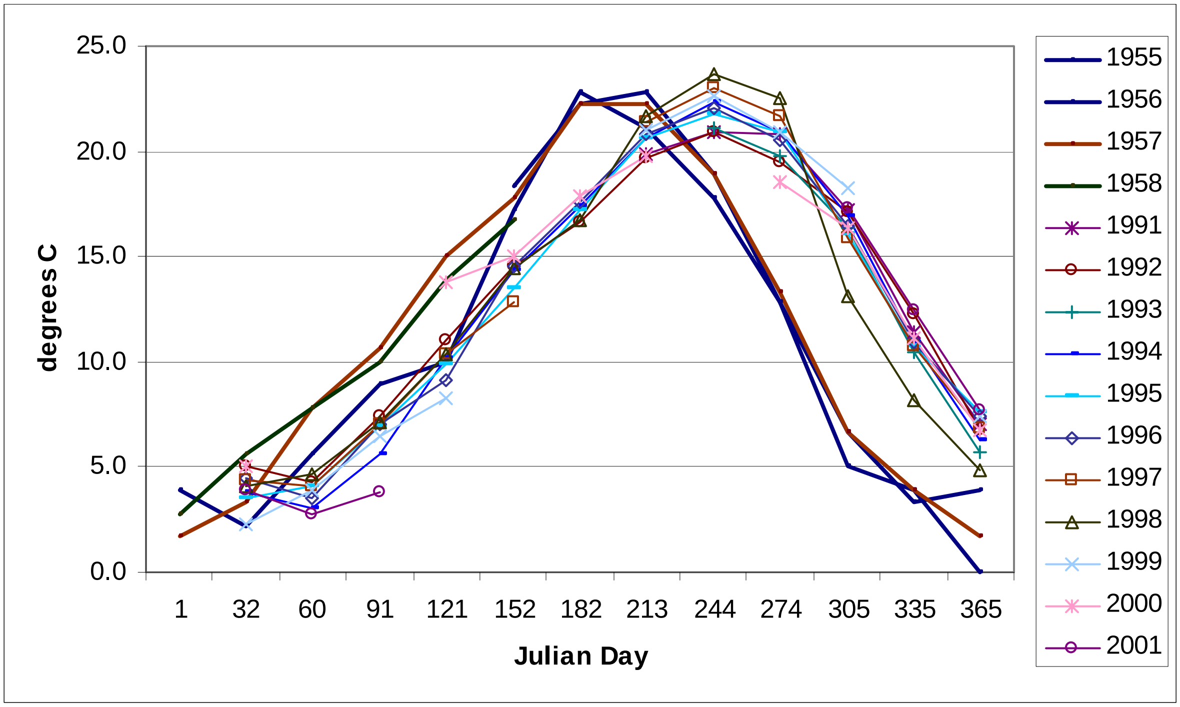


Figure 3.6.2 h. Comparison of the monthly average of daily maximum water temperatures below Hells Canyon Dam pre-construction (RM 203) and post-construction (RM 202).

conditions as a substantial level of diversion and impoundment was occurring upstream when the data were collected.

Post-construction water temperature data is available for RM 202 (1991 through 2001) that covers a range of water years including 1995, a close to average water year (94% of the 50-year average), 1996, a high water year (131% of the 50-year average), and 1991, a low water year (55% of the 50-year average). Data was provided as daily maxima, minima and mean water temperatures (IPCo, 2002). Daily mean water temperatures were averaged to monthly means to provide consistency in this comparison (Figure 3.6.2 h). The water temperature data available for this segment show that monthly average water temperatures are in excess of the 17.8 ^{o}C salmonid rearing/cold water aquatic life target from mid-June through mid-September, Julian days 170 through 265 for pre-construction data (approximately 90 days total). Post-construction data show exceedences occur between the first week of July and mid-October, Julian day 182 through 295 (approximately 113 days total). However, the overall shape of the curve observed on the downsloping side of the post-construction plots does not appear different from the pre-construction plots, only the timing is changed. Additionally, while these periods of exceedence are temporally shifted by approximately two weeks, they are of very similar duration.

The 1950s data pre-dates completion of the three Hells Canyon Complex dams. Data from 1991 through 2001 are representative of post-construction conditions. In both cases, exceedences of the 17.8 ^{o}C salmonid rearing/cold water aquatic life target occurred. This comparison demonstrates quite clearly that changes in water temperature specific to the impoundments in the SR-HC TMDL reach are related to how the water is processed through the Hells Canyon

Photo 3.6.1. Snake River at approximately RM 250, near the Hells Canyon Dam site, circa 1939 to 1940. This photo was proposed to be used for a state stamp. Photo from the collection of Dr. Lyle M. Stanford.

Complex. The impoundments themselves do not act as heat sources, but rather act to delay temperature changes within the mainstem Snake River downstream. The water temperature curve described by the post-construction data shows a shifted temporal distribution where water temperatures following construction of the Hells Canyon Complex reservoirs are slightly warmer for longer in the fall and cooler for longer in the spring. Upstream sources of elevated water temperature, many potentially in place prior to the completion of the Hells Canyon Complex, are the primary source of increased water temperature within the SR-HC TMDL reach.

Overall, the data available for the Downstream Snake River segment (RM 247 to 188) show that average monthly summer water temperatures in this segment were higher prior to the construction of the Hells Canyon Complex reservoirs. The Hells Canyon Complex reservoirs act to cool the overall summer water temperature below those observed in the Snake River upstream of Brownlee Reservoir (Figure 3.6.2 i). Data collected 1991 through 2001, above Brownlee Reservoir at RM 345 and below Hells Canyon Dam at RM 247 show that cooling occurs throughout the spring and summer months relative to inflow water temperatures. The average magnitude of cooling observed during July and August (Julian days 182 through 250) is approximately 4 °C. This trend is not as dominant during the later fall months of September or October (Julian days 253 through 304) due to the temporal lag in water temperatures discussed earlier. The data plotted in Figure 3.6.2 i represent a wide range of water years; 1995 was a relatively average water year (94% of the 50-year average annual flow), 1996 and 1997 were high water years (131% and 170% of the 50-year average annual flow respectively), and 1991 was a relatively low water year (55% of the 50-year average annual flow).

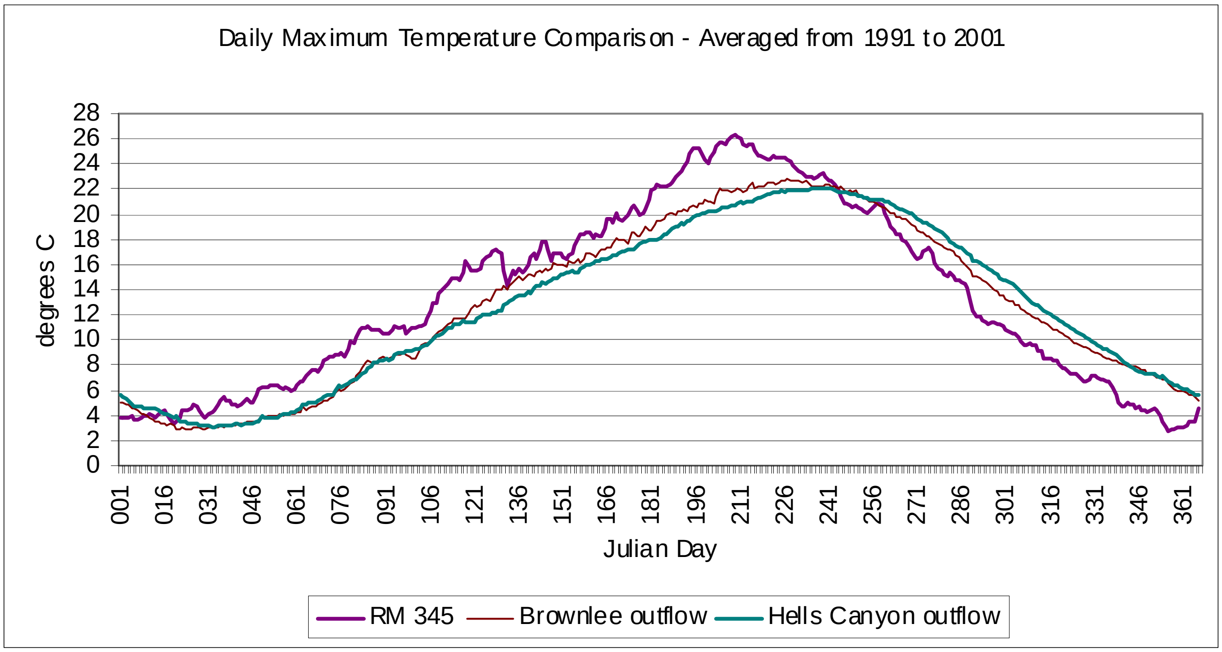


Figure 3.6.2 i. Differences in daily maximum surface water temperatures observed between the Upstream Snake River segment (measured downstream of Weiser, Idaho (RM 345)) and the Downstream Snake River segment (measured below the Hells Canyon Dam site (RM 247)).

It should be recognized that the Snake River above RM 345, and the tributary inflows to the SR-HC TMDL reach reflect the effects of substantial diversion and impoundment upstream and therefore are not representative of natural temperature or flow conditions for this system.

The Imnaha River flows into the Snake River at RM 191. Temperature data available from 1995 and 1996 for the Imnaha show daily maximum water temperatures that average 18.8 °C during July, 20.7 °C during August and 17.1 °C during September, Julian days 182 through 273 (Figure 3.6.3). Exceedences of the 17.8 °C salmonid rearing/cold water aquatic life target occur during July, August and part of September (Julian days 196 through 256).

3.6.5.6 THREATENED AND ENDANGERED SPECIES AND SALMONID SPAWNING.

A number of species listed as threatened or endangered under the Federal Endangered Species Act (ESA), are known to inhabit the SR-HC TMDL reach. The SR-HC TMDL reach provides habitat for the Idaho spring snail (*Pyrgulopsis idahoensis,* formerly *Fontelicella idahoensis*), identified in the region between RM 422 and 393 and between RM 372 and 366; and the Bliss

Photo 3.6.2. The mouth of the Imnaha River (RM 191), circa 1939 to 1940. Photo shows boatmen collecting mail from a receptacle anchored on the shoreline. Photo from the collection of Dr. Lyle M. Stanford.

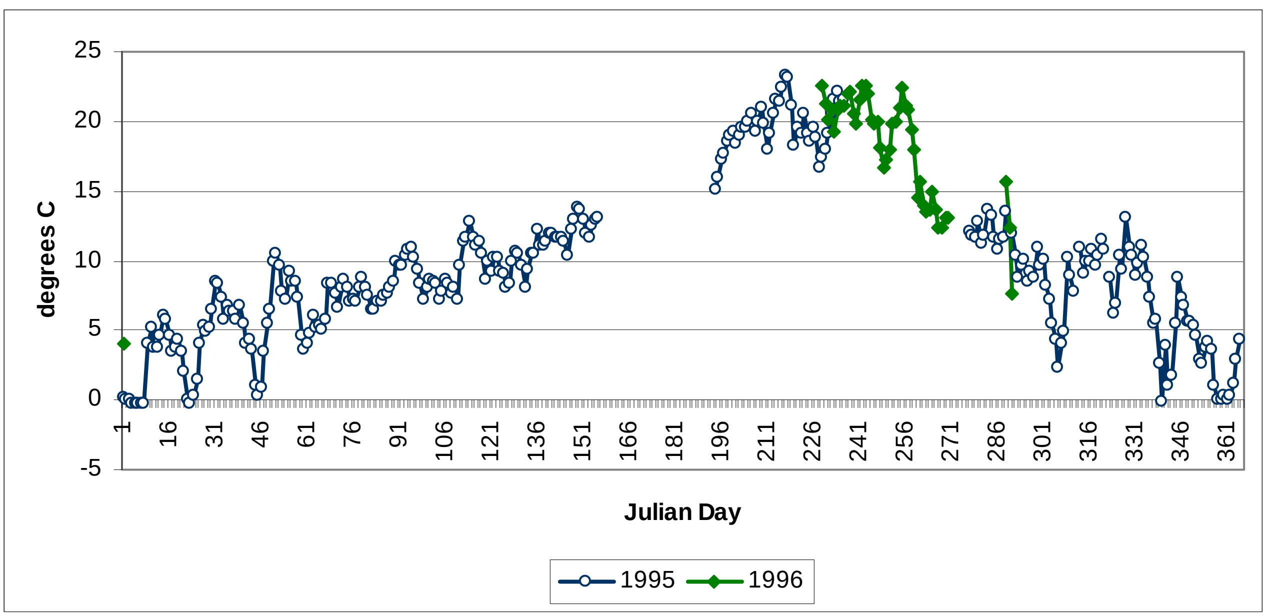


Figure 3.6.3. Water temperatures measured in the Imnaha River during 1995 and 1996.

Rapids snail (*Taylorconcha serpenticola*), identified in the region between RM 228 and 225 and in several areas of the Snake River upstream of the SR-HC TMDL reach. Both of these snail species are listed as threatened under the ESA, both are listed as requiring cold, clear, well oxygenated water for full support. Adult bull trout (*Salvelinus confluentus*), known to utilize the reservoir segments, are listed as threatened under the ESA. The SR-HC TMDL reach and some inflowing tributaries below Hells Canyon Dam also provide habitat for the Snake River fall (*Oncorhynchus tshawytscha*) and spring/summer chinook (*Oncorhynchus tshawytscha*), as well as steelhead (*Oncorhynchus mykiss*), all of which are listed as threatened under the ESA. A more complete description of these species, their status and their habitat needs is outlined in the Subbasin Assessment (Section 2.2.2.3).

All of the species listed above as threatened or endangered rely on good water quality for survival. Some species are sensitive to elevated water temperatures.

3.6.5.7 Salmonid Spawning and Rearing

Waters are designated for salmonid spawning and rearing in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach. Waters so designated are required to exhibit appropriate levels of water column dissolved oxygen, intergravel dissolved oxygen, temperature, pH, ammonia, toxics, and turbidity for full support of fish during the spawning, incubation and rearing periods for those salmonid species inhabiting the designated waters. General time periods for spawning and incubation of the salmonid species identified to use the Downstream Snake River segment (RM 247 to 188) are:

- Chinook salmon (fall) October 23 through April 15 (Julian day 296 to 105)*
- Mountain Whitefish Nov 01 through March 30 (Julian day 305 to 89)*

* represents spawning and incubation times identified as specific to the SR-HC TMDL reach.

A complete table of fish species in the SR-HC TMDL reach is available in section 3.6.9.2 of this document.

3.6.5.8 Influence of Impoundments on Downstream Water Temperatures Relative to Salmonid Rearing/Clod Water Aquatic Life and Salmonid Spawning

Water temperatures in the Downstream Snake River segment (RM 247 to 188) are shown in Figure 3.6.2 h for the 1950s, pre-construction of the Hells Canyon Complex and the 1990s, post-construction. Pre-construction water temperature data is available for RM 203, (approximately 44 miles downstream of the Hells Canyon Dam-site) for water years 1955 through 1958 as monthly averages representing a variety of low, average and high water years. Post-construction water temperature data is available for RM 202 (1991 through 2001) and also covers a range of water years. Daily mean water temperatures from 1991 through 2001 were averaged to monthly means to provide consistency.

Data available for the pre-impoundment time period (1955 through 1958) are monthly mean water temperature values and therefore cannot be used to determine if the 13 ^{o}C maximum weekly maximum target value was exceeded. A general evaluation of pre-impoundment data shows that monthly averages above 13 ^{o}C occurred at the beginning of the salmonid spawning period identified by this TMDL and extended for approximately 2 weeks.

A general evaluation of this data shows that monthly averages above 13 ^{o}C did not occur within this data set during the fall chinook spawning period (Julian day 296 to 105). Please note, Figure 3.6.4 a shows daily mean water temperature data, and Figure 3.6.2 h shows monthly average daily maximum water temperature data for post-construction (current) conditions.

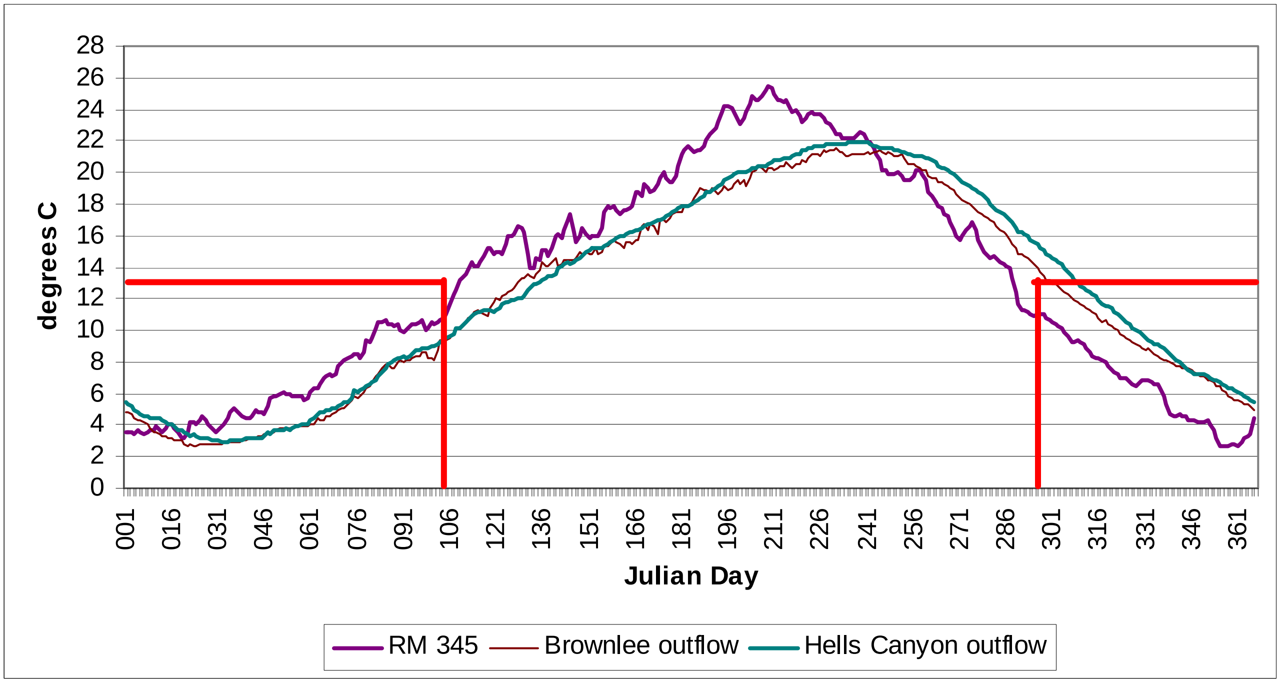


Figure 3.6.4 a. Post-construction daily mean water temperature data for the Snake River above and below the Hells Canyon Complex dams. (Salmonid spawning periods (boxes) for the Snake River below Hells Canyon Dam are displayed specific to fall chinook in this reach.)

The data displayed in Figure 3.6.2 h and Figure 3.6.4 a indicate several points. First, the effect of the Hells Canyon Complex of dams on water temperatures is one of cooling during much of the year, particularly through the time of peak summer temperatures. Secondly, an effect of the Hells Canyon Complex reservoirs has been to delay cooling of stored water in the fall relative to upstream water temperatures. Warm summer temperatures in water inflowing to Brownlee Reservoir, coupled with the storage capacity of the impoundment are factors in the timing and magnitude of this delayed cooling effect downstream of Hells Canyon Dam.

Finally, both the summer cooling and the delayed fall cooling effect appears largely attributable to Brownlee Reservoir as indicated by the narrow difference between the average outflow water temperature from Brownlee Dam as compared to the average outflow water temperature of Hells Canyon Dam (Figure 3.6.4 a). Brownlee Dam (RM 285) is the farthest upstream of the Hells Canyon Complex dams. It backs up the only significant storage reservoir of the three. By comparing water temperatures measured at RM 345 to those below Hells Canyon Dam at RM 247, the effect of the Hells Canyon Complex, primarily Brownlee Reservoir, on downstream Snake River water temperatures can be observed.

3.6.5.9 SITE POTENTIAL ASSESSMENT

To more accurately assess the influence of the Hells Canyon Complex on water temperatures in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach, an approach using thermal "site potential" has been employed. For the purposes of this TMDL, site potential is defined as the temperature that is predicted to have occurred without the influence of the Hells Canyon Complex dams and other direct sources of heat to the mainstem itself, but with the current altered hydrological regime, climate, and tributary inputs. Use of site potential relates to provisions in the water quality standards of the states of Idaho and Oregon, which allow for natural conditions when such conditions result in water temperatures, which exceed numeric criteria. These water quality standards further prescribe a small allowable increase in water temperatures when natural conditions, ergo "site potential", are above numeric criteria or target thresholds.

For the purpose of modeling mainstem Snake River site potential, tributary inflows were modeled at their current (recent) condition irrespective of their specific temperatures in relation to water quality criteria. The assumptions made in relation to modeled temperature influences for the mainstem Snake River should be applied only as appropriate within this assessment. Caution must be used when interpreting and applying the results of this temperature model analysis more broadly to other systems, particularly the tributaries. While the major heat contributions to large rivers may be predominantly due to natural atmospheric inputs, this is not likely to be the case for smaller streams and rivers, including most of the tributaries to this TMDL reach. As such, it is expected that a more comprehensive evaluation of temperature loading to tributary systems will be conducted when TMDLs for the tributaries are prepared. The assumptions made in this TMDL should not be applied to the tributary-specific TMDLs. It is likely that a more detailed analysis of the tributaries will indicate that temperature reductions are needed in the tributaries and upstream of this TMDL segment in order to fully attain water quality standards.

Since modeling to date has determined that water temperatures in the mainstem would still exceed criteria under site potential, the goal of the TMDL is to not exceed the small incremental increase in water temperature allowed by applicable water quality rules in such circumstances. Mathematical notation for this change in water temperature is delta T (ΔT). This TMDL seeks to limit the incremental effect of heat loads to that which does not cause violation of the temperature target (Oregon's 0.14 °C allowable increase, the most limiting criterion). Water temperatures measured at RM 345 were used as site potential for the downstream temperature assessment. It should be noted that while water temperatures at RM 345 should not be interpreted as "natural conditions", this approach acts to remove the effect of the Hells Canyon Complex on estimation of site potential further downstream.

Data available (1996 to 2001) show that mainstem water temperatures at RM 345 (Figure 3.6.4 b) exceed criteria at times under the site potential scenario, though for a shorter period of time than observed at the outflow of Hells Canyon Dam (Figure 3.6.4 a).

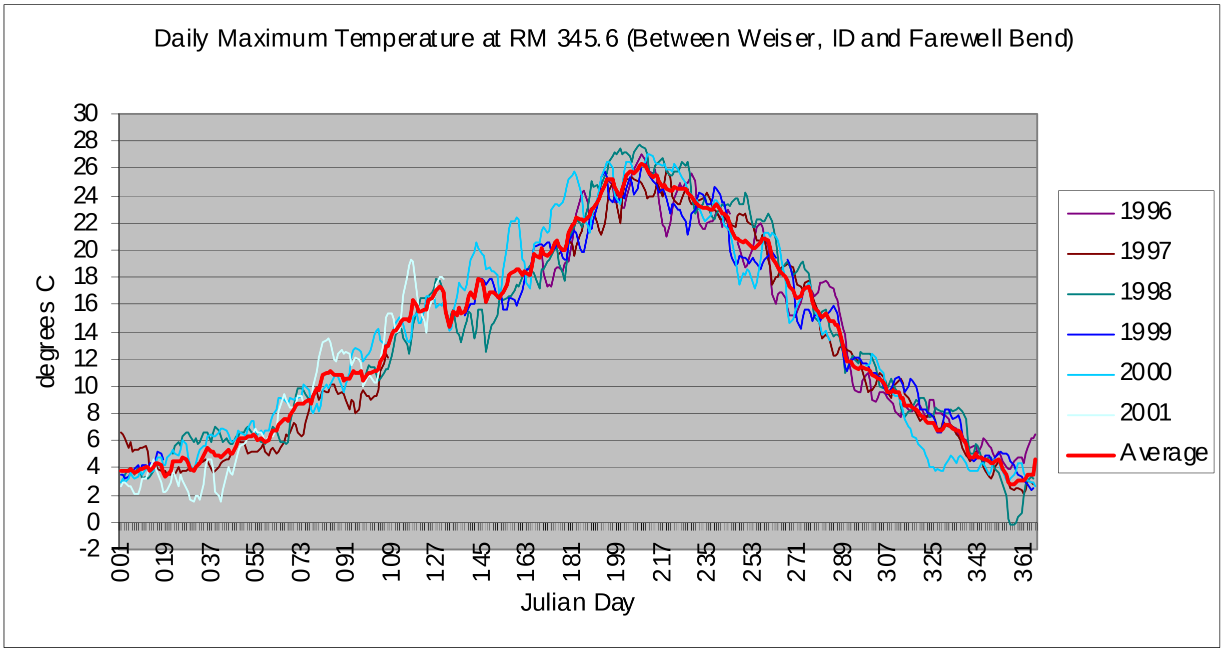


Figure 3.6.4 b. Daily maximum water temperature data for the Snake River at RM 345, 10 miles upstream from the headwaters of Brownlee Reservoir.

If existing water temperatures at RM 345 are in fact a high estimate of natural conditions this would cause a slightly higher estimate of site potential downstream, and would in turn result in a conservative estimate of load reductions needed below Hells Canyon Dam to limit the change in temperature.

3.6.6 Determination of Temperature Loading

As discussed previously, there are a variety of sources that influence water temperature in the SR-HC TMDL reach. These sources may act to increase or decrease water temperature within the mainstem Snake River. They include inflowing tributaries and drains, ground water and industrial discharges. In addition to these sources, it is well recognized that in hot arid climates such as that in which the SR-HC TMDL reach is located, natural atmospheric heat sources will also have a noticeable influence on water temperatures.

Tributaries, drains and industrial discharges can act as heating, neutral or cooling influences on the mainstem depending on their temperature relative to that of the Snake River. The influence of these inflowing waters can be measured in-river if the resulting difference is of sufficient magnitude, or can be calculated using known temperature and flow volume/dilution relationships.

Ground water inflows can also be heating, neutral or cooling influences on the mainstem depending on their temperature relative to the Snake River. Geothermal waters would generally be heating influences. Ground water from aquifer or irrigation sources is generally a cooling or a neutral source during the summer months.

3.6.6.1 TEMPERATURE INPUT CALCULATION MECHANISMS.

An assessment of temperature sources to the SR-HC TMDL reach has been incorporated as part of this TMDL process. Industrial discharge influences were evaluated through direct discharge volume measurements, available discharge temperature data and estimation based on best professional judgement where data were not available.

Temperature influences from tributary, drain, ground water and natural atmospheric sources were also evaluated. Due to the variability and interconnected nature of surface and ground water systems, a calculational model was used to evaluate the influences of these inflows on water temperature in the mainstem Snake River. A spreadsheet water temperature model reported by Sharpe (1980) was used to calculate the change in water temperature in the mainstem Snake River due to tributary, drain and ground water inflows. The magnitude of the temperature influence exerted on the mainstem by tributary, drain and ground water inflows was calculated directly using the model. Model output was then compared to the measured temperature change within the system. The magnitude of natural atmospheric temperature influences and non-quantifiable influences was determined by difference. The difference between the instream temperatures produced by modeled inflow values and the measured water temperature was assumed to be the combination of the net natural atmospheric heat input and these non-quantifiable influences (these influences are discussed in more detail in Section 3.6.8.3).

Consecutive, daily water temperature and flow data were critical to this modeling effort. Consecutive daily maximum average water temperature and flow data were available for the major tributaries in the Upstream Snake River segment (RM 409 to 335) for summer months in 1999 or summer months in 2000. Few tributaries had data for both years (See Table 3.6.1). The data set included water temperature and flow measurements for all tributary and mainstem sites. Where data was available, data was compiled for the same day and year. In cases where data was unavailable, correlations between overlapping data sets were derived using direct linear interpolation and applied to the appropriate day and year for the compiled data set. Because they represent the most complete data set available, and the most current conditions, 1999 and 2000 data were selected for use in this exercise.

Within these two years of collected data, the most complete set for the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach contained data from June, July and August. June data, while relatively complete, required some estimation of temperature values based on linear interpolation from 1996 and therefore was not as robust as data available for July and August, which did not require as much estimation. However, July and August represent the months in which the greatest and most consistent elevation of water temperature is observed to occur. These two months therefore represent the basis of this analysis. June generally shows temperature exceedences occurring consistently at the latter end of the month, and September data generally shows the majority of temperature exceedences occurring at the beginning of the month. In those instances where flow data was unavailable (the Malheur and Owyhee Rivers and drains) calculated data from USBR was utilized (USBR, 2001) and from previous monitoring efforts (IPCo, 2000c; US EPA 1974 to 1995).

Consecutive, daily water temperature and flow information was not available for the Burnt or Powder rivers. The understanding of temperature influences to the Upstream Snake River segment (RM 409 to 335) was therefore applied with accommodation for increases in total surface area to the extent possible.

Precipitation levels from 1999 and 2000 are reasonably close to average conditions. The 1999 and 2000 data therefore represent median conditions for the SR-HC TMDL system, thus characterization of these conditions for relative temperature influences would be expected to apply the majority of the time. In-river, low flow years would be expected to exhibit higher levels of natural atmospheric-induced heating due to lower flow volume and decreased water depth in the mainstem, while high water years would be expected to show less natural atmospheric-induced heating due to greater flow volume and water depth.

Temperature loads from agricultural drains discharging to the SR-HC TMDL reach were determined using available temperature data. Neither water temperature nor flow data were plentiful; however, data were collected between 1975 and 1980, most as part of US EPA studies (US EPA STORET data, 1998). Temperature data for monitored drains were available for June, July and August of 1975 and August of 1977. Collected data show water temperatures that average 19.5 ^{o}C in June, 21.4 ^{o}C in July, 22.8 ^{o}C in August, and 17.6 ^{o}C in September. The data were not collected on a consistent time schedule, and do not necessarily represent maximum daily averages. These data are instantaneous measurements only; therefore, average water temperatures were used as the best estimate of overall drain temperatures. The available temperature data set did not include consistent flow data.

For the purposes of this exercise, available flow information was utilized. In some cases, flows were estimated using general flow descriptions supplied by the US EPA study (1974 and 1975), in other cases, return flow information by drainage area supplied by the USBR (USBR, 2001) was utilized. Care was taken to preserve the highest possible level of accuracy in these calculations, however, due to the level of uncertainty associated with water temperature and flow determinations for the agricultural drains, these values should be viewed as best estimates only. If drain-specific data become available during the implementation of this TMDL they should be used in place of these estimates.

Only limited data are available on ground water inflows to the Snake River. However, a substantial amount of information is available on the temperature of ground water in the Snake River Basin. These data were utilized to estimate average ground water temperatures in the SR-HC TMDL reach (USGS, 1999; IDEQ, 2000c; IDWR, 2000). Data available from ground water (well) records in the SR-HC TMDL watershed were evaluated. Wells less than 75 feet deep were selected as being most representative of ground water inflows to the Snake River in the SR-HC TMDL reach. Of the well records available in this area, 780 were 75 feet deep or less. The majority of the wells identified for this evaluation were located on the Idaho side of the river. Many well records were available for the Oregon side of the river but the majority of these was over 75 feet in depth and thus did not meet the depth requirement for this assessment. Temperature values obtained for the selected wells ranged from 8 ^{o}C to 21.5 ^{o}C but most (85%) were well correlated with a fairly narrow temperature range (13 ^{o}C to 16 ^{o}C). The mean ground water temperature was calculated to be 14.7 ^{o}C (median = 14.5 ^{o}C). In order to estimate ground water temperatures conservatively, a 95th percentile temperature value of 17.5 ^{o}C was used in place of the mean ground water temperature value of 14.7 ^{o}C. A complete set of all well data utilized is available in Appendix E.

The temperature model was applied using the available daily water temperature and flow volumes from all measured tributaries and drains. Ground water influences were calculated using the 17.5 ^{o}C temperature identified and the flow multiplied by the linear distance between gauges for the purposes of this calculational model.

Flow within the SR-HC TMDL reach was quantified using gauged measurements where possible and calculated flows where gauged measurements were not available. This was most critical for the Owyhee and Malheur rivers where gauged flows near the mouth were not always available. Flows for these systems were calculated using gauge data from upstream locations and calculating downstream increases based on estimated diversion and return flows within the system.

Ungauged gain/loss measurements within the reach were calculated from flow data evaluated over the time periods to which the modeling effort was applied. The overall reach "gain/loss" measurements identified using the water balance calculated for the loading analysis process were compared to those calculated by the USBR (USBR, 2001). The USBR quantified 1991 and 1992 (relatively low water years) and 1997 and 1998 (relatively high water years).

Daily water temperature and flow data used were collected from 1999 and 2000 (reasonably average water years). While there is no direct overlap between these data sets, the reach gain/loss values calculated for 1999 and 2000 are an approximate average of the low and high water year values, which is logical. For the purposes of this modeling effort, the ungaged flow difference was assumed to be related to a mixture of ungaged ground and surface water input, and was assumed to enter the river evenly on a per mile basis between the two gauges.

The maximum ungaged gains in flow from 1999 and 2000 were selected as conservative overall estimates of ungaged flows. These values were then evaluated as if the entire volume were from ground water inflows (representing a maximum cooling influence) and as if the entire volume were from surface water inflows (a maximum heating influence). To allow the determination of a relative range of temperature variation from ground and surface water inflows, ungaged flows were applied evenly over the stretches for which they were measured by dividing the total gained flow by the length of the segment in miles.

Using this modeled approach, the overall influence of surface and ground water inflows was evaluated. A comparison was then made to calculate the difference between the modeled and measured water temperatures. This difference was assumed to be the combination of the net natural atmospheric heat input and these non-quantifiable influences on water temperatures within the SR-HC TMDL reach.

An example calculation of the average mainstem water temperature after mixing is outlined below.

$$Tm = [(Q*T) + (Qi*Ti)] / (Q + Qi)$$

Where:

Q	= mainstem river flow, cfs
T	= mainstem river temperature, ^{o}C
Qi	= tributary flow, cfs
Ti	= tributary temperature, ^{o}C
Tm	= average mainstem temperature after mixing, ^{o}C

Example day: 30 July, from RM 453.5 to RM 396.7, based on daily maximum average water temperatures. (NOTE: for the sake of simplification, only major inflows were used in this example)

A	Per mile ungaged flow	=	6 cfs
B	Ground water temperature	=	17.5 ^{o}C
C	Snake River flow at RM 409	=	6,880 cfs
D	River temperature at RM 409	=	23.0 ^{o}C
E	Owyhee River flow	=	123 cfs
F	Owyhee River temperature	=	20.9 cfs
G	Boise River flow	=	1100 cfs
H	Boise River temperature	=	23.6 ^{o}C

Temperature after the Boise River is mixed into the Snake River:

(((C*D)+(E*F)+(G*H))+((A*12.3)*B)) / (C+E+G) +(A*12.3))

(Note that the per-mile ground water flow, 6 cfs, is multiplied by 12.3 miles, the total flow is then multiplied by 17.5 ^{o}C.)

- If only tributary and drain inflows are assessed, the mixed (modeled) water temperature in the mainstem = 23.05 ^{o}C
- If tributary and drain inflows are assessed, in combination with ungaged flows assumed to be 100 percent ground water, the mixed (modeled) water temperature in the mainstem = 23.0 ^{o}C
- If tributary and drain inflows are assessed, in combination with ungaged flows assumed to be 100 percent surface water inflows, the mixed (modeled) water temperature in the mainstem = 23.12 ^{o}C

The measured mainstem water temperature at the downstream end of this reach = 25.5 ^{o}C

In this example, if all of the ungaged flow is assigned to ground water inflows, the model shows that the mainstem water temperature is essentially unchanged over this section of the SR-HC TMDL reach. (Inflow temp was measured at 23 ^{o}C, and outflow temperature is calculated to equal 23 ^{o}C.) If all of the ungaged flow is assigned to surface water inflows (using an averaged temperature of 21.5 ^{o}C from measured drain data), the model shows that the mainstem water temperature increases by 0.12 ^{o}C over this section of the SR-HC TMDL reach.

The measured water temperature changed by 2.5 ^{o}C over the same section, increasing from 23 ^{o}C to 25.5 ^{o}C. The calculated temperature influence from tributary and drain inflows accounted for 0.05 ^{o}C of this change. Ungaged ground and/or surface water inflows in this same section accounted for between -0.05 ^{o}C (where all ungaged flow was assumed to be ground water inflow) and 0.07 ^{o}C (where all ungaged flow was assumed to be surface inflow). Assuming an even mixture of ground and ungaged surface water inflows, this temperature change is calculated to be 0.01 ^{o}C. The total modeled temperature change resulting from tributary, drain and ungaged inflows (assuming a 50/50 mixture of ground and surface water) is 0.06 ^{o}C (0.05 ^{o}C + 0.01 ^{o}C = 0.06 ^{o}C). Natural atmospheric and non-quantifiable temperature influences based on an equal mixture of ungaged inflows and the measured tributary and drain inflows are responsible for the remaining warming, equal to 2.44 ^{o}C (2.5 ^{o}C – 0.06 ^{o}C = 2.44 ^{o}C). Tributary, drain and ground water influences accounted for 2.4 percent of the heating that occurred, the combination of natural atmospheric and non-quantifiable influences accounted for 97.6 percent of the warming.

The mechanism for determining the relative contribution of temperature sources outlined in this example was applied to the SR-HC TMDL reach. The following discussion details the assumptions made and results obtained from this analysis.

3.6.6.2 ASSUMPTIONS.

Several assumptions were made in order to allow the calculation of temperature changes in mainstem Snake River water temperatures as a result of inflowing surface and ground water, and natural atmospheric temperature influences. The assumptions made are discussed below.

Temperature Variation.

The calculational model used only daily maximum water temperatures. There is no accommodation for cooling from lower nighttime air temperatures, or for cooling due to weather or heat loss throughout the system as water moves downstream. These factors result in an overestimation of the downstream influence of both mainstem water temperature increases and inflowing sources.

Mixing.

The temperature modeling analysis assumed uniform mixing of both surface and ground water inflows to the mainstem river. This analysis does not attempt to quantify variability of water temperatures laterally or through the depth of the river in the Upstream Snake River and Downstream Snake River segments. Temperature differences at varying depths within the reservoir segments were identified in a semi-quantitative fashion as discussed below. Temperatures within the reservoirs were assumed to be laterally uniform.

Water Temperatures in Tributaries.

Natural atmospheric temperatures are expected to influence water temperatures in tributaries to the Snake River. This influence may occur to a greater or lesser degree than that calculated for the mainstem Snake River depending on water depth, flow volume, and other factors. However, the magnitude of this influence was not directly assessed for the tributaries in this evaluation. All inflow temperatures were assessed as occurring at the point of discharge to the Snake River.

Water Temperatures in Tributaries without Monitoring.

Minor tributary and drain influences were calculated where flow and water temperature data were available. Where flow and water temperature data were not available, these inputs were assumed to be included in the "ungaged" inflow/outflow calculation.

Natural Temperature Loading.

Natural atmospheric temperature sources can be divided into two general categories: (1) Direct solar radiance, where sunlight striking the water results in a transfer of energy from the light waves to heat in the water, and (2) Direct heat conduction from the air itself. This calculational model does not differentiate between these two mechanisms, but rather seeks to identify the total atmospheric input that occurs from both processes simultaneously.

3.6.6.3 POINT SOURCE TEMPERATURES.

Six NPDES permitted discharges are identified in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL (Table 3.6.3). Two of these point sources are industrial discharges, four are municipal discharges. Only two of the NPDES permits for this segment have identified temperature discharge limits. There are three additional NPDES permitted point sources in the SR-HC TMDL reach; all are related to the operation of the Hells Canyon Complex dams (Brownlee, Oxbow and Hells Canyon). These discharges are composed of cooling water from the turbines in Brownlee, Oxbow and Hells Canyon dams. Discharge mixes directly with the outflow of the dams.

Table 3.6.3. Point source discharge volume and water temperature information for the Snake River - Hells Canyon TMDL reach.

Point Source	Discharge Volume (average)	Permitted Discharge Temperature
City of Nyssa	0.33 MGD	none
Amalgamated Sugar	Seepage ponds	< 32 ^{o}C
City of Fruitland	0.23 MGD	none
Heinz Frozen Foods	2.5 MGD	none
City of Ontario	1.9 MGD*	none
City of Weiser	1.8 MGD	none
Brownlee Dam	10 MGD	Not to exceed 79 ^{o}F
Oxbow Dam	11 MGD (max)	Not to exceed background + 10 ^{o}F
Hells Canyon Dam	9 MGD (max)	Not to exceed background + 10 ^{o}F

* land application during the critical season

Discharge volumes are available for all point source discharges. Temperature data however, is very limited. Where both discharge temperature and volume data were available, this information was used directly in the calculations. Where water temperature data was not available, as in the case of the Upstream Snake River segment (RM 409 to 335) wastewater treatment plant discharges, the maximum water temperature observed in smaller tributaries was applied.

Wastewater treatment plant discharge data available from other drainage basins show that discharge temperatures are commonly lower than those observed in the tributaries. The estimate applied in this modeling effort is therefore most probably and over estimate of the total increase in temperature contributed by the permitted point sources. This value was retained in the calculation effort as it represents a conservative (worst case scenario) overall.

The point source discharges represent no-measurable-increase in the water temperature of the mainstem Snake River within the SR-HC TMDL reach. (No-measurable-increase is defined by the State of Oregon as 0.25 ^{o}F (0.14 ^{o}C), and by the State of Idaho as 0.3 ^{o}C.) The point source discharges are calculated to contribute less than 0.012 ^{o}F (0.0066 ^{o}C) increase in mainstem water temperature in the Upstream Snake River segment (RM 409 to 335).

3.6.6.4 GROUND WATER.

Ground water influences were addressed in two ways to provide a relative range of effect:

1. In the first scenario, all of the flow unaccounted for in the water balance on a segment-specific basis was assumed to be ground water inflow. This volume was distributed evenly by distance along the length of the segment. This scenario represents the greatest possible ground water influence on a segment, given the data available. Because ground water is generally cooler than the surface water during the months for which natural atmospheric temperature influences were evaluated, this scenario represents the "coolest" conditions as calculated by the temperature model.
2. In the second scenario, none of the flow unaccounted for in the water balance on a segment-specific basis was assumed to be ground water. All ungaged inflow was assumed to be surface water. The temperature assigned to this ungaged flow was calculated as the average temperature of the measured drains in the segment. This scenario represents the least effect ground water may have on the mainstem Snake River water temperature. Because surface water is generally similar in temperature to the mainstem flow, or warmer, this scenario represents the "warmest" conditions as calculated by the temperature model.

This two part scenario provides a relative range for interpretation of the potential variability in calculated values. The actual conditions probably fall somewhere between the extremes represented by these two scenarios. This evaluation also provided information on the relative influence of ground water inflows on water temperatures in the mainstem Snake River. During the summer months of July and August, the greatest ground water influence calculated here is shown to average 0.33 ^{o}C of cooling.

3.6.7 Temperature Loading Analysis

Water temperature data from 1999 to 2000 was selected for use in this calculational modeling effort because it represented the best coverage for the SR-HC TMDL reach overall. The fact that this data also represents a reasonably average water year was very fortunate. Had the best coverage been available on a water year representing extreme conditions, a greater level of estimation and associated level of error would have been necessary to define generally occurring conditions.

The critical months of June, July and August were the focus of this evaluation. June shows the initial increase from spring to summer temperatures, and July and August represent those months where the greatest temperature exceedences occur. September could not be evaluated, as a complete data set was not available for most of the major tributaries. However, a similar, opposite trend in water temperature as observed in June is assumed to apply (i.e. Water temperature was observed to increase gradually over the first two weeks of June, with the majority of exceedences occurring the last two weeks of the month. A reverse of this trend is assumed to occur in September with the majority of water temperature exceedences occurring the first two weeks of the month, observed to decrease gradually over the last two weeks of the month.)

As in the example above, the level of increase in water temperature was evaluated based on tributary and drain inflows. Ungaged flow was assessed in two ways: assuming that all of the flow was the result of ground water inflows, and (2) assuming that all of the flow was the result of surface water inflows. Both of these scenarios were assessed separately and a separate equal mixture was also evaluated. The calculated output from the water temperature model is shown in Table 3.6.4.

Table 3.6.4. Calculated model output for temperature influences in the Upstream Snake River segment (RM 409 to 335) of the Snake River - Hells Canyon TMDL reach. (GW = ground water, SW = surface water)

JUNE	100% GW Temp change	100% GW Percent change	100% SW Temp change	100% SW Percent change	50/50 mix Temp change	50/50 mix Percent change	Range (+/-)
Modeled Tributary Influence	0.297 ^oC	7.1%	0.297 ^oC	7.1%	0.297 ^oC	7.1%	
Modeled Drain Influence	0.022 ^oC	0.5%	0.022 ^oC	0.5%	0.022 ^oC	0.5%	
Modeled Ungaged Flow Influence	-0.143 ^oC	-3.4%	0.034 ^oC	0.8%	-0.055 ^oC	-1.3%	0.177 ^oC
Modeled Point Source Influence	0.007 ^oC	0.2%	0.007 ^oC	0.2%	0.007 ^oC	0.2%	
Total Modeled Temperature Change	0.183 ^oC	4.4%	0.360 ^oC	8.6%	0.271 ^oC	6.5%	0.177 ^oC
Total Measured Temperature Change	4.2 ^oC		4.2 ^oC		4.2 ^oC		
Natural Atmospheric and Non-Quantifiable Influence	4.02 ^oC	95.7%	3.84 ^oC	91.4%	3.93 ^oC	93.6%	0.177 ^oC

JULY	100% GW Temp change	100% GW percent change	100% SW Temp change	100% SW percent change	50/50 mix Temp change	50/50 mix percent change	Range (+/-)
Modeled Tributary Influence	0.785 ^oC	15.1%	0.785 ^oC	15.1%	0.785 ^oC	15.1%	
Modeled Drain Influence	-0.030 ^oC	-0.6%	-0.030 ^oC	-0.6%	-0.030 ^oC	-0.6%	
Modeled Ungaged Flow Influence	-0.500 ^oC	-9.6%	-0.031 ^oC	-0.6%	-0.266 ^oC	-5.1%	0.469 ^oC
Modeled Point Source Influence	0.006 ^oC	0.1%	0.006 ^oC	0.1%	0.006 ^oC	0.1%	
Total Modeled Temperature Change	0.261 ^oC	5.0%	0.730 ^oC	14.0%	0.495 ^oC	9.5%	0.469 ^oC
Total Measured Temperature Change	5.2 ^oC		5.2 ^oC		5.2 ^oC		
Natural Atmospheric and Non-Quantifiable Influence	4.9 ^oC	95.0%	4.47 ^oC	86.0%	4.71 ^oC	90.5%	0.469 ^oC

AUGUST	100% GW Temp change	100% GW percent change	100% SW Temp change	100% SW percent change	50/50 mix Temp change	50/50 mix percent change	Range (+/-)
Modeled Tributary Influence	0.449 ^oC	12.8%	0.449 ^oC	12.8%	0.449 ^oC	12.8%	
Modeled Drain Influence	0.004 ^oC	0.1%	0.004 ^oC	0.1%	0.004 ^oC	0.1%	
Modeled Ungaged Flow Influence	-0.350 ^oC	-10%	0.004 ^oC	0.1%	-0.173 ^oC	-4.9%	0.354 ^oC
Modeled Point Source Influence	0.007 ^oC	0.2%	0.007 ^oC	0.2%	0.007 ^oC	0.2%	
Total Modeled Temperature Change	0.110 ^oC	3.1%	0.464 ^oC	13.3%	0.287 ^oC	8.2%	0.354 ^oC
Total Measured Temperature Change	3.5 ^oC		3.5 ^oC		3.5 ^oC		

AUGUST	100% GW Temp change	100% GW percent change	100% SW Temp change	100% SW percent change	50/50 mix Temp change	50/50 mix percent change	Range (+/-)
Natural Atmospheric and Non-Quantifiable Influence	3.39 °C	96.9%	3.04 °C	86.9%	3.21 °C	91.7%	0.354 °C

3.6.8 Loading Analysis Results

The relative change in mainstem water temperature in the Upstream Snake River segment (RM 409 to 335) from modeled tributary, drain and point source influence is shown for June, July and August (Table 3.6.4).

Modeled total tributary temperature influences range from 0.297 °C to 0.785 °C. The calculated temperature influences are higher in July, when the highest air and water temperatures are observed, and lowest in June when water and air temperatures start out relatively cool and then increase sharply as summer progresses. Calculated temperature influences in August are midway between those for June and July, and represent the slower cooling trend observed in the fall. Total tributary temperature influences account for an average of 12 percent of the temperature change in the mainstem river. July shows the highest relative percent contribution with 15.1 percent (monthly average).

Modeled temperature influences from the drains are also greatest in the month of July, where they represent 0.6 percent of the total temperature change modeled. During both June and August, the drains show a small positive temperature influence on mainstem temperatures (0.022 °C and 0.004 °C respectively), while in July they exert a cooling influence (-0.030 °C). This may be an outcome of shading from maturing plant growth in irrigated areas or an artifact of using averaged drain data in the calculation, as daily maximum water temperature data is unavailable. Averaged data do not allow differences in water temperature due to variations in sampling time and weather to be accounted for. Therefore, drain data taken in early morning hours may show cooler water temperatures due to the fact that most drains are fairly small and shallow and would respond to atmospheric temperature changes more rapidly than the mainstem Snake or major tributaries. However, both heating and cooling influences calculated for the drains are small compared to the overall temperature changes measured and should not be a dominant factor in determining the relative heat source balance.

Modeled point source temperature influences on the mainstem are very small, and relatively constant, ranging from 0.006 °C to 0.007 °C. The overall relative temperature change calculated for point sources averaged 0.17 percent. As stated previously, this is an overestimation of the total point source temperature influence, and is applied as a conservative value.

The relative change in mainstem water temperature calculated for the ungaged flows is shown for the two scenarios outlined, influence assuming that the total ungaged flow is ground water (maximum cooling effect) and the influence assuming that the total ungaged flow is surface water (maximum warming effect). In the first scenario, where all ungaged flow is assumed to be ground water, the ungaged inflows consistently represented a cooling influence during the critical time period. These flows resulted in the greatest cooling influence occurring in July (-0.500 ^{o}C overall) when the relative difference between ground and surface water temperatures is the greatest and would have the most effect. The smallest calculated cooling influence occurred in June (-0.143 ^{o}C) when the relative difference between ground and surface water temperatures is the least and the temperature change from ground water would be minimized by cooler instream water temperatures before mixing. August showed a value midway between those for June and July (-0.350 ^{o}C), and again represents the slower cooling trend of surface waters observed in the fall. The relative temperature change calculated for this scenario ranged from 3.4 percent to 10 percent and was consistently a cooling influence on mainstem water temperatures.

The second scenario showed a somewhat different outcome, as would be expected. In this scenario the total ungaged flow is assumed to be surface water. The temperature of the ungaged flow was assigned to be that of the measured drains. Little precipitation falls in the SR-HC TMDL reach during June, July and August. It was assumed that if the ungaged flow were associated with surface runoff, the majority of this flow would be from unmeasured agricultural and storm drains. Therefore, a similar temperature range should apply. In this evaluation, the ungaged inflows mimicked the temperature influence from the drains, exerting a relatively modest warming influence on the mainstem water temperature during June and August (0.034 ^{o}C and 0.004 ^{o}C respectively), and a relatively modest cooling influence in July (-0.031 ^{o}C). The relative temperature change calculated for this scenario ranged from 0.1 percent (warming) to 0.6 percent (cooling).

The overall range in the two scenarios was calculated to be 0.177 ^{o}C in June, 0.469 ^{o}C in July and 0.354 ^{o}C in August. While this exercise is helpful in determining a relative operating range for further interpretation, neither of the two scenarios modeled have a high probability of occurring within the SR-HC TMDL reach. A more realistic estimate of actual temperature influences from ungaged flows is a combination of ground and surface water inflows. As the range for possible conditions is well defined by the above discussion, an equal distribution of ground and surface water inflows was used to characterize the ungaged flow.

An equal (50:50) distribution was selected for further modeling based on the return flow calculations of the USBR and best current understanding of the SR-HC TMDL reach during summer months. This modeled scenario resulted in calculated values halfway between the two scenarios modeled previously. Cooling influences were consistently projected for this scenario, but were smaller in magnitude than those projected for the total ground water modeling. The temperature influence from the ungaged flow exerted a relatively modest cooling influence on the mainstem water temperature during June and August (-0.055 ^{o}C and -0.173 ^{o}C respectively), and a moderately higher cooling influence in July (-0.266 ^{o}C). The relative temperature change calculated for this scenario ranged from 1.3 percent to 5.1 percent (cooling).

Using the equal distribution scenario, the sum of all modeled temperature influences in the Upstream Snake River segment (RM 409 to 335) equaled 0.271 ^{o}C in June, 0.495 ^{o}C in July and 0.287 ^{o}C in August. The vast majority of the modeled differences are from the tributary influences. The measured difference in water temperature equaled 4.2 ^{o}C in June, 5.2 ^{o}C in July and 3.5 ^{o}C in August. The modeled values represent less than 10 percent of the measured change in water temperature within the Upstream Snake River segment (6.5%, 9.5% and 8.2% respectively). July showed the highest relative temperature influence from modeled inflows.

The calculated combination of the net natural atmospheric heat input and these non-quantifiable influences on the Upstream Snake River segment equals 93.6 percent of the total increase in June, 90.5 percent of the total temperature increase in July, and 91.8 percent of the total temperature increase in August. These calculations indicate that the dominant source of temperature increase in the mainstem Snake River is attributable to natural atmospheric inputs and non-quantifiable influences (discussed in detail in Section 3.6.8.3).

3.6.8.1 Determination of Tributary-Based Anthropogenic Temperature Loading

As stated previously, tributary inflows were modeled using water temperatures measured at the inflow to the Snake River. No tributary-specific modeling was undertaken to distinguish the relative influence of natural atmospheric inputs and non-quantifiable influences to these systems. However, tributary systems flowing into the mainstem Snake River in the SR-HC TMDL reach encounter the same hot, arid climate as they leave higher elevations and make their way across the valley floor to their inflow to the Snake River.

Flow volume and channel depth are smaller for all tributaries flowing into the Snake River, than those existing within the mainstem Snake River, therefore, natural atmospheric conditions have the probability to exert a larger influence on these systems than on the mainstem Snake River. Given these circumstances, and the modeled information on natural atmospheric influences and non-quantifiable influences on the mainstem Snake River, a general differentiation of these sources and quantifiable anthropogenic temperature sources for tributary inflows was undertaken.

In estimating the magnitude of natural atmospheric and non-quantifiable temperature influences to the inflowing tributary systems, the overall relative temperature influence determined for the mainstem Snake River was applied. As outlined previously, given the lower flow volumes and shallower depths of the inflowing tributaries as compared to the mainstem Snake River, the relative natural atmospheric influence on the tributaries would generally be greater than that determined for the mainstem river. For the purposes of this calculation, the relative influence of drains and point sources was assumed to be entirely (100%) anthropogenic. The calculated influence of ungaged flows was acknowledged to be a cooling influence on the system, but was not included in the calculations due to the level uncertainty involved. The relative percent natural atmospheric and non-quantifiable influence from the Snake River mainstem was only applied to the tributary inflows. Therefore, this application of Snake River values represents a conservative estimate of the natural atmospheric and non-quantifiable influences within the SR-HC TMDL reach. Table 3.6.5 shows the calculated changes in tributary temperature influences relative to anthropogenic loading.

The total anthropogenic temperature load to the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach as calculated by this method equals 0.048 ^{o}C in June (1.1% of the total measured load), 0.026 ^{o}C in July (0.5% of the total measured load) and 0.048 ^{o}C in August

Table 3.6.5 Estimated Relative Temperature Influence of Anthropogenic Sources to the Snake River – Hells Canyon TMDL Reach

	June (model total)	June (calculated anthropogenic influence)	July (model total)	July (calculated anthropogenic influence)	August (model total)	August (calculated anthropogenic influence)	Average Calculated Anthropogenic Influence
Anthropogenic influences on water temperature in the Upstream Snake River Segment of the Snake River – Hells Canyon TMDL listed in this table were calculated using the relative percent anthropogenic influence calculated for the mainstem Snake River							
Modeled Tributary Influence	0.297 ^{o}C	0.019 ^{o}C	0.785 ^{o}C	0.050 ^{o}C	0.449 ^{o}C	0.037 ^{o}C	0.035 ^{o}C
Modeled Drain Influence	0.022 ^{o}C	0.022 ^{o}C	-0.030 ^{o}C	-0.030 ^{o}C	0.004 ^{o}C	0.004 ^{o}C	0.001 ^{o}C
Modeled Ungaged Flow Influence*	cooling	cooling	cooling	cooling	cooling	cooling	cooling
Modeled Point Source Influence	0.007 ^{o}C	0.007 ^{o}C	0.006 ^{o}C	0.006 ^{o}C	0.007 ^{o}C	0.007 ^{o}C	0.007 ^{o}C
Total Calculated Anthropogenic Influence		0.048 ^{o}C		0.026 ^{o}C		0.048 ^{o}C	0.043 ^{o}C
Measured Temperature Change		4.2 ^{o}C		5.2 ^{o}C		3.5 ^{o}C	4.3 ^{o}C
Percent of Total Measured Temperature Change from Calculated Anthropogenic Influences		1.1%		0.5%		1.5%	1.0%
Percent of Temperature Increase Calculated as Atmospheric (Background) Influences		98.9%		99.5%		98.5%	99.0%

* These values assume a 50/50 mixture of ground and surface water for ungaged flows.

(1.5% of the total measured load). The average calculated anthropogenic loading is 0.043 ^{o}C (1.0% of the total measured load).

The State of Oregon has defined "no-measurable-increase" as less than 0.25 ^{o}F (0.14 ^{o}C). The State of Idaho has recently approved a definition of "no-measurable-increase" as 0.3 ^{o}C. The US EPA has defined "no-measurable-increase" as 0.3 ^{o}C in association with joint efforts to identify water quality standards for the Colville Tribe. These definitions are not arbitrary units assigned for measurement purposes only, but rather carry an inferred interpretation that changes in water temperature must be at levels greater than this amount to be biologically significant to aquatic life. For the purposes of this TMDL, the State of Oregon definition of 0.14 ^{o}C has been applied as the most conservative definition of no-measurable-increase. This value is less than one half of the amount identified by the US EPA, and that defined by the State of Idaho.

Using the methodology outlined previously, the calculated change in water temperature in the Snake River in the SR-HC TMDL reach due to measurable anthropogenic influences during the critical time period is well below the defined no-measurable-increase value of 0.14 ^{o}C. Even if a 100 percent margin of error was assumed, and the calculated anthropogenic loadings were doubled, they would still fall well below the defined no-measurable-increase limit of 0.14 ^{o}C.

Therefore, the findings of this TMDL effort indicate that natural atmospheric sources and non-quantifiable influences on temperature are the dominant source of elevated water temperatures in the mainstem Snake River. This indicates that, in the case of salmonid rearing/cold water aquatic life targets, site potential is above the 17.8 ^{o}C therefore, the target is no more than 0.14 ^{o}C increase from anthropogenic sources. (Salmonid spawning is discussed in the following sections.)

Stream temperature change is an expression of heat exchange between a stream and its environment. This dynamic exchange process can only be evaluated when the individual components of the heat exchange process are either known or estimated. This information is required to accurately predict the temperature of the river, and its response to the surrounding environment. The accuracy of the prediction correspondingly depends on the accuracy of the data or estimates used in the analysis.

The analysis provided in this TMDL did not include any evaluation of the heat exchange processes within the river system. Instead, it was assumed for the purpose of the analysis, that all heat exchange processes or heat inputs outside of the discretely measured sources are natural or non-quantifiable and the result of "natural atmospheric and non-quantifiable influences." Using this assumption, the TMDL utilized a mixing zone evaluation (model) to predict the relative impacts of pollutant loads from external sources (i.e., tributaries, point source discharge, groundwater and other ungaged flows).

It should be recognized however, because of the underlying assumptions used, that the level of analysis to evaluate the magnitude of natural atmospheric or non-quantifiable influences within this TMDL is rough. Moreover, while the assumption that all other sources of heat inputs are "natural or non-quantifiable" may be correct, there is only limited information in this TMDL to support this conclusion. It will be necessary to collect more data and conduct additional analyses to determine the accuracy of this assumption.

Accordingly, caution must be applied when interpreting and applying the results of this temperature model analysis more broadly to other systems, particularly the tributaries. While the major heat contributions to large rivers may be due to natural atmospheric inputs, this is not likely to be the case for smaller streams and rivers, including most of the tributaries to this TMDL reach. As such, it is expected that a more comprehensive evaluation of the temperature loading to tributary systems will be conducted when TMDLs for the tributaries are prepared. The assumptions made in this TMDL should not be applied to those TMDLs. Furthermore, it should be clearly understood that the assessment in this TMDL only evaluates the impact of current tributary temperatures on the Snake River and makes no attempt to analyze compliance with water quality standards in the tributaries themselves.

Site potential as used in this analysis is based upon a cursory or general review of the watershed. A more intense review might determine that, in some areas, riparian conditions are at less than site potential due to anthropogenic causes. It is likely that a more detailed analysis of the tributaries will indicate that temperature reductions are needed in the tributaries and upstream of this TMDL segment in order to fully attain water quality standards. The information developed and the conclusions reached in the tributary and upstream processes will be reviewed and incorporated, as appropriate, into future revisions to this mainstem TMDL.

Thus, for the purposes of clarity, the temperature loading assessment in this TMDL only analyzed the impact of current tributary temperatures on the Snake River and made no direct attempt to collect data and assess quantitatively whether or not the tributaries are currently complying with State water quality standards.

In interpreting and applying the outcome of this temperature assessment, it is critical to bear in mind the assumptions utilized in developing this TMDL. For instance, the TMDL does not attempt to address temperature modifications due to upstream mainstem and tributary sources, impoundments, water withdrawals, channel straightening and diking and removal of streamside vegetation. While these limitations are qualitatively outlined in Section 3.6.8.3, they are not reflected in the quantification to establish the loading capacity and loading allocations in the TMDL. It is important to remember that these alterations can lead to increases in water temperature (at least locally) and thus the TMDL addresses existing site potential conditions as opposed to natural conditions. As such, in addressing water quality management in the Snake River basin, these other factors should be considered.

3.6.8.2 Hells Canyon Complex and Downstream Temperature Loading.

There are few anthropogenic temperature sources in the Hells Canyon Complex. As stated previously, the impoundments do not function as heat sources. Rather, the temperature issue related to the dams is the result of the impoundment and how the water is stored and processed. In addition to the small permitted point source discharges associated with the operation of the dams, the Burnt and Powder rivers represent the source of the majority of anthropogenic inputs to the system as a whole.

Within Brownlee Reservoir, there are no permitted point sources discharges. Agricultural land use around the reservoir is very limited and no major drain flows have been identified. Therefore, the Burnt and Powder rivers represent the most likely source of non-atmospheric temperature influences to the reservoir segment. Data are not available to evaluate the water temperature influences from the Burnt and Powder Rivers, however, an evaluation of the Upstream Snake River segment (RM 409 to 335), where the majority of the instream flow was from tributaries, showed that water temperature influences from anthropogenic sources were below the defined no-measurable-increase level of 0.14 ^{o}C. It is unlikely therefore, that the Burnt and Powder rivers, which collectively equal less than 4 percent of the total inflow to Brownlee Reservoir, would exert sufficient warming to create a measurable water temperature increase. Other tributaries to Brownlee Reservoir, such as Brownlee Creek, contain minimal anthropogenic sources and are therefore not estimated to increase water temperatures measurably. They are, in fact, known to be a source of cooling inflows to the reservoir.

While surface water temperatures exceed the 17.8 ^{o}C target in Brownlee Reservoir during the critical time period, the lower layers of the reservoir are cooled well below the surface temperatures (See Figures 3.6.2 b and 3.6.4 a). The overall effect for Brownlee Reservoir is that of cooling to the downstream segments. As they are acting in a similar manner and flowing directly from one into another, the reservoir segments as a whole can be assumed to act as cooling influences on the water column. Figure 3.6.4 a shows discharge temperatures from Hells Canyon Dam. When compared to mainstem water temperatures at RM 345, a marked cooling effect can be observed over the critical time period. Given the available data, water exiting Hells Canyon Dam is cooler than that entering the SR-HC TMDL reach near Murphy during the critical time period (June through September).

One permitted point source (cooling water for the turbines at Brownlee Dam) discharges to Oxbow Reservoir. This discharge has been evaluated using the maximum discharge temperature and the maximum flow value recorded in the discharge monitoring reports for this facility. It is likely that this is an overestimate of the actual temperature influence of this facility. Using the calculational model discussed previously with averaged maximum daily water temperatures (data were not available for all days of the month), and calculated average monthly discharge values for Brownlee Dam, the total influence on water temperature within Oxbow Reservoir was calculated to be 0.0175 ^{o}C in June, 0.0102 ^{o}C in July and 0.0105 ^{o}C in August. These calculated values represent the maximum allowable temperature of permitted discharge to the reservoir, but do not necessarily represent the maximum temperature influence due to lack of consistent outflow temperature data. However, they act to give a relative magnitude of temperature influence that is obviously well below the defined measurable increase level of 0.25 ^{o}F (0.14 ^{o}C).

One permitted point source (cooling water for the turbines at Oxbow Dam) discharges to Hells Canyon Reservoir. This discharge has been calculated in the same manner as outlined for Oxbow Reservoir above and is also likely to be an overestimate of the actual temperature influence of this facility. Using the calculational model discussed previously with averaged maximum daily water temperatures (data were not available for all days of the month), and calculated average monthly discharge values for Oxbow Dam, the total influence on water temperature within Hells Canyon Reservoir was calculated to be 0.0066 ^{o}C in June, 0.0058 ^{o}C in July and 0.0096 ^{o}C in August. As in Oxbow Reservoir, these calculated values represent the maximum allowable temperature of permitted discharge to the reservoir, but do not necessarily represent the maximum temperature influence. However, they provide a relative magnitude of temperature influence that is obviously well below the defined measurable increase level of 0.25 ^oF (0.14 ^oC).

The Hells Canyon Complex reservoirs act to cool water within the SR-HC TMDL reach. Direct temperature loading and designated beneficial support needs for the reservoir system are discussed in the following sections.

There is one permitted point source that discharges to the Downstream Snake River segment (RM 247 to 188). It is the cooling water for the turbines at Hells Canyon Dam. This discharge has been calculated as outlined previously and the total influence on water temperature within the Downstream Snake River segment was calculated to be 0.0044 ^oC in June, 0.0040 ^oC in July and 0.0066 ^oC in August. As in Oxbow Reservoir, these calculated values represent the maximum allowable temperature of permitted discharge to the reservoir, but do not necessarily represent the maximum temperature influence. However, they provide a relative magnitude of temperature influence that is obviously well below the defined measurable increase level of 0.25 ^oF (0.14 ^oC).

Given an average flow contribution and average daily maximum water temperatures from 1995, the inflow from the Imnaha River was calculated to influence the water temperature in the mainstem Snake River by a maximum of -0.12 ^oC during July, -0.05 ^oC during August and -0.06 ^oC during September. All calculations showed a cooling effect on the mainstem Snake River.

In the absence of water column data to generate a quantitative assessment of relative temperature loading to the reservoir segments, the data available show that the reservoirs act to cool the overall water volume released to temperatures below those measured in the mainstem Snake River near Weiser, and that the permitted point source influences are below the defined measurable increase level of 0.25 ^oF (0.14 ^oC).

Water temperature data collected from 1991 through 2001 show that the presence of the Hells Canyon Complex causes a shift in temperatures from those that would occur were the Hells Canyon Complex not in place. While peak summer temperatures are several degrees cooler due to withdrawals from below the reservoir surface, the decline in temperatures in the fall is delayed from that observed immediately upstream of the Hells Canyon Complex. This temperature delay is commonly observed to begin in early September. While the temporal distribution of this temperature shift is due to the delay in flow caused by water moving through the Hells Canyon Complex, the actual heat load (warmer water) is not. The impoundments are not a heat source. Sources of elevated water temperature include natural, unquantifiable and anthropogenic sources upstream of the Hells Canyon Complex and similar sources on inflowing tributaries.

Modeling work completed by IPCo (IPCo, 2002b) has shown that if the water inflowing to Brownlee Reservoir at RM 335 were at or below 17.8 ^oC, water leaving the Hells Canyon Complex at Hells Canyon Dam would also be at or below 17.8 ^oC, regardless of the temperature shift specific to the Hells Canyon Complex. While the DEQs do not agree that the 17.8 ^oC water temperature used in this modeling is an appropriate or attainable condition (as outlined in the discussion of the calculational model earlier in this document), the modeling does show that the Hells Canyon Complex is not the source of the heat load in the reservoirs and that if upstream conditions were cooler, the water exiting the Hells Canyon Complex would also be cooler. Therefore, it is concluded that the Hells Canyon Complex is not contributing to temperature exceedences specific to the cold water aquatic life/salmonid rearing designated use

However, the IPCo water temperature modeling also shows that even if the inflowing water temperature were less than or equal to 17.8 ^{o}C, the water exiting the Hells Canyon Complex would not meet the salmonid spawning criteria (although by only a small margin) because of the temporal shift created by the Hells Canyon Complex. Data assessment and calculational modeling by the DEQs (as discussed earlier) have identified a similar trend. It is, therefore, concluded that the responsibility for exceeding the salmonid spawning criteria is specific to the presence and operation of the Hells Canyon Complex.

3.6.8.3 Anthropogenic Influences on Temperature not Accounted for in this Analysis

The Pacific Northwest Water Quality Temperature Criteria Guidance Project (US EPA, 2002) identified the four largest sources of increased temperature in the Pacific Northwest to be (1) removal of streamside vegetation, (2) channel straightening or diking, (3) water withdrawals, and (4) dams and impoundments. The fourth item listed, dams and impoundments, has been discussed in the preceding sections. Water temperature data collected from sites within, above and below the Hells Canyon Complex show that the impoundments result in cooler overall maximum water temperatures during the summer months and a slight delay in heating (spring) and cooling (fall) below the Hells Canyon Complex (as discussed in Section 3.6.5.5 and Section 3.6.8.2).

While this analysis makes full use of the data and methodologies appropriate to evaluate temperature influences on the SR-HC TMDL reach, changes in water temperature due to items one through three above are non-quantifiable on a watershed scale. While these influences undoubtedly result in increased water temperatures within the SR-HC TMDL reach, the magnitude of this increase is unknown.

Removal of Streamside Vegetation.

Streamside vegetation on the mainstem and inflowing tributaries acts to reduce heating from solar radiation through shading. This effect is minimal on a site-specific basis, especially in the mainstem Snake River where the channel is very wide compared to the width of the riparian area, however, cumulative effects on smaller tributary systems can result in improved cool water refugia for aquatic species. The removal of this vegetation reduces the potential for shading within the system. While available water temperature data for the SR-HC TMDL are not sufficient to quantify the magnitude of this change, it is projected to result in increased water temperatures on, at minimum, a site-specific scale. Additional, consistent water temperature data would allow the use of more advanced modeling techniques that will aid in the identification of water temperature changes through restoration of streamside vegetation. If identified as an appropriate mechanism for reducing water temperatures, ground surveys to identify areas where streamside vegetation is degraded or non-existent can be undertaken as part of the implementation process. Areas identified as needing treatment could then be re-vegetated and water temperature monitored on a site-specific basis.

Channel Straightening or Diking.

The effects of channel straightening or diking on water temperatures in the SR-HC TMDL reach have not been quantified in this assessment. As with streamside vegetation removal, the influence of this action on water temperatures in both the mainstem and the tributaries can have both site-specific and cumulative effects. The magnitude of this effect is unknown at this time.

Water Withdrawal.

The analysis of relative temperature influences detailed previously does not account for anthropogenic influences due to changes in stream flow from water withdrawal for either the mainstem Snake River or the tributary systems. This analysis does not attempt to quantify the increase in water temperature due to diversion of mainstem Snake River or tributary flow. It is recognized that such diversions lead (during some portions of the growing season) to elevated water temperatures due to removal of instream flow. Water is diverted from the mainstem Snake River and inflowing tributaries as per existing water rights. The resulting reductions in instream flow result in shallower water, more susceptible to atmospheric heating. It is also recognized that such diversions (especially during the summer irrigation season) often act to increase naturally occurring instream flows through late season irrigation recharge and drain flow.

Diversion flows and total river flow (April through October) were calculated for the mainstem Snake River between Murphy and Weiser by the USBR (2001). This information was used to make a comparison of diverted flows and instream flows. Data was available for low (1991) and high (1997) water years. The comparison showed that the total flow (April through October) in the Snake River in 1991 (a low water year) was approximately 2,920,000 acre-feet at Murphy (RM 453.5) and 4,220,000 acre-feet at Weiser (RM 351). The total flow diverted during 1991 was approximately 1,980,000 acre-feet. The diverted flow is equal to 68 percent of the total instream volume at Murphy and 47 percent of the total instream volume at Weiser. The total flow (April through October) in the Snake River in 1997 (a high water year) was approximately 7,150,000 acre-feet at Murphy and 12,060,000 acre-feet at Weiser. The total flow diverted during 1997 was approximately 2,100,000 acre-feet. The diverted flow is equal to 29 percent of the total instream volume at Murphy and 17 percent of the total instream volume at Weiser.

While it is estimated that nearly half of the water diverted from the Snake River in the SR-HC TMDL reach returns to the system, that return is spread out between surface and ground water inflows and the return period is estimated to be close to a year (USBR, 2001). The management and diversion of water within the SR-HC TMDL reach, and upstream of this TMDL reach have a substantial influence on water flow and volume within the SR-HC TMDL reach. In the case of the SR-HC TMDL reach, the volume of water diverted in the dry year (1991) was over one and a half times more than the difference in water volume between 1991 and 1997. (The diverted flow is 1.5 times the difference between a high and a low water year.) This indicates that diverted flows, especially in average or low water years, represent a very substantial portion of the water volume in the river, and thus potentially have a large influence on the water temperature. This effect is not quantified by the temperature evaluation detailed here.

Return flows, in the form of subsurface recharge, are observed to have a cooling effect on surface water temperatures as shown in the previous analysis. A portion of the return flows in the SR-HC TMDL reach is in the form of subsurface recharge and no doubt exerts a cooling influence on the river. A general evaluation of the potential magnitude of this cooling influence was undertaken as part of the temperature source assessment; however, it provides only a general estimate. These same flows often act to increase late season stream flows over that which would occur naturally without management.

Other Considerations.

Changes in the water table resulting from water management practices have resulted in reduction of riparian or marshy areas along the mainstem Snake River in the SR-HC TMDL reach. Photos showing the Snake River in 1909 (too dark for reproduction) in the archives of the Oregon Historical Society show large marshy areas in the Snake River near the present day site of Ontario, Oregon. The existence of these areas historically in the SR-HC TMDL reach has been discussed repeatedly during the public meetings held as part of the SR-HC TMDL process.

Work currently in progress in the John Day River system has shown that recharge through such marshy areas can result in a substantial cooling influence on water temperatures. Temperature effects resulting from the loss of these types of marshy/riparian areas on the mainstem Snake River and the inflowing tributaries have not been quantified. Data collected from other systems may be generalized to project what the influences on the SR-HC TMDL reach may be, but it is doubtful that SR-HC specific data can be generated to quantify this influence directly.

Additionally, the fact that the Snake River is heavily impounded, together with the return flows from diversions along the SR-HC TMDL reach have resulted in a more stable, static flow pattern within the mainstem. Summer flow volumes in low water years are, without question, greater than those observed before the current level of management was in place.

3.6.8.4 AIR TEMPERATURE.

As stated previously, natural atmospheric temperature sources can be divided into two general categories: (1) Direct solar radiance, where sunlight striking the water results in a transfer of energy from the light waves to heat in the water, and (2) Direct heat conduction from the air itself. As the SR-HC TMDL reach and the mouths of many of the inflowing tributaries are contained in wide, relatively shallow channels where vegetation (current and historic) is sparse, direct solar radiance will result in efficient heat transfer to the system. Additionally, daily high air temperatures over the SR-HC TMDL reach regularly exceed 32 ^{o}C (90 ^{o}F) and often are over 37 ^{o}C (100 ^{o}F). During the majority of the summer months, maximum daily air temperatures routinely exceeded the maximum average daily water temperature in the mainstem river. This condition results in a situation where energy flows from the atmosphere into the river throughout the major portion of the sunlight hours, leading to substantial levels of naturally induced heating.

As natural atmospheric and non-quantifiable influences were shown to be a dominant factor in mainstem and potentially tributary water temperatures, air temperatures were assessed in correlation with water temperature target exceedences. Air temperature data was available for three sites in close proximity to the SR-HC TMDL reach. Data collected at Boise, Idaho, Weiser, Idaho and Brownlee Dam (RM 285) by the Western Regional Climate Center (WRCC) include daily minimum, average, and maximum air conditions. These data were available for 1999 to 2000. Figures 3.6.5 a and b show the average and maximum air temperatures in these locations throughout the summer season.

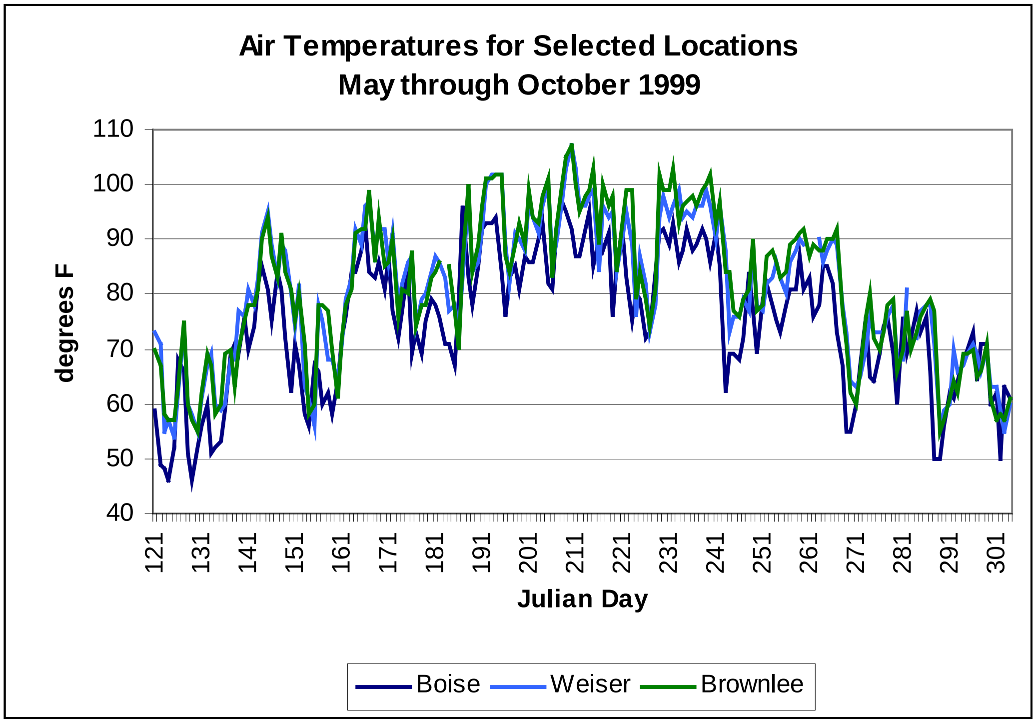


Figure 3.6.5 a. Air temperatures recorded at Boise, Weiser and Brownlee Dam from May through October of 1999.

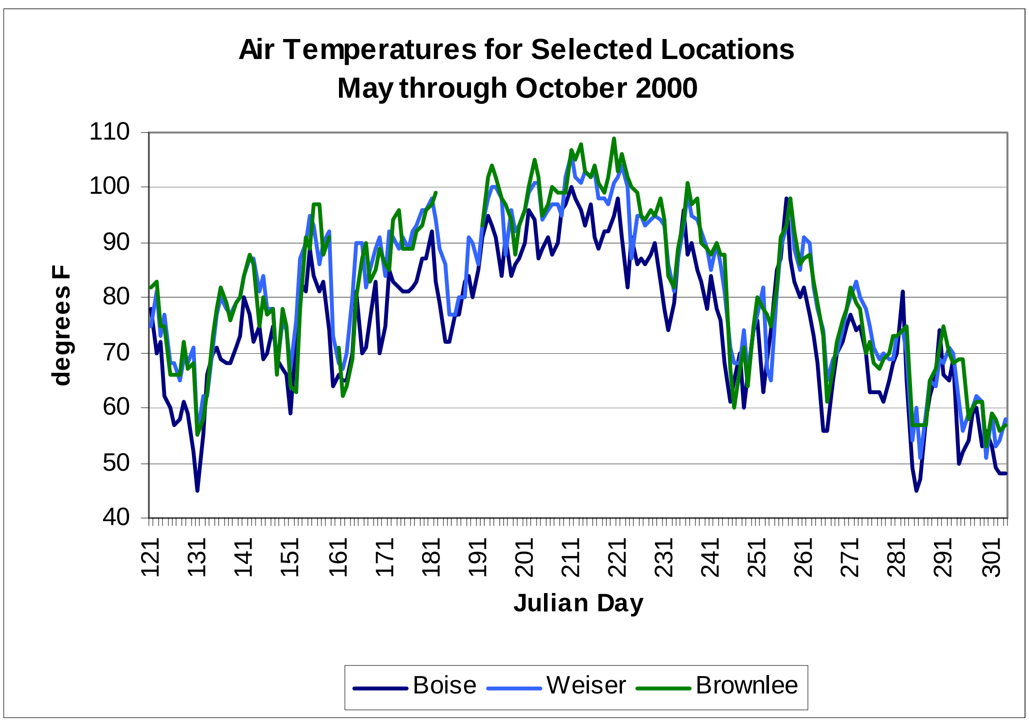


Figure 3.6.5 b. Air temperatures recorded at Boise, Weiser and Brownlee Dam from May through October of 2000.

The pattern of highs and lows in air temperature closely follows that observed in the water temperatures recorded for the same time period.

Air temperatures associated with maximum water temperatures exceeding the salmonid rearing/cold water aquatic life criterion of 17.8 ^oC are substantially warmer than the air temperatures associated with days on which the maximum water temperatures are less than 17.8 ^oC. Table 3.6.6 shows the typical daily maximum air temperatures associated with exceedence and non-exceedence water temperatures in the SR-HC TMDL reach.

Air temperature data from the Boise area, when compared with water temperatures in the mainstem Snake River near Murphy, Idaho, RM 453.5 (air temperatures from Murphy were not available), averaged approximately 6.2 ^oC (11.1 ^oF) higher on days when maximum water temperatures were greater than 17.8 ^oC. For air temperatures in the Weiser area this difference was even more pronounced, averaging 12 ^oC (21.6 ^oF) higher when water temperatures were greater than 17.8 ^oC.

Table 3.6.6. Mean daily maximum air temperatures at Boise, Weiser and Brownlee Dam, 1999 to 2000.

Month	Air temperatures when max. water temperatures do not exceed 17.8 ^oC	Air temperatures when max. water temperatures exceed 17.8 ^oC
Boise		
June	75.2 ^oF	84.3 ^oF
July	None	87.4 ^oF
August	None	87.2 ^oF
Mean	**75.2 ^oF**	**86.3 ^oF**
Difference	**11.1 ^oF**	
Weiser		
June	71.0 ^oF	89.9 ^oF
July	None	93.4 ^oF
August	None	94.6 ^oF
Mean	**71.0 ^oF**	**92.6 ^oF**
Difference	**21.6 ^oF**	
Brownlee Dam		
June	55 ^oF	64 ^oF
July	None	92.7 ^oF
August	None	95 ^oF
September	None	88 ^oF
October	65 ^oF	None
Mean	**60 ^oF**	**85 ^oF**
Difference	**25 ^oF**	

Daily maximum average water temperatures were not available for Brownlee Reservoir. Instantaneous data was used for the purposes of this comparison and showed a similar trend. On days when the available surface water temperature were greater than 17.8 ^{o}C, the corresponding air temperatures were more than 13.9 ^{o}C (25 ^{o}F) higher than those measured on days when water temperatures did not exceed the 17.8 ^{o}C target.

This substantial difference in temperature supports the relatively high level of natural atmospheric and non-quantifiable temperature influence calculated above.

3.6.8.5 TRIBUTARY COOLING EVALUATION.

After analyzing the existing conditions in the SR-HC TMDL reach, the effects of cooling the tributaries to the mainstem Snake River in the SR-HC TMDL reach were examined using the same calculational model described earlier. For this analysis, the water temperatures for all major tributaries to the mainstem Snake River in the SR-HC TMDL reach were gradually reduced to simulate cooling of the inputs to the river. Point sources, agricultural drains and ungaged inflows were kept at the initial values described earlier. The scenario modeling an equal (50:50) distribution of surface and ground water within the ungaged flow was employed in these calculations. This analysis used daily maximum water temperatures for an average water year as they represented the most complete data set available. However, the resulting outputs most likely represent a slight overestimation of the actual cooling necessary, as daily maximum water temperatures do not account for diurnal cooling influences.

The results of this analysis showed that the tributaries would all have to be cooled substantially to ensure that exceedences of the 17.8 ^{o}C seven-day average of daily maximum water temperatures instream in the mainstem Snake River at the Weiser gauge (RM 351) occurred less than 10 percent of the time.

The calculated reductions in daily maximum tributary water temperatures are as follows:

- an average of 7 ^{o}C during the month of June
- an average of 10 ^{o}C during the month of July
- an average of 10 ^{o}C during the month of August

Even when acknowledged to be a slight overestimate of the actual cooling necessary, these results show that the reductions needed in tributary water temperatures are very large, and unlikely to be achievable. The result is not unexpected given that in the initial evaluation performed, natural atmospheric and non-quantifiable temperature influences were identified as the primary factor driving temperature conditions in the mainstem river.

3.6.8.6 CONCLUSIONS.

From the temperature loading assessment discussed above, several conclusions can be drawn:

1. Ground water inflows exert a cooling effect on water temperatures observed within the mainstem Snake River. However, given the assumptions used in this calculation, the magnitude of cooling projected appears to be well within the general error and assumptions associated with this modeling exercise.

2. The overall magnitude of the influence of point sources on mainstem water temperatures within the SR-HC TMDL reach is calculated conservatively at 0.007 ^{o}C. This accounts for less than 0.2 percent of the total temperature load during the critical months of June, July, August and September. (Due to lack of consistent data, September temperature influences were not calculated, but were estimated to occur at a level similar to that observed in June.)

3. The average magnitude of the influence of tributary and drain inflows on mainstem water temperatures within the SR-HC TMDL reach is calculated conservatively at 0.5 ^{o}C. This accounts for approximately 12 percent of the total temperature during the critical months of June, July, August and September. (Due to lack of consistent data, September temperature influences were not calculated, but were estimated to occur at a level similar to that observed in June.). This does not account for natural atmospheric and non-quantifiable temperature influences within tributary systems. If the relative proportion of natural atmospheric and non-quantifiable temperature loading calculated for the mainstem Snake River within the SR-HC TMDL reach is applied to the tributary water temperature influences, the calculated average measurable anthropogenic temperature load to the Upstream Snake River segment (RM 409 to 335) would equal approximately 0.043 ^{o}C.

4. Calculated measurable anthropogenic temperature influences to the mainstem Snake River within the SR-HC TMDL reach are well below the "no-measurable-increase" value defined by the State of Oregon as 0.14 ^{o}C (0.25 ^{o}F).

5. Calculated natural and non-quantifiable temperature influences to the mainstem Snake River within the SR-HC TMDL reach equal over 90 percent of the increase in water temperature for the critical months of June, July, August and September. Natural atmospheric and non-quantifiable inputs are clearly the dominant influence on the water temperature of the river. Air temperature plays an important role in water temperature in the SR-HC TMDL reach.

3.6.9 Temperature and Designated Use Support Status

In correlation with the evaluation of the relative magnitude of temperature sources to the SR-HC TMDL reach discussed above, the existing language in the Oregon and Idaho state standards addressing temperature violations occurring from natural causes, and the ongoing process for improved temperature standards and policy in the Pacific Northwest, this TMDL recognizes the fact that water temperatures above those identified in the appropriate state standards can and do occur within the SR-HC TMDL reach due to natural atmospheric sources. Because of the situation occurring in the SR-HC TMDL reach, careful consideration has been given to the needs of designated aquatic life uses within the reach.

Although there are data that show water temperatures that exceed the temperature target in the reach, there is considerable information (data as well as anecdotal) available that indicates there were water temperatures over this target historically (prior to dam construction), even when aquatic species were present in healthy populations (USFWS, 1957 and 1958). One explanation for this is the occurrence of colder water refugia during periods of high stream temperatures in the bulk of the waterway. Such refugia are known to be present in the form of cold water tributaries in the SR-HC TMDL reach, and may also include springs or other ground water inflows where localized water temperatures are cooler than those observed for the system as a whole.

A second explanation is that water temperatures have always been elevated in much of the SR-HC TMDL reach and the lower portions of its tributaries due to high summer air temperatures, high solar radiation, and low summer flows. Climatologically, this area is classified as xeric, indicating little precipitation and high summer air temperatures. Native fish species may have adapted to these conditions. Fish species present (both native species and those introduced due to stocking or other management practices) may be capable of surviving and thriving in water temperatures in excess of those defined by the targets identified in this TMDL either with physiological or migration adaptations. Cold water refugia may have been more extensive historically than it is today due to anthropogenic effects in tributaries and the upstream Snake River. It is assumed that a combination of more extensive cold water refugia and an evolutionary temperature tolerance may both have been factors in supporting healthy population levels historically.

Both explanations have validity in this segment of the Snake River. Cold water refugia may have been more extensive historically than it is today due to anthropogenic effects in tributaries, the upstream Snake River and dam construction. It is assumed that a combination of more extensive cold water refugia and an evolutionary temperature tolerance may both have been factors in supporting healthy population levels historically. Both factors are explored further in the application of the creative approach outlined in the general loading analysis portion of this document.

The basic premise for developing the SR-HC TMDL is that the targets for the water body (Snake River mainstem from RM 409 to RM 188) must be set so that the water body will meet water quality standards. The reason water quality standards are established is the protection of designated beneficial uses. The criteria within water quality standards are developed as surrogate measures of beneficial use health/support, and it is assumed that attainment of those criteria will provide for full support of the designated beneficial uses. Therefore, water quality targets within the Snake River-Hells Canyon TMDL must be set so that water quality standards are met in such a manner that the designated beneficial uses are protected.

A second premise of this approach is the acknowledgement that there are distinct spatial and temporal (including seasonal) use patterns of the specific segments by the designated beneficial uses within the Snake River-Hells Canyon aquatic ecosystem. These spatial/temporal use patterns are not always captured in designation of beneficial uses by reach or watershed. Therefore, the Snake River-Hells Canyon TMDL targets and resulting implementation strategies need to recognize those spatial/temporal use patterns that exist, as well as the needed connectivity within the mosaic of designated beneficial uses (including critical habitat for sensitive species) throughout the waterbody. This would provide for full support of existing uses and the restoration of impaired designated uses within that mosaic. The Snake River-Hells Canyon TMDL also recognizes that this ecosystem is comprised of a variety of aquatic environments that include lentic, lotic and transition areas, each with their own characteristic attributes and beneficial uses.

3.6.9.1 COLD WATER REFUGIA.

It has been observed that there is often a natural component to any water body that may represent a source of pollutant loading. Surface water temperatures are observed to exceed water quality criteria within the SR-HC TMDL reach. The dominant cause of these exceedences is natural temperature loading. However, even with these exceedences, the Hells Canyon Complex manages to support viable populations of cold water species such as rainbow and redband trout.

Population Distribution.

Studies completed by IPCo have documented the distribution of salmonid species within the Snake River (Figure 3.6.6). Viable populations of rainbow trout have been documented to occur within the river system from American Falls to Swan Falls. While there is some variation in species composition throughout the studied sections of the mainstem Snake River, noticeably

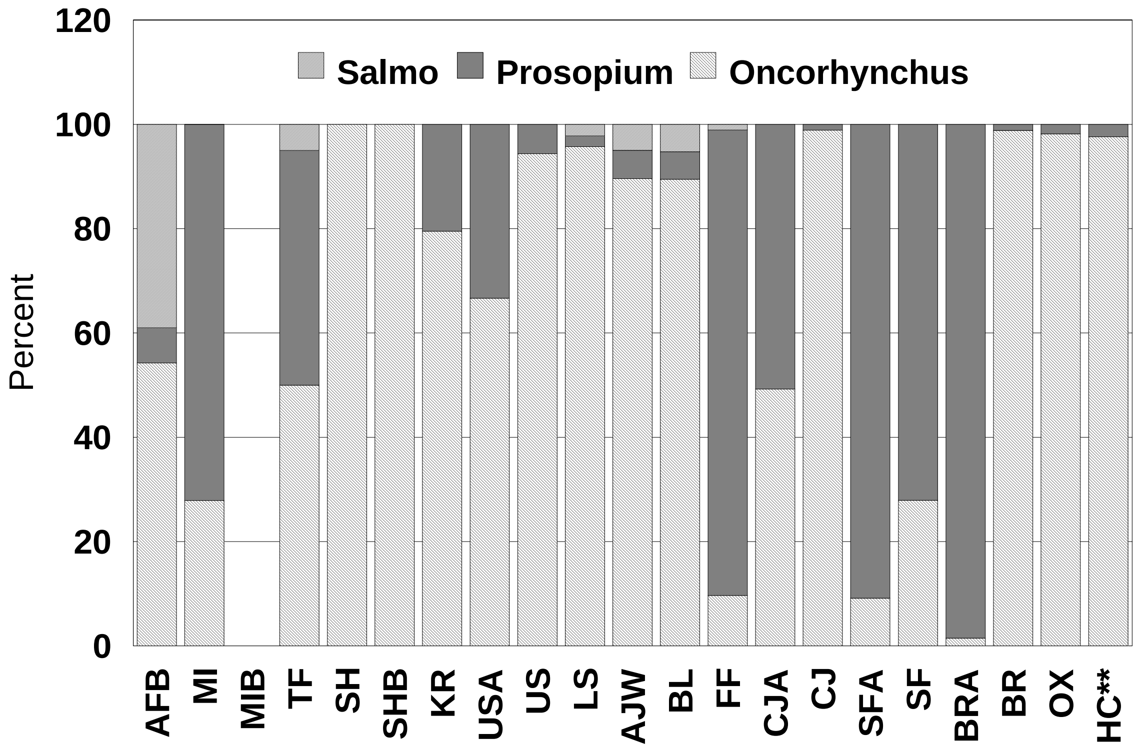


Figure 3.6.6. Percent composition of the family Salmonidae in the Snake River from the tailrace of American Falls Dam to Hells Canyon Dam. The genus *Salvelinus* is also present in small numbers in Hells Canyon Reservoir. Sampling is based on electrofishing spring and fall months periodically from 1991 to 2000. (Data was collected and plots were generated by Idaho Power Company).

The reach codes are as follows: AFB – American Falls Dam Tailrace, MI – Milner Reservoir, MIB – Milner Bypass Reach, TF – Twin Falls Reservoir, SH – Shoshone Falls Reservoir, SHB – Below Shoshone Falls to Pillar Falls, KR – Snake River from Buhl Bridge to Kanaka Rapids, USA – Snake River from Box Canyon to Thousand Springs, US – Upper Salmon Falls Reservoir, LS – Lower Salmon Falls Reservoir, AJW – Snake River from Lower Salmon Falls Dam to the upper end of Bliss Reservoir, BL – Bliss Reservoir, FF – Snake River from Bliss Dam to the upper end of CJ Strike Reservoir, CJ – CJ Strike Reservoir, SFA – CJ Strike Dam to the upper end of Swan Falls Reservoir, SF – Swan Falls Reservoir, BRA – Swan Falls Dam to the upper end of Brownlee Reservoir, BR – Brownlee Reservoir, OX – Oxbow Reservoir, HC – Hells Canyon Reservoir.

smaller relative populations of rainbow trout were observed in the sections of the Snake River from Bliss Dam to the upper end of CJ Strike Reservoir, in Swan Falls Reservoir and in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach where whitefish dominate. The Upstream Snake River segment of the SR-HC TMDL reach showed the lowest relative rainbow trout populations in the study.

Downstream of the Upstream Snake River segment (RM 409 to 335), populations of rainbow trout rebound as the dominant salmonid species within the Hells Canyon Complex reservoirs. Both stocked and wild trout populations have been tracked in this study. Figure 3.6.7 shows the relative abundance of wild and hatchery rainbow trout in the mainstem Snake River. Although hatchery fish are more abundant, Brownlee, Oxbow and Hells Canyon reservoirs support viable populations of wild fish. Similar wild populations have not been observed in the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach.

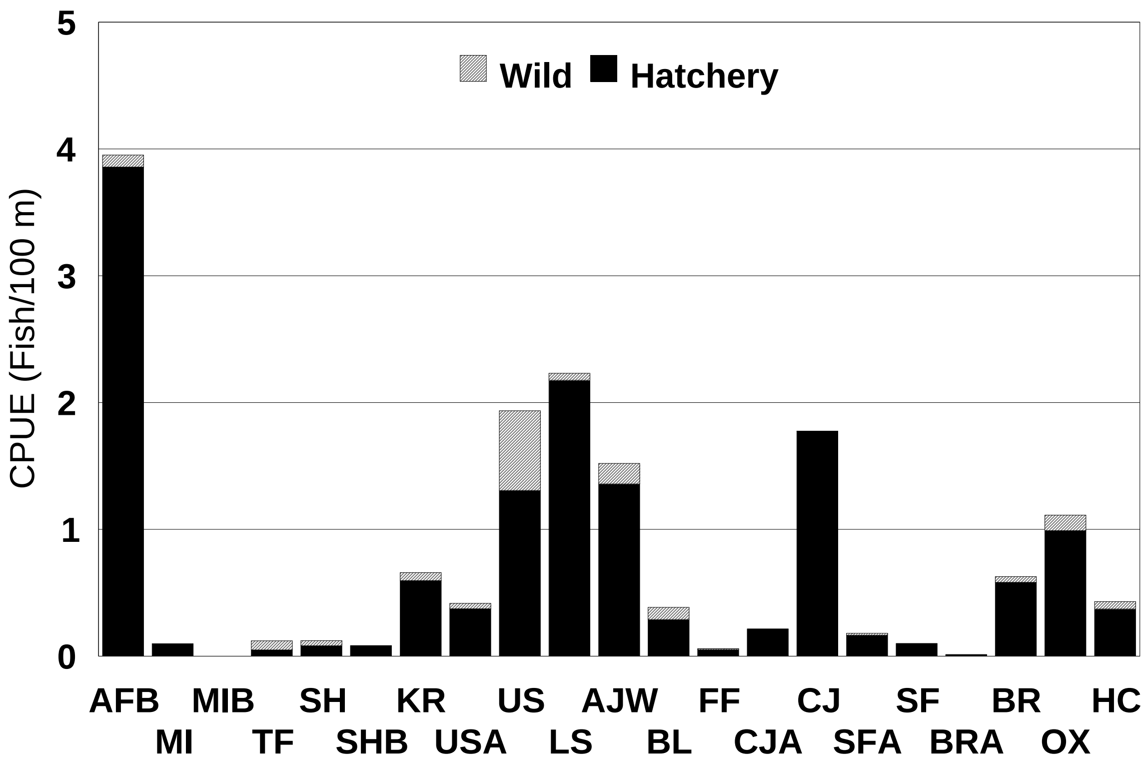


Figure 3.6.7. Relative abundance of wild and hatchery rainbow trout based on catch per unit of effort (CPUE fish/100 m of shoreline) in the Snake River from electrofishing effort in the Snake River from American Falls Dam tailrace to Hells Canyon Dam. Sampling is based on electrofishing spring and fall months periodically from 1991 to 2000. (Data was collected and plots were generated by Idaho Power Company). (The reach codes are defined in Figure 3.6.6)

A breakdown of spatial distribution within most of the SR-HC TMDL reach is displayed in greater detail in Figure 3.6.8. The data illustrated in this figure show hatchery rainbows present in the Snake River near Swan Falls Dam. Wild rainbows have not been documented in this section of the river. No rainbow populations (wild or hatchery) are observed between the area

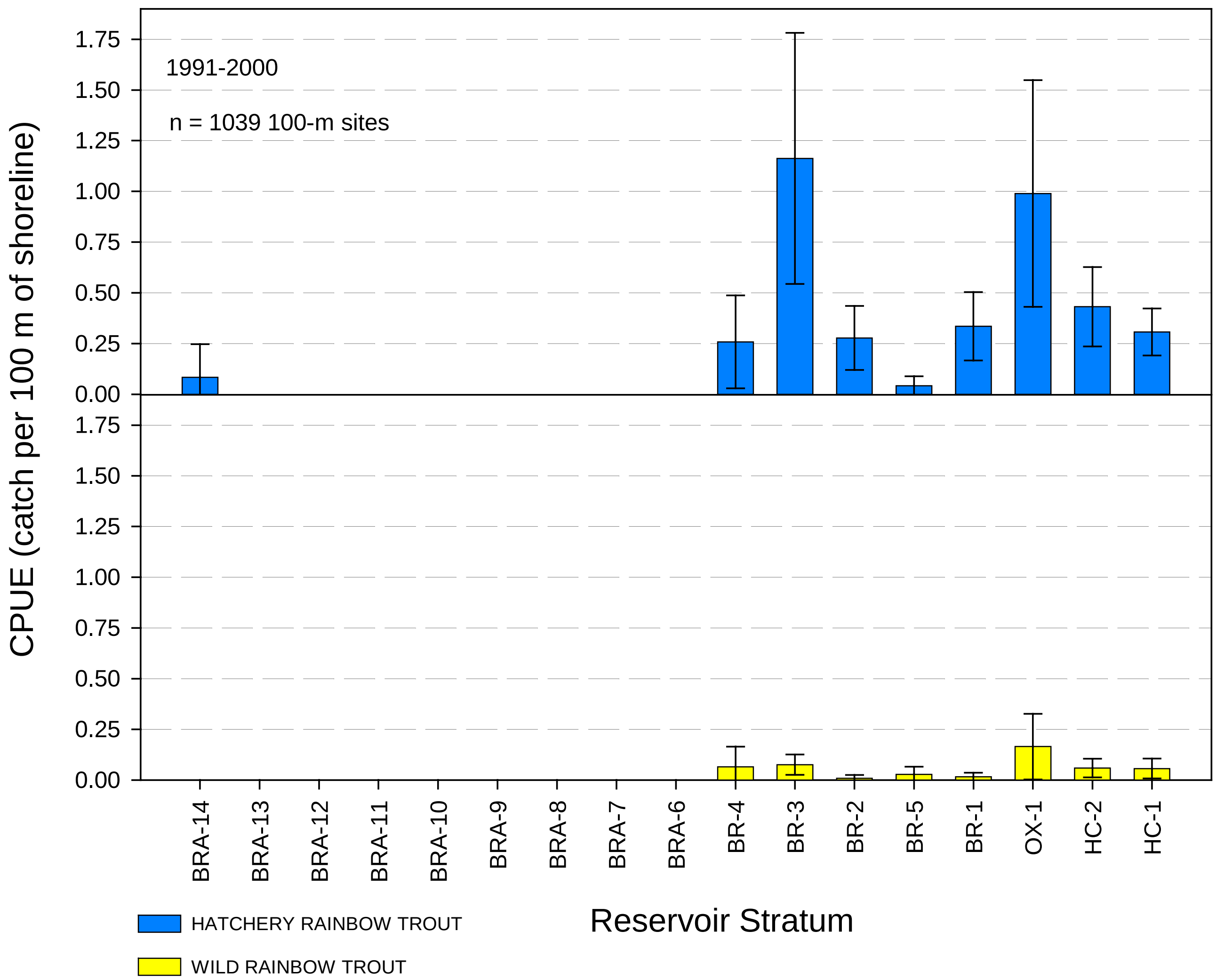


Figure 3.6.8. Relative abundance based on catch per unit of effort (CPUE per 100 m of shoreline electrofishing) of hatchery and wild rainbow trout in the Snake River from Swan Falls Dam to Hells Canyon Dam by sampling stratum. Sampling occurred annually during spring and fall, 1991 to 2000. Sampling strata BRA-14 to BRA-6 include the free-flowing reach from Swan Falls Dam to Brownlee Reservoir, sampling strata BR4-BR1 include Brownlee Reservoir, and sampling stratum BR-5 includes the Powder River Arm of the Brownlee Reservoir, OX1 includes Oxbow Reservoir, and HC1-HC2 include Hells Canyon Reservoir. (Data collected and plots generated by Idaho Power Company). (The reach codes are defined in Figure 3.6.6)

downstream of Swan Falls Dam and the inflow of Brownlee Reservoir. Within the reservoir segments however, both hatchery and wild rainbows are observed. The largest relative abundance based on catch per unit of effort values for both hatchery and wild rainbow trout were observed in Brownlee Reservoir (at BR3) and in Oxbow Reservoir.

The rainbow trout observed in Brownlee, Oxbow and Hells Canyon reservoirs and the Downstream Snake River segment (RM 247 to 188) showed a fairly wide range of size classes. As total body length in most fish species is substantially dependent on habitat, genetic and climatological factors, a straight length to age correlation cannot be accurately applied. Site-specific data is recommended for any such correlation. A study conducted by ODFW in McGraw Creek (a tributary to Hells Canyon Reservoir) provides a general estimation of these site-specific correlations.

This study developed length to age relationships for rainbow trout by using scale characteristics to age fish for which length measurements had been recorded. As fish age, thicker bands or growth “rings” known as annulus are formed, usually during cooler winter months when growth is slower. By counting the number of these rings present on scales a general idea of the number of winters a fish had lived could be determined. This study found that rainbow trout with scales containing 2+ annulus averaged 160 mm (6.3 inches) in length; these fish were estimated to be approximately 2 years old. Rainbow trout with 6+ annulus averaged 288 mm (11.3 inches) in length, these fish were estimated to be approximately 6 years old. Fish with 1+ annulus (considered fingerling fish) averaged 51 mm (2.0 inches) in length; these fish were estimated to be approximately 1 year old or less. If these same relationships are applied to the fish length data collected by IPCo shown in Figure 3.6.9, it can be seen that the reservoirs and the Downstream Snake River segment (RM 247 to 188) are home to a broad age range of fish.

Within Brownlee Reservoir, wild rainbows range from fingerling fish one year of age or less to over six years of age. In Brownlee Reservoir wild rainbows aged from fingerlings to approximately two years of age were most abundant. Wild rainbow trout in Oxbow range from approximately one year to over six years of age. In Oxbow Reservoir wild rainbows aged from two years to over six years were the most abundant. In Hells Canyon Reservoir wild rainbow trout range from fingerlings to over six years in age. In Hells Canyon Reservoir wild rainbows approximately two years of age and those over six years of age were the most abundant. Below Hells Canyon Dam, in the Downstream Snake River segment (RM 247 to 188), wild rainbow trout ranged from approximately six years in age.

Current beneficial use reconnaissance protocol defines full support criteria for fishes as supporting three age classes. If the assumptions above are correct, all three reservoirs support the designated salmonid rearing/cold water aquatic life use.

Spatial and Temporal Use Patterns.

As stated previously, a primary premise of the approach applied by this TMDL is the acknowledgement of distinct spatial and temporal (including seasonal) use patterns of the specific segments by the designated beneficial uses within the Snake River-Hells Canyon aquatic ecosystem. Within the complex system of mainstem and tributary waters within the SR-HC TMDL reach, these spatial and temporal use patterns are not always completely captured in designation of beneficial uses by reach or watershed. In the reservoir and Downstream Snake River segments of the SR-HC TMDL, joint use of reservoir and tributary systems provides support of salmonid rearing/cold water aquatic life designated uses.

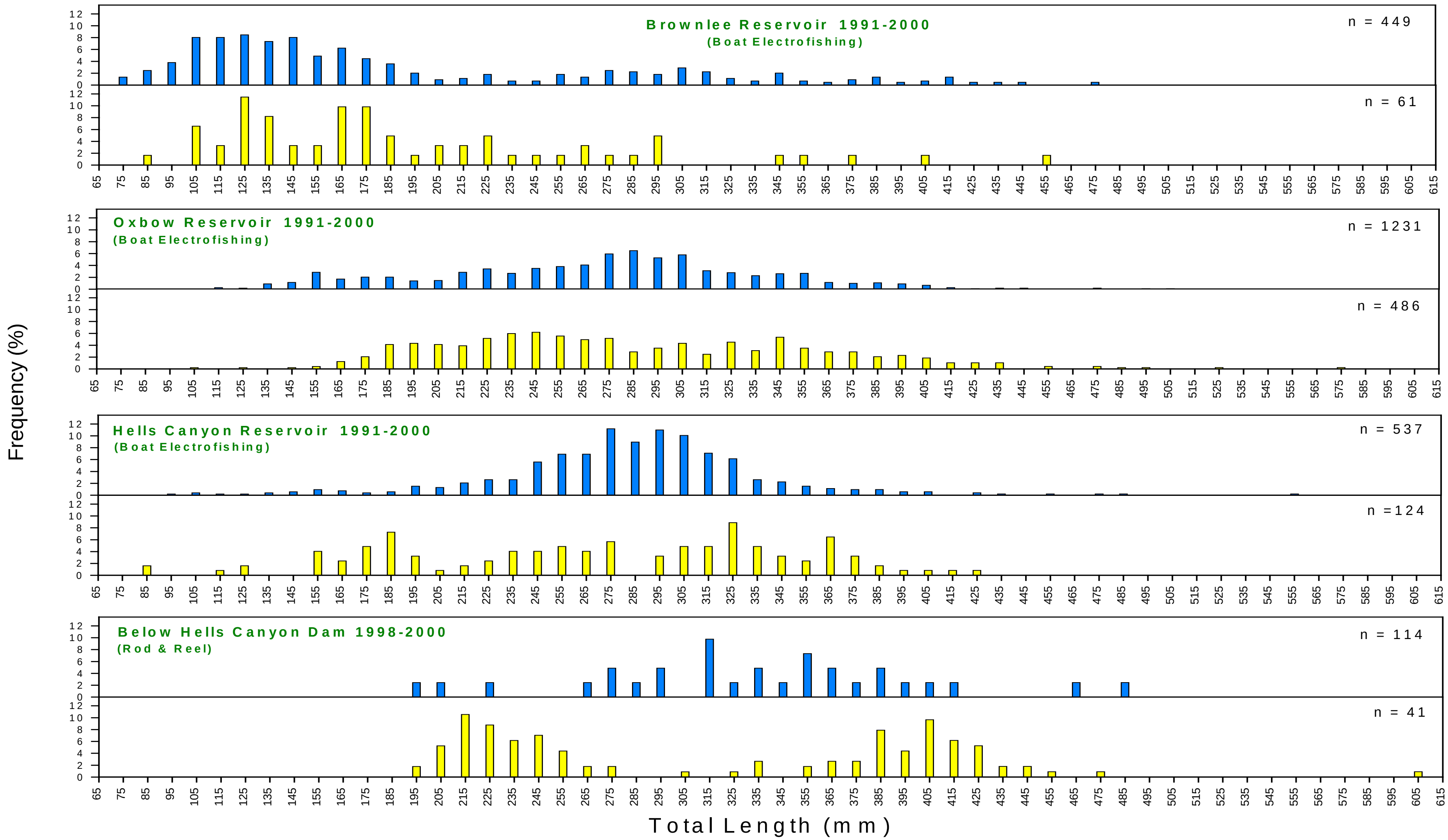


Figure 3.6.9. Percent length frequencies of wild and hatchery rainbow trout in Brownlee, Oxbow and Hells Canyon reservoirs from annual shoreline electrofishing sampling during spring and fall months from 1991 to 2000 (top three graphs). Percent length frequencies of wild and hatchery trout below Hells Canyon Dam from rod and reel sampling from 1998 to 2000 (bottom graph). (Data were collected and plots generated by Idaho Power Company.)

This temporal and spatial use mosaic is documented through a tracking study authored by IPCo for the reservoir and Downstream Snake River segments. Data was collected to identify relative population distributions on a monthly basis in the mainstem Snake River in the Hells Canyon Complex. The collected data for the 1998 through 2000 time period are shown in Figure 3.6.10.

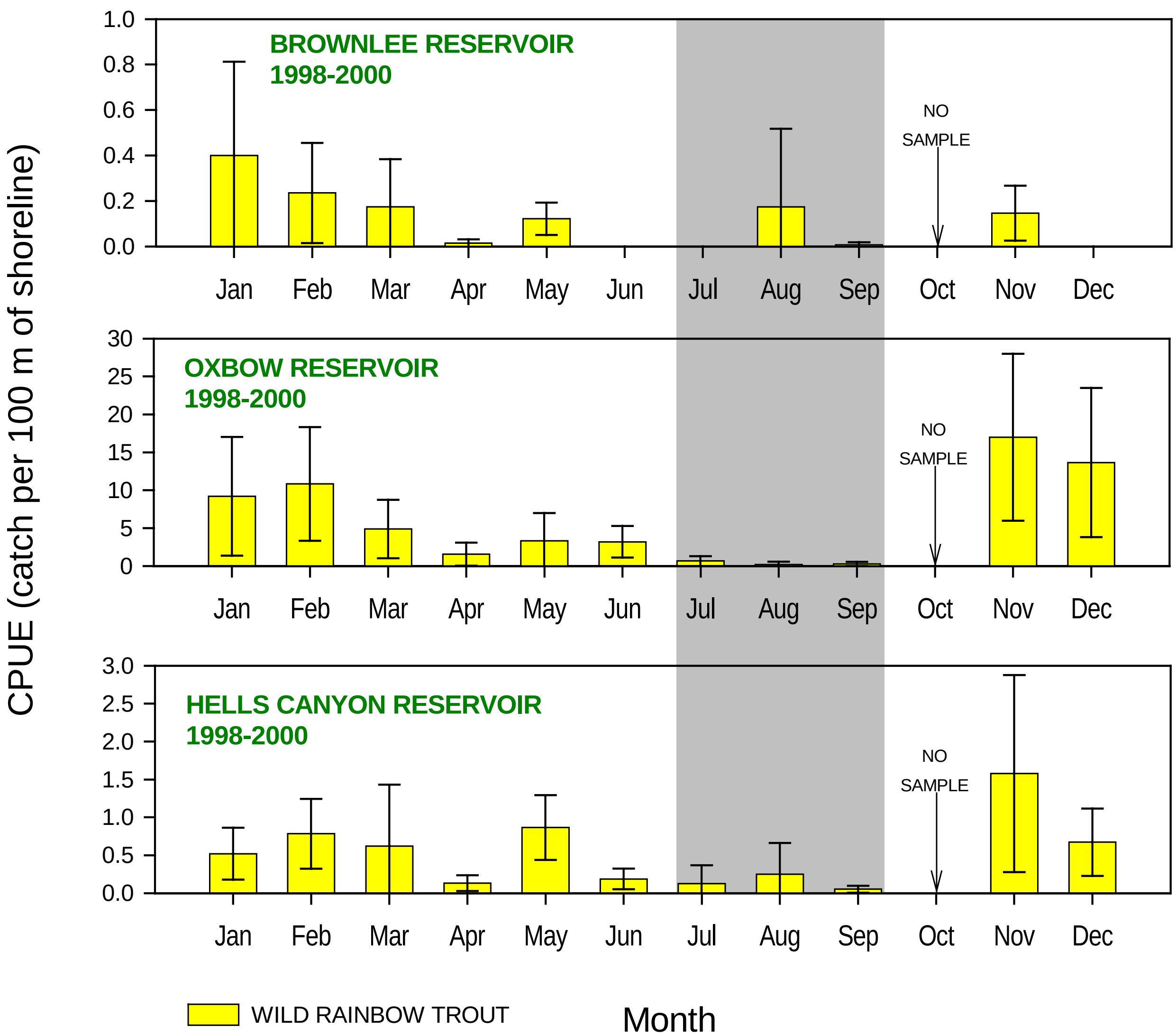


Figure 3.6.10. Monthly relative abundance of wild rainbow trout in Brownlee, Oxbow and Hells Canyon Reservoirs based on catch per unit of effort (CPUE per 100 m of shoreline electrofishing) during 1998 to 2000. Gray shaded area represents the period of warm summer water temperatures. (Data were collected and plots generated by Idaho Power Company.)

For all three reservoir systems, relative abundance of wild rainbow trout increases during the fall and winter months, then decreases during late spring and summer months. Data collected for hatchery raised rainbow trout show a similar relative abundance pattern.

When compared to the available water temperature data for the Hells Canyon Complex discussed in the preceding sections, a temperature triggered pattern is evident. Wild populations are present in Brownlee, Oxbow and Hells Canyon reservoirs throughout the winter and spring months (November through May). During the month of June, when water temperatures become elevated, relative abundance of rainbow trout in the reservoirs start to decrease. The lower relative abundance levels in-reservoir continue through the summer months (July through September) and then increases again in November.

Tributary monitoring through migrant weir placement shows an opposite pattern. In-migration to the reservoir occurs in October and November. Out-migration from the tributaries was observed during this same time period. Figures 3.6.11 a – c illustrate this pattern for tributaries to Brownlee Reservoir (Brownlee Creek), Oxbow Reservoir (Wildhorse Creek), Hells Canyon Reservoir (Indian Creek) and the Downstream Snake River segment (Sheep Creek). Relatively few fish were detained behind the migrant weirs in early to mid-September; frequency of daily captures increases throughout late September into October, and then decreases through November.

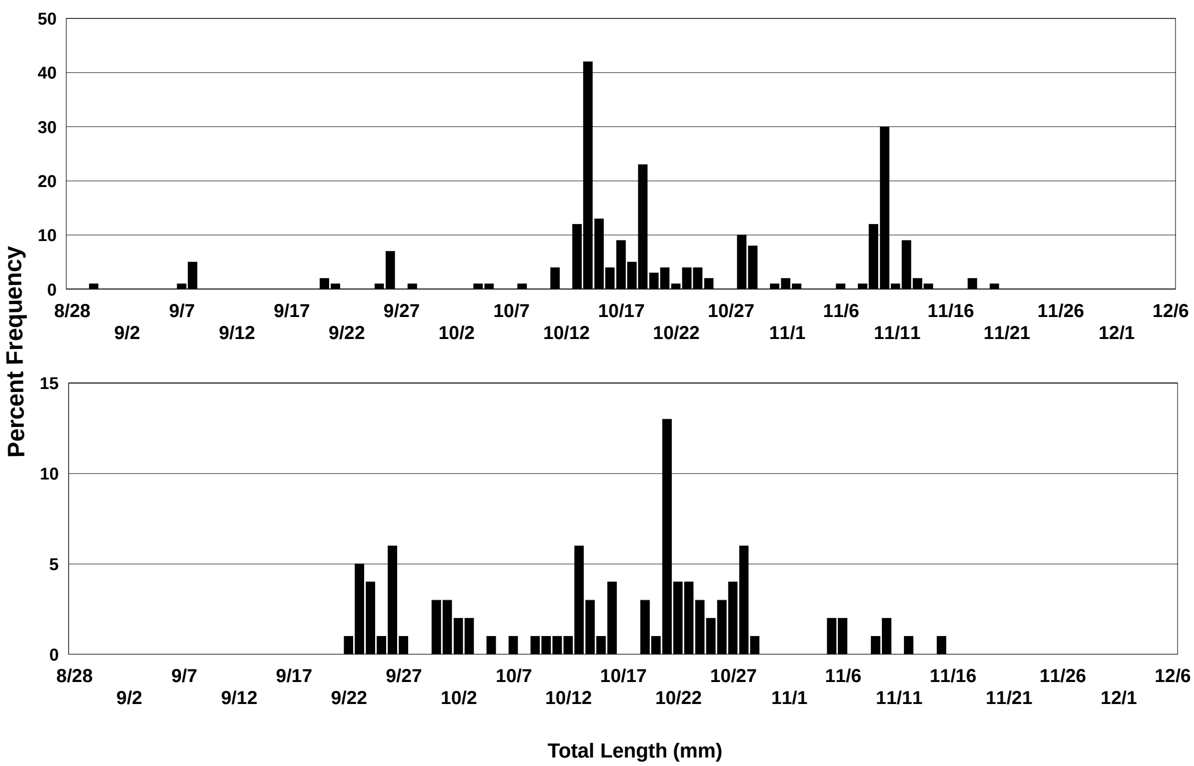


Figure 3.6.11 a. Frequency of daily captures of wild rainbow trout in a downstream migrant weir in Wildhorse River during 1998, and Brownlee Creek during 2000. (Data collected and plots generated by Idaho Power Company.)

This observed migratory pattern correlates well with water temperature increases in the mainstem Snake River in early summer (i.e. water temperatures above 18 ^{o}C become common near the surface in Brownlee Reservoir) and with water temperature decreases in the reservoir systems and tributaries in the late fall. The water temperature data shown in Figure 3.6.12 suggests that tributary temperatures below 10 ^{o}C may act as a trigger for migration into the reservoir systems. Observed relative abundance of both wild and hatchery rainbow trout in Brownlee, Oxbow and Hells Canyon reservoir rebound in close correlation with the occurrence of these temperature levels in the inflowing tributaries. It is theorized that the somewhat higher water temperatures in the reservoir segments may represent a less stressful overwinter environment for some fish species than the inflowing tributaries that experience substantial ice cover during the winter months.

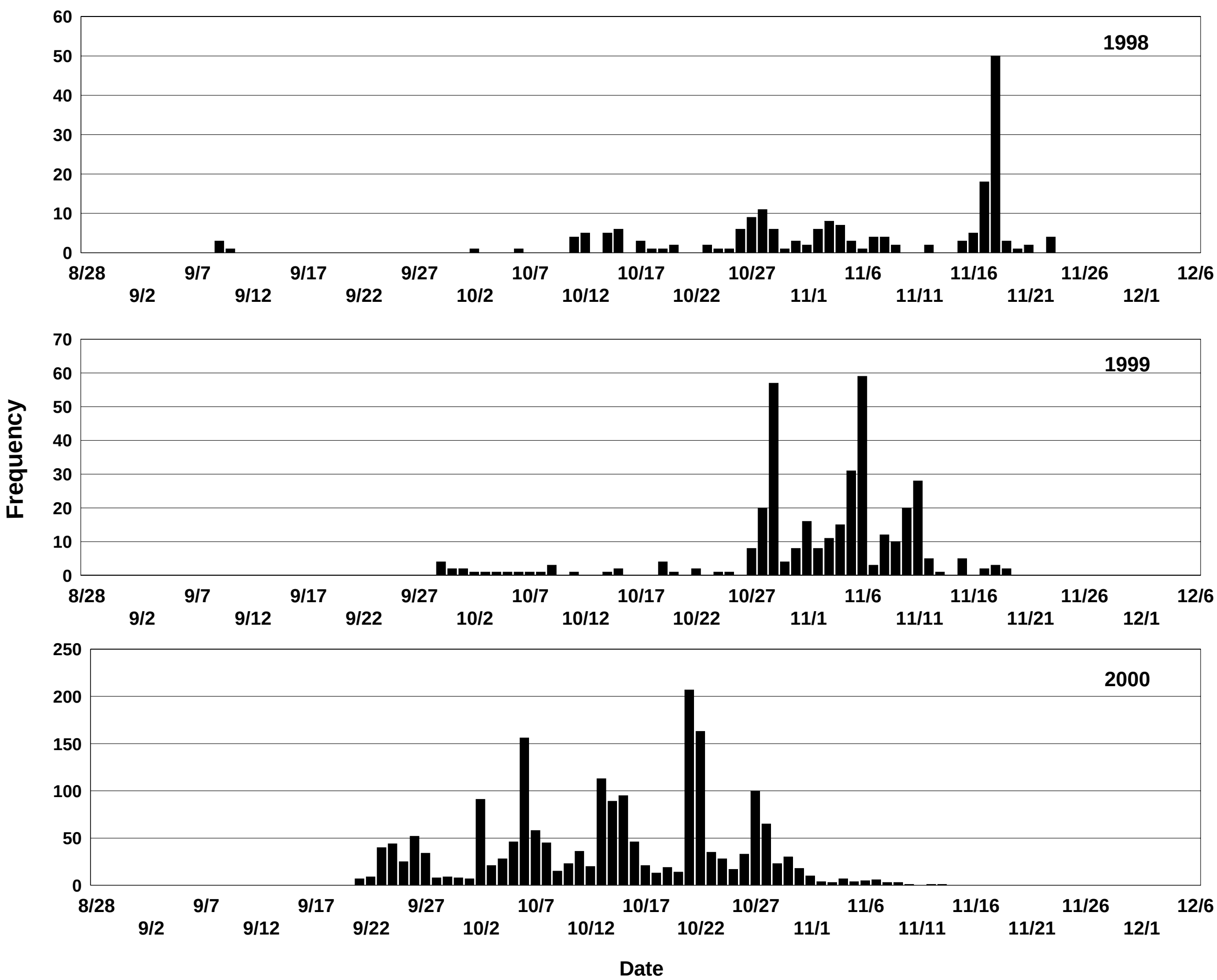


Figure 3.6.11 b. Frequency of daily captures of wild rainbow trout in a downstream migrant weir in Indian Creek during 1998, 1999 and 2000. (Data collected and plots generated by Idaho Power Company.)

As shown in Figure 3.6.13 a – c, the age distribution of migrating tributary populations observed in the above study correlate well with those identified for Brownlee, Oxbow and Hells Canyon reservoirs and the Downstream Snake River segment (RM 247 to 188). In Brownlee Creek (discharging to Brownlee Reservoir at RM 285.5), wild rainbows range from fingerling fish one year of age or less to over six years of age. In Brownlee Creek wild rainbows approximately two years of age were most abundant. Wild rainbow trout in Wildhorse Creek (discharging to Oxbow at RM 284.4) range from approximately one year to over six years of age.

In Oxbow Reservoir wild rainbow fingerlings and those from two years to three years of age were the most abundant. In Indian Creek (discharging to Hells Canyon Reservoir at RM 270) wild rainbow trout range from fingerlings to over six years in age. Indian Creek wild rainbows approximately two years of age and under were the most abundant. In Sheep Creek (discharging to the Downstream Snake River segment at RM 229), wild rainbow trout ranged from

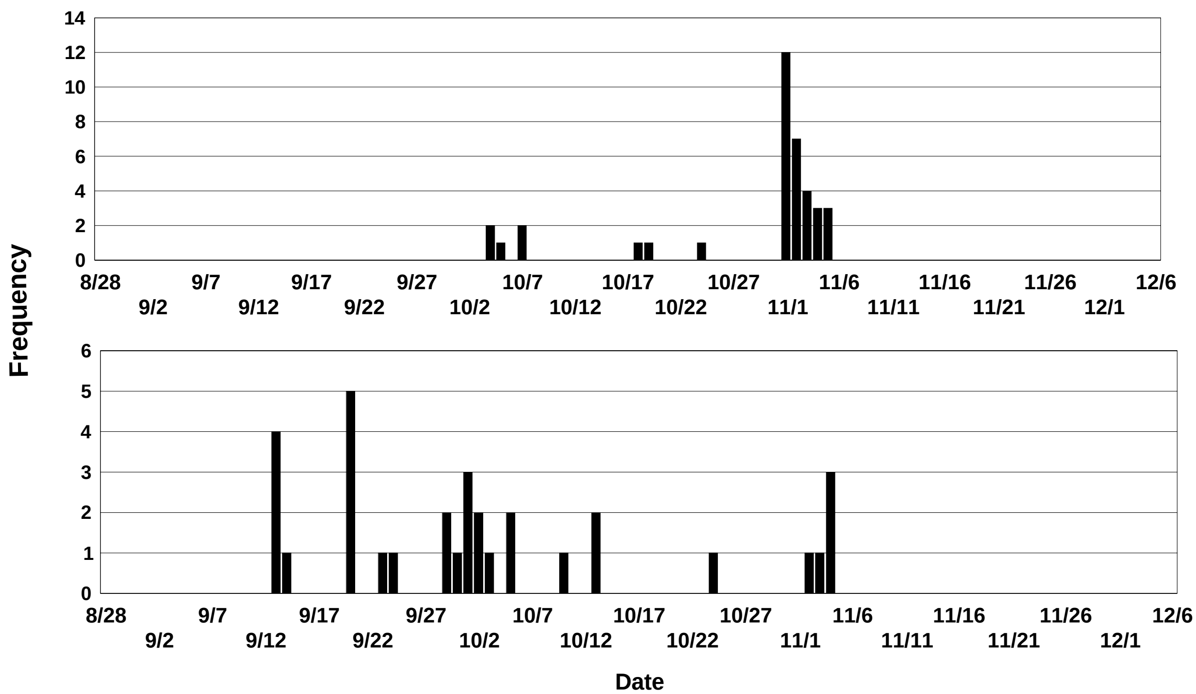


Figure 3.6.11 c. Frequency of daily captures of wild rainbow trout in a downstream migrant weir in Sheep Creek during 1999 and 2000. (Data collected and plots generated by Idaho Power Company.)

approximately six years in age, with wild rainbows approximately two years of age and under being the most abundant.

The tributaries to Brownlee, Oxbow and Hells Canyon reservoirs and the Downstream Snake River Segment are cooler during the critical summer months than the reservoir waters. Thus these tributaries provide cold water refugia that allows cold water species to avoid the higher water temperatures in the reservoirs during the summer months. The collected data show that designated beneficial use support is occurring given joint use of both reservoir and tributary systems. Within the Hells Canyon Complex of reservoirs and the Downstream Snake River segment, these distinct spatial and temporal (seasonal) use patterns occur to support salmonid rearing/cold water aquatic life designated beneficial uses.

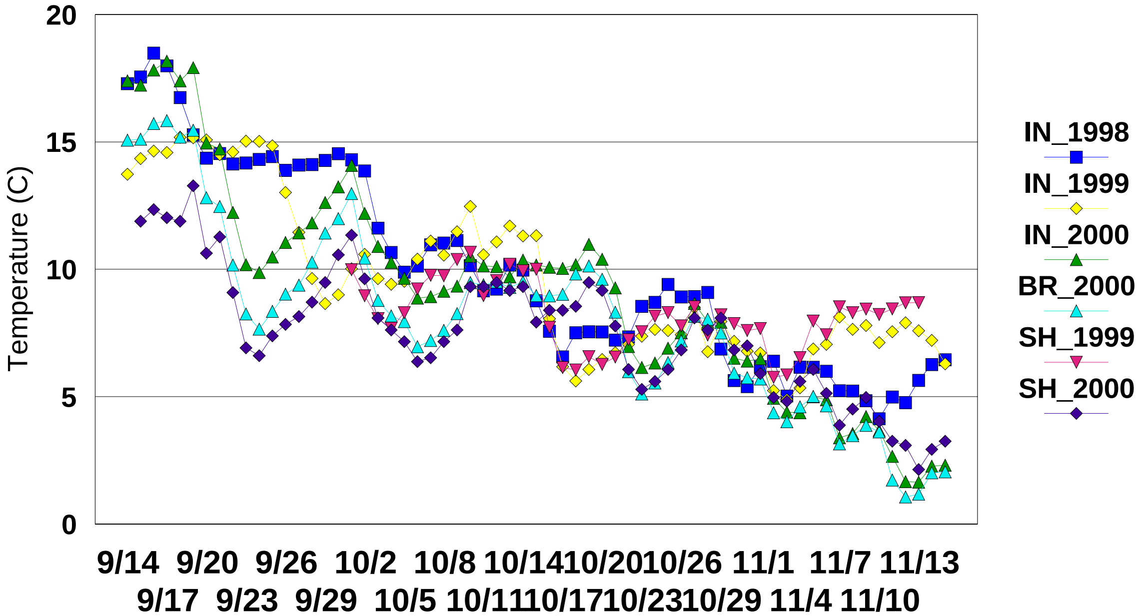


Figure 3.6.12. Water temperature (°C) from Indian Creek (IN), Brownlee Creek (BR), and Sheep Creek (SH) during fall months of 1998 to 2000. (Data collected and plots generated by Idaho Power Company.)

In contrast, rainbow trout populations in the Upstream Snake River segment (RM 409 to 335) are nearly nonexistent. For the most part, the tributaries discharging to the Snake River in this segment are not cold, fast moving streams like those inflowing to the Hells Canyon Complex reservoirs and do not provide the necessary level of cold water refugia for rainbows and other cold water fish in the system. Therefore, a viable population of rainbows is not observed in the Upstream Snake River segment (RM 409 to 335).

Creation of this type of refugia in the Upstream Snake River segment may represent a possible mechanism to deal with natural temperature loading concerns and lower rainbow trout populations in this section. Where slopes are more gradual in this section, it is unclear how possible or successful the creation of such refugia would be. A separate option is a full evaluation of the appropriateness of the designated beneficial uses of salmonid rearing and cold water aquatic life in this segment of the SR-HC TMDL reach. An effort toward this end is currently underway by stakeholders of the SR-HC TMDL process. Data generated by this effort will be evaluated within the iterative nature of the SR-HC TMDL process. If designated use refinement is judged to be necessary, the appropriate legislative processes will be followed and the TMDL will be adjusted accordingly.

Within the Hells Canyon Complex and the Downstream Snake River segment (RM 247 to 188), designated beneficial uses are being supported through availability of cold water refugia. Without question, existing refugia in the SR-HC TMDL reach must be protected and improved as necessary to continue support of the designated beneficial uses.

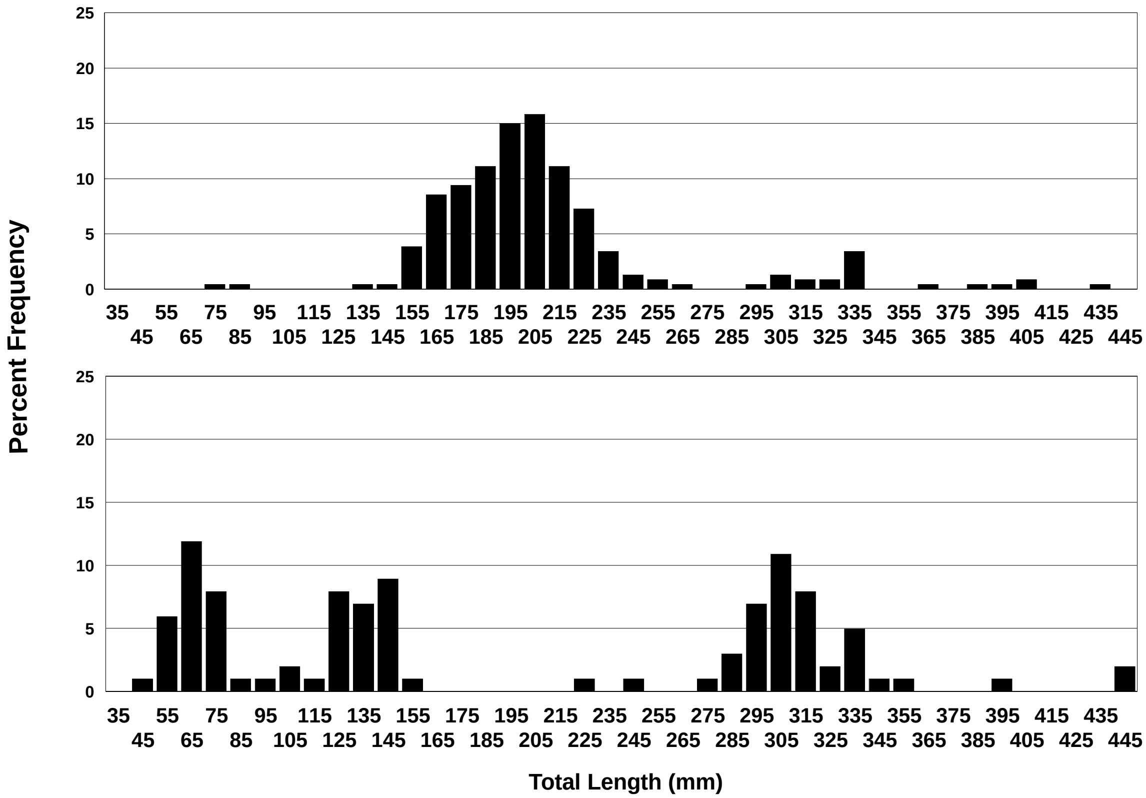


Figure 3.6.13 a. Length frequencies (percent) of wild rainbow trout captured in the downstream migrant weir near the mouth of Wildhorse River during fall of 1998 (top graph) and near the mouth of Brownlee Creek during fall of 2000 (bottom graph). (Data collected and plots generated by Idaho Power Company.)

In correlation with the proposed approach therefore, tributaries currently providing cold water refugia must be managed so that they continue to represent alternative habitat for salmonid rearing/cold water aquatic life during the critical months of June, July, August and September. Additionally, those tributaries that could provide such refugia but are not currently doing so due to anthropogenic influences should be managed so that such refugia is provided as appropriate.

In this way those portions of the SR-HC TMDL system that are being utilized as habitat for support of the designated beneficial uses of salmonid rearing/cold water aquatic life, namely those tributaries that currently are or could be providing cold water refugia during the critical time period, will meet criteria, and will support designated beneficial uses without imposing inappropriate and unreachable water quality targets and implementation expectations on the system as a whole.

3.6.9.2 Adaptation of Fish Species Present.

The alternative explanation proposed above, that water temperatures have always been elevated in much of the SR-HC TMDL reach due to climatological influences and that native fish species may have adapted to these conditions with either physiological or migration adaptations also has some application. The discussion of cold water refugia above cited work by IPCo showing

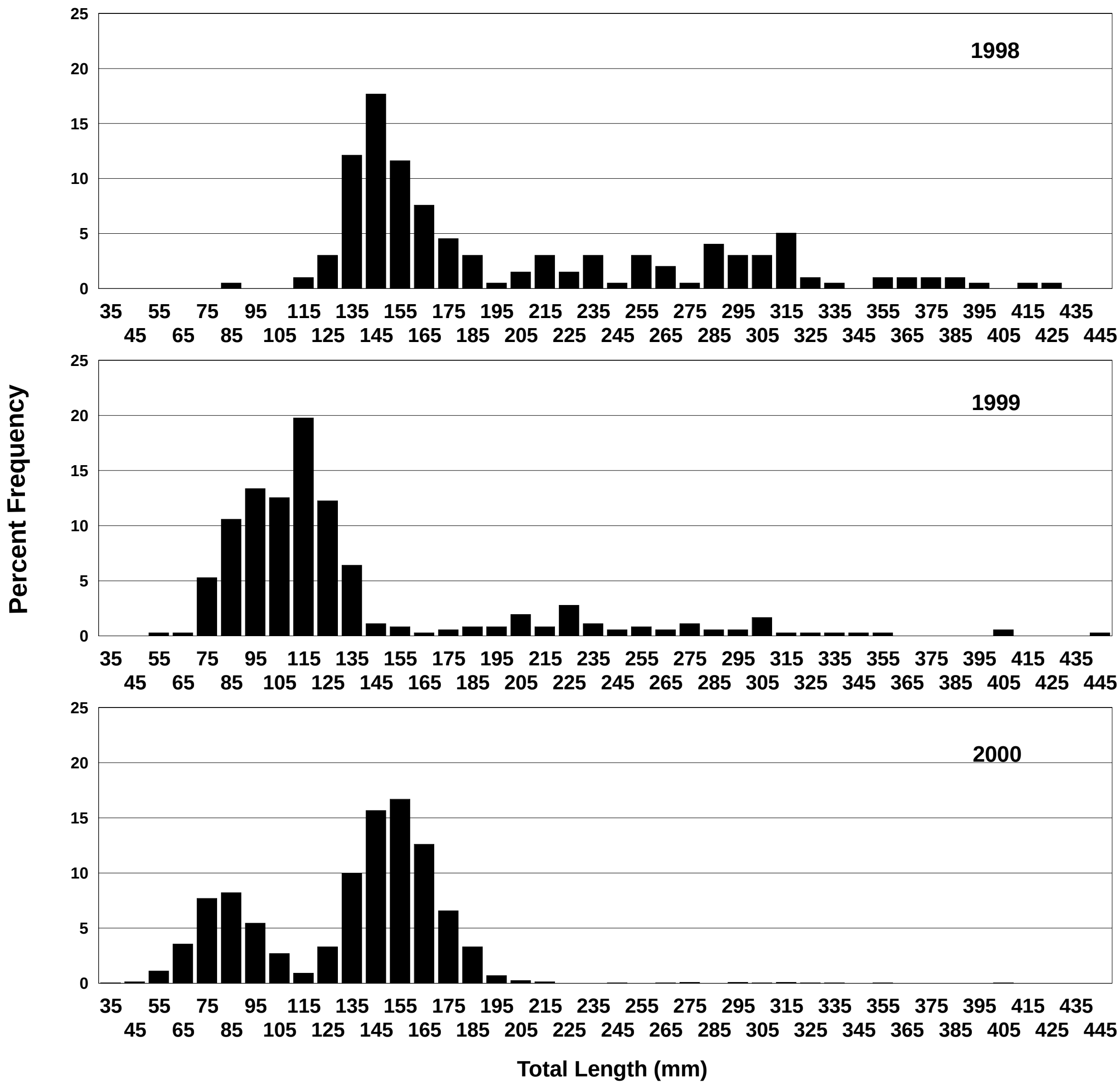


Figure 3.6.13 b. Length frequencies (percent) of wild rainbow trout captured in the downstream migrant weir near the mouth of Indian Creek during fall months of 1998, 1999 and 2000. (Data collected and plots generated by Idaho Power Company.)

migration patterns of rainbow trout within the Hells Canyon Complex (IPCo, 2001g). This migration is an adaptive behavior apparently triggered by temperature changes within the water column. Warm water temperatures trigger the out-migration to cooler tributary waters during the critical time period of June through September. Return-migration also appears to be temperature driven in that the majority of movement from the tributaries to the reservoir occurs when the tributary water temperatures first drop below 10 ^{o}C.

This adaptive behavior serves two purposes for the migrating fish. It removes them from tributaries that may not have enough flow to support a larger population over the winter period

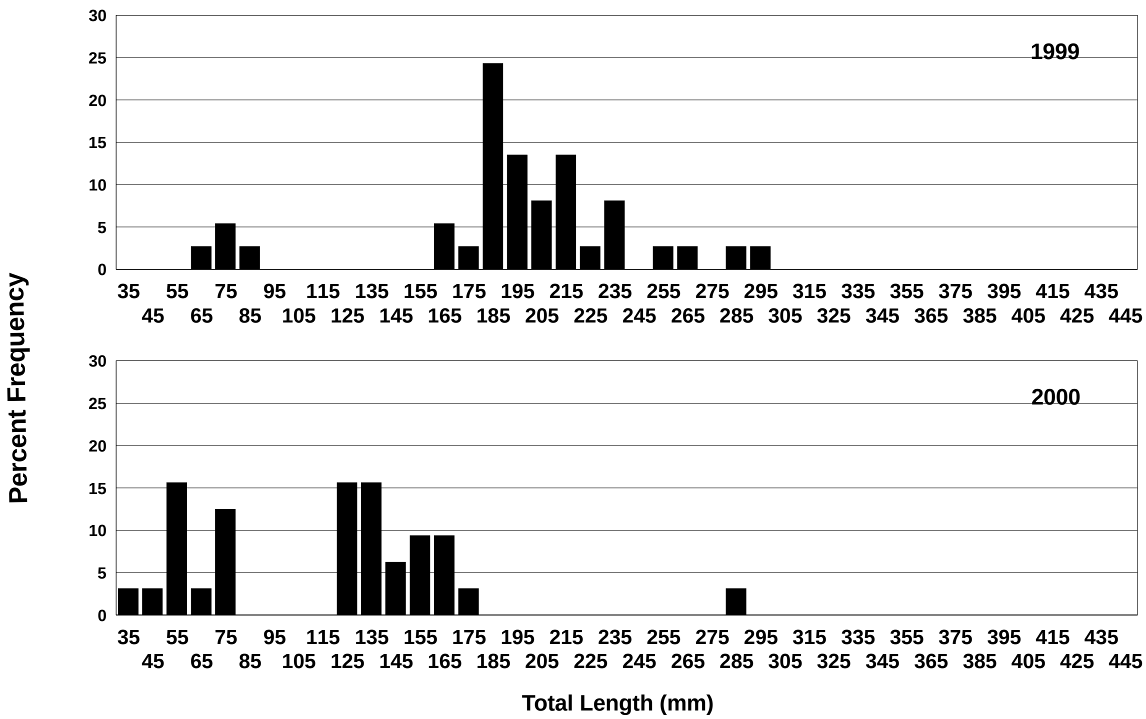


Figure 3.6.13 c. Length frequencies (percent) of wild rainbow trout captured in the downstream migrant weir near the mouth of Sheep Creek during fall months of 1999 and 2000. (Data collected and plots generated by Idaho Power Company.)

(ice-in and over winter concerns increase with smaller pool size and depth) and provides, through migration back into the reservoir, and more plentiful food source than would be available in the tributaries over the winter months. Studies have shown that moderate water temperatures result in better growth characteristics than waters that are substantially colder over extended periods of time (Appendix C and associated references). Therefore, this temperature triggered migration potentially provides a source of cool water during the critical summer months and an improved food supply during the colder winter months.

Additionally, an assessment of total population distribution for the SR-HC TMDL reach shows that warm water fishes dominate the system. Data on species distribution is available from before the CWA was finalized in 1975 (IDFG, 1973a and b) that indicates that warm water species were the dominant population. More recent studies (IPCo, 2000a; IDFG, 2000; ODFW, 2001) show that a similar distribution remains today within the SR-HC TMDL reach.

Rainbow trout, redband trout and mountain whitefish are listed as present in the Upstream Snake River segment (RM 409 to 335); although population counts like the one described earlier (Figure 3.6.6) show that the dominant cold water species in this segment is mountain whitefish. In the Brownlee and Oxbow reservoir segments rainbow trout, redband trout and mountain whitefish are listed as the cold water species present. While the population of mountain whitefish does not dominate in the reservoirs, the warmwater and coolwater species still substantially outnumber the cold water species (Table 3.6.7).

Table 3.6.7. Fish species present in the Snake River - Hells Canyon TMDL reach as identified by IDFG, ODFW, IDEQ, USFWS/IPCo and ACOE.

Segment	Warm Water Species	Cool Water Species	Cold Water Species
Upstream Snake River	largemouth bass channel catfish flathead catfish bluegill white crappie black crappie bullhead	smallmouth bass yellow perch pumpkinseed bridgelip sucker largescale sucker white sturgeon	rainbow trout* redband trout* mountain whitefish white sturgeon
Brownlee Reservoir	largemouth bass channel catfish bluegill white crappie black crappie bullhead common carp tadpole madtom flathead catfish warmouth	smallmouth bass pumpkinseed chiselmouth northern pike minnow bridgelip sucker largescale sucker peamouth sculpin[1] yellow perch white sturgeon	rainbow trout* redband trout* mountain whitefish* sculpin[1] white sturgeon
Oxbow Reservoir	largemouth bass bluegill white crappie black crappie bullhead common carp bridgelip sucker largescale sucker bridgelip sucker warmouth	smallmouth bass yellow perch pumpkinseed chiselmouth northern pike minnow white sturgeon	rainbow trout* redband trout* mountain whitefish* sculpin white sturgeon
Hells Canyon Reservoir	largemouth bass channel catfish bluegill white crappie black crappie bullhead common carp warmouth	smallmouth bass yellow perch pumpkinseed chiselmouth northern pike minnow bridgelip sucker largescale sucker sculpin[1] white sturgeon	rainbow trout* redband trout* mountain whitefish* bull trout** sculpin[1] white sturgeon
Downstream Snake River	largemouth bass channel catfish flathead catfish bluegill white crappie black crappie bullhead goldfish common carp tadpole madtom	stoneroller[2] smallmouth bass pumpkinseed chiselmouth northern pike minnow longnose dace bridgelip sucker largescale sucker yellow perch white sturgeon	chinook salmon (spring)* chinook salmon (summer)* chinook salmon (fall) sockeye salmon** rainbow trout/steelhead* redband trout* mountain whitefish kokanee salmon bull trout** white sturgeon

* Indicates species that spawn in the tributaries only – not in the mainstem.

[1] Depending on Species
[2] Not previously described in Idaho

** Indicates species that spawn in the <u>upper</u> tributaries only – not in the mainstem

The Hells Canyon Reservoir shows the addition of adult Bull Trout to the cold water species list but the warm water species still substantially outnumber the cold water species. Tributaries to the SR-HC TMDL reach are often nearly exclusively cold water species, especially in the upper reaches; however, the mainstem segments are consistently dominated by warm water species.

In the Downstream Snake River segment (RM 247 to 188), cold water species represent a greater portion of the overall fish population but warm water species are still present in a nearly equal role. The shift from cold to warm water species with distance downstream from the headwaters is certainly driven to some extent by water temperatures. Cold water fish are observed to be more plentiful in those areas where water temperatures are lower and warmer water species are more plentiful in areas with elevated water temperatures.

In addition to the overall population distribution however, some selectivity has been noted within the cold water species. Redband trout are plentiful in the Hells Canyon Complex. These fish are somewhat more elastic than the rainbow trout in adapting to elevated water temperatures, and show viable populations in the reservoir complex (IPCo, 2001g).

Fish requiring colder water temperatures or more stringent substrate conditions are not known to spawn within the SR-HC TMDL reach. Rather, these fish have been observed to spawn higher up in the tributaries to the system, using the available resources in a spatial and temporal fashion to meet habitat requirements for all life stages within the SR-HC watershed.

3.6.10 Conclusions

Temperature increases naturally within the SR-HC TMDL reach, the relative levels calculated for natural atmospheric and non-quantifiable (background) temperature influence in the Upstream Snake River segment (RM 409 to 335) during June equal 98.9 percent of the total, during July equal 99.5 percent of the total, during August equal 98.5 percent of the total and during September are assumed to be comparable to the values calculated for June (> 98%).

Temperature increases calculated for the permitted point sources within the Hells Canyon Complex of reservoirs and the Downstream Snake River segment (RM 247 to 188) are less than 10 percent of the level defined as no-measurable-increase by the State of Oregon, and less than 5 percent of the level defined as no-measurable-increase by the US EPA (Colville tribe) and the State of Idaho. All calculations were made in a conservative fashion and are based on available data.

The calculations indicate that natural atmospheric and non-quantifiable sources are clearly the dominant influence on the water temperature of the river, and that air temperature plays an important role in the elevated water temperatures observed in the SR-HC TMDL reach.

An evaluation of cold water aquatic life focusing on rainbow trout and redband trout show that they are present in viable populations in Brownlee, Oxbow and Hells Canyon Reservoirs. Evidence indicates that these populations have adapted to the naturally elevated water temperatures in the SR-HC TMDL reach by migrating into cold water tributaries during the summer season when reservoir temperatures exceed the conditions appropriate for salmonids. Alternatively, the reservoirs provide an appropriate habitat for over-winter growth when the tributary temperatures drop below approximately 10 ^{o}C. Support of these species is being provided by the availability of cold water refugia during the critical time period of June through September.

The same level of support is not available in the Upstream Snake River segment (RM 409 to 335), as is evidenced by the lack of diversity in local populations and the dominance of mountain whitefish as opposed to rainbow trout and other salmonid species. This section of the SR-HC TMDL reach experiences elevated water temperatures due predominantly to natural atmospheric and non-quantifiable influences. As the climate and landforms are very similar throughout the lower end of the Snake River Basin, it is expected that exceedence of water quality targets in inflowing tributary systems is also driven predominantly by natural atmospheric and non-quantifiable influences.

The Hells Canyon Complex causes a shift in temperatures from those that would occur were the Hells Canyon Complex not in place. Peak summer temperatures are several degrees cooler due to withdrawals from below the reservoir surface, and the decline in temperatures in the fall is delayed from that observed immediately upstream of the Hells Canyon Complex. While the temporal distribution of this temperature shift is due to the delay in flow caused by water moving through the Hells Canyon Complex, the actual heat load (warmer water) is not. The impoundments are not a heat source.

Data available to this TMDL effort and modeling work completed by IPCo shows that the Hells Canyon Complex is not the source of the heat load in the reservoirs and that if upstream conditions were cooler, the water exiting the Hells Canyon Complex would also be cooler. Therefore, it is concluded that IPC is not contributing to temperature exceedences specific to the cold water aquatic life/salmonid rearing designated use

However, data assessment and calculational modeling by the DEQs, and IPCo water temperature modeling also shows that water exiting the Hells Canyon Complex would not meet the salmonid spawning criteria (although by only a small margin) because of the temporal shift created by the Hells Canyon Complex. It is, therefore, concluded that the responsibility for exceeding the salmonid spawning criteria is specific to the presence and operation of the Hells Canyon Complex.

3.7 Total Dissolved Gas Loading Analysis

3.7.1 Water Quality Targets and Guidelines

The purpose of TMDL development is to meet applicable water quality standards. The SR-HC TMDL is a bi-state effort; both Oregon and Idaho share the same numeric water quality standard for total dissolved gas (TDG). The target concentration for the SR-HC TMDL reach is therefore, the common water quality standard; that the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection shall not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood flow (See Section 2.2.4.7). Attainment of this target will ensure that the water quality requirements of both states will be met. Currently, exceedences of this target are known to have occurred downstream of Brownlee Dam.

The State of Oregon has an additional requirement that in hatchery receiving waters and waters of less than two feet in depth, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection shall not exceed 105 percent of saturation. The total dissolved gas target for the SR-HC TMDL will include this additional requirement where applicable.

While total dissolved gas exceedences have been documented to occur within the SR-HC TMDL reach, no segment of the reach is listed for total dissolved gas by either the State of Oregon or the State of Idaho. However, as part of the public process outlined in Idaho by House Bill 1284, if a local watershed advisory group (WAG) requests that an unlisted pollutant be addressed in a TMDL, IDEQ should make every reasonable effort to accommodate the request. Two members of the SR-HC Public Advisory Team (which acts as the WAG for the SR-HC TMDL process) requested that the SR-HC TMDL address total dissolved gas. In an effort to accommodate this request, total dissolved gas has been incorporated into this loading assessment.

The Hells Canyon Complex is licensed by FERC, and requires 401 Certification from both the State of Oregon and the State of Idaho. Re-licensing of the Hells Canyon Complex is running somewhat concurrently with the TMDL process, and 401 Certification will run concurrently with the FERC re-licensing process. A very broad and capable effort involving many at the private, state and federal level is currently working to identify the full extent of total dissolved gas concerns, designated use support needs, and viable treatment options associated with total dissolved gas violations in the Hells Canyon Complex. As the re-licensing process proceeds, these efforts will be used to augment the general discussion included here, through 401 Certification of the Hells Canyon Complex. In addition, these processes will act in an enforcement capacity to provide reasonable insurance that total dissolved gas improvements in the Hells Canyon Complex will be realized and designated beneficial uses fully supported.

3.7.2 Designated Beneficial Use Impairment

Elevated total dissolved gas concentrations (above 110% of saturation) are known to have a detrimental effect on aquatic biota. High concentrations of gas dissolved in the water can result in *gas bubble trauma*. This condition occurs when air bubbles form in the circulatory systems of salmon and resident fish (USA COE, 1999) "Gas bubble trauma results when the sum of the dissolved gas pressures exceeds the compensating pressures of hydrostatic head, blood, tissue, and water surface tension" (IPCo, 1998c, 1999b, 1999f).

The severity of the effects of this condition varies among the different aquatic species and among life stages within a species. Signs of gas bubble trauma have been observed in trapped adult fish below Hells Canyon Dam. Spring chinook salmon and steelhead trout are exposed to elevated total dissolved gas concentrations during spills, in both the adult and smolt stages of life. Fall chinook juveniles are exposed to elevated total dissolved gas. Little is known about the life stages and populations of resident and fluvial bull trout within the Snake River (IPCo, 1998c).

Elevated total dissolved gas levels from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas levels that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

3.7.2.1 SALMONID SPAWNING.

This designated beneficial use applies to the Downstream Snake River segment (RM 247 to 188) only, and is specific to those salmonids identified to spawn in this area, namely fall chinook and mountain whitefish. When runoff volume forecasts consistently indicate that an upcoming season will be an above average runoff year, reservoir volumes are evacuated to make a sort of buffer for the snowmelt/runoff. As a result, spill occurs and total dissolved gas concentrations downstream have the potential to exceed the state standards for saturation. This can often occur for much of the juvenile and adult spring migration period (April through June).

3.7.2.2 THREATENED AND ENDANGERED SPECIES.

A number of species listed as threatened or endangered under the Federal ESA, are known to inhabit the SR-HC TMDL reach. Adult bull trout, known to utilize the reservoir segments, are listed as threatened under the ESA. The SR-HC TMDL reach and some inflowing tributaries below Hells Canyon Dam also provide habitat for the Snake River fall and spring/summer chinook as well as steelhead, all of which are listed as threatened under the ESA.

A more complete description of these species, their status and their habitat needs is outlines in the Subbasin Assessment (Section 2.2.2.3). A general listing is included below.

Bliss Rapids snail (*Taylorconcha serpenticola*)
Distribution: mainstem Snake River below Hells Canyon Dam from RM 229 to 225 (IPCo, 2001a).

Bull Trout (*Salvelinus confluentus*)
Distribution: mainstem Snake River from RM 272.5 to RM 188

Fall Chinook (*Oncorhynchus tshawytscha*)
Distribution: Mainstem Snake River from RM 247 to RM 188.

Spring and Summer Chinook (*Oncorhynchus tshawytscha*)
Distribution: Mainstem Snake River from RM 247 to RM 188.

Steelhead (*Oncorhynchus mykiss*)
Distribution: Mainstem Snake River from RM 247 to RM 188.
All of the species listed above as threatened or endangered rely on good water quality for survival. Waters are designated for salmonid spawning and rearing in the downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach. Waters so designated are required to exhibit appropriate concentrations of water column dissolved oxygen, intergravel dissolved oxygen, temperature, pH, ammonia, toxics, and turbidity for full support of fish during the spawning, incubation and rearing periods for those salmonid species inhabiting the designated waters. General time periods for spawning and incubation of the salmonid species identified to use the Downstream Snake River segment are shown below. A complete table of fish species in the SR-HC TMDL reach is available in section 3.6.9.2 of this document.

- Chinook salmon (fall) Oct 23 to April 30*
- Mountain Whitefish Nov 01 to March 15*

*represents spawning times identified by IDFG and ODFW as specific to the SR-HC reach.

Elevated total dissolved gas concentrations from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas concentrations that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

3.7.3 Sources

Elevated total dissolved gas from hydropower operations is a wide spread problem throughout the Pacific Northwest. Gas supersaturation is caused when air becomes dissolved in water while spilling over a dam into the depth of a plunge pool. High hydrostatic pressure causes the air to be driven into solution, resulting in supersaturation. The detrimental effects of supersaturation on aquatic biota are well documented. Elevated total dissolved gas concentrations pose a potential threat to threatened and endangered species of fish along with other aquatic biota within the Snake River (IPCo, 1998c, 1999b, 1999f). Elevated total dissolved gas concentrations are the result of spilling water over spillways of dams. Spill at Brownlee and Hells Canyon Dams is the only source of elevated total dissolved gas in the SR-HC reach.

3.7.3.1 Natural Sources.

There are no known natural sources of total dissolved gas that result in substantial loading or standards violations in the SR-HC TMDL reach.

3.7.3.2 Anthropogenic Sources.

Elevated total dissolved gas concentrations are the result of spilling water over spillways of dams. Spill at Brownlee and Hells Canyon Dams is the only source of elevated total dissolved gas in the SR-HC reach.

Voluntary Spill. At this time, voluntary spill does not occur within the Hells Canyon Complex. Spill at dams occurs only involuntarily, usually as a result of flood control constraints.

Involuntary Spill. The US Army Corps of Engineers (USA COE) is responsible for defining flood control requirements for the Hells Canyon Complex. At times of rapid runoff within the Snake River system, upstream facilities may not be able to retain the quantity of water passing through. In these cases, Brownlee Reservoir may be required to evacuate some reservoir volume to retain this excess flow and prevent flood events downstream. In this event, water may be spilled with attendant high total dissolved gas concentrations. Brownlee Reservoir is the only reservoir in the Hells Canyon Complex to be operated for flood control. The decision to release water from Brownlee Dam for flood control purposes is made on a system wide basis, and may be in response to conditions upstream rather than in response to hydraulic capacity concerns specific to Brownlee Reservoir or the Hells Canyon Complex.

3.7.4 Transport and Delivery

A study conducted by IPCo in 1999 showed a declining trend in total dissolved gas concentrations with distance downstream from the Hells Canyon Dam. Spill episodes at Hells Canyon Dam over 19,000 cfs caused exceedences of the less than 110 percent of saturation standard throughout the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL. Total dissolved gas concentrations did not drop below 110 percent of saturation upstream of RM 188 at this level of discharge. Standard exceedences from spill volumes between 9,000 cfs and 13,400 cfs were not observed below RM 200, and spill volumes of 2,400 cfs showed standard exceedences that extended downstream to RM 230 only. The total distance downstream of the dam where water was observed to exceed the less than 110 percent of saturation standard was directly related to the volume of the spill. When spill occurred at 16,500 cfs at Brownlee Dam, but with no spill at Hells Canyon Dam, the less than 110 percent of saturation standard was not observed to be exceeded downstream of Hells Canyon Dam. In this case, elevated total dissolved gas concentrations were not “transported” through the reservoir complex to downstream segments.

3.7.5 Data Available for the Snake River - Hells Canyon TMDL Reach

Only summary data was available for this assessment. Plant capacities for the Hells Canyon Complex Reservoirs are 35,00 cfs (Brownlee Dam), 28,000 cfs (Oxbow Dam), and 30,500 cfs (Hells Canyon Dam) (IPCo, 1998c, 1999b, 1999f). Because of the limited capacity for flood storage within the Hells Canyon Complex reservoirs, high flows are spilled through the three dams on a regular basis. Whenever the reservoirs are full, river flows that exceed the hydropower plant capacity of the dams are passed over the spillway (IPCo, 1998c, 1999b, 1999f).

Spill within the SR-HC TMDL reach generally occurs during the time period from December through June/July for the Hells Canyon Complex reservoirs. The highest frequency of spill is during the time period from April through June.

It should be noted that while upstream impoundments are known to have no effect on total dissolved gas concentrations in Brownlee Reservoir, water entering the reservoir is often at or near saturation (100%).

3.7.5.1 Observed Effects of Spills from Brownlee Dam.

Spill tests were conducted at Brownlee Dam on June 4, 1998 at a spill level of 39,000 cfs. The tests were conducted to determine if spilling through the upper or lower gates resulted in a measurable difference in total dissolved gas in the downstream waters. The total dissolved gas concentrations observed from spilling through the upper gates averaged 114 percent of saturation while spill through the lower gates averaged 127.7 percent of saturation. This difference, probably due to degassing from wave effects and surface turbulence after the plunge from the spillway, was considered to represent a potential benefit to aquatic species in the Oxbow and Hells Canyon reservoirs as spill from Brownlee Dam is the largest influence on total dissolved gas concentrations within these reservoirs (IPCo, 1998c, 1999b, 1999f).

When spill occurred at 16,500 cfs at Brownlee Dam, with no spill at Hells Canyon Dam, the less than 110 percent of saturation standard was not observed to be exceeded downstream of Hells Canyon Dam. Therefore, while elevated total dissolved gas concentrations from spill at Brownlee Dam have been observed to have an effect on the total dissolved gas in Oxbow and Hells Canyon reservoirs, the effect is not observed to extend to the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach.

3.7.5.2 Observed Effects of Spills from Hells Canyon Dam.

Spill tests were conducted at Hells Canyon Dam on June 3, 1998 at a spill level of 28,000 cfs. The tests were conducted to determine if spilling through the upper or lower gates resulted in a measurable difference in total dissolved gas in the downstream waters. The total dissolved gas concentrations observed from spilling through the upper gates averaged 139 percent of saturation while spill through the lower gates averaged 135 percent of saturation. This difference was much smaller than that observed with Brownlee Dam, but was considered to represent sufficient benefit to aquatic species in the Downstream Snake River segment (RM 247 to 188) that the lower gates were recommended to be used for spill when ever possible.

Spill episodes at Hells Canyon Dam over 19,000 cfs caused exceedences of the less than 110 percent standard throughout the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL. Total dissolved gas concentrations did not drop below 110 percent of saturation upstream of RM 188 at this level of discharge. Standard exceedences from spill volumes between 9,000 cfs and 13,400 cfs were not observed below RM 200, and spill volumes of 2,400 cfs showed standard exceedences to RM 230 only. The total distance downstream of the dam where water was observed to exceed the less than 110 percent standard was directly related to the volume of the spill.

During the period of no spill, the state standard of less than 110 percent of saturation within the Snake River below Hells Canyon Dam was never exceeded.

Hourly monitoring of total dissolved gas concentrations below Hells Canyon Dam in 1999 (IPCo, 1999f) showed a defined relationship between spill and total dissolved gas below the dam. Total dissolved gas in the tailwater area of Hells Canyon Dam ranged from 108 percent of saturation to 136 percent of saturation while spill was occurring from Hells Canyon Dam. Nearly all levels of spill monitored resulted in total dissolved gas concentrations above the less than 110 percent of saturation target. The data collected indicate that total dissolved gas concentrations in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL are largely dependent on the occurrence of spill at Hells Canyon Dam and that upstream spill has little effect (IPCo, 1999f). Turbine operations seem to have little affect on total dissolved gas concentrations relative to the effects of spill (IPCo, 1999f, 2000e).

3.7.6 Determination of Total Dissolved Gas Loading

An accurate determination of total dissolved gas loading is not possible with the limited amount of data available to the SR-HC TMDL process. This assessment is being accomplished as part of the FERC re-licensing process, and will be evaluated as part of the State 401 Certification processes. It is not critical to this effort therefore, to generate an estimate of total loading at this time. Rather, it is sufficient to observe that the Hells Canyon Complex reservoirs along with dam operations have resulted in periodic exceedences of the less than 110 percent of saturation total dissolved gas target within the SR-HC TMDL reach.

Exceedences of the total dissolved gas target of less than 110 percent of saturation occur in both Oxbow and Hells Canyon reservoirs (as related to spill from Brownlee Dam in excess of 2,000 to 3,000 cfs).

Similarly, spills from Hells Canyon Dam in excess of 2,000 to 3,000 cfs result in total dissolved gas concentrations exceeding the total dissolved gas target of less than 110 percent of saturation in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach (IPCo, 1998c, 1999b, 1999f).

As they represent both a direct violation of state standards and an exceedence of the SR-HC TMDL target, and therefore pose a potential threat to threatened and endangered species of fish along with other aquatic biota within the Snake River, a TMDL for total dissolved gas in the SR-HC TMDL reach has been established that will ensure support of designated beneficial uses and attainment of the SR-HC total dissolved gas target. This will result in attainment of State total dissolved gas standards.

3.7.7 TMDL Determination

The TMDL for total dissolved gas in the SR-HC TMDL reach is set at the target value of less than 110 percent of saturation.

The total allowable mass of total dissolved gas (as nitrogen) equates to: Allowable Saturation ($\leq$110%) multiplied by the solubility constant of N_2 (as determined for the appropriate temperature and pressure), multiplied by the appropriate flow value for the designated mixing zone. This applies to all discharge flows not exceeding the ten-year, seven-day average flood flow volume for Brownlee and Hells Canyon Dams, identified by Idaho Power Company as 72,500 cfs.

It is recognized that the FERC re-licensing and State 401 Certification processes may utilize site specific data and designated beneficial use needs to identify a more site specific target for total dissolved gas in the SR-HC TMDL reach. If this occurs, and if the alternative target proposed by these processes is shown to fully support the designated beneficial uses within the system, the load allocation from this TMDL will be revised to reflect the new target.

3.7.8 Load Allocations

Section 4.0 contains detail on load allocations for total dissolved gas.

3.7.9 Appropriate Actions

Controlling elevated total dissolved gas can be achieved through controlling spill. If possible, spilling from projects with the least propensity for developing high total dissolved gas level, changing the spill patterns, and using spillway bays with deflectors are all potential options for reducing total dissolved gas exceedences. Additional options in a managed system may include storing more water in the upstream reservoirs within the system, putting more water through the turbines, or transferring spills outside the system.

Unfortunately, given the nature of the SR-HC TMDL system and the conditions during which spill occurs (high runoff volumes), there is not always enough time or system capacity to utilize the full suite of options.

A number of options for the management of total dissolved gas within the Hells Canyon Complex have been discussed as part of the FERC re-licensing process. The options selected will be the decision of the Complex operators (IPCo) and the overall requirements of the re-licensing process. Obviously, key decisions needed to manage high total dissolved gas will be driven by aquatic life support considerations, based on projected spill and total dissolved gas conditions.

The implementation of the final TMDL load allocation requirements for total dissolved gas will be incorporated into the state specific 401 Certification process, thus lending a substantial amount of assurance that a mechanism for implementation will be available to the process.

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Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Section 4.0 Load Allocations

4.0 Load Allocations

Pollutant sources, load capacities, and pollutant loading have been discussed in detail in the preceding pollutant-specific sections. This section contains a summary of all load allocation information on a pollutant-specific basis. The pollutant load allocations assessed include a margin of safety to take into account seasonal variability and uncertainty. It is acknowledged that uncertainty may be attributed to incomplete knowledge or understanding of the system, incomplete data, or variability in data.

Allocable loads were identified using a combination of information including pollutant loading, margin of safety, natural loads, and reserve capacities as appropriate. As discussed previously, appropriate margins of safety were used in determining load capacity for all pollutants for which a TMDL was completed. Natural pollutant loading was recognized and quantified to the extent possible in all cases. Reserve capacities were recognized for point sources for those pollutants where such capacities were appropriate. Load allocations were then determined using the remaining load capacity for each SR-HC TMDL segment.

For the purposes of the SR-HC TMDL, "point sources" refer only to those permitted facilities that discharge directly to the mainstem Snake River within the SR-HC TMDL reach (Section 3.0). These sources as listed in Table 2.5.0. Point sources that discharge to the tributaries will be accounted for in the tributary TMDL processes. Point sources that discharge to the mainstem above or below the SR-HC TMDL reach will be accounted for in the separate TMDL processes for the Snake River segments into which they discharge.

Tributary inflows to the SR-HC TMDL reach have been treated as discrete, nonpoint sources for the purposes of loading analysis and allocation within this TMDL. Gross allocations have been assigned to each inflowing tributary. Existing or future tributary TMDL processes will distribute load allocations in the form of load allocations and/or waste load allocations within their specific watersheds. It should be kept in mind that while inflowing loads to the SR-HC TMDL reach represent nonpoint sources within the SR-HC TMDL framework, actual tributary loading is composed of both point and nonpoint discharges within the respective tributaries. In some tributary watersheds, point source discharges from municipalities or industries combine with nonpoint discharges from agricultural and rural stormwater in the river channel as flow moves downstream. All of these will be represented as nonpoint source loading to the Snake River for purposes of the SR-HC TMDL.

In some cases, tributaries to the Snake River – Hells Canyon TMDL have been assigned load allocations for pollutants for which the tributaries do not have 303(d) listings.

In the case where a TMDL for other pollutants is already in place (Payette and Boise Rivers), IDEQ will prepare a tributary-specific TMDL through the existing tributary TMDL process as part of the Implementation Plan for the approved TMDL. This TMDL will be written as an extension of the SR-HC TMDL process, but will utilize the WAG and other technical and stakeholder groups that participated in the preparation of the tributary TMDL.

In the case where a TMDL is not already in place (Weiser, Owyhee and Malheur Rivers), IDEQ will prepare a tributary-specific TMDL through the existing tributary TMDL process as part of the scheduled tributary TMDL. This TMDL will be written as an extension of the SR-HC TMDL process, but will utilize the WAG and other technical and stakeholder groups that participate in the preparation of the tributary TMDL.

The Oregon Department of Environmental Quality does not intend to list the tributaries to the Snake River/Hells Canyon TMDL for these pollutants. ODEQ, however, does intend to analyze pollutant levels and sources within the tributary subbasins and set allocations as appropriate as part of the development of TMDLs for the subbasins. The water quality management plan (WQMP) for the subbasins will also address implementation of pollutant load allocations as appropriate. If the analyses indicate that the target criteria for the inflow of the tributary to the Snake River cannot be achieved as a result of non-anthropogenic sources, the Department will, as resources allow, reopen the Snake TMDL and adjust the allocations accordingly, as appropriate.

It should be clarified that the allocations discussed in the following sections are based only upon an assessment of what is required to attain water quality standards in the mainstem Snake River within the SR-HC TMDL reach. This TMDL attempts no assessment of whether these conditions will attain tributary water quality criteria. Thus, it is possible that future tributary work could require reductions greater than those assigned in the SR-HC TMDL and could find conditions different from those assumed herein. In particular, the assumptions made herein regarding natural and anthropogenic contributions of heat in the tributaries are not to be assumed to be accurate for purposes of developing tributary TMDLs.

4.0.1 Mercury

Due to the fact that essentially no water column data are available to this effort, a TMDL cannot be established for mercury for the SR-HC TMDL reach. Therefore, IDEQ and ODEQ have determined it is in the public interest to reschedule the mercury TMDL for the SR-HC TMDL reach. IDEQ will reschedule the mercury TMDL to 2006 in order to gather additional data to better determine the sources and extent of mercury contamination. ODEQ's schedule for the mercury TMDL coincides with this date.

The state of Oregon is developing capability to model site-specific bioaccumulation factors. This schedule change will allow a better use of these capabilities and the opportunity to collect additional data.

Both Idaho and Oregon have interim measures in place to deal with mercury contamination such as sediment controls and fish consumption advisories as described in Section 3.1. It is the opinion of the DEQs that this schedule change will not present an adverse impact to the SR-HC TMDL reach.

4.0.2 Nutrients/Dissolved Oxygen

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.2.4.1, 2.2.4.3, 2.3.1.2, 2.3.2.2, 2.3.3.2, and 3.2.

4.0.2.1 LOADING

Nutrient concentrations are closely linked with dissolved oxygen and organic matter concentrations. Elevated concentrations of nutrients can lead to increased growth of algae and associated organic matter when other conditions such as water flow, depth, clarity, sunlight penetration, and temperature are conducive to enhanced growth. Algae and aquatic plants in turn consume oxygen from the water column during periods when respiration is the dominant process and in the aerobic decomposition of the dead algae and other detritus (non-living organic material). Total phosphorus has been identified as the nutrient of concern in the SR-HC TMDL reach. Improvements in dissolved oxygen can be achieved through attainment of growth-limiting concentrations of phosphorus (Section 3.2). Tables 4.0.5 and 4.0.6 contain calculated total phosphorus loading for point and nonpoint sources within the SR-HC TMDL reach.

Table 4.0.5. Total phosphorus waste loads from point sources in the Snake River - Hells Canyon TMDL reach for the critical time period based on 1995, 2000 data (May through September).

Point Source	NPDES Permit Number	Location (RM)	Current Design-Flow Load (kg/day)
City of Nyssa	101943 OR0022411	385	11
Amalgamated Sugar	101174 OR2002526	385	50
City of Fruitland	ID0020907	373	5.5
Heinz Frozen Foods	63810 OR0002402	370	412
City of Ontario	63631 OR0020621	369	0 [1]
City of Weiser (WWTP)	ID0020290	352	32
City of Weiser (WTP)	ID0001155	352	5.5 (max)
Brownlee Dam (IPCo)	ID0020907	285	Unmeasured assumed minimal[2]
Oxbow Dam (IPCo)	101275 OR0027286	272.5	Unmeasured assumed minimal[2]
Hells Canyon Dam (IPCo)	101287 OR0027278	247	Unmeasured assumed minimal[2]

1 City of Ontario uses land application in the summer months and does not currently contribute a phosphorus load to the SR-HC TMDL reach during the critical season.
2 Facilities sump discharge and turbine cooling water, not a phosphorus or waste treatment source.

Table 4.0.6. Calculated total phosphorus loading from tributary and nonpoint sources to the Snake River - Hells Canyon TMDL reach for the critical time period based on 1995, 1996 and 2000 data and average flow values (May through September).

Load Type	Location	Load (kg/day)	Estimation Method
Snake River Inflow	RM 409: Upstream Snake River Segment	1,912	See Section 3.2
Owyhee River	RM 396.7: Upstream Snake River Segment	265	See Section 3.2
Boise River	RM 396.4: Upstream Snake River Segment	1,114	See Section 3.2
Malheur River	RM 368.5: Upstream Snake River Segment	461	See Section 3.2
Payette River	RM 365.6: Upstream Snake River Segment	710	See Section 3.2
Weiser River	RM 351.6: Upstream Snake River Segment	392	See Section 3.2
Drains	Upstream Snake River segment (RM 409 to 335)	660	See Section 3.2
Ungaged flows	Upstream Snake River segment (RM 409 to 335)	385	See Section 3.2
Agriculture, Stormwater and Forestry	Upstream Snake River segment (RM 409 to 335)	Included in the ungaged flow loading	See Section 3.2
Burnt River	RM 327.5: Brownlee Reservoir Segment	52	See Section 3.2
Powder River	RM 296: Brownlee Reservoir Segment	126	See Section 3.2
Agriculture, Stormwater and Forestry	Brownlee Reservoir segment (RM 335 to 285)	Cannot be calculated due to reservoir “sink” effect, assumed small	See Section 3.2
Agriculture, Stormwater and Forestry	Oxbow Reservoir segment (RM 285 to 272.5)	Cannot be calculated due to reservoir “sink” effect, assumed small	See Section 3.2

The available data show that total phosphorus loading to the SR-HC reach originates almost entirely from the Upstream Snake River segment (RM 409 to 335). Measured total phosphorus loading to this segment accounts for the majority of the phosphorus load to the SR-HC reach, tributary loading equals 76 percent, point source loading represents approximately 8 percent, ungaged (estimated) drain flows accounting for 10 percent of the total system load and unmeasured sources accounting for approximately 6 percent of the total. Sources of unmeasured load may include nonpoint source runoff from anthropogenic sources and precipitation events, unidentified small tributaries and drains, error in gauged flow measurements and ground water sources.

Nutrient processing within the Hells Canyon Complex results in dramatic changes in measured total phosphorus concentrations downstream of Hells Canyon Dam as compared to those measured in the Upstream Snake River segment (RM 409 to 335). The change in phosphorus form and phosphorus sink characteristics of the reservoirs makes it impossible to determine loading from nonpoint sources within the immediate drainage area to the Hells Canyon Complex. The potential loading from these sources has been evaluated and assumed to be small as the incidence of recreational housing, agricultural practices (cropping and ranching) and municipal stormwater runoff is minimal, as is the intensity of use.

4.0.2.2 LOAD CAPACITY

Load capacity is calculated as the sum of the natural background load, point source loads and nonpoint source loads. In the tributary systems, the allocable load is equal to the load capacity, as outlined in the following equation.

> *Load Capacity = Allocated Tributary Load = Natural Background Load + Point Source Contribution + Nonpoint Source Contribution*

The SR-HC TMDL reach load capacity for nutrients (Table 4.0.7) was determined by calculation using the target of 0.07 mg/L total phosphorus identified for the SR-HC TMDL, and average flow values (Table 2.1.1). These values represent total phosphorus loading capacity as identified for average flows. While these values are helpful in giving a relative understanding of the reductions required, and will apply reasonably over most water years, it should be noted that the absolute level of reduction required will depend on flow and concentration values specific to a given water year. The target shown to result in attainment of water quality standards and support of designated uses in the SR-HC TMDL reach is an instream concentration of less than or equal to 0.07 mg/L total phosphorus.

Table 4.0.7. Total phosphorus allocable load for segments in the Snake River - Hells Canyon TMDL reach based on the water column target concentration of 0.07 mg/L and calculated average flows (May through September).

Segment	Location	Load (kg/day)
Total Upstream Snake River segment	RM 409 to 335	2,735
Total Brownlee Reservoir segment *	RM 335 to 285	2,829
Total Oxbow Reservoir segment **	RM 285 to 272.5	2,839

*equal to the measured inputs of the upstream Snake River plus the Powder and Burnt Rivers, plus the estimated inputs of unmeasured tributaries (such as Brownlee Creek). Loads from unmeasured tributaries were estimated at 80 kg/day (approximately 2x the loading assessed for the Weiser Flat tributaries that discharge into the Snake immediately upstream of Brownlee Reservoir, most is projected to be delivered in the spring and summer seasons).
** equal to the measured inputs of Brownlee Reservoir, plus the estimated inputs of unmeasured tributaries (such as Wild Horse River). Loads from unmeasured tributaries were estimated at 20 kg/day (approximately 50% the loading assessed for the Weiser Flat tributaries that discharge into the Snake immediately upstream of Brownlee Reservoir, most is projected to be delivered in the spring and summer seasons). Load allocations to unmeasured tributaries were calculated at 50% reduction from estimated loads due to high probability for high natural loading.

Transport and deposition of phosphorus, and the resulting algal growth within the SR-HC TMDL reach is seasonal in nature. Transport and delivery of natural loading occurs primarily as a result of erosive forces during spring flows. Other natural sources of nutrient loading are discussed in Section 2.2.4.3. Transport and delivery of anthropogenic loading and the resulting algal growth occurs primarily during early summer to early fall. Therefore, the 0.07 mg/L total phosphorus target is seasonal in nature, extending from the beginning of May through the end of September. For the determination of allocable load for the five tributary streams to the Snake River, tributary specific data will be collected and reviewed as part of the implementation plan process. These data will allow for accurate, tributary-specific estimates of naturally occurring total phosphorus concentrations so that anthropogenic loads can be identified and allocated to point and nonpoint sources within the tributary systems. The sum of total phosphorus load and waste load allocations in each tributary will equal the load capacities listed in Table 4.0.7. These allocations will be identified on a tributary by tributary basis using tributary TMDL processes with the goal of establishing accurate site-specific targets for each anthropogenic source.

4.0.2.3 Margin of Safety

A 13 percent margin of safety has been applied to total phosphorus load allocations and capacity for this TMDL as determined by the accuracy and representativeness of sampling techniques and analytical methods. This margin of safety has been incorporated into the identification of the 0.07 mg/L total phosphorus target for the SR-HC TMDL. Other areas of uncertainty such as system uptake, assimilative capacity, and relative impairment to different use categories were addressed to the extent possible through the use of conservative assumptions in the identification of the nutrient target, sensitive designated uses and critical period.

4.0.2.4 Background/Natural Loading

For the mainstem Snake River portion of the SR-HC TMDL reach, the natural total phosphorus loading was calculated using the natural background concentration of 0.02 mg/L total phosphorus identified within the SR-HC TMDL, along with average flow values for the Snake River (Table 2.1.1). A necessary set of data for the tributary streams is not currently available. Therefore, natural background concentrations for all tributaries will be determined as part of upcoming TMDL development on the Weiser, Owyhee, and Malheur Rivers, and tributary implementation plans for the Payette and Boise Rivers.

4.0.2.5 Reserve

Waste load allocations to point sources were determined based on design capacity. The reserve capacity allocation is therefore the difference between the current discharge and design flow discharge. This allows for expansion of existing sources or addition of new point source discharges through trading or demonstration of an offset within the SR-HC system.

4.0.2.6 Total Phosphorus Load Allocations

Total Phosphorus load and waste load allocations have been identified for point and nonpoint sources in the SR-HC TMDL reach based on the less than 0.07 mg/L total phosphorus target and the seasonal application period (May through September).

Point Sources.

Biological nutrient removal (BNR) was identified as an appropriate mechanism for phosphorus removal for point sources currently employing activated sludge as a treatment process and discharging directly to the Snake River within the SR-HC TMDL reach. Application of this treatment reduction mechanism commonly results in an 80 percent reduction of total phosphorus concentration in the discharged effluent. As BNR represents a reasonable mechanism for the reduction of total phosphorus concentrations in point source discharges, and as the reductions commonly realized from BNR approximate the average reductions required from nonpoint sources (direct and tributary discharges to the Snake River) within the SR-HC TMDL reach, this mechanism was used as an initial basis for assigning total phosphorus waste load allocations for point sources discharging directly to the Snake River within the SR-HC TMDL reach (as outlined in Appendix I).

Table 4.0.8 contains waste load allocations for those permitted point sources that discharge directly to the Snake River within the SR-HC TMDL reach. Waste load allocations have been assigned to permitted point source discharges based on an evaluation of phosphorus reduction mechanisms available, the relative loading from each point source and type of treatment currently in place.

Waste load allocations to point sources discharging directly to the Snake River within the SR-HC TMDL reach have been assigned as follows:

- The critical time period over which total phosphorus reductions apply is from May through September.
- Point sources currently employing facultative lagoons (Table 4.0.8) represent a miniscule proportion of the total point source phosphorus loading (1.2%) within the SR-HC TMDL reach and will therefore not receive specific total phosphorus reduction requirements at this time. These facilities will prepare facilities plans to determine the costs and time frames associated with upgrading treatment mechanisms which will be used as the basis for future evaluation of potential phosphorus reductions.
- Point sources (activated sludge or other treatment method) (Table 4.0.8) represent a greater proportion of the total point source phosphorus loading (98.8%) within the SR-HC TMDL reach. These facilities will reduce total phosphorus loading by 80 percent (applied daily on a monthly average basis and based on design flows). While BNR was utilized as a basis for assigning appropriate point source load reductions, it is not required as a method of reduction under this TMDL. Any approved mechanism or treatment alternative (or combination of such) that results in the required daily 80 percent reduction (calculated on a monthly average basis) required will be acceptable under this TMDL (for example, land application during the target season would potentially be an acceptable method of achieving the total phosphorus reduction required if it were implemented in an approved and responsible fashion).
- The waste load allocations identified here for permitted point sources apply ONLY to those point sources discharging directly to the Snake River within the SR-HC TMDL reach. Waste load allocations to point sources discharging to tributaries that flow into the SR-HC TMDL reach will be the result of tributary TMDLs crafted through the state-specific tributary TMDL processes and will be completed on a state-specific basis and schedule.
- The current level of effort for total phosphorus reduction on the part of Amalgamated Sugar Company, and the identified goal of load minimization through stockpile removal are recognized in the waste load allocation identified in Table 4.0.8. Progress toward the identified goal will be documented through the iterative TMDL process and appropriate adjustments to the waste load allocation will be made if necessary.
- The current loading and thus the waste load allocations are based on limited effluent data. Waste load allocations for permitted point sources may be modified through the facility planning process if new information indicates that actual design loads were higher than originally determined.

Table 4.0.8. Total phosphorus waste load allocations (WLAs) for permitted point sources in the Snake River - Hells Canyon TMDL reach. (Waste load allocations are based on design flows and discharge concentrations from Table 2.5.0 for the critical period: May through September)**.**

Point Source	NPDES Permit Number	River Mile	Treatment Type	Total phosphorus Concentration (mg/L)	Current Design-Flow Load (kg/day)	Waste Load Allocation (kg/day)	% Reduction
City of Nyssa	101943 OR0022411	385	Activated sludge	3.5 mg/L[1]	11 kg/day	2.2 kg/day	80%
Amalgamated Sugar	101174 OR2002526	385	Seepage ponds	50 kg/day[2] (estimated)	50 kg/day	50 kg/day (initial) and continue with current reduction measures	
City of Fruitland	ID0020907	373	Facultative lagoon	2.9 mg/L	5.5 kg/day[3]	5.5 kg/day	0%
Heinz Frozen Foods	63810 OR0002402	370	Activated sludge	32 mg/L	412 kg/day	83 kg/day	80%
City of Ontario	63631 OR0020621	369	Facultative lagoon	3.5 mg/L[1]	0 kg/day [4]	0 kg/day	0%
City of Weiser (WWTP)	ID0020290	352	Activated sludge	3.5 mg/L[1]	32 kg/day	6.4 kg/day	80%
City of Weiser (WTP)	ID0001155	352	Settling pond	3.5 mg/L[1]	5.5 kg/day[3] (max)	5.5 kg/day	0%
Brownlee Dam (IPCo)	ID0020907	285		Assumed Negligible[5]	Unmeasured assumed minimal	Appropriate BMPs and source control	
Oxbow Dam (IPCo)	101275 OR0027286	272.5		Assumed Negligible[5]	Unmeasured assumed minimal	Appropriate BMPs and source control	
Hells Canyon Dam (IPCo)	101287 OR0027278	247		Assumed Negligible[5]	Unmeasured assumed minimal	Appropriate BMPs and source control	

1. Estimated value provided by Boise City Public Works for use in absence of monitored data.
2. Estimated value provided by Amalgamated Sugar for use in absence of monitored data.
3. Wastewater treatment systems utilizing lagoons will be required to prepare facilities plans showing potential treatment mechanisms to reduce phosphorus loading as part of any proposed upgrade or expansion of the facility.
4. City of Ontario uses land application in the summer months and does not currently contribute a phosphorus load to the SR-HC TMDL reach during the critical season.
5. Facilities sump discharge and turbine cooling water, not a phosphorus or waste treatment source.

Nonpoint Sources.

Table 4.0.9 lists the total phosphorus load allocations to nonpoint sources in the SR-HC TMDL reach.

Tributary inflows to the SR-HC TMDL reach have been treated as discrete, nonpoint sources for the purposes of loading analysis and allocation within this TMDL. Gross allocations have been

Table 4.0.9. Calculated total phosphorus load allocations for tributary, point and nonpoint sources to the Snake River - Hells Canyon TMDL reach based on calculated average flows (May through September).

Segment	Load Allocation[a,b] (kg/day)	Percent Reduction
Snake River Inflow	1,379	28
Owyhee River	71	73
Boise River	242	78
Malheur River	58	88
Payette River	469	34
Weiser River	136	65
Drains	91	86
Ungaged flows	137	64
Total Upstream Snake River Load Allocations	2582	54
Total Upstream Snake River Waste Load Allocations	153	
Total Upstream Snake River Segment Load and Waste Load Allocations	2,735[c]	
Burnt River	21	60
Powder River	33	74
Unmeasured Tributaries to Brownlee	40	50
Total Brownlee Reservoir Segment	2,829[d]	
Unmeasured Tributaries to Oxbow	10	50
Total Oxbow Reservoir Segment	2,839	

[a] The SR-HC TMDL target for total phosphorus for each tributary is a concentration of less than or equal to 0.07 mg/L total phosphorus as measured at the mouth of the tributary and applies from May through September. Because the total phosphorus target is concentration-based, actual allowable tributary load allocations under the TMDL are dependant on actual tributary flow and will fluctuate year to year. The total phosphorus load allocations listed in this table are based on averaged tributary flows measured in 1979, 1995 and 2000, which were average Snake River flow years, not necessarily average tributary flow years. Therefore they do not necessarily represent the calculated load allocations for any specific year or different series of years.

[b] Future data collection and analyses may determine that, due to natural conditions or other factors, the target concentrations for the mouths of the tributaries cannot be practicably achieved. This, in most cases, will occur when TMDLs are conducted on the tributaries. If subsequent tributary TMDLs indicate that the target concentration is not achievable, the Snake River/Hells Canyon TMDLs for total phosphorus will be reopened and appropriately revised.

[c] Total allocable load for this segment is 2,735 kg/day (2,582 kg/day from nonpoint sources and 153 kg/day from point sources)

[d] Total allocable load includes point source wasteload allocation from upstream sources. A dissolved oxygen load allocation has also been established for this segment.

assigned to each inflowing tributary equal to the load capacities listed in Table 4.0.7. Existing or future tributary TMDL processes will distribute load allocations in the form of load allocations and/or waste load allocations within their respective watersheds. Tributary loads are allocated to the mouth of the tributary and do not attempt to identify point and nonpoint source contributions within the tributary watersheds. Load allocations for tributaries are based on the less than or equal to 0.07 mg/L total phosphorus target and average flows (Table 2.1.1), and applies at the mouth of the tributary system. It is anticipated that tributary-specific data will be collected and will allow for accurate estimates of the naturally occurring total phosphorus loading so that anthropogenic loads can be identified and distributed to point and nonpoint sources within each tributary.

4.0.2.7 IMPLEMENTATION

The geographic scope of the SR-HC TMDL is extensive. The SR-HC watershed encompasses a 221 mile stretch of the Snake River with a 73,000 square mile drainage area. It is expected that attaining the SR-HC TMDL targets will require implementation of control strategies throughout this massive watershed, from facilities and return flows that discharge directly to the Snake River, to more remote activities affecting tributaries many miles upstream of their confluences with the Snake River.

Water users, administrative agencies, and research organizations in Idaho and Oregon have many years of experience developing and implementing strategies to improve water quality. Efforts in several tributary (e.g. Rock Creek) and upstream Snake River (e.g. the Middle Snake River) watersheds have become more focused during recent years as instream water quality objectives have been defined through TMDLs and other programs. These ongoing efforts provide incremental improvements to water quality as new treatments are applied to additional agricultural lands, storm drains, and point source discharges.

SR-HC PAT members and other PAT participants and consultants representing water users, administrative and research groups, together with the DEQs, utilized their collective experience to determine the time frame required to implement necessary control strategies throughout the SR-HC watershed to attain SR-HC TMDL targets. Due to the extraordinary size and complexity of the SR-HC watershed, its hydrology, and the various factors that affect the implementation of control strategies (discussed in Appendix I), it was determined that a time frame of approximately 50 to 70 years will be required to implement all necessary control strategies and fully attain SR-HC TMDL targets. This does not mean, however, that Snake River water quality will not improve until the TMDL targets are fully attained. For example, the DEQs have determined that there is a direct relationship between instream phosphorus concentrations and algal growth so that algal biomass will decrease incrementally as the instream concentration of phosphorus decreases. Water quality will consistently improve as treatments are applied to point and nonpoint discharges. To ensure measurable, consistent progress, interim, 10-year objectives (corresponding to 0.01 mg/l reductions in instream phosphorus concentrations) will be established. Progress in implementing control strategies will be reviewed periodically, and the time frame for full implementation can be evaluated in light of data and experience.

In identifying an appropriate time frame for implementation, the schedules of the tributary TMDLs and their Implementation Plans have to be considered. While there are some tributary TMDLs currently in place, others will not all be completed until the end of 2006. The tributary TMDLs must then be approved by EPA. The approval process can take several months. Implementation plans are completed approximately 18 months following EPA approval of TMDLs. For tributary TMDLs already in place this 18-month time frame starts with the approval of the SR-HC TMDL. For tributary TMDL processes that are not yet complete, the implementation plan will be prepared within 18 months of the approval of the tributary TMDL.

After completing an implementation plan, site-specific analyses must be performed to determine the most appropriate and effective control strategies for particular locations and land use activities. The time required for ground-level planning and project approval process varies widely depending upon the nature of the land and related hydrology, the land use, the parties involved, the type of treatment selected, and other factors.

Construction and implementation of management practices follows project approval. As with the planning and approval process, the time required to complete a project and realize water quality improvements varies from more the more immediate, as with introduction of rotational grazing as a management practice, to longer term, as with streambank re-vegetation and created wetlands (6 to 7 years may be necessary to establish vegetation that will produce adequate results).

In addition to the time required to achieve effective reductions, the time required for the river and reservoirs to fully respond to the improvement in inflowing water quality and process the existing pollutant loads already in place within the system must also be recognized. The occurrence of low water years or drought cycles can extend the instream response time by affecting the processing and transport of preexisting loads, just as high flows, which increase transport, and streambank erosion can affect instream response time.

In identifying what effect such an extended time frame for implementation would have on aquatic species that are currently at risk due to water quality concerns, it should be noted that generally the initial phases of implementation result in the most substantial reductions. Starting implementation as soon as possible, in a manner that will address the areas of greatest concern first and then work toward the areas of lower priority will allow substantial improvements in the water quality to occur in a shorter period of time than that described by the total implementation timeframe. While these initial improvements will most likely not result in meeting water quality targets all the time, everywhere, all at once, they will undoubtedly result in substantial, consistent improvement in water quality conditions throughout the reach.

As time and implementation progresses, the level of improvement will also increase until water quality targets are met. If dissolved oxygen concentrations in the areas of sturgeon habitat can be increased from near lethal levels to concentrations that are much closer to the target, then the support status will improve as well. This offers the potential for a positive outlook in the case of at-risk aquatic life such as the white sturgeon in the Upstream Snake River segment (RM 409 to 335). They will benefit from these initial improvements in habitat in many places, and from the improvement in water quality conditions overall.

4.0.2.8 DISSOLVED OXYGEN LOAD ALLOCATION

In addition to the total phosphorus load allocations for the Upstream Snake River segment (RM 409 to 335) and the tributaries, a dissolved oxygen load allocation has been established for Brownlee Reservoir (RM 335 to 285) (IPCo) to offset the calculated reduction in assimilative capacity due to the Hells Canyon Complex reservoirs.

The dissolved oxygen allocation requires the addition of 1,125 tons of oxygen (1.02 $\times 10^6$ kg) into the metalimnion and transition zone of Brownlee Reservoir (approximately 17.3 tons/day (15,727 kg/day)). The total dissolved oxygen mass required to address the loss of assimilative capacity in the metalimnion over this time frame is 1,053 tons (957,272 kg). This is equivalent to an even distribution of 16.2 tons/day (14,727 kg/day) over 65 days. The total dissolved oxygen mass required to address the loss of assimilative capacity in the transition zone over this time frame is 72 tons (65,454 kg). This is equivalent to an even distribution of 3.0 tons/day (2,727 kg/day) over 24 days.

The calculated time period when exceedences occurred in the metalimnion of Brownlee Reservoir is between Julian days 182 and 247 (the first of July through the first week of September) when dissolved oxygen sags are observed to occur to a greater degree than those identified as the result of poor water quality inflowing from the upstream sources. However, this time frame should not be interpreted as an absolute requirement. This approach recognizes that the actual mass of dissolved oxygen necessary per day is not static. It is variable depending on system dynamics and may vary from a few tons to as many as 30 tons per day. Timing of oxygen addition or other equivalent implementation measures should be such that it coincides with those periods where dissolved oxygen sags occur and where it will be the most effective in improving aquatic life habitat and support of designated beneficial uses. Water column dissolved oxygen monitoring is expected to be undertaken as part of this scheduling effort.

This load allocation does not require direct oxygenation of the metalimnetic and transition zone waters. It can be accomplished through equivalent reductions in total phosphorus or organic matter upstream, or other appropriate mechanism that can be shown to result in the required improvement of dissolved oxygen in the metalimnion and transition zones to the extent required. A reduction of 1.7 million kg of organic matter/algal biomass would equate to the identified dissolved oxygen mass. This translates to approximately 11,000 kg/day over the critical period (May through September) or 26,000 kg/day over the 65-day load period identified in the calculations for reduced assimilative capacity. Direct oxygenation can be used, but should not be interpreted as the only mechanism available. Cost effectiveness of both reservoir and upstream BMP implementation should be considered in all implementation projects.

Because there are both total phosphorus and dissolved oxygen load allocations assigned within different segments of the SR-HC TMDL reach, it must be clearly understood that Upstream Snake River segment (RM 409 to 335) pollutant sources are responsible for those water quality problems occurring in the Upstream Snake River segment. They are not responsible for those water quality problems that would occur if the waters flowing into Brownlee Reservoir met water quality standards and are exclusive to the reservoir. Similarly, IPCo (as operator of the Hells Canyon Complex) is responsible for those water quality problems related exclusively to impoundment effects that would occur if inflowing water met water quality standards.

Load allocations for the Upstream Snake River (RM 409 to 335) pollutant sources were identified to meet water quality standards in the Upstream Snake River segment and load allocations for Brownlee Reservoir (RM 335 to 285) were identified to address those water quality violations that would occur if the waters flowing into the Hells Canyon Complex met water quality standards.

It should not be interpreted from this load allocation scenario that the load allocations to Brownlee Reservoir (RM 335 to 285) do not have to be implemented until after all implementation has been completed upstream. All implementation (both that in the Upstream Snake River segment and that required from the Brownlee Reservoir segment) will be expected to proceed concurrently in a timely fashion following the approval of the SR-HC TMDL.

This TMDL will proceed toward completing site-specific implementation plans within 18 months of approval of the TMDL. Data collection will continue throughout the implementation process to determine progress and improve understanding of the SR-HC TMDL system. As this TMDL is a phased process, it is projected that the goals and objectives of this TMDL will be revisited periodically to evaluate new information and assure that the goals and milestones are consistent with the overall goal of meeting water quality standards in the SR-HC TMDL reach.

Monitoring of both point source discharge loads and instream water column concentrations will be undertaken as part of the implementation process. Instream monitoring will be identified in more detail in the site-specific implementation plans that will be completed 18 months following the approval of the SR-HC TMDL. It is expected that at minimum such monitoring will include the measurement of water column total phosphorus, chlorophyll *a*, and dissolved oxygen within each segment during time frames that represent high, low and average flow conditions. Measurement of sediment/water interface dissolved oxygen will also be accomplished in the Upstream Snake River segment (RM 409 to 335) during the first phase of implementation (5 year from approval of the SR-HC TMDL), or sooner.

4.0.2.9 TOTAL PHOSPHORUS LOAD AND WASTE LOAD ALLOCATION MECHANISMS.

As stated in Section 1.0, the overall goal of the SR-HC TMDL is to improve water quality in the SR-HC TMDL reach by reducing pollution loadings from all appropriate sources to restore full support of designated beneficial uses within the SR-HC TMDL reach. Two elements critical to achieving this goal are:

- To establish load allocation mechanisms that will allow attainment of the water quality targets through (to the extent possible) fair and equitable distribution of the identified pollutant loads, and result in productive implementation without causing undue hardship on any single pollutant source.
- To outline necessary implementation steps to attain the SR-HC TMDL pollutant targets. (This is accomplished in a general fashion in the water quality management plan (Oregon) and implementation plan (Idaho) submitted with this document, and in detail in the implementation plans to be completed within 18 months of US EPA TMDL approval).

Establishing long-term, scientifically supported water quality objectives, interim targets and load allocations based on feasible and attainable control strategies is consistent with the goal of the Clean Water Act and associated administrative rules for Oregon and Idaho that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. It is also consistent with the agencies' responsibility to provide reasonable assurance that TMDL objectives can be met.

With these principles in mind, members of the SR-HC PAT have worked together to develop a load allocation strategy for total phosphorus for point and nonpoint sources within the SR-HC TMDL reach. A complete copy of the strategy for point and nonpoint source dischargers is included in Appendix I.

This strategy seeks to establish interim targets and load allocations designed to reflect feasible control strategies and time frames within which those strategies can be implemented. These interim targets and load allocations were developed to recognize the various factors affecting the nature and extent of feasible and attainable BMP implementation.

As with the long-term targets and load allocations, periodic review will enable the DEQs and the stakeholders to adjust these interim targets and load allocations in accordance with information, analysis, and experience developed during the implementation of the SR-HC TMDL objectives.

The DEQs fully support and encourage stakeholder participation in this process and acknowledge the substantial progress that has been made on a multi-stakeholder front to develop an allocation mechanism for total phosphorus that will meet the requirements of the CWA and the TMDL process, while addressing the needs of the implementation participants.
The TMDL processes for both Oregon and Idaho require that water quality targets and the accompanying load allocation mechanisms will collectively result in attainment of water quality standards. Therefore, the goal of this total phosphorus TMDL for the SR-HC TMDL reach is to meet and sustain instream mainstem concentrations of 0.07 mg/L or less total phosphorus during the critical period of May through September. The framework of this approach is to meet TMDL targets and represents a valid process for implementation of the total phosphorus TMDL. As with any implementation process, progress on the ground and monitored water quality trends will be critical indicators as to whether this approach is successful in attaining the implementation goals identified.

Periodic review of additional data, level of implementation, system response and other pertinent factors will be carried out and necessary changes made. These changes may, among others, occur on the part of the TMDL, with better understanding of the system; on the part of the implementation process and the associated goals and interim milestones, and the part of the allocation mechanism discussed here.

Feasible pollution control strategies as those that can reasonably be taken by stakeholders to improve water quality within the physical, operational, economic and other constraints which affect their individual enterprises and their communities. Control strategies that will injure existing or future social and economic activity and growth are neither reasonable nor feasible. Attainable water quality goals are those that reflect control strategies that are feasible on a broad, watershed basis and recommended that highest cost management practices should not be the basis for water quality planning.

The SR-HC PAT members further identified several factors affecting BMP implementation for irrigated agriculture. As with irrigated agriculture, available funding is the primary constraint on BMP implementation for municipalities and other point sources. Most of the municipalities whose discharges affect the SR-HC reach are small communities with modest economies and tax bases. The principal factors affecting the implementation and effectiveness of BMPs for point sources are available funding, BMP costs, and the limits of currently available technology in reducing phosphorus in point source discharges. These factors are particularly important for small communities.

It is neither reasonable nor feasible to expect BMP implementation throughout the SR-HC TMDL watershed to achieve zero discharge, or widespread conversion to sprinkler irrigation, due to the extremely high costs and potential hydrologic impacts. Similarly, it is not reasonable to expect point sources to implement highest cost BMPs.

Nonpoint Source Load Allocation Mechanism

Attainable interim water quality goals for irrigated agriculture can be defined by identifying or estimating: (1) historically available private and public funding for water quality projects; (2) BMP costs; (3) pollutant reductions resulting from the installation of BMPs; (4) the status of BMP implementation within a watershed, community, or at a farm; and (5) the number of acres to be treated. Each of these factors was applied to an analysis of the Malheur, Boise, and Payette watersheds to project BMP implementation and resulting overall pollutant reductions over time from irrigation agriculture.

Assuming that historic annual funding for BMP implementation continues, and that funding doubles at least every 20 years to pay for replacement of equipment, so that all the identified priority acres are treated with $500.00 per acre treatment (representing feasible treatment strategies) to yield 68 percent overall reduction in the discharge of loads, the above analysis projects annual BMP implementation and corresponding reductions in total phosphorus loading from irrigated lands of 0.47 percent from the Payette watershed, 0.54 percent from the Boise watershed, and 0.97 percent from the Malheur watershed. The projected average annual total phosphorus reduction from irrigated lands in these watersheds is 0.66 percent. Since these three watersheds represent nearly 600,000 irrigated acres, and there are active, long-standing programs to implement BMPs in these watersheds, this rate of reduction can be used to project a rate of reduction throughout the SR-HC TMDL watersheds. At this rate of reduction, it would take 103 years to reach the maximum feasible 68 percent reduction of total phosphorus from irrigated lands in the SR-HC TMDL watersheds.

In order to compress the time frame for attainment of 68 percent total phosphorus reduction from irrigated lands, it will be assumed that federal and state funding levels increase to those currently available for BMP implementation in the Malheur River and Owyhee River watersheds. This will require doubling funding for the other watersheds, from $4.04 per acre annually in the Payette watershed and $4.66 per acre annually in the Boise watershed for all priority acres to the $8.43 per acre level that has been expended in the Malheur & Owyhee watersheds for all priority acres. This means that, for the Payette River and Boise River watersheds alone, federal and state programs and/or pollution trading must increase the annual non-farm investment in BMP implementation from $371,706 to $1,827,500. This increase is significant when annual state BMP funding, for the entire State of Idaho, has been approximately $1,500,000, and has recently been reduced to $1,400,000. It will also be assumed that funding doubles every 20 years to pay for replacement of equipment so that treatment of additional acres at the assumed rate of treatment may continue.

If this additional funding is made available, it is possible to project an annual total phosphorus reduction of 1 percent from irrigated lands in SR-HC TMDL watersheds, assuming the other factors affecting BMP implementation, cost, and performance do not impose their own constraints on BMP implementation. Applying an annual 1 percent total phosphorus reduction rate results in the following interim, ten-year load reduction objectives for the aggregate of irrigated lands in the Owyhee, Boise, Malheur, Payette, Weiser and Snake Rivers below RM 409.

Increased funding can affect the **rate** at which BMP implementation occurs (annually .66% vs. 1.0%) and the overall time it takes to attain 68 percent reductions from irrigated lands (103 years vs. 68 years). Currently, based on known techniques, technologies, BMP costs, hydrology, crop requirements, and the other factors that affect BMP implementation, it is not possible to project total phosphorus reductions from irrigated lands in the aggregate greater than 68 percent. Watershed-wide nonpoint source reductions greater than 68 percent will require currently unforeseeable changes in the factors affecting BMP implementation. This reduction rate together with projected reductions in point source loads and private industry participation in total phosphorus reduction through pollution trading is used to determine interim, ten-year targets and load allocations.

Annual 1% nonpoint source total phosphorus reductions

Current	10 (2014)	20 (2024)	30 (2034)	40 (2044)	50 (2054)	60 (2064)	68 (2064)
6,452 lbs/day	5,806(10%)	5,162(20%)	4,516(30%)	3,871(40%)	3,226 (50%)	2,581(60%)	2,065(68%)

Figure 4.0.1 Example interim load reduction goals based on 10-year objectives for irrigated agriculture. NOTE: The dates identified above are for illustration purposes only and are based on the assumption that the SR-HC TMDL will be approved in 2002, and that site-specific implementation plans will be completed by 2004. If the SR-HC TMDL is approved on a different time frame, the dates for the implementation process will follow the actual completion date of the site-specific implementation plans at 10-year increments.

Point Source Waste Load Allocation Mechanism

In correlation with the load allocation strategy for nonpoint sources above, a similar assessment was completed by members of the SR-HC PAT for point source discharges. The findings of this assessment are summarized below:

1. Based on recent Idaho experience, anticipated nonpoint source reductions could be 65 to 70 percent, however post treatment concentrations likely will be >100 ug/l where furrow irrigation is the primary irrigation practice.
2. Point Source controls occur in three technology steps. Cost increase rapidly after the first increment. Total phosphorus reduction costs range from $<5 to $2,600 lb/day and removal rates vary from 80 to 94 percent depending on technology used.
3. An allocation alternative evaluation is useful and provides critical information to the allocation process and decision makers. Allocation method has significant influence on basinwide TMDL implementation costs.

4. The members of the SR-HC PAT determined that, based on known techniques, point source controls beyond biological nutrient removal are neither feasible nor equitable.
5. Nutrient criteria or target determination methods have not been adopted be either Idaho or Oregon. Technical and regulatory approach to determine nutrient targets are rapidly evolving and likely will result in changes to the target during the implementation period anticipated for this TMDL, making adaptive management an important aspect of this TMDL.
6. Trading is a necessary tool in achieving cost effective implementation and should be an acceptable tool incorporated in the TMDL as an option in meeting allocations.

Preliminary, interim goals for total phosphorus reduction (cumulative point and nonpoint source activities) have been identified as part of this load allocation process. They include a reduction goal for total phosphorus concentration of 0.01 mg/L every 10 years. It is expected that this preliminary schedule will encourage the identification of implementation priorities that will result in consistent reduction activities. It is also expected that these preliminary goals will be refined as site-specific implementation plans are finalized and information on reduction efficiency is collected.

4.0.3 Pesticides

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.3.3.2, and 3.3.

4.0.3.1 LOADING

As the pesticides of concern (DDT and dieldrin) are no longer in use (both are banned pesticides), the existing loading is assumed to occur solely from legacy application or contamination. Anthropogenic sources are confined to runoff from areas that have been treated historically and areas where storage or spillage occurred historically. Current practices make municipal or stormwater sources from urban areas very unlikely to be significant loading sources. Point source loading is considered negligible. Pesticide concentrations in treated effluent occur as the result of concentrations in incoming source water rather than as an artifact of the treatment process.

No pesticide data are available for the Oxbow Reservoir segment (RM 285 to 272.5). The data set available for the Upstream Snake River and Brownlee Reservoir segments (RM 409 to 285) were used to provide a rough approximation of pesticide loading to the SR-HC TMDL reach. Loading at the USGS gage at Weiser (mainstem Snake River) was calculated to be approximately 42 kg/year t-DDT and 28 kg/year dieldrin for an average water year. Assuming that the data collected were representative of the average annual concentrations in the water column, this shows that the current pesticide loading is between 30 and 100 times greater in the Upstream Snake River segment (RM 409 to 335) of the SR-HC reach than the targets would allow.

4.0.3.2 LOAD CAPACITY

The SR-HC TMDL reach load capacity for t-DDT and dieldrin (Table 4.0.10) was determined by calculation using the target of 0.024 ng/L DDT water column concentration and the 0.07 ng/L dieldrin water column concentration identified for the SR-HC TMDL, and average flow values (calculated from 1979, 1995 and 2000 flow data). Water column data was available for the Upstream Snake River segment (RM 409 to 335) only.

Table 4.0.10. t-DDT and dieldrin (pesticide) load capacity for segments in the Snake River - Hells Canyon TMDL reach based on the water column target concentrations of 0.024 ng/L (DDT) and 0.07 ng/L (dieldrin) and calculated average flows.

Segment	Annual Load Capacity t-DDT (kg/year)	Annual Load Capacity Dieldrin (kg/year)
Upstream Snake River Segment (RM 409 to 335)	0.34	0.98
Brownlee Reservoir Segment (RM 335 to 285)	0.37	1.1
Oxbow Reservoir Segment (RM 285 to 272.5)	0.37	1.1

4.0.3.3 Margin of Safety

An explicit margin of safety of 10 percent has been used in calculation of the load allocation. An implicit margin of safety is also present, based on conservative values identified for the assimilative capacity. Other areas of uncertainty such as bioconcentration capacity and relative threat to different use categories are accounted for to the extent possible in the identification of the target concentrations as a conservative value.

4.0.3.4 Background/Natural Loading

There is no natural DDT or dieldrin loading.

4.0.3.5 Reserve

Due to the fact that these are banned pesticides, no reserve capacity was established for DDT or dieldrin.

4.0.3.6 Load Allocations

Table 4.0.11 lists the load allocations for DDT and dieldrin on a general basis for the Upstream Snake River segment (RM 409 to 335). Insufficient data are available to further differentiate pollutant sources within the segment. These load allocations represent the sum of point and nonpoint source-related loading to the SR-HC TMDL reach, and therefore to the Oxbow Reservoir segment (RM 285 to 272.5), the only segment in the SR-HC TMDL reach that is listed for pesticides.

Due to the lack of data necessary to accurately characterize pesticide loading to the Oxbow Reservoir segment (RM 285 to 272.5), and the diffuse and widespread legacy nature of pesticide loading to the Snake River; a watershed-based approach will be employed wherein reductions in pesticide loading will be accomplished through best management practices for sediment control. This reduction strategy will be implemented in direct correlation with other reduction efforts identified by this TMDL and concurrent efforts already underway in the SR-HC drainage. In the SR-HC TMDL, sediment (total suspended solids, TSS) targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

Table 4.0.11. Identified load allocations for the reduction of pesticides in the Snake River - Hells Canyon TMDL reach.

Segment	Load Allocation for t-DDT (kg/year)	Load Allocation for Dieldrin (kg/year)
Load allocation specific to legacy applications		
Upstream Snake River Segment (RM 409 to 335)	0.31	0.88
Brownlee Reservoir Segment (RM 335 to 285)	0.33	1.0
Oxbow Reservoir Segment (RM 285 to 272.5)	0.33	1.0
Load allocation specific to current application		
Upstream Snake River Segment (RM 409 to 335)	0	0
Brownlee Reservoir Segment (RM 335 to 285)	0	0
Oxbow Reservoir Segment (RM 285 to 272.5)	0	0

In this manner, diffuse legacy sources will be effectively addressed by best management practices that will improve water quality for a number of listed constituents simultaneously (i.e. mercury, pesticides, sediment and nutrients). Load allocations for pesticides do not vary seasonally and will be applied year-round. Critical conditions, when the majority of transport is projected to occur, are April through October, encompassing the spring runoff and summer irrigation seasons.

NOTE: The load allocations identified do not require monitoring of pesticide loading or load reductions. Such monitoring is not considered feasible and will therefore not be required as part of this TMDL process. Rather, appropriate management techniques specific to responsible stewardship will be employed as part of the TMDL implementation process. These management techniques are projected to result in reduction of overall DDT and dieldrin loading related to nonpoint source discharge to the mainstem Snake River.

Available data do not yield a clear answer on the support status of designated beneficial uses but indicate that sufficient concern exists to justify the collection of additional water column data in both the Oxbow Reservoir segment (RM 285 to 272.5) and the segments upstream.

4.0.4 pH and Bacteria

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.2.4.4, 2.3.1.2, and 3.4.

4.0.4.1 LOADING

Based on the available data, the SR-HC TMDL process recommends that the mainstem Snake River (RM 409 to RM 347, OR/ID border to Scott Creek inflow) be delisted for bacteria by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent to the approval of the SR-HC TMDL. The SR-HC TMDL process further recommends that monitoring of bacteria levels (*E. coli*), especially in those areas of the SR-HC TMDL reach where recreational use consistently occurs, continue to be an integral part of the water quality monitoring of the Upstream Snake River segment (RM 409 to 335).

Based on the available data, the SR-HC TMDL process recommends that the mainstem Snake River from RM 409 to RM 347 (OR/ID border to Scott Creek inflow) and from RM 335 to RM 285 (Brownlee Reservoir) be delisted for pH by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent approval of the SR-HC TMDL. The SR-HC TMDL process further recommends that monitoring of pH continue to be an integral part of the water quality monitoring of the Upstream Snake River segment (RM 409 to 335).

4.0.4.2 Load Allocations

The data showed no exceedences of water quality targets for the SR-HC TMDL reach. Delisting of these two pollutants is recommended; therefore no load allocations have been identified.

4.0.5 Sediment

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.2.4.5, 2.3.1.2, 2.3.2.2, 2.3.3.2, and 3.5.

4.0.5.1 Loading

The Upstream Snake River (RM 409 to 335), Brownlee Reservoir (RM 335 to 285) and Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL are listed for impairment due to sediment. No duration data is available to assess the extent of impairment or support in these reaches. During the first phase of implementation (the five years following the approval of the SR-HC TMDL) duration data will be collected to determine if designated aquatic life uses are being impaired. Targets have been set in a conservative fashion so that aquatic life uses will be protected in the listed segments.

Sediment loading within the SR-HC TMDL reach is also of concern because of the attached pollutant loads (mercury, pesticides and nutrients) that the sediment carries. In the SR-HC TMDL, sediment (total suspended solids (TSS)) targets and monitored trends will function as indicators of changes in the transport and delivery of these attached pollutants.

The available data show that sediment loading into the SR-HC reach originates almost exclusively from the Upstream Snake River segment (over 95%). Sources of unmeasured load may include nonpoint source runoff from anthropogenic sources and precipitation events, unidentified small tributaries and drains, error in gauged flow measurements and ground-water sources.

Tables 4.0.12 and 4.0.13 contain calculated total suspended solids loads for point and nonpoint sources in the SR-HC TMDL reach.

Sediment deposition and processing within the Hells Canyon Complex reservoirs results in dramatic changes to the measured total suspended solids concentration as compared to upstream concentrations. This change makes it impossible to determine loading from nonpoint sources within the immediate drainage area to the Hells Canyon Complex. The potential loading from these sources has been evaluated and assumed to be small as the incidence of agricultural

Table 4.0.12. Sediment (TSS) loads from point sources in the Snake River - Hells Canyon TMDL reach based on 1995, 2000 data.

Point Source	NPDES Permit Number	Location (RM)	Current Design-Flow Load (kg/day)
City of Nyssa	101943 OR0022411	385	32 kg/day
Amalgamated Sugar	101174 OR2002526	385	Negligible
City of Fruitland	ID0020907	373	62 kg/day
Heinz Frozen Foods	63810 OR0002402	370	396 kg/day
City of Ontario	63631 OR0020621	369	209 kg/day
City of Weiser (WWTP)	ID0020290	352	213 kg/day
City of Weiser (WTP)	ID0001155	352	Negligible
Brownlee Dam (IPCo)	ID0020907	285	Negligible
Oxbow Dam (IPCo)	101275 OR0027286	272.5	Negligible
Hells Canyon Dam (IPCo)	101287 OR0027278	247	Negligible

practices (cropping and ranching) and municipal stormwater runoff is minimal, as is the intensity of use.

4.0.5.2 Load Capacity

The SR-HC TMDL reach load capacity for total suspended solids was determined by calculation using the target of 50 mg/L monthly average water column concentration identified for the SR-HC TMDL, and average flow values (Table 2.1.1), as shown in Table 4.0.14.

Transport and deposition of sediments into and within the SR-HC TMDL reach is seasonal in nature. Erosion of natural sources and transport of anthropogenic sources occurs primarily during spring and summer flows.

4.0.5.3 Margin of Safety

An implicit margin of safety is incorporated into the SR-HC TMDL sediment targets, as all parameters used to identify these targets were conservative in nature. An additional explicit margin of safety of 10 percent has been used in calculation of the load allocations.

4.0.5.4 BACKGROUND/NATURAL LOADING

As there are no undeveloped watersheds in the SR-HC TMDL reach to use as a reference system for determining natural loading, an estimate was derived using the data available for spring runoff in the SR-HC TMDL reach as described in Section 3.5.3.1. The average relative natural sediment loading delivered was calculated at 24 percent of the total suspended solids loading for the mainstem Snake River and represents a conservative estimate.

A necessary set of data for the tributary streams is not currently available. Therefore, natural background concentrations for all tributaries will be determined as part of upcoming TMDL development on the Weiser, Owyhee, and Malheur Rivers, and tributary implementation plans for the Payette and Boise Rivers.

Table 4.0.13. Sediment (TSS) loads from nonpoint sources in the Snake River - Hells Canyon TMDL reach for 1995, 1996 and 2000 data and average flow values.

Load Type	Location	Load (kg/day)	Estimation Method
Snake River Inflow	RM 409: Upstream Snake River Segment	677,785	See Section 3.5
Owyhee River	RM 396.7: Upstream Snake River Segment	66,152	See Section 3.5
Boise River	RM 396.4: Upstream Snake River Segment	130,466	See Section 3.5
Malheur River	RM 368.5: Upstream Snake River Segment	92,870	See Section 3.5
Payette River	RM 365.6: Upstream Snake River Segment	137,887	See Section 3.5
Weiser River	RM 351.6: Upstream Snake River Segment	53,617	See Section 3.5
Drains	Upstream Snake River segment (RM 409 to 335)	143,430	See Section 3.5
Ungaged flows	Upstream Snake River segment (RM 409 to 335)	181,484	See Section 3.5
Agriculture, Stormwater and Forestry	Upstream Snake River segment (RM 409 to 335)	Included in the ungaged flow loading	See Section 3.5
Upstream Snake River Segment Total Loading	RM 409 to 335	1,483,691	See Section 3.5
Burnt River	RM 296: Brownlee Reservoir Segment	13,274	See Section 3.5
Powder River	RM 327.5: Brownlee Reservoir Segment	14,857	See Section 3.5
Agriculture, Stormwater and Forestry	Brownlee Reservoir segment (RM 335 to 285)	Cannot be calculated, assumed small	See Section 3.5
Agriculture, Stormwater and Forestry	Oxbow Reservoir segment (RM 285 to 272.5)	Cannot be calculated, assumed small	See Section 3.5

4.0.5.5 RESERVE

Waste load allocations to point sources were determined based on design capacity. The reserve capacity allocation is therefore the difference between the current discharge and design flow discharge. This allows for expansion of existing sources or addition of new point sources discharge through trading or demonstration of an offset within the SR-HC system.

4.0.5.6 LOAD ALLOCATIONS

Table 4.0.15 a and b identify the load and waste load allocations for point and nonpoint sources in the SR-HC TMDL reach. Point source discharges represent less than 0.04 percent of the total load capacity for the SR-HC TMDL reach. Many point sources employ treatment measures that dramatically reduce the sediment concentrations in their effluent as compared to the source water. Due to the fact that point source loading represents such a miniscule proportion of the total load, waste load allocations have been established at existing NPDES permit levels for all point sources discharging directly to the mainstem Snake River. In cases where existing NPDES permits do not identify limits for total suspended solids (or an appropriate equivalent measure), limits will be established at no greater than 50 mg/L applied on a monthly average. Quantitative load allocations in kg per unit of time can be calculated from Table 4.0.15 a by multiplying the existing permit limits by the design flows identified in Table 2.0.5.

Table 4.0.14. Sediment (TSS) load capacity for segments in the Snake River - Hells Canyon TMDL reach based on the water column target concentration of 50 mg/L (monthly average), current discharge concentrations and calculated average flows.

Segment	Location	Load (kg/day)
Snake River Inflow	RM 409: Upstream Snake River Segment	1,171,626
Owyhee River	RM 396.7: Upstream Snake River Segment	53,341
Boise River	RM 396.4: Upstream Snake River Segment	165,077
Malheur River	RM 368.5: Upstream Snake River Segment	46,735
Payette River	RM 365.6: Upstream Snake River Segment	329,478
Weiser River	RM 351.6: Upstream Snake River Segment	134,604
Drains	Upstream Snake River segment (RM 409 to 335)	64,031
Ungaged flows	Upstream Snake River segment (RM 409 to 335)	131,309
Total Upstream Snake River Segment	RM 409 to 335	2,096,201
Burnt River	RM 296: Brownlee Reservoir Segment	10,792
Powder River	RM 327.5: Brownlee Reservoir Segment	29,276
Total Brownlee Reservoir Segment	RM 335 to 285	2,098,835
Total Oxbow Reservoir Segment	RM 285 to 272.5	2,116,038

If monitored trends indicate that sediment concentrations are increasing, despite implementation efforts, new, more conservative targets will be considered and load allocations will be revised. If monitored trends indicate that sediment concentrations are decreasing in correlation with implementation efforts, an associated decrease in attached pollutants will be assumed to occur and load allocations will not be reduced.

In the meantime, while duration data is being collected, the targets will function as a loading "cap" in the listed segments, representing a reasonable assurance that aquatic life uses are being protected until a more accurate of designated use support can be made.

This allocation mechanism does not place additional restrictions on those sources already at or below target concentrations. Due to the nature of most nutrient reduction BMPs, total suspended solids loading is expected to decrease with implementation for total phosphorus load allocations. These two processes are highly correlated and implementation is projected to occur in a complimentary fashion

This TMDL will proceed toward completing site-specific implementation plans within 18 months of approval of the TMDL. Data collection for duration information is projected to be accomplished within the first five years following the approval of the TMDL. Additional data gathering will throughout the implementation process to determine progress and improve

Table 4.0.15 a. Total suspended solids (TSS) waste load allocations for point sources discharging directly to the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

Point Source	NPDES Permit Number	Location (RM)	Load Allocation (no greater than)
City of Nyssa	101943 OR0022411	385	30 mg/L (monthly average)
Amalgamated Sugar	101174 OR2002526	385	4,924 lbs/day (monthly average)
City of Fruitland	ID0020907	373	70 mg/L (monthly average)
Heinz Frozen Foods	63810 OR0002402	370	4,200 lbs/day (monthly average)
City of Ontario	63631 OR0020621	369	85 mg/L (monthly average)
City of Weiser (WWTP)	ID0020290	352	400 mg/L (daily average)
City of Weiser (WTP)	ID0001155	352	50 mg/L (monthly average)
Brownlee Dam (IPCo)	ID0020907	285	50 mg/L (monthly average)
Oxbow Dam (IPCo)	101275 OR0027286	272.5	50 mg/L (monthly average)
Hells Canyon Dam (IPCo)	101287 OR0027278	247	0.25 lbs/day (monthly average)

understanding of the SR-HC TMDL system. As this TMDL is a phased process, it is projected that the goals and objectives of this TMDL will be revisited periodically to evaluate new information and assure that the goals and milestones are consistent with the overall goal of meeting water quality standards in the SR-HC TMDL reach.

Monitoring of both point source discharge loads and instream water column concentrations will be undertaken as part of the implementation process. Instream monitoring will be identified in more detail in the site-specific implementation plans that will be completed 18 months following the approval of the SR-HC TMDL. However, it is expected that at minimum such monitoring

Table 4.0.15 b. Total suspended solids (TSS) load allocations (shown in bold type), sediment thresholds and percent reductions required for nonpoint sources within the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

Source	Location (RM)	Calculated Load (kg/day)	Load Allocations [a] (kg/day)	Loading Capacity (kg/day)	% Reduction Required
Snake River Inflow	RM 409: Upstream Snake River Segment	677,785	677,785		0%
Owyhee River	RM 396.7: Upstream Snake River Segment	66,152	**48,007**		27%
Boise River	RM 396.4: Upstream Snake River Segment	130,466	130,466		0%
Malheur River	RM 368.5: Upstream Snake River Segment	92,870	**42,062**		55%
Payette River	RM 365.6: Upstream Snake River Segment	137,887	137,887		0%
Weiser River	RM 351.6: Upstream Snake River Segment	53,617	53,617		0%
Drains	Upstream Snake River segment (RM 409 to 335)	143,430	**57,628**		60%
Ungaged flows	Upstream Snake River segment (RM 409 to 335)	181,484	**118,178**		35%
Total Upstream Snake River Segment	RM 409 to 335	1,483,691		1,265,630	15% [c]
Burnt River	RM 296: Brownlee Reservoir Segment	13,274	**9,713**		27%
Powder River	RM 327.5: Brownlee Reservoir Segment	14,857	14,857		0%
Total Brownlee Reservoir Segment	RM 335 to 285	n/a [b]		1,290,200	
Total Oxbow Reservoir Segment	RM 285 to 272.5	n/a [b]		1,305,682	

[a] Load allocations (shown in bold type) are based on calculated load capacities, less a 10% margin of safety. In those cases where measured sediment concentrations were not observed to exceed the target values, no reductions are required. However, in an effort to prevent further degradation within the SR-HC TMDL reach, threshold values have been established at the current sediment loads. These thresholds will be recognized in considering future management options, and will act to direct future decisions to those options that will not result in an increase in sediment loading from these tributaries to the SR-HC TMDL reach.

[b] The sediment loading to these reaches cannot be accurately calculated due to the sink effect of the reservoirs. Thresholds have been determined using load capacity determinations and upstream loading calculations.

[c] The % reduction listed is representative of the reduction in total loading to the identified segment as a result of required reductions in loading realized upstream.

will include the measurement of duration-based water column total suspended solids within each segment during time frames that represent high, low and average flow conditions.

Load allocations and reductions identified in Tables 4.0.15 a and b, and Table 3.5.6 are specific to those tributaries discharging at total suspended solids concentrations greater than 50 mg/L monthly average. These reductions are expected to minimize the potential for site specific degradation of habitat and impairment of designated uses at the inflow point within the mainstem Snake River.

The majority of treatment mechanisms to reduce total phosphorus also offer sediment reduction benefits. Therefore, it is anticipated that implementation measures for sediment and total phosphorus reduction will be mutually beneficial. Full implementation for attainment of total phosphorus targets (Section 3.2) is expected to result in attainment of sediment targets in many cases.

4.0.6 Temperature

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.2.4.6, 2.3.1.2, 2.3.2.2, 2.3.3.2, 2.3.4.2, 2.3.5.2 and 3.6.

4.0.6.1 LOADING

The assumptions utilized in the loading assessment for this TMDL were applied for the purpose of calculating the potential impact of tributary loading on main stem temperatures. These assumptions have not been verified and thus, may not reflect the actual conditions present in the tributaries. In addition, this TMDL does not address temperature reductions that may be required in the tributaries themselves to meet water quality standards in the tributaries. Those will be assessed through the tributary TMDL process.

Load and waste load allocations identified are based on the attainment of water quality targets for salmonid rearing/cold water aquatic life and salmonid spawning as outlined below.

4.0.6.2 SALMONID REARING/COLD WATER AQUATIC LIFE BENEFICIAL USES

The temperature target identified for the protection of salmonid rearing/cold water aquatic life when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: 17.8 ^oC (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^oC. If and when the site potential is greater than 17.8 ^oC, the target is no more than a 0.14 ^oC increase from anthropogenic sources.

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^oC increase from anthropogenic sources.

The salmonid rearing/cold water aquatic life temperature target identified for the SR-HC TMDL reach applies to RM 409 to 188. This target applies year-round; the critical time period (as defined by elevated water temperatures) is from June through September.

Although it is observed that water temperatures throughout the SR-HC TMDL reach exceed the water quality targets for salmonid rearing/cold water aquatic life during the critical time period (June through September) the analysis of temperature sources undertaken as part of this TMDL has demonstrated that natural atmospheric and non-quantifiable influences preclude the attainment of these targets rather than quantifiable anthropogenic influences. Available data on fish species and temporal/spatial distribution within the Hells Canyon Complex of reservoirs indicates that the designated salmonid rearing/cold water aquatic life use is supported through the availability of cold water refugia. Such refugia does not appear to exist in the Upstream Snake River segment (RM 409 to 335) of this TMDL at the same level as in the reservoir systems.

Modeling work completed by IPCo (IPCo, 2002b) has shown that if the water inflowing to Brownlee Reservoir at RM 335 were at or below numeric temperature targets for salmonid rearing/cold water aquatic life, water leaving the Hells Canyon Complex at Hells Canyon Dam would also be at or below numeric temperature targets for salmonid rearing/cold water aquatic life, regardless of the temperature shift specific to the Hells Canyon Complex. This modeling shows that the Hells Canyon Complex is not the source of the heat load in the reservoirs during the summer season. Therefore, it is concluded that the Hells Canyon Complex is not contributing to temperature exceedences specific to the to salmonid rearing/cold water aquatic life designated use and no requirement for temperature adjustment, specific to salmonid rearing/cold water aquatic life use has been identified for the Hells Canyon Complex dams.

Point Sources.

Waste load allocations specific to temperature for this TMDL will limit point sources to existing loads based on design flow. Currently, cumulative, calculated anthropogenic increases in temperature do not occur above the defined “no-measurable-increase” value of 0.14 ^{o}C. Therefore, the focus of this TMDL is to ensure that additional, anthropogenic temperature influences do not occur over the defined no-measurable-increase value, to protect the cold water refugia currently in place within the SR-HC TMDL reach, and to improve water temperatures in a site-specific fashion in the Upstream Snake River segment (RM 409 to 335) where cold water refugia may be restored. Table 4.0.16 outlines general waste load allocations.

These allocations are calculated on estimated average daily discharge temperatures and design flows. Point source waste load allocations were calculated using the following equation:

WLA = (Discharge Quantity (design flow), # water/day) x (Pt. Source Average Daily Temperature, ^{o}F)

A waste load allocation for future point sources of no measurable increase has been identified as part of this TMDL.

Specific actions identified to accomplish these goals are as follows:

- Point source allocations will be set at current discharge levels.
- Specific temperature effluent limitations in NPDES permits for permitted point sources as listed in Table 3.6.8 will be determined using additional data collection and analysis provided through the facilities plan required of each point source.

- In addition to meeting specified waste load allocations, point source permits will also be expected to address any potential, near field (or mixing zone) water quality issues.

Table 4.0.16. Permitted point source discharge temperature waste load allocations specific to cold water aquatic life/salmonid rearing for the Snake River - Hells Canyon TMDL reach (RM 409 to 188).

Point Source	Point Source Average Daily Temperature (^oF)	Discharge Volume (design flow)	Allocated Heat Load in Million BTU/day
City of Nyssa	72*	0.8 MGD	480
Amalgamated Sugar		Seepage ponds	NA
City of Fruitland	72*	0.5 MGD	300
Heinz Frozen Foods	32 ^oC (90 ^oF)*	3.4 MGD	2,557
City of Ontario	72*	Land Application	NA
City of Weiser	72*	2.4 MGD	1,440
Brownlee Dam	76**	15 MGD	9,500
Oxbow Dam	76**	11 MGD	6,880
Hells Canyon Dam	76**	9 MGD	4,750

* Estimated values.
** Existing permit effluent limits.

These allocations are specific to the salmonid rearing/coldwater aquatic life target, which applies year-round. The critical period for this target in the SR-HC TMDL reach (that time period in which target exceedences are most likely to occur) is from May through September. During the non-critical period, NPDES permits shall ensure that discharges are limited to ensure that each source does not violate water quality standards.

These findings and requirements will be periodically reviewed as additional data and information become available to ensure that the assumptions made and the goals identified remain consistent with full support of designated beneficial uses.

More precise data will be collected and analyzed as part of the facility planning process discussed in the Water Quality Management Plan included with the TMDL. Actual effluent limitations will be derived from the facility plan data.

Also, it must be recognized that the temperature TMDL and associated load allocations are intended to address far field or accumulative impacts from point sources. Permits must also address near field impacts to ensure that appropriate standards are not violated either outside or inside the regulatory mixing zone.

Nonpoint Sources.

Table 4.0.17 lists load allocations specific to cold water aquatic life/salmonid rearing designated beneficial uses.

A gross nonpoint source temperature load allocation has been established as a total anthropogenic loading of less than 0.14 ^oC. (This load allocation applies primarily to agricultural and stormwater drains and similar inflows.) This allocation applies at discharge to the Snake

River in the SR-HC TMDL reach, during those periods of time that the site potential temperature in the mainstem Snake River is greater than 17.8 ^{o}C. It is projected that implementation associated with total phosphorus and suspended solids reduction will result in reduced inflow temperatures in the smaller drains and tributaries to the mainstem Snake River as many of the approved methods for the reduction of total phosphorus and suspended solids are based on streambank re-vegetation and similar methodologies that will increase shading.

Table 4.0.17. Nonpoint source temperature load allocations specific to cold water aquatic life/salmonid rearing for the Snake River - Hells Canyon TMDL reach (RM 409 to 188). Applicable when water temperatures are in excess of 17.8 ^{o}C.

Segment	Nonpoint Source Load Allocation
Nonpoint sources discharging directly to the Snake River in the SR-HC TMDL reach	
SR-HC TMDL Reach	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Associated actions: assessment of impacts to anthropogenic loading as part of management changes	
Tributary sources discharging directly to the Snake River in the SR-HC TMDL reach	
Upstream Snake River (RM 409 to 335)	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Brownlee Reservoir (RM 335 to 285)	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Oxbow Reservoir (RM 285 to 272.5)	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Hells Canyon Reservoir (RM 272.5 to 247)	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Downstream Snake River (RM 247 to 188)	total anthropogenic loading less than 0.14 ^{o}C at RM 409 during that period of time that the site potential of the mainstem Snake River is above 17.8 ^{o}C due to natural or non-quantifiable temperature sources.
Associated actions: assessment of anthropogenic loading at the mouth as part of the tributary TMDL process	

* Direct monitoring of anthropogenic temperature increases is not feasible for these sources and therefore will not be required as part of this TMDL process. Rather, appropriate management techniques specific to proper stewardship will be employed as part of the overall TMDL implementation process. These management techniques are projected to result in reduction of overall anthropogenic temperature increases related to nonpoint source discharge to the mainstem Snake River.

A gross nonpoint source temperature load allocation has been established at no greater than 0.14 ^{o}C for tributaries discharging to the SR-HC TMDL reach. This is equal to the sum of the waste load allocation and the load allocation for anthropogenic tributary sources. This allocation applies at the inflow to the Snake River in the SR-HC TMDL reach, during those periods of time that the site potential temperature in the mainstem Snake River is greater than 17.8 ^{o}C. For this TMDL, there was neither time nor resources to specifically analyze anthropogenic loads in the individual tributaries. Both IDEQ and ODEQ, however, will evaluate these loads when tributary-specific temperature TMDLs are completed. If the calculations of tributary heat loads are significantly different from those determined in this TMDL, the load allocations will be adjusted accordingly.

It should be noted that no explicit load allocation is provided to natural background due to the form of the load capacity.

4.0.6.3 SALMONID SPAWNING DESIGNATED BENEFICIAL USES

The temperature target identified for the protection of salmonid spawning when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is less than or equal to a maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C (temporary rule, effective by action of the IDEQ board 11-14-03, pending approval by Idaho Legislature 2005, subject to US EPA action). If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources. (The State of Oregon definition of no measurable increase (0.14 ^{o}C) was used, as it is more stringent than the State of Idaho definition of 0.3 ^{o}C.)

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

This target applies only when and where salmonid spawning occurs and is specific to those salmonids identified to spawn in this area, namely fall chinook (October 23rd through April 15th) and mountain whitefish (November 1st through March 30th). The salmonid spawning target applies from RM 247 to 188. The critical period for salmonid spawning in the Downstream Snake River segment (RM 247 to 188) is from October 23 to April 15. This period is protective of both fall chinook and mountain whitefish.

The start of fall chinook spawning was identified using data collected by IPCo and USFWS from 1991 through 2001. The information and methodologies used to identify the spawning period is discussed in detail in Section 3.6.1.2. Chinook spawning does not occur above Hells Canyon Complex as the Complex represents a barrier to upstream migration.

Point Sources.

There is one permitted, point source discharge to the Downstream Snake River segment (RM 247 to 188). This discharge is for turbine cooling water from Hells Canyon Dam. Current discharge limits are 7.5 MGD, temperature not to exceed background + 10 ^{o}F. Due to the very small temperature loading associated with this discharge as compared to the total outflow of Hells Canyon Dam, no additional permit limits will imposed on this discharge at this time. The waste load allocation for this source will be set at the existing NPDES permit limits. If further information or understanding of the SR-HC TMDL system identifies a need for temperature reductions specific to this discharge, the permit requirements will be revisited as part of the iterative TMDL process.

Nonpoint Sources.

Water temperature modeling by IPCo shows that even if the inflowing water temperature were less than or equal to numeric criteria for salmonid rearing/cold water aquatic life uses, the water exiting the Hells Canyon Complex would not meet the salmonid spawning criteria (although by only a small margin) because of the temporal shift created by the Hells Canyon Complex. Data assessment and calculational modeling by the DEQs (as discussed earlier) have identified a similar trend. It is, therefore, concluded that the responsibility for exceeding the salmonid spawning criteria is specific to the presence and operation of the Hells Canyon Complex dams.

Available water temperature data show that numeric salmonid spawning targets are exceeded during the first few weeks of the spawning period for fall chinook for some years. Limited data collected in the 1950's suggest that criteria were also exceeded before the completion of the Hells Canyon Complex dams in the 1950's, but for a shorter period of time (Figure 3.6.4 a). At those times when exceedences occur, a reduction in thermal loading is needed to bring water temperature during spawning down to the 13 °C daily maximum temperature or to site potential temperatures as defined at RM 345. The critical period for this portion of the temperature TMDL begins on October 23 of each year and extends through the spawning period as long as water temperatures at the outflow from Hells Canyon Dam are 13 °C (daily maximum) or greater.

The 13 °C daily maximum temperature target is utilized as an instantaneous measurement that can be applied in "real time" to determine compliance. Calculation of a daily average temperature would create a time lag in the measurement of ΔT and the management of operations to achieve the target value. This situation could result in short-term exceedences within the outflow.

The site potential comparison approach (water temperatures at RM 345 above Brownlee Reservoir compared to water temperatures at RM 247 below Hells Canyon Dam (1992 to 2001)) is at present the best available estimate of the effect of the Hells Canyon Complex dams on water temperature in the Snake River below Hells Canyon Dam.

The temperature change required by the thermal load allocation consists of a change in water temperature such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at RM 345, or the 13 °C daily maximum temperature target for salmonid spawning. Specific compliance parameters for meeting this load allocation will be defined as part of the 401 Certification process. Figure 4.0.2 outlines this temperature load allocation as calculated from daily maximum temperatures averaged from 1991 through 2001.

The actual excess thermal load (allowable load) is flow dependent. It may be nominally calculated by: flow x ΔT x K, where flow is the discharge rate at any time of concern; ΔT is the difference between the observed temperature at the outflow of Hells Canyon Dam (RM 247) and the target temperature; and K is a conversion factor taking into account the time period of interest, units of energy, and heat capacity and density of water, such as to express a thermal load in terms of energy/time.

Load (kcal/day) = [ΔT x Q_R x (86400 sec/day) x (62.4#water/ft^3)]/ (1.1 x (3.968 BTU/kcal)

where: ΔT = allowable change in temperature
(When river temperatures below Hells Canyon Dam are greater than 13 °C (daily maximum), ΔT is no more than 0.14 °C increase over site potential temperature at RM 345)
Q_R = flow in the river in cfs
1.1 = safety factor of 10 percent

The entire thermal load allocation consists of the required change in temperature (such that the temperature of water released from Hells Canyon Dam is less than or equal to the flow-weighted average temperature at RM 345, or the 13 °C daily maximum temperature target for salmonid spawning) and the allowable temperature change described by the preceding equation. The entire load for the Downstream Snake River segment (RM 247 to 188) is allocated to the Hells Canyon Complex of dams owned and operated by IPCo.

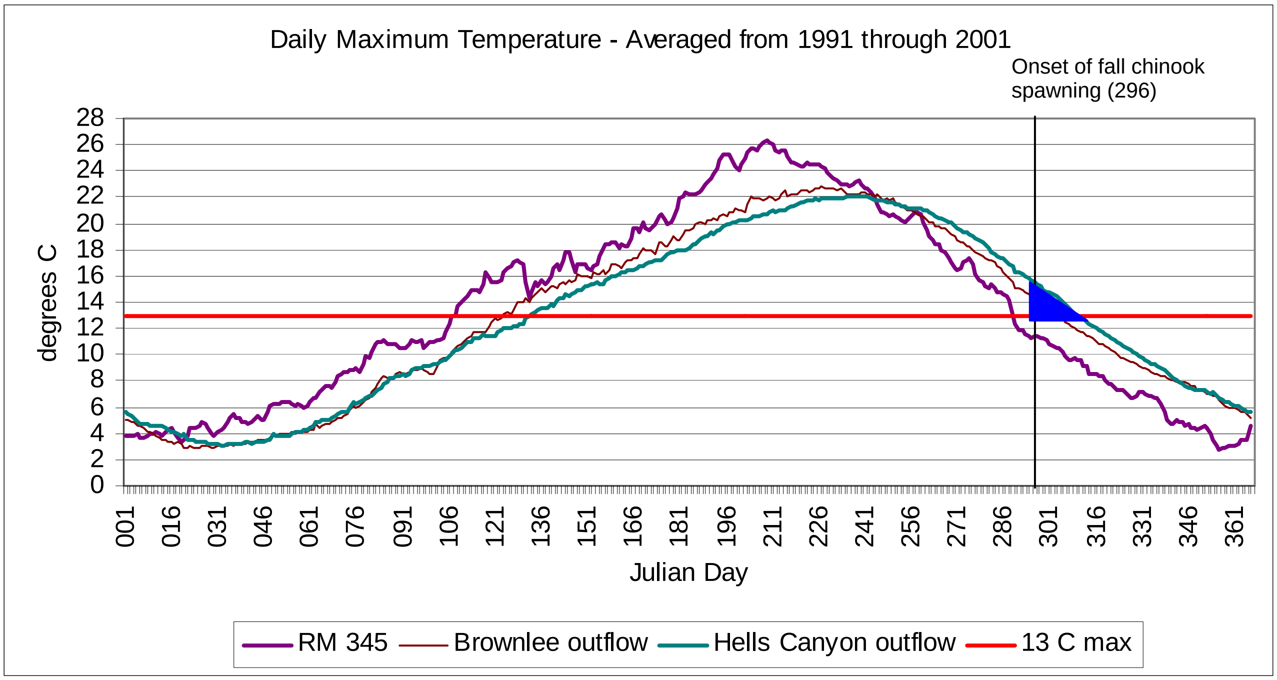

Figure 4.0.2 Load allocation for temperature change below Hells Canyon Dam using a comparison of daily maximum water temperatures for the Snake River at RM 345 (10 miles upstream of the headwaters of Brownlee Reservoir) which acts as the "thermal site potential" surrogate for the Hells Canyon Complex, and water temperatures at the outflow of Hells Canyon Dam (RM 247). (The horizontal line describes the 13 °C maximum allowable temperature that applies from October 23 (Julian day 296) through April 15 (Julian day 105) for Hells Canyon fall chinook. The vertical line identifies the start of salmonid spawning period (October 23, Julian day 296). The triangle describes the mean temperature change necessary to meet the temperature load allocation below Hells Canyon Dam, RM 247).

In the plot in Figure 4.0.2, the 13 °C salmonid spawning temperature target for the SR-HC TMDL is identified, as is the change in temperature required at the outflow of Hells Canyon Dam to meet the target (no greater than 13 °C maximum weekly maximum water temperature) or less than 0.14 °C increase due to anthropogenic influences from the water temperature at RM 345 (the thermal potential surrogate for the Hells Canyon Complex). The data plotted are the mean values derived from water temperature data collected from 1991 through 2001. The maximum temperature change illustrated by this data would be 2.6 ^{o}C (occurring on October 23rd) the minimum change would be 0 ^{o}C (occurring on Nov 6th). The mean temperature change described by the plotted data is 1.3 ^{o}C. The mean duration of the required change described by the plotted data is 14 days.

The development of this load allocation, like the TMDL, is an iterative process. This load allocation will remain in effect until such time as additional data and further analysis warrant its reconsideration and the load allocation is changed through an appropriate process. This thermal load is a load allocation; it is not a waste load allocation. By the use of the term load allocation, however, the DEQs do not waive their right to assert in any proceeding related to this TMDL, the Hells Canyon Hydro-Electric Complex or any other TMDL or hydro-electric project, that a hydro-electric project is a point source under the federal Clean Water Act. Should sufficient data become available to allow an accurate determination of natural warming for the Hells Canyon Complex, this information will be reviewed as part of the iterative TMDL process and revisions to the TMDL and the associated load allocation will be made as appropriate.

Data collected by IPCo and USFWS indicate that fall chinook spawning is occurring under existing conditions throughout the 100 mile reach of the Snake River from below Hells Canyon Dam (RM 245) downstream to Asotin WA (RM 145). While this TMDL stops at the confluence of the Salmon River, the entire reach from Hells Canyon Dam downstream to Asotin, WA currently supports (to some extent) salmonid spawning activity. The majority of spawning activity occurs from October 23rd through the first week of December. Currently, the peak of spawning in the river downstream of Hells Canyon Dam occurs when daily mean and maximum water temperatures are between 12 ^{o}C and l6 ^{o}C.

Data currently available (IPCo, 2001c, 2001e, 2001f) do not identify impairment to fall chinook spawning due to water temperatures in excess of the current criteria occurring in the late fall. Moreover, studies undertaken by IPCo suggest that warmer fall and winter water temperatures can lead to accelerated hatching and fry development, which may provide a survival benefit to out-migrating juvenile fall chinook. However, these data, and their interpretation, are preliminary. If additional data or study further clarify the support status of fall chinook and/or the effects of water temperature on spawning, or result in changes to salmonid spawning criteria, this information will be reviewed as part of the iterative TMDL process and revisions to the TMDL and the associated load allocations will be made as appropriate.

4.0.7 Total Dissolved Gas

A detailed discussion of sources, available data, associated water quality-related concerns and loading is available in Sections 2.2.4.7, 2.3.3.2, 2.3.4.2, 2.3.5.2 and 3.7.

4.0.7.1 LOADING

Elevated total dissolved gas levels are the result of releasing water over the spillways of dams. Spill at Brownlee and Hells Canyon Dams is the only source of elevated total dissolved gas in the SR-HC reach. At this time, voluntary spill does not occur within the Hells Canyon Complex.

Spill at dams occurs only involuntarily, usually as a result of flood control constraints. The magnitude of the exceedence (to some extent) and the total distance downstream of the dam where water was observed to exceed the less than 110 percent of saturation target are observed to be directly related to the volume of the spill.

Observed ranges of total dissolved gas loading to the Oxbow Reservoir (RM 285 to 272.5), Hells Canyon Reservoir (RM 272.5 to 247) and Downstream Snake River segment (RM 247 to 188) are shown in Table 4.0.18.

Table 4.0.18. Total dissolved gas waste loads from sources in the Snake River - Hells Canyon TMDL reach.

Load Type	Location	Load	Estimation Method
Spill from Brownlee Reservoir	Oxbow and Hells Canyon Reservoir Segments	114% to 128%	Monitoring
Spill from Hells Canyon Reservoir	Downstream Snake River Segment	108% to 136%	Monitoring

4.0.7.2 Load Capacity

In order to ensure that designated aquatic life uses are protected, total dissolved gas concentrations cannot exceed 110 percent of saturation. This concentration therefore defines the load capacity for the Oxbow Reservoir (RM 285 to 272.5), Hells Canyon Reservoir (RM 272.5 to 247) and Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach (Table 4.0.19).

Table 4.0.19. Total dissolved gas load capacity for segments in the Snake River - Hells Canyon TMDL reach.

Segment	Annual Load Capacity
Oxbow Reservoir segment (RM 285 to 272.5)	less than 110% of saturation
Hells Canyon Reservoir segment (RM 272.5 to 247)	less than 110% of saturation
Downstream Snake River segment (RM 247 to 188)	less than 110% of saturation

4.0.7.3 Margin of Safety

An implicit margin of safety is incorporated into the SR-HC TMDL total dissolved gas target as it is established as a conservative criterion for the protection of aquatic life designated uses.

4.0.7.4 Background/Natural Loading

There are no known natural sources of total dissolved gas that result in substantial loading or standards violations in the SR-HC TMDL reach.

4.0.7.5 Reserve

No reserve capacity was built into the calculation of load allocations for total dissolved gas.

4.0.7.6 Load Allocations

Load allocations specific to total dissolved gas exceedences are identified in Table 4.0.20.

Table 4.0.20. Total dissolved gas load allocations for the Hells Canyon Complex reservoirs.

Segment	Load Allocation
Oxbow Reservoir segment (RM 285 to 272.5)	less than 110% of saturation at the edge of the aerated zone below Brownlee Dam*
Hells Canyon Reservoir segment (RM 272.5 to 247)	less than 110% of saturation at the edge of the aerated zone below Oxbow Dam*
Downstream Snake River segment (RM 247 to 188)	less than 110% of saturation at the edge of the aerated zone below Hells Canyon Dam*

* The specific location of compliance points and protocol for monitoring will be determined as part of the Hells Canyon Complex 401 Certification process for each state.

The load allocation can be calculated using the following equation:

Load = (110%)(K)(flow conversion constant)
where K = the gas conversion constant for N_2

This load allocation has been established to ensure that the less than 110 percent of saturation target is attained. This load allocation applies to all discharge flows not exceeding the ten-year, seven-day average flood flow for Brownlee and Hells Canyon Dams, identified by Idaho Power Company as 72,500 cfs. As spill over Brownlee Dam and Hells Canyon Dam (both facilities owned and operated by IPCo) is the sole source of elevated total dissolved gas in the SR-HC TMDL reach, the entire load allocation goes to the Hells Canyon Complex.

If a separate target is established through the FERC, 401 Certification process or other appropriate mechanism, and shown to support the designated beneficial uses, the load allocation will be revised to reflect the new target.

The SR-HC TMDL will proceed toward completing site-specific implementation objectives within 18 months of approval of the TMDL. Data collection is projected to continue throughout the implementation process to determine progress and improve understanding of the SR-HC TMDL system. As this TMDL is a phased process, it is projected that the goals and objectives of this TMDL will be revisited periodically to evaluate new information and assure that the goals and milestones are consistent with the overall goal of meeting water quality standards in the SR-HC TMDL reach.

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4.1 Reasonable Assurance

For watersheds that have a combination of point and nonpoint sources where pollution reduction goals can only be achieved by including some nonpoint source reduction, a reasonable assurance that reductions will be met must be incorporated into the TMDL (EPA, 1991). The SR-HC TMDL will rely on nonpoint source reductions to meet the load allocations to achieve desired water quality and to restore designated beneficial uses. The State of Oregon Water Quality Management Plan and the State of Idaho Implementation Plan (Section 6.0) contain more detailed information on implementation programs that will provide reasonable assurance of implementation.

To ensure that nonpoint source reduction mechanisms are operating effectively, and to give some quantitative indication of the reduction efficiency for in-place BMPs, monitoring will be conducted. The monitoring will not be carried out on a site specific basis for each implemented BMP, but rather as a suite of indicator analyses monitored at the inflow and outflow of the segments within the SR-HC TMDL reach and at other appropriate locations such as the inflow of tributaries. For example, a decrease in total phosphorus over time as monitored at the Boise River inflow to the SR-HC TMDL reach would serve as an indicator that BMPs employed within the Boise River watershed were acting to reduce total phosphorus levels within the tributary water column. This data will be further utilized, in conjunction with flow measurements, to evaluate the overall decrease in total pollutant mass being delivered to the SR-HC TMDL reach.

Concurrent monitoring of mainstem water quality will be undertaken to determine the direct effects of the monitored inflowing concentration trends on mainstem water quality. If instream monitoring indicates an increasing pollutant concentration trend (not directly attributable to environmental conditions) or a violation of standards despite use of approved BMPs or knowledgeable and reasonable efforts, then BMPs for the nonpoint sources 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 "feedback loop" in which BMPs or other efforts are periodically monitored and modified if necessary to ensure protection of beneficial uses. With continued instream monitoring, the TMDL will initiate the feedback loop process and will evaluate the success of BMP implementation and its effectiveness in controlling nonpoint source pollution.

All identified point sources discharging to the Snake River within the SR-HC TMDL reach are permitted facilities administered by the US EPA (Idaho facilities) or the State of Oregon (Oregon facilities). Wasteload reductions can be precipitated by modification of the NPDES permit. However, the load reductions needed to achieve desired water quality and restore full support of designated beneficial uses in the SR-HC TMDL reach will not be achieved in their entirety by upgrades of the point sources.

The states have responsibility under Section 401 of the CWA to provide water-quality certification. Under this authority, the states review the projects to determine applicability to local water-quality issues.

Under Section 319 of the CWA, each state is required to develop and submit a nonpoint source management plan. The nonpoint management program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. Since the development of the original Nonpoint Management Programs, revisions of the water-quality standards have occurred. Many of these revisions have adopted provisions for public involvement, such as the formation of Basin Advisory Group (BAGs) and WAGs (Idaho Code 39-3614, 3615, 39-3601, 39-3616), as discussed in section 2.0.5.1. The WAGs (SR-HC PAT) are to be established in high priority watersheds to assist DEQ and other state agencies in developing TMDLs and Watershed Management Plans (WMPs) for those segments.

The State of Idaho and State of Oregon water-quality standards refer to other programs whose mission is to control nonpoint pollution sources. Some of these programs and responsible agencies are listed in Tables 4.1.1 and 4.1.2.

Table 4.1.1 State of Idaho regulatory authority for nonpoint pollution sources.

Citation	IDAPA Citation	Responsible Agency
Rules governing forest practices	16.01.02350.03(a)	Idaho Department of Lands
Rules governing solid waste management	16.01.02350.03(b)	Idaho Department of Health and Welfare
Rules governing subsurface and individual sewage disposal systems	16.01.02350.03(c)	Idaho Department of Health
Rules and standards for stream channel alteration	16.01.02350.03(d)	Idaho Department of Water Resources
Rules governing exploration and surface mining operations in Idaho	16.01.02350.03(e)	Idaho Department of Lands
Rules governing placer and dredge mining in Idaho	16.01.02350.03(f)	Idaho Department of Lands
Rules governing dairy waste	16.01.02350.03(g) or IDAPA 02.04.14	Idaho Department of Agriculture

The State of Idaho uses a voluntary approach to control agricultural nonpoint sources. However, regulatory authority can be found in the state water-quality standards (IDAPA 16.01.02350.01 through 16.01.02350.03). IDAPA 16.01.02054.07 refers to the Idaho Agricultural Pollution Abatement Plan (IAPAP) (IDHW, SCC, EPA; 1993) which provides direction to the agricultural community for approved BMPs. As a portion of the IAPAP, it outlines responsible agencies or elected groups (SCDs) that will take the lead if nonpoint pollution problems need addressing. For agricultural activity it assigns the local SCDs to assist the landowner/operator to develop and implement BMPs to abate nonpoint pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may provide injunctive relief for those situations that may be determined to present imminent and substantial danger to public health or environment (IDAPA 16.01.02350.02 (a)).

If a nonpoint pollutant(s) is determined to be impacting beneficial uses and the activity already has in-place referenced BMPs, or knowledgeable and reasonable practices, the state may request the BMPs be evaluated and/or modified to determine appropriate actions. If evaluations and/or modifications do not occur, injunctive relief may be requested (IDAPA 16.01.02350.2, ii (1)).

Table 4.1.2 State of Oregon regulatory authority for nonpoint pollution sources.

Citation	Citation	Responsible Agency
Rules governing forest practices	ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, and OAR 340-041-0120	Oregon Department of Forestry
Rules governing solid waste management	ORS 459, ORS 459a, OAR 340-093-0005 through 340-096-0050	Oregon Department of Environmental Quality
Rules governing subsurface and individual sewage disposal systems	ORS 454.600,OAR 340-71, OAR 340-73	Oregon Department of Environmental Quality
Rules and standards for stream channel alteration	ORS 196.800-196.990, ORS 390.805-390.925, OAR 141-085-0005 through 141-085-0666	Oregon Division of State Lands
Rules governing exploration and surface mining operations in Oregon	ORS 517.010-517.950, OAR 632-030-0005 through 0007	Oregon Department of Geology and Mineral Industries
Rules governing placer and dredge mining in Oregon	ORS 517.010-517.950, OAR 141-085-0005 through 0085, OAR 141-100-0000 through 0090	Oregon Division of State Lands
Rules governing dairy waste and other CAFOs	ORS 468B.200-468B.230;OAR 340-51, ORS 603-074-0005 through 603-074-0080	Oregon Department of Agriculture

The Oregon Department of Agriculture has primary responsibility for control of pollution from agriculture sources. This is accomplished through the Agriculture Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010 Adopted by the Oregon State Legislature in 1993. The AWQM Act directs the ODA to work with local farmers and ranchers to develop water quality management plans for specific watersheds that have been identified as violating water quality standards and have agriculture water pollution contributions. The agriculture water quality management plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct the problems.

It is expected that a voluntary approach will be able to achieve load allocations needed for the SR-HC TMDL. Public involvement along with the eagerness of the agricultural community has demonstrated a willingness to implement BMPs and protect water quality. In the past, cost-share programs have provided the agricultural community technical assistance, information and education (I & E), and the cost share incentives to implement BMPs. The continued funding of these projects will be critical to achieving the load allocations identified in the SR-HC TMDL.

In 1995 the State of Idaho passed Senate Bill 1284, now incorporated into the Idaho Code Section 39-3613 and Section 39-3615. This bill established the formation of the WAGs and BAGs to assist state and federal agencies with water-quality planning in high priority watersheds. The Snake River – Hells Canyon Public Advisory Team (SR-HC PAT), which functions as the WAG for the SR-HC TMDL reach, was formed in March of 2000 in response to Idaho Code Section 39-3615 and public interest in the development of a TMDL for the SR-HC reach. The SR-HC PAT was recognized as the representative body for the watershed by DEQ in that same year.

4.1.1 Forestry Practices

The Idaho Forest Practices Act was passed in 1974 (revised 1992; Title 38, Chapter 13, Idaho Code). Rules that implement the Act establish required minimum BMPs for forestry practices to protect state water quality. In addition to logging, forestry practices include road construction, slash management and other activities associated with silviculture. The rules, which govern activities on Forest Service, private and state lands, primarily address sediment and erosion of streams impacted by logging activity. Reductions in the export of nutrients are not directly assessed; rather, they are addressed through reduction in sediment and sediment transport. Moreover, forestry BMPs do not address the export of nutrients and sediment caused by land disturbing activities that occurred prior to 1974. However, Boise and Payette National Forests, and Idaho Department of Lands (IDL), in conjunction with Boise Cascade Corporation have jointly developed the Forestry Source Plan (1998) to achieve load reductions. The Forests have also identified a method to determine sediment and phosphorus yield from roads and landslides and have developed a list of forestry practice BMPs and treatments with an estimate of their effectiveness in reducing phosphorus (sediment).

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forested lands in Oregon. The Oregon Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMPs for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness. The Environmental Quality Commission, Board of Forestry, ODEQ, and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards. ODF provides on the ground field administration of the Forest Practices Act (FPA). For each administrative rule, guidance is provided to field administrators to insure proper, uniform and consistent application of the Statutes and Rules. The FPA requires penalties, both civil and criminal, for violation of Statutes and Rules. Additionally, whenever a violation occurs, the responsible party is obligated to repair the damage.

Current forestry BMPs in Oregon and Idaho will remain as each state's forestry component of the TMDL.

4.1.2 Agricultural Practices

For agricultural activities in Idaho there are no required BMPs. Consequently, agricultural activities must use knowledgeable and reasonable efforts to achieve water-quality standards. Generally, voluntary implementation of BMPs would be considered a knowledgeable and reasonable effort. A list of recommended BMP component practices 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, a variety of state and federal funding sources are available to provide cost share incentives. Projects are directed at improving water quality through control of nonpoint source pollution at the subwatershed level using BMPs developed by the Natural Resources Conservation Service (NRCS). Cost share funds are dispersed to private landowners through local Soil Conservation Districts. Contracts with landowners require that BMPs be implemented for ten years, but changes in management practices should provide longer-term benefits. Currently, BMPs are directed at changes in irrigation practice, fencing or other access-restriction of riparian areas, creation of wetland habitat, establishment of off-site watering facilities and related practices.

In Oregon it is the Oregon Department of Agriculture's (ODA) statutory responsibility to develop agricultural water quality management (AWQM) plans and enforce rules that address water quality issues on agricultural lands. The AWQM Act directs ODA to work with local farmers and ranchers to develop water quality management area plans for specific watersheds that have been identified as violating water quality standards and having agriculture water pollution contributions. The agriculture water quality management area plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct those problems. These water quality management plans are developed at a local level, reviewed by the State Board of Agriculture, and then adopted into the Oregon Administrative Rules. It is the intent that these plans focus on education, technical assistance, and flexibility in addressing agricultural water quality issues. These plans and rules will be developed or modified to achieve water quality standards and will address the load allocations identified in the TMDL. In those cases when an operator refuses to take action, the law allows ODA to take enforcement action. ODEQ will work with ODA to ensure that rules and plans meet load allocations.

4.1.3 Monitoring

A rigorous monitoring plan and schedule is critical to the SR-HC TMDL. There is no way to determine progress, define trends, fill data gaps or enlarge understanding without an understanding of the changes occurring in the system. The State of Idaho includes a monitoring plan in all TMDL implementation plans prepared in the state. By including this plan in the implementation plan, it allows greater opportunity for ground-truthing and interagency participation. It also allows the monitoring plan to be constructed with a better understanding of the implementation activities that will be undertaken, and where and when these activities will occur so that monitoring can be tailored to the needs of the system as well as tracking the improvements that will be made.

These implementation plans are completed in much the same way as a TMDL is put together, with public, agency and stakeholder input. They are reviewed in a public process and comments are responded to.

Given this understanding, a monitoring plan that is appropriate in scope will be prepared as part of the site-specific implementation plans completed 18 months following the approval of the SR-HC TMDL. IDEQ has an acknowledged role in construction of this plan and oversight of the monitoring activities. In other TMDLs in the State of Idaho, IDEQ monitoring has played a prominent role in progress evaluation. Other entities, such as state and federal agencies have also often been partners in providing monitoring support for TMDL implementation. It is expected that the monitoring accomplished on the SR-HC TMDL will follow a similar pattern of participation. ODEQ has committed to participate to the fullest extent possible contingent on available resources.

The implementation of the SR-HC TMDL and the correlated system response is projected to be a lengthy process lasting several decades. Therefore it is critical that a schedule for long-term monitoring be committed to. In order to accomplish this, the general level of monitoring will need to be tailored in such a way that a sustainable level of routine monitoring can be accomplished while still allowing site-specific response to immediate conditions. For example, routine chlorophyll *a* monitoring should be scheduled at a frequency that will allow trend identification but should not be undertaken at a frequency that will make the assessment of a specific bloom impossible due to budget constraints.

While detailed plans cannot be accurately identified at this time, the monitoring effort on the SR-HC TMDL is expected to include (at minimum):

MONITORING TO FILL DATA GAPS

Constituents:

- Dissolved Oxygen at the sediment/water interface in the Upstream Snake River segment, mercury (water column), pesticides (Oxbow Reservoir), sediment (duration data)

Schedule:

- Final evaluations completed within the first phase of implementation

ROUTINE PROGRESS MONITORING

Constituents:

- Phosphorus, nitrogen, dissolved oxygen, chlorophyll *a*, sediment, temperature

Locations:

- Monitoring points located upstream and downstream in the defined TMDL segments, namely Upstream Snake River (RM 409 to 335), the Reservoir Complex (RM 335 to 247), and Downstream Snake River segments (RM 247 to 188). As Brownlee Reservoir (RM 335 to 285) acts not only as the source water for the downstream reservoirs, but also as the recipient of upstream waters where water quality objectives will have a noticeable influence if attained, it is expected that a greater level of monitoring will be focussed on Brownlee Reservoir than on Oxbow or Hells Canyon reservoirs.
- Monitoring of major tributaries at their inflow to the SR-HC TMDL reach

Schedule:

- Routine monitoring frequency is projected to occur monthly or (at minimum) seasonally as water quality needs require.
- Monitoring of major tributaries at their inflow to the SR-HC TMDL reach on a monthly or (at minimum) a seasonal basis to determine loading trends.

These projected goals of the SR-HC monitoring plan will be a joint effort on the part of many government and private participants. Specific responsibility will be identified as the implementation planning process proceeds.

5.0 Conclusions

There is a substantial amount of data available to this effort. While some parameters will require additional monitoring in order to complete the TMDL process, this robust database has made an initial assessment of system needs and designated use requirements possible

- The assessment of water quality conditions within the SR-HC TMDL reach identified substantial water quality concerns centered on excessive nutrient loading in the Upstream Snake River and Brownlee Reservoir segments and low dissolved oxygen in the Brownlee Reservoir segment.

- Total dissolved gas was identified as a pollutant of concern by SR-HC PAT members and load allocations meeting the required standard were assigned to the Brownlee and Hells Canyon Dams.

- Mercury concentrations were observed to be in excess of the SR-HC TMDL fish tissue targets in over 85% of the data and fish tissue consumption advisories remain in place, but no final TMDL could be prepared due to a lack of water column data. This TMDL has been postponed to 2006. Data will be collected during the intervening time period and a full assessment completed by 2006.

- Similarly, the influence of sediment, listed as a pollutant in the Upstream Snake River, Brownlee and Oxbow Reservoir segments, on aquatic life uses could not be fully assessed due to lack of duration data, but was identified as a transport mechanism for mercury, pesticides and nutrients within the system and has been targeted as an indicator for tracking pollutant loading while duration data is being collected.

- While little data was available for pesticides within the SR-HC TMDL reach, and no data was available for the listed segment (Oxbow Reservoir), the initial assessment that pesticide transport within the system should be minimized was possible. Implementation of concurrent pollutant reductions for sediment and total phosphorus should result in reductions in pesticide transport within the SR-HC TMDL reach. Data collection will allow designated use status identifications to be made during the first phase of implementation.

- Atmospheric influences were identified as a primary source of temperature exceedences and an in-depth evaluation of cold water refugia in the reservoirs demonstrated the critical nature of such habitat to the arid Snake River system.

- Bacteria and pH listings were not found to be supported by the data and have been recommended for delisting.

As demonstrated by the size and diversity of the issues addressed in this document, the SR-HC TMDL reach is a highly complex system and will no doubt yield unexpected results as implementation and further data collection proceeds. The challenges encountered in determining designated beneficial use support and system impairment are an outgrowth of this complexity and will require additional assessment and re-visitation as understanding of the system evolves. Additionally, due to the complexity encountered and the enormous geographic scope of this effort, an extended time period for implementation and system response will be required. Generally, TMDL processes are expected to be completed within ten to 15 years of approval, this system, with its sequential tributary TMDL processes, wide diversity of land use and staggering size will not doubt require several decades to respond completely to implementation projects and changes in management.

Because of the complex nature and the extended time frame required, it is absolutely critical that the SR-HC TMDL remain a truly iterative process whereby improved understanding of the system can be re-applied to the initial targets and goals as time passes, and that these targets and goals can be updated to better reflect system needs and appropriate management.

Snake River - Hells Canyon Total Maximum Daily Load (TMDL)

Section 6.0 General Water Quality Management and Implementation Plans

6.0 Snake River – Hells Canyon TMDL General Water Quality Management and Implementation Plans

The Snake River - Hells Canyon (SR-HC) Total Maximum Daily Load (TMDL) is a joint effort between the Idaho Department of Environmental Quality (IDEQ) and the Oregon Department of Environmental Quality (ODEQ), with participation by the US Environmental Protection Agency (US EPA) and local stakeholders.

The purpose of this water quality management plan document is to act as a general outline for implementation of the SR-HC TMDL. This TMDL has been prepared as a bi-state process between Idaho and Oregon.

To fulfil the requirements of the State of Oregon TMDL process, an implementation plan must be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, this general plan is being submitted with the SR-HC TMDL and other, more specific implementation plans will be prepared and submitted according to the appropriate IDEQ or ODEQ procedure.

This general document is being submitted to fulfill the requirements of the TMDL process. However, substantial differences in state procedure and policy for implementation of TMDLs exist between Oregon and Idaho. Therefore, this document contains two separate, state-specific plans:

- The State of Oregon General Water Quality Management plan (Section 6.1), and
- The State of Idaho General Implementation Plan (Section 6.2)

Together, these documents represent the general water quality management plan (implementation plan) for the SR-HC TMDL.

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6.1 State of Oregon General Water Quality Management Plan

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Oregon Snake River – Hells Canyon

Water Quality Management Plan (WQMP)

Prepared by: Oregon Department of Environmental Quality
July 2003

DEQ
State of Oregon
Department of
Environmental
Quality

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CHAPTER 1 - INTRODUCTION

The Snake River - Hells Canyon (SR-HC) Subbasin Total Maximum Daily Loads (TMDLs) were developed by the Oregon Department of Environmental Quality and the Idaho Department of Environmental Quality. The Oregon Snake River - Hells Canyon Water Quality Management Plan (WQMP), prepared by the Oregon Department of Environmental Quality, is intended to describe strategies for how the SR-HC Subbasin Total Maximum Daily Loads (TMDLs) will be implemented and achieved in the State of Oregon. It includes a description of activities, programs, legal authorities, and other measures for which ODEQ, which regulates industrial and municipal point sources, and the subbasin's designated management agencies (DMAs), which regulate all other sources of pollution, have regulatory responsibilities. This WQMP is the overall framework describing the management efforts to implement the Snake River - Hells Canyon Subbasin TMDLs.

A separate plan describing how SR-HC TMDLs will be implemented and achieved in the State of Idaho has been prepared by the Idaho Department of Environmental Quality.

The Oregon point sources and DMAs named in the Snake River - Hells Canyon Subbasin TMDLs are or will be developing preliminary site and source specific Implementation Plans (IPs). For point sources, IPs will be in the form of source-specific facility plans. All IPs will be submitted within 18 months of this TMDL being approved by the US Environmental Protection Agency. These IPs, when complete, are expected to fully describe point source and DMA efforts to achieve their appropriate allocations, and ultimately, water quality standards. Since DMAs will require time to fully develop IPs once the TMDLs are finalized, the first iteration of their IPs are not expected to completely describe all necessary management efforts.

Appended to this document are completed Oregon DMA IPs for forestlands, agricultural lands, transportation systems, and public lands within the SR-HC subbasin. These plans describe each DMA's existing or planned efforts to implement their portion of the TMDLs. Point source IPs will be added as they are completed. This relationship is presented schematically in Figure 1, below.

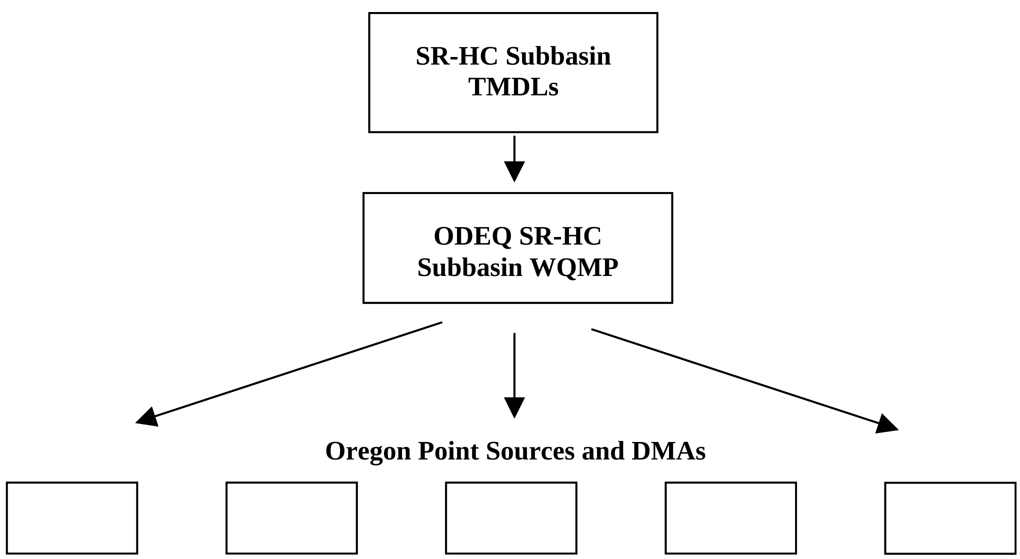

Figure 1 : TMDL/WQMP/Implementation Plan (IP) Schematic

ODEQ recognizes that TMDL implementation is critical to the attainment of water quality standards. Additionally, the support of point sources and DMAs in TMDL implementation is essential. In instances where ODEQ does not have direct authority for implementation, they will work with DMAs to ensure attainment of the TMDL allocations and, ultimately, water quality standards. Where ODEQ has direct authority, such as in issuing permits to point sources, they will use that authority to ensure attainment of the TMDL allocations and water quality standards.

This document is the first iteration of the Oregon Water Quality Management Plan (WQMP) for Snake River - Hells Canyon Subbasin TMDLs. As explained in "Element 6" of this document, DMA-specific IPs will be more fully developed once the current TMDLs are submitted to the U. S. Environmental Protection Agency (EPA) and approved. This WQMP will establish proposed timelines (following final TMDL approval) to develop full point source and DMA IPs. ODEQ will work cooperatively in the development of TMDL IPs and will assure that the plans adequately address the elements described below under "TMDL Water Quality Management Plan Guidance".

ODEQ recognizes that meeting TMDLs in the SR-HC subbasin may be economically challenging. Therefore, the State or Oregon will make every effort possible to minimize economic impacts required to meet TMDLs while at the same time complying with state and federal regulations intended to protect water quality.

The Relationship Between SR-HC TMDLs, WQMP, and IPs

The goal of the Clean Water Act and associated Oregon administrative rules is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest water quality attainable. This is a long-term goal in many watersheds, particularly where non-point sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

Total Maximum Daily Loads (TMDLs) are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met and designated beneficial uses, such as fishing, swimming, and recreation, are supported. ODEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and some other analytical techniques are simplifications of these complex processes and, while they are useful in interpreting data and in predicting trends in water quality, they are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

For the purposes of the Snake SR-HC TMDL, this general Water Quality Management Plan (WQMP) will be submitted to EPA as part of the TMDL document. Following this submission, in accordance with approved state schedules and protocols, specific point source and DMA Implementation Plans (IPs) will be prepared for all Oregon pollutant sources. IPs available at the completion of the TMDL will be referenced in the WQMP. Appropriate agencies and/or entities as designated by the state will assist in the development and oversight of the specific plans. IPs will be designed to reduce pollutant loads to meet the TMDLs established for listed pollutants.

It is ODEQ's initial expectation that point sources will meet their specific waste load allocations in five years or sooner if feasible. During this time frame each point source will prepare a facilities plan (Implementation Plan - IP) that will investigate alternative methods for meeting waste load allocations. If a point source's IP documents that achieving waste load allocations within the five-year time frame is not feasible, the point source may request an extension.

ODEQ recognize it may take some period of time – from several years to several decades – to fully implement the appropriate non-point source management practices. ODEQ also recognizes that it may take additional time after implementation has been accomplished before the management practices identified in the WQMP or DMA IPs become fully effective in reducing and controlling pollution. In addition, ODEQ recognizes that technology for controlling nonpoint source pollution is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated targets and surrogates cannot be achieved as originally established. ODEQ further recognizes that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated targets and surrogates. Such events could be, but are not limited to floods, fire, insect infestations, and drought. In these kinds of situations, if a non-point source that is covered by the TMDLs complies with its IP, it will be considered in compliance with the TMDL.

For some pollutants in the Snake River - Hells Canyon TMDLs, pollutant surrogates have been defined as alternative targets for meeting the TMDLs. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. It is the expectation, however, that the WQMP and associated IPs will address how human activities will be managed to achieve the water quality targets and surrogates. It is also recognized that full attainment of pollutant surrogates at all locations may not be feasible due to physical, legal, or other regulatory constraints. To the extent possible IPs should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise.

ODEQ intends to regularly review progress of this WQMP and its IPs to achieve TMDLs. If and when ODEQ determines the WQMP and the associated IPs have been fully implemented, that all feasible management practices have reached maximum expected effectiveness, and that a TMDL or its interim targets have still not been achieved, ODEQ shall reopen the TMDL and adjust it or its interim targets and the associated water quality standard(s) as necessary.

The implementation of TMDLs and the associated IPs are enforceable under the applicable provisions of the water quality standards by ODEQ, which regulates point sources, and by other State of Oregon agencies and local governments (DMAs), which regulate non-point sources. However, it is envisioned that sufficient initiative exists on the part of local stakeholders to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that ODEQ or the responsible agency (DMA) will work with point sources or land managers to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. This could occur through direct intervention from state or local DMAs or ODEQ. The latter may be based on departmental orders to implement management goals leading to water quality standards.

If a source is not given a load allocation, it does not necessarily mean that the source is prohibited from discharging any wastes. A source may be permitted to discharge by ODEQ if the source can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when site temperature is achieved. Alternatively, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source may be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

Adaptive Management

In employing an adaptive management approach to the TMDLs, the WQMP, and the associated IPs, ODEQ has the following expectations and intentions:

* Subject to available resources, ODEQ intends to review the progress of the TMDLs, WQMP, and the associated IPs, on a five-year basis.

* In conducting this review, ODEQ will evaluate the progress towards achieving the TMDLs (and water quality standards) and the success of implementing the WQMP and associated IPs.

* ODEQ expects that point sources and designated management or oversight agencies (DMAs) in Oregon will also monitor and document their progress in implementing the provisions of the IPs for those pollutant

sources for which they are responsible. This information will be provided to ODEQ for use in reviewing the TMDL.

* ODEQ expects that point sources and DMAs will identify benchmarks for the attainment of TMDL targets and surrogates as part of IP development. As implementation of the WQMP and the associated IPs proceeds, these established benchmarks will be used to measure progress toward the goals outlined in the SR-HC TMDL.

* Where implementation of the IPs or effectiveness of management techniques are found to be inadequate, ODEQ expects point sources and DMAs to revise the components of IPs to address these deficiencies.

* If ODEQ, in consultation with point sources and DMAs, conclude that all feasible steps have been taken to meet the TMDL and its associated targets and surrogates, and that the TMDL, or the associated targets and surrogates are not practicable, the TMDL may be reopened and revised as appropriate. ODEQ will also consider reopening the TMDL should new information become available indicating that the TMDL or its associated targets and/or surrogates should be modified.

Effluent Trading

ODEQ recognizes the desire of stakeholders to equalize the economic burden of meeting the TMDL. One way to achieve this is to allocate loads based upon costs so that everyone pays the same per unit of reduction. Unfortunately, there is insufficient time and information to base allocations on equal cost. This could only be done after each allocated source completed a facilities plan to determine various means and the associated costs of reducing loads.

Instead ODEQ recommends that point and non-point source DMAs expand their planning efforts to consider means and costs of reducing their loads further than necessary to meet allocations. Sources could then market their additional load reductions to others and, if their load reductions were cheaper to achieve, sell them. ODEQ is willing to adjust allocations after the TMDL is established provided the parties involved have enforceable contracts, permits, or other instruments to ensure that effluent trades can and will be implemented.

CHAPTER 2 - TMDL WATER QUALITY MANAGEMENT PLAN GUIDANCE

In February 2000, ODEQ entered into a Memorandum of Agreement (MOA) with the U.S. Environmental Protection Agency (EPA) that describes the basic elements needed in a TMDL Water Quality Management Plan (WQMP).   That MOA was endorsed by the Courts in a Consent Order signed by United States District Judge Michael R. Hogan in July 2000. The elements of this agreement, as outlined below, will serve as the framework for this WQMP.

WQMP Elements

1. Condition assessment and problem description
2. Goals and objectives
3. Identification of responsible participants
4. Proposed management measures
5. Timeline for implementation
6. Reasonable assurance

7. Monitoring and evaluation
8. Public involvement
9. Costs and funding
10. Citation to legal authorities

This Snake River - Hells Canyon Subbasin WQMP is organized around these plan elements and is intended to fulfill the requirement for a management plan contained in OAR 340-041-0745.

CHAPTER 3 – CONDITION ASSESSMENT AND PROBLEM DESCRIPTION

Geographic Region of Interest

The Snake River Basin includes areas of Idaho, Nevada, Oregon, Utah, Washington and Wyoming. The Snake River is the 10th longest river system in the United States, extending over 1000 miles from its headwaters in Yellowstone National Park, Wyoming, to its confluence with the Columbia River near Pasco, Washington. The Snake River is the major tributary in the Columbia River system. It drains about 87 percent of the State of Idaho (about 73,000 square miles) and approximately 17 percent of the State of Oregon (about 16,900 square miles). In addition, over 18 percent of the State of Washington (approximately 19,600 square miles) is also located in the Snake River Basin. The Snake River stretches across nearly 760 miles of southern and southwestern Idaho, with about 270 miles of this segment acting as the border between Oregon and Idaho. Near Lewiston the Snake River leaves Idaho (having left Oregon upstream near China Garden Creek), traveling the remainder of its length westward across Washington toward its confluence with the Columbia River.

Conditions within this system vary ecologically, geologically, and hydrologically between upstream and downstream segments. Ecological variations within the river system are evident in the changes in climate, vegetation, animal populations and fisheries throughout the listed segments. Geologic variation such as changes in elevation, soil, rock type, landforms and relative impact of naturally occurring erosive processes are observed upstream to downstream. Equally evident are the hydrologic variation that occur with distance traveled from the fast-flowing upstream section of the river, through the slower-flowing, more lacustrine (lake-like) reservoir systems, to the rapid, white-water section downstream of Hells Canyon Dam. In addition to changes in flow and velocity, hydrologic variations include differences in relative ground and surface-water inflows and channel morphology throughout the listed segments. Variations in water quality and quantity also occur over time. Temporal variations cover a wide range of factors including historical vs. current land use and river management conditions, changes induced by differences in flow and precipitation in a wet year vs. a dry year, and seasonal variation in both water quality and quantity.

For more information on the characterization of the Snake River basin watershed, see section 2.1 of the Snake River - Hells Canyon Subbasin Assessment.

Beneficial Uses

Designated surface water beneficial use classifications are intended to protect the various uses of public surface waters. The specific designated beneficial uses for the Snake River - Hells Canyon Subbasin differ slightly between Oregon and Idaho, but the basic concepts are consistent. The various designated beneficial uses can be grouped into five bi-state categories. (See table 1)

Table 1

Oregon Beneficial Use	*Idaho Beneficial Use*	*Bi-State Beneficial Use*
Public Domestic Water Supply	Cold Water Biota	Aquatic Life
Private Domestic Water Supply	Primary Contact Recreation	Recreation
Industrial Water Supply	Domestic Water Supply	Water Supply
Irrigation	Special Resource Water	Wildlife habitat
Livestock Watering	Salmonid Spawning	Aesthetics
Fishing and Boating		
Resident Fish and Aquatic Life		
Anadromous Fish Passage		
Wildlife and Hunting		
Fishing		
Water Contact Recreation		
Salmonid Rearing and Spawning		
Hydropower		
Commercial Navigation and Transport		
Aesthetic Quality		

Numeric and narrative water quality standards are designed to protect the most sensitive of each state's beneficial uses.

Current Conditions

The mainstem Snake River from where the river intersects the OR/ID border at river mile 409 downstream to immediately above the Salmon River at river mile 188 has been identified as water quality limited due to violations of water quality standards for both states (See table 2)

Table 2

Oregon 303(d) Listed Pollutants	*Idaho 303 (d) Listed Pollutants*
Mercury*	Bacteria
Temperature	Dissolved Oxygen (DO)
	Nutrients
	Sediment
	pH
	Mercury*
	Temperature

*Because of a lack of water column data for mercury in the Snake River, IDEQ and ODEQ have agreed to postpone development of a mercury TMDL until 2006.

Existing Sources of Water Pollution

The following parameters have been identified as causing violations of Oregon and Idaho water quality standards in the section of the Snake River covered in this TMDL

Dissolved Oxygen

Dissolved oxygen (DO) is important for fish and other aquatic life. Low DO levels in the Snake River are caused primarily by oxygen-demanding pollutants and by respiration effects of algae

Nutrients

Nutrients help promote the growth of algae. Respiring algae consume oxygen. During the day, when sunlight drives photosynthesis, the effects of respiration are offset by the production of oxygen. At night, however, when the sun cannot drive photosynthesis, the algae consume oxygen from the water column. In addition, decomposition of algae and other detritus can deplete oxygen from the water and sediment. The following is a listing of possible nutrient sources in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable sources of nutrients in the subbasin.

- Urban runoff
- Rural runoff
- Agricultural runoff
- Forestry runoff
- Instream and nearstream erosion
- Algal and detritus

Biochemical Oxygen Demand (BOD)

BOD is a measure of the oxygen required to oxidize organic material. The following is a listing of possible causes of BOD in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable sources of nutrients in the subbasin.

- Naturally occurring algae and detritus
- Increased naturally occurring algae and detritus
- Municipal waste
- Agricultural waste
- Industrial waste

Nutrients

Excess nutrients, primarily phosphorus and nitrogen, cause nuisance aquatic growth that can adversely affect aquatic life and recreational uses.

Phosphorous

Although phosphorus is naturally occurring in the Snake River basin, there are also anthropogenic sources. The following is a listing of possible phosphorus sources in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable sources of phosphorus in the subbasin.

- Natural geologic inputs
- Irrigation induced erosion
- The creation of artificial water ways and water levels through agricultural practices
- Instream and near-stream erosion
- Applied fertilizers in farming and landscaping
- Duration and density of livestock grazing
- Erosion from forest lands
- Sewage and septic waste

Nitrogen

Nitrogen also has natural as well as anthropogenic sources. The following is a listing of possible nitrogen sources in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable sources of nitrogen in the subbasin.

- Biological fixation
- Irrigation induced erosion
- Industrial wastewater
- Municipal wastewater
- Septic discharges

pH

pH is the measure of acidity or alkalinity in a system. Extreme high levels of pH can be toxic to aquatic life. In the Snake River - Hells Canyon subbasin reach variations in pH are buffered by naturally occurring minerals. The photosynthetic process of algae can drive the pH up to alkaline levels that are toxic. The following is a listing of possible factors affecting pH in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable impacts of pH levels in the subbasin.

- Biological buffering
- Industrial and municipal waste
- Ammonia production during organic matter decomposition
- Agricultural run-off
- Carbon dioxide uptake during photosynthesis

Sediment

Suspended sediment and bedload sediment can have a negative impact on aquatic life, including interfering with feeding behavior, gill damage, reduced growth rates, smothering eggs and fry, and death. The following is a listing of possible sediment sources in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable sources of sediment in the subbasin.

- High flow events
- Erosion from roadways
- Erosion from agricultural lands
- Urban and suburban stormwater run-off
- Landslides
- Forest fires

Temperature

Temperature is a key factor in determining water quality, particularly in regards to fish health and aquatic habitat. High temperatures can be harmful to fish at all stages of life, especially if they occur in combination with other habitat limitations. In the Snake River - Hells Canyon reach natural environmental factors such as a hot, dry climate, high solar radiation, and sparse, low growing native vegetation play a major role in determining water temperature. The following is a listing of factors affecting temperature in the subbasin. This listing is not meant to be comprehensive, but it does contain the most probable temperature impacts in the subbasin.

- Anthropogenic cooling due to water storage and release and stabilization of tributary and mainstem river flows
- Agricultural inputs
- Industrial inputs
- Sewage treatment plant discharges
- Riparian vegetation disturbance in upstream reaches and tributaries

Total Dissolved Gas

Supersaturation of total dissolved gas can lead to gas bubble trauma disease in sub-yearling and yearling salmon. The primary cause of supersaturation of total dissolved gas in the water column is:

- Spills and releases from impoundments

Chapter 4 – Goals and Objectives

The overall goal of the TMDL Water Quality Management Plan (WQMP) is to achieve compliance with water quality standards for each of the Oregon 303(d) listed parameters and streams in the Snake River - Hells Canyon Subbasin. Specifically the WQMP combines a description of Designated Management Agencies (DMA) and point source Implementation Plans that are or will be in place to address the load and wasteload allocations in the TMDL. The specific goal of this WQMP is to describe a strategy for reducing discharges from nonpoint sources to the level of the load allocations and for reducing discharges from point sources to the level of the waste load allocations described in the TMDL. As discussed above, this plan is preliminary in nature and is designed to be adaptive as more information and knowledge is gained regarding the pollutants, allocations, management measures, and other related areas.

The expectations of all point sources and DMAs are to:

1. Develop Best Management Practices (BMPs) to achieve load allocations and waste load allocations.
2. Give reasonable assurance that management measures will meet load allocations through both quantitative and qualitative analysis of management measures.
3. Adhere to measurable milestones for progress.
4. Develop a timeline for implementation, with reference to costs and funding.
5. Develop a monitoring plan to determine if:
    a. BMPs are being implemented
    b. Individual BMPs are effective
    c. Load and wasteload allocations are being met
    d. Water quality standards are being met

Chapter 5 - Identification of Responsible Participants

The purpose of this element is to identify the organizations (point sources and DMAs) responsible for the implementation of the WQMP in Oregon and to list the major responsibilities of each organization. What follows is a simple list of those organizations and responsibilities. This is not intended to be an exhaustive list of every participant that bears some responsibility for improving water quality in the Snake River - Hells Canyon Subbasin. Because this is a community wide effort, a complete listing would have to include every business, every industry, every farm, and ultimately every citizen living or working within the subbasin. We are all contributors to the existing quality of the waters in the Snake River - Hells Canyon Subbasin and we all must be participants in the efforts to improve water quality.

Oregon Department of Environmental Quality

- NPDES Permitting and Enforcement
- WPCF Permitting and Enforcement
- Technical Assistance
- Financial Assistance

Oregon Department of Agriculture

- Agricultural Water Quality Management Plan Development, Implementation & Enforcement.
- CAFO Permitting and Enforcement
- Technical Assistance
- Revise Agricultural WQMAP
- Rules under Senate Bill (SB) 1010 to clearly address TMDL and Load Allocations as necessary
- Riparian area management

Oregon Department of Forestry

- Forest Practices Act (FPA) implementation
- Conservation Reserve Enhancement Program
- Revise statewide FPA rules and/or adopt subbasin specific rules as necessary
- Riparian area management

Oregon Department of Transportation

- Routine Road Maintenance, Water Quality and Habitat Guide Best Management Practices
- Pollution Control Plan and Erosion Control Plan
- Design and Construction

Idaho Power Company

- Comply with Conditions of Section 401 WQ Certification

Federal Land Management Agencies (Forest Service and BLM)

- Follow standards and Guidance listed in PACFISH and INFISH
- Follow range management standards

Amalgamated Sugar Company, American Fine Foods, Heinz Frozen Foods, Idaho Power Company, City of Ontario, City of Nyssa

- Comply with NPDES permits

City of Adrian, Alta Gold, Farewell Bend Inc., Idaho Concrete Company, City of Richland

- Comply with WPCF permits

Alta Gold, Larry Hallam, Heinz Frozen Foods, Idaho Concrete, Kesler Farms Inc., Neal Mishler, Northwest Essential Oils Inc., Ontario Asphalt and Concrete Inc., City of Ontario

- Comply with general permits

Cities of Adrian, Nyssa, Ontario

- Construction, operation, and maintenance of the municipal separate storm sewer system within the city limits
- Land use planning/permitting
- Maintenance, construction and operation of parks and other city owned facilities and infrastructure
- Riparian area management

Malheur, Baker, and Wallowa Counties

- Construction, operation and maintenance of county roads and county storm sewer system
- Land use planning/permitting
- Maintenance, construction and operation of parks and other county owned facilities and infrastructure
- Inspection and permitting of septic systems
- Riparian area management

CHAPTER 6 – PROPOSED MANAGEMENT MEASURES

This section of the plan outlines the proposed management measures that are designed to meet the wasteload allocations and load allocations of each TMDL. The timelines for addressing these measures are given in the following section.

The management measures to meet the load and wasteload allocations may differ depending on the source of the pollutant. Given below is a categorization of the sources and a description of the management measures being proposed for each source category.

Wastewater Treatment Plants

The wasteload allocations assigned to wastewater treatment plants (WWTP) will be implemented through modifications to their National Pollutant Discharge Elimination System (NPDES) permits. Permit modifications, however, will likely be preceded by the establishment of Mutual Agreements and Orders (MAOs) between ODEQ and individual sources.

Upon approval of the TMDLs by EPA, Oregon DEQ will develop mutual agreements and orders (MAOs) with the permitted sources. Each MAO will include a compliance schedule for: preparing a facilities plan which will identify alternatives and costs for meeting the source's WLAs; for preparing plans and specifications for the alternative selected to meet the WLAs; and a time frame for completing necessary improvements and for meeting the WLAs. In cases where a source can demonstrate that costs of achieving WLAs are burdensome, ODEQ will consider extension of time frames or other steps as appropriate and reasonable to meet the WLAs. NPDES permits that implement the TMDLs will be prepared based upon the selected alternative in the facilities plan. In deriving permit limits from the established WLAs, DEQ permit writers will recognize that the WLAs only apply to the critical periods defined in the TMDLs. The critical period, however, may not pertain to other water quality standards violations or issues (such as mixing zone requirements) not addressed in the TMDL. Permit writers will also recognize that, where WLAs are defined as existing loads or as a percent reduction of existing loads, final determination of existing loads will be determined in the facilities planning process.

General NPDES Permitted Sources

All general NPDES permits will be reviewed and, if necessary, modified to ensure compliance with load allocations. Either numeric effluent limits will be incorporated into the permits or specific management measures and plans will be developed. In cases where incorporation of assigned WLAs cannot be covered under a general permit, sources will be asked to apply for a conventional permit. These permits will be administered as described above for wastewater treatment plants.

Other Sources

For discharges from sources other than the WWTPs and those permitted under general NPDES permits and WPCF permits (non-point sources), ODEQ has assembled an initial listing of management categories. This listing, given below, is designed to be used by the designated management agencies (DMAs) as guidance for selecting management measures to be included in their Implementation Plans (IPs). Each DMA will be responsible for examining the categories to determine if the source and/or management measure is applicable within their jurisdiction. This listing is not comprehensive and other sources and management measures will most likely be added by the DMAs where appropriate. For each source or measures deemed applicable a listing of the frequency and extent of application should also be provided. In addition, each of the DMAs is responsible for source assessment and identification, which may result in additional categories. It is crucial that management measures be directly linked with their effectiveness at reducing pollutant loading contributions.

County and City Government

Public Awareness/Education

- General and Targeted Outreach

New Development and Construction

- Planning, permitting, and design procedures
- Education and outreach
- Construction and post construction control procedures
- Storm drain system construction

Existing Development

- Storm drain system operation and maintenance and retrofitting

- Street and road sweeping and maintenance
- Septic system inspection and enforcement
- Parking lot sweeping
- Commercial and industrial facilities controls
- Urban and commercial source controls (i.e. fertilizers and pet waste)

Riparian Area Management
- Revegetation
- Streambank stabilization

Community Facility Management
- Parks, public water bodies, public buildings and facilities

Best Management Practices
- Implementation and monitoring

Rules and Ordinances
- Creation of local rules and ordinances to meet load allocations and water quality standards

Forest Practices
- Riparian Area Management
- Road and Culvert Management
- BMP implementation and monitoring
- Public awareness and education

Agricultural Practices
- Riparian area management
- Erosion control
- Animal waste control
- Nutrient management
- BMP implementation and monitoring
- Public awareness and education

Transportation
- Road construction, maintenance, and repair
- BMP implementation and monitoring
- Public awareness and education

CHAPTER 7 – TIMELINE FOR IMPLEMENTATION

The purpose of this element of the WQMP is to demonstrate a strategy for implementing and maintaining the plan and the resulting water quality improvements over the long term. Included in this section are timelines for the implementation of ODEQ activities. Each point source and DMA Implementation Plan (IP) will also include timelines. Timelines should be as specific as possible and should include a schedule for Best Management Practices (BMP) installation and/or evaluation, monitoring schedules, reporting dates and milestones for evaluating progress.

Point source and DMA IPs will be designed to reduce pollutant loads from sources to meet TMDLs, their associated loads, and water quality standards. ODEQ recognizes that where implementation involves significant habitat restoration or reforestation, water quality standards may not be met for decades. In addition, the ODEQ recognizes that technology for controlling nonpoint source pollution is, in some cases, in the development stages and will likely take one or more iterations to develop effective techniques.

The Department intends to regularly review progress of the IPs. The plans, this overall WQMP, and the TMDLs are part of an adaptive management process. Modifications to the WQMP and the IPs are expected to occur on an annual or more frequent basis. Review of the TMDLs are expected to occur approximately five years after the final approval of the TMDLs, or whenever deemed necessary by ODEQ. Figure 2, below, gives the timeline for activities related to the WQMP and associated point source and DMA Implementation Plans.

Figure 2. Estimated timeline for activities related to the WQMP and associated point source and DMA Implementation Plans.

Activity	2003		2004		2005		2006		
ODEQ Establishment of Mutual Agreements and Orders to Require Facilities to prepare Facilities Plans (Implementation Plans – IPs) for meeting WLAs and NPDES Permits									
ODEQ Issuance of MS4 Permits (if appropriate)									
ODEQ Modification of General Permits to meet WLAs									
DMA Development and Submittal of Implementation and Monitoring Plans									
NPDES Permit Holders Develop Facilities Plans (IPs)									
DMA Implementation of Plans									
ODEQ Modification of WWTP Permits to meet WLAs									
NPDES Permit Holders Implement Facilities Plans (IPs) for Meeting WLAs									
ODEQ/DMA/Public Review of TMDL and WQMP									
DMA Submittal of Annual Reports									

(December 2007 marks the end of the first five-year "phase" of implementation. Consecutive five-year phases will follow with assessment of system wide progress at the end of each phase (i.e. 2012, 2017, 2022, etc.)

CHAPTER 8 – REASONABLE ASSURANCE

This section of the WQMP is intended to provide reasonable assurance that the WQMP (along with the associated point source and DMA Implementation Plans) will be implemented and that the TMDL and associated allocations will be met.

There are several programs that are either already in place or will be put in place to help assure that this WQMP will be implemented. Some of these are traditional regulatory programs such as specific requirements under NPDES discharge permits. Other programs address non-point sources under the auspices of State of Oregon law, such as on agricultural and forested lands, and through voluntary efforts.

Point Sources

Reasonable assurance that implementation of the point source wasteload allocations will occur will be addressed through the issuance or revision of NPDES and WPCF permits.

NPDES and WPCF Permit Programs

The ODEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollutant Discharge Elimination System (NPDES) permits for surface water discharge; and Water Pollution Control Facilities (WPCF) permits for onsite (land) disposal. The NPDES permit is also a Federal permit, which is required under the Clean Water act for discharge of waste into waters of the United States. ODEQ has been delegated authority to issue NPDES permits by the EPA. The WPCF permit is unique to the State of Oregon. Adherence to permit conditions is required by State and Federal Law and ODEQ and EPA have the responsibility to ensure NPDES permit compliance.

All general permits within the subbasin will also be revised to address the appropriate WLAs as appropriate and necessary.

Oregon NPDES municipal separate storm sewer (MS4) permits will also be revised where appropriate and necessary to address the appropriate waste load allocations. It is envisioned each MS4 permit within the Snake River - Hells Canyon Subbasin will be revised, reissued, or issued with requirements that:

- A detailed implementation plan be prepared that presents reasonable assurance that WLAs will be met.
- The portion of the Implementation Plan (IP) addressing the WLAs is implemented in a timely fashion.

In Oregon MS4 permits provisions will also need to address the pertinent OAR language pertaining to temperature management plans (as described earlier in this document).

Nonpoint Sources

Forestry

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forested lands in Oregon.

The Oregon Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMPs for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness. The Environmental Quality Commission, Board of Forestry, ODEQ, and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards. ODF provides on the ground field administration of the Forest Practices Act (FPA). For each administrative rule, guidance is provided to field administrators to insure proper, uniform and consistent application of the Statutes and Rules. The FPA requires penalties, both civil and criminal, for violation of Statutes and Rules. Additionally, whenever a violation occurs, the responsible party is obligated to repair the damage.

Federal lands follow Forest Practices Act as described in Forest Plans.

For more information, refer to the Management Measures element of this Plan.

ODF and ODEQ are involved in several statewide efforts to analyze existing forest practice measures and to better define the relationship between the TMDL load allocations and the forest practice measures designed to protect water quality.

As a DMA for water quality management on nonfederal forestlands, the ODF is also working with the ODEQ through a memorandum of understanding (MOU) signed in June of 1998. This MOU was designed to improve the coordination between the ODF and the ODEQ in evaluating and proposing possible changes to the forest practice rules as part of the Total Maximum Daily Load process. The purpose of the MOU is also to guide coordination between the ODF and ODEQ regarding water quality limited streams on the 303d list. An evaluation of rule adequacy will be conducted (also referred to as a “sufficiency analysis”) through a water quality parameter by parameter analysis. This statewide demonstration of forest practices rule effectiveness in the protection of water quality will address the following specific parameters and is expected to be completed by the end of calendar year 2001.

1) Temperature
2) Sediment and turbidity
3) Aquatic habitat modification
4) Bio-criteria
5) Other parameters

These sufficiency analyses will be reviewed by peers and other interested parties prior to final release. The analyses will be designed to provide background information and techniques for watershed-based assessments of BMP effectiveness and water quality assessments for watershed with forest and mixed land uses. Once the sufficiency analyses are completed, they will be used as a coarse screen for common elements applicable to each individual TMDL to determine if forest practices are contributing to water quality impairment within a given watershed and to support the adaptive management process. See Appendix A for a more detailed description of Oregon Department of Forestry TMDL-related activities.

Current forestry BMPs in Oregon and Idaho will remain as each state's forestry component of the TMDL.

Appendix A includes the Forestry Water Quality Management plan for the Snake River - Hells Canyon Subbasin.

Agriculture

In Oregon it is the Oregon Department of Agriculture's (ODA) statutory responsibility to develop agricultural water quality management (AWQM) plans and enforce rules that address water quality issues on agricultural lands, including the water quality rules of individual basin plans. The AWQM Act directs ODA to work with local farmers and ranchers to develop water quality management area plans for specific watersheds that have been identified as violating water quality standards and having agriculture water pollution contributions. The agriculture water quality management area plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct those problems. These water quality management plans are developed at a local level, reviewed by the State Board of Agriculture, and then adopted into the Oregon Administrative Rules. It is the intent that these plans focus on education, technical assistance, and flexibility in addressing agriculture water quality issues. These plans and rules will be developed or modified to achieve water quality standards and will address the load allocations identified in the TMDL. In those cases when an operator refuses to take action, the law allows ODA to take enforcement action. ODEQ will work with ODA to ensure that rules and plans meet load allocations. Individual water quality plans to be administered by ODA include the Owyhee, Malheur, Burnt and Powder Rivers and the Wallowa Agricultural Water Quality Management Plan and Rules. The Malheur River Water Quality Plan and the Wallowa Agricultural Water Quality Management Plan and Rules have been completed and can be accessed at http://oda.state.or.us/Natural_Resources/agwqmpr.htm.

Appendix B will include the Agricultural Water Quality Management plan for the Snake River - Hells Canyon Subbasin.

Transportation

The Oregon Department of Transportation (ODOT) has been issued an NPDES MS4 waste discharge permit. Included with ODOT's application for the permit was a surface water management plan which has been approved by ODEQ and which addresses the requirements of a Total Maximum Daily Load (TMDL) allocation for pollutants associated with the ODOT system. Both ODOT and ODEQ agree that the provisions of the permit and the surface water management plan will apply to ODOT's statewide system. This statewide approach for an ODOT TMDL watershed management plan addresses specific pollutants, but not specific watersheds. Instead, this plan demonstrates how ODOT will incorporate water quality protection into project development, construction, and operations and maintenance of the state and federal transportation system that is managed by ODOT, thereby meeting the elements of the National Pollutant Discharge Elimination System (NPDES) program, and the TMDL requirements.

The MS4 permit and the plan:

- Streamlines the evaluation and approval process for the watershed management plans
- Provides consistency to the ODOT highway management practices in all TMDL watersheds.
- Eliminates duplicative paperwork and staff time developing and participating in the numerous TMDL management plans.

Temperature and sediment are the primary concerns for pollutants associated with ODOT systems that impair the waters of the state. ODEQ is still in the process of developing the TMDL water bodies and determining pollutant levels that limit their beneficial uses. As TMDL allocations are established by watershed, rather than by pollutants, ODOT is aware that individual watersheds may have pollutants that may require additional consideration as part of the ODOT watershed management plan. When these circumstances arise, ODOT will work with DEQ to incorporate these concerns into the statewide plan.

Appendix 3 includes the transportation water quality management plan for the Snake River - Hells Canyon Subbasin.

Federal Forest Lands

All management activities on federal lands managed by the U.S. Forest Service (USFS) and the Bureau of Land Management must follow standards and guidelines (S&Gs) as listed in the respective Land and Resource Management Plans (LRMPs), as amended, for the specific land management units.

PACFISH

A significant LRMP amendment affecting USFS land management was the implementation of interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California; otherwise known as PACFISH (USFS 1995). This amendment added further protection to anadromous fish and their habitat following their listing under the Federal Endangered Species Act (ESA).

The PACFISH revision to the National Forest LRMPs provides interim direction for establishment and management of Riparian Habitat Conservation Areas (RHCAs) and S&Gs for Key Watersheds. All National Forest watersheds in the Snake River - Hells Canyon Subbasin have been designated as Key Watersheds. The PACFISH RHCAs include traditional riparian corridors, wetlands, intermittent streams, and other areas that help maintain the integrity of aquatic ecosystems by: (1) influencing the delivery of sediment, organic matter, and woody debris to streams, (2) providing root strength for channel stability, (3) shading the stream, and (4) protecting water quality. Interim buffer widths are described as follows:

1. Fish-bearing streams: Includes the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge; or to the outer edges of the 100-year floodplain; or to the outer edges of riparian vegetation; or to the distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet, including both sides of the stream channel), whichever is greatest.

2. Permanently flowing non-fish bearing streams: Includes the stream and the areas of the active stream channel of the 100-year flood plain; or a distance equal to the height of one site-potential tree; or 150 feet slope distance (300 feet, including both sides of the stream channel), whichever is greatest.

3. Ponds, lakes, reservoirs, and wetlands greater than 1 acre: Includes the waterbody and the area to the outer edges of the riparian vegetation, or to the extent of the seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of one site potential tree, or 150 feet slope distance from the edge of the maximum pool elevation of constructed ponds and reservoirs or from the edge of the wetlands pond or lake, whichever is greatest.

4. Seasonally flowing or intermittent streams, wetlands less than 1 acre, landslides, and landslide-prone areas: At a minimum, these widths must include: The extent of landslides and landslide-prone areas; the

intermittent stream channel and the area to the top of the inner gorge; the intermittent stream channel or wetland and the area to the outer edges of the riparian vegetation; the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one site-potential tree; or 100 feet slope distance, whichever is greatest.

Standards and Guidelines

Specific and general S&Gs found in Forest LRMPs, PACFISH, and Biological Opinions are applied to various National Forest management activities such as Timber Management, Roads Management, Range Management, and Fire and Fuels Management and are listed below. Standards and Guidelines for other Forest management activities such as recreation, mining, fisheries restoration, and watershed management can be found in the respective Forest LRMPs (USFS 1990) and in PACFISH (USFS 1995).

Appendix D includes Federal Land Management Water Quality Management Plan for the Snake River **-** Hells Canyon Subbasin.

Urban and Rural Sources

Responsible participants for implementing DMA specific water quality management plans for urban and rural sources were identified in Chapter 5 of this Water Quality Management Plan. Upon approval of the Snake River - Hells Canyon Subbasin TMDLs, it is ODEQ's expectation that identified, responsible participants will develop, submit, and implement individual Implementation Plans (IPs) that will achieve the load allocations established by the TMDLs. These activities will be accomplished by the responsible participants in accordance with the Schedule in Chapter 7 of this Water Quality Management Plan. The DMA specific water quality management plans must address the following items:

1) Proposed management measures tied to attainment of the load allocations and/or established surrogates of the TMDLs, such as vegetative site potential for example.
2) Timeline for implementation.
3) Timeline for attainment of load allocations.
4) Identification of responsible participants demonstrating who is responsible for implementing the various measures.
5) Reasonable assurance of implementation.
6) Monitoring and evaluation, including identification of participants responsible for implementation of monitoring, and a plan and schedule for revision of Implementation Plan.
7) Public involvement.
8) Maintenance effort over time.
9) Discussion of cost and funding.
10) Citation of legal authority under which the implementation will be conducted.

Should any responsible participant fail to comply with their obligations under this WQMP, ODEQ will take all necessary action to seek compliance. Such action will first include negotiation, but could evolve to issuance of Department or Commission Orders and other enforcement mechanisms.

Appendix E will include water quality management plans for the cities and counties identified in Chapter 5 of this Water Quality Management Plan

The Oregon Plan

The Oregon Plan for Salmon and Watersheds represents a major effort, unique to Oregon, to improve watersheds and restore endangered fish species. The Oregon Plan is a major component of the demonstration of “ reasonable assurance “ that this TMDL WQMP will be implemented.

The Plan consists of four essential elements:

Coordinated Agency Programs:

Many state and federal agencies administer laws, policies, and management programs that have an impact on salmon and water quality. These agencies are responsible for fishery harvest management, production of hatchery fish, water quality, water quantity, and a wide variety of habitat protection, alteration, and restoration activities. Previously, agencies conducted business independently. Water quality and salmon suffered because they were affected by the actions of all the agencies, but no single agency was responsible for comprehensive, life-cycle management. Under the Oregon Plan, all government agencies that impact salmon are accountable for coordinated programs in a manner that is consistent with conservation and restoration efforts.

Community-Based Action:

Government, alone, cannot conserve and restore salmon across the landscape. The Oregon Plan recognizes that actions to conserve and restore salmon must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done. Government programs will provide regulatory and technical support to these efforts, but local people will do the bulk of the work to conserve and restore watersheds. Education is a fundamental part of the community-based action. People must understand the needs of salmon in order to make informed decisions about how to make changes to their way of life that will accommodate clean water and the needs of fish.

Monitoring:

The monitoring program combines an annual appraisal of work accomplished and results achieved. Work plans will be used to determine whether agencies meet their goals as promised. Biological and physical sampling will be conducted to determine whether water quality and salmon habitats and populations respond as expected to conservation and restoration efforts.

Appropriate Corrective Measures:

The Oregon Plan includes an explicit process for learning from experience, discussing alternative approaches, and making changes to current programs. The Plan emphasizes improving compliance with existing laws rather than arbitrarily establishing new protective laws. Compliance will be achieved through a combination of education and prioritized enforcement of laws that are expected to yield the greatest benefits for salmon.

Voluntary Measures

There are many voluntary, non-regulatory, watershed improvement programs (Actions) that are in place and are addressing water quality concerns in the Snake River - Hells Canyon Subbasin. Both technical expertise and partial funding are provided through these programs. Examples of activities promoted and accomplished through these programs include: planting of conifers, hardwoods, shrubs, grasses and forbs along streams; relocating legacy roads that may be detrimental to water quality; replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems. These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues.

Landowner Assistance Programs

A variety of grants and incentive programs are available to landowners in the Snake River - Hells Canyon Subbasin. These incentive programs are aimed at improving the health of the watershed, particularly on private lands. They include technical and financial assistance, provided through a mix of state and federal funding. Local natural resource agencies administer this assistance, including the Oregon Department of Forestry, the Oregon Department of Fish and Wildlife, ODEQ, and the National Resources Conservation Service.

Field staff from the administrative agencies provide technical assistance and advice to individual landowners, watershed councils, local governments, and organizations interested in enhancing the subbasin. These services include on-site evaluations, technical project design, stewardship/conservation plans, and referrals for funding as appropriate. This assistance and funding is further assurance of implementation of the TMDL WQMP.

Financial assistance is provided through a mix of cost-share, tax credit, and grant funded incentive programs designed to improve on-the-ground watershed conditions. Some of these programs, due to source of funds, have specific qualifying factors and priorities. Cost share programs include the Forestry Incentive Program (FIP), Stewardship Incentive Program (SIP), Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentive Program (WHIP).

CHAPTER 9 – MONITORING AND EVALUATION

Monitoring and evaluation has two basic components: 1. Implementation of point source and DMA Implementation Plans (IPs) identified in this document and 2. Physical, chemical and biological parameters for water quality and specific management measures. This information will provide information on progress being made toward achieving TMDL allocations and achieving water quality standards and to use as we evaluate progress as described under Adaptive Management in Chapter 1: Introduction.

The information generated by each of the agencies/entities gathering data in the Snake River - Hells Canyon Subbasin will be pooled and used to determine whether management actions are having the desired effects or if changes in management actions and/or TMDLs are needed. This detailed evaluation will typically occur on a 5-year cycle. If progress is not occurring then the appropriate management agency will be contacted with a request for action.

The objectives of this monitoring effort are to demonstrate long-term recovery, better understand natural variability, track implementation of projects and BMPs, and track effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the “reasonable assurance of implementation” for the Snake River - Hells Canyon Subbasin TMDL WQMP.

This WQMP and the DMA-specific IPs will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. The mechanism for tracking DMA implementation efforts will be annual reports to be submitted to ODEQ.

CHAPTER 10 – PUBLIC INVOLVEMENT

To be successful at improving water quality a TMDL WQMP must include a process to involve interested and affected stakeholders in both the development and the implementation of the plan. In addition to the ODEQ public notice policies and public comment periods associated with TMDLs and permit applications, future Snake River - Hells Canyon Subbasin TMDL public involvement efforts will focus specifically on urban, agricultural and forestry activities. DMA-specific public involvement efforts will be detailed within the IPs included in the appendices.

CHAPTER 11 – COSTS AND FUNDING

Designated Management Agencies will be expected to provide a fiscal analysis of the resources needed to develop, execute and maintain the programs described in their Implementation Plans.

The purpose of this element is to describe estimated costs and demonstrate there is sufficient funding available to begin implementation of the WQMP. Another purpose is to identify potential future funding sources for project implementation. There are many natural resource enhancement efforts and projects occurring in the subbasin that are relevant to the goals of the plan. These efforts, in addition to proposed future actions are described in the Management Measurers element of this Plan.

Potential Sources of Project Funding

Funding is essential to implementing projects associated with this WQMP. There are many sources of local, state, and federal funds. The following is a partial list of assistance programs available in the Snake River - Hells Canyon Subbasin.

Program	Agency/Source
Oregon Plan for Salmon and Watersheds	OWEB
Environmental Quality Incentives Program	USDA-NRCS
Wetland Reserve Program	USDA-NRCS
Conservation Reserve Enhancement Program	USDA-NRCS
Stewardship Incentive Program	ODF
Access and Habitat Program	ODFW
Partners for Wildlife Program	USDI-FSA
Conservation Implementation Grants	ODA
Water Projects	WRD
Nonpoint Source Water Quality Control (EPA 319)	ODEQ-EPA
Riparian Protection/Enhancement	COE
Oregon Community Foundation	OCF
State Revolving Funds	ODEQs
TEA 21 programs	ODOT

Grant funds are available for improvement projects on a competitive basis. Field agency personnel assist landowners in identifying, designing, and submitting eligible projects for these grant funds. For private landowners, the recipient and administrator of these grants is generally the local Soil and Water Conservation District. Grant fund sources include:

Oregon Watershed Enhancement Board (OWEB)

OWEB funds watershed improvement projects with state money. This is an important piece in the implementation of Oregon's Salmon Plan. Current and past projects have included road relocation/closure/improvement projects, in-stream structure work, riparian fencing and revegetation, off stream water developments, and other management practices.

Bonneville Power Administration (BPA)

BPA funds are federal funds for fish habitat and water quality improvement projects. These have also included projects addressing road conditions, grazing management, in-stream structure, and other tools.

Individual grant sources

Individual grant sources for special projects have included Forest Health money available through the State and Private arm of the USDA Forest Service.

CHAPTER 12 – CITATION TO LEGAL AUTHORITIES

Clean Water Act Section 303(d)

Section 303(d) of the 1972 federal Clean Water Act as amended requires states to develop a list of rivers, streams and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Waters that need this additional help are referred to as “water quality limited” (WQL). Water quality limited waterbodies must be identified by the Environmental Protection Agency (EPA) or by a state agency which has been delegated this responsibility by EPA. In Oregon, this responsibility rests with the ODEQ. In Idaho it rests with IDEQ. ODEQ and IDEQ update the list of water quality limited waters every two years. The list is referred to as the 303(d) list. Section 303 of the Clean Water Act further requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on the 303(d) list. A TMDL defines the amount of pollution that can be present in the waterbody without causing water quality standards to be violated. A WQMP is developed to describe a strategy for reducing water pollution to the level of the load allocations and waste load allocations prescribed in the TMDL, which is designed to restore the water quality and result in compliance with the water quality standards. In this way, the designated beneficial uses of the water will be protected for all citizens.

The Oregon Department of Environmental Quality is authorized by law to prevent and abate water pollution within the State of Oregon pursuant to the following statute:

ORS 468B.020 **Prevention of pollution** (1) Pollution of any of the waters of the state is declared to be not a reasonable or natural use of such waters and to be contrary to the public policy of the State or Oregon, as set forth in ORS 468B.015.

(2) In order to carry out the public policy set forth in ORS 468B.015, the department shall take such action as is necessary for the prevention of new pollution and the abatement of existing pollution by:

- (a) Fostering and encouraging the cooperation of the people, industry, cities and counties, in order to prevent, control and reduce pollution of the waters of the state; and
- (b) Requiring the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015 and to conform to the standards of water quality and purity established under ORS 468B.048.

NPDES and WPCF Permit Programs

ODEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollution Discharge Elimination System (NPDES) permits for waste discharge; and Water Pollution Control Facilities (WPCF) permits for waste disposal. The NPDES permit is also a Federal permit and is required under the Clean Water Act. The WPCF permit is a state program. As permits are renewed they will be revised to insure that all 303(d) related issues are addressed in the permit.

Oregon Administrative Rules

The following Administrative Rules provide numeric and narrative criteria for parameters of concern. Due to the bi-state nature of the Snake River - Hells Canyon TMDL, the water quality targets identified are based on the most stringent of these criteria:

TMDL Parameter: Temperature
Applicable Rules: OARs 340-41-725,765,805, 845 (2)(b)(A&B)

TMDL Parameter: Dissolved Oxygen
Applicable Rules: OAR 340-041-725,765,805,845 (2)(a)(D)
OAR 340-041-725,765,805,845 (2)(a)(E)
OAR 340-041-725,765,805,845 (2)(a)(A)
OAR 340-041-725,765,805,845 (2)(a)(B)
OAR 340-041-725,765,805,845(2)(a)(F)

TMDL Parameter: pH
Applicable Rules: OAR 340-41-725,765,805,845 (2)(d)

TMDL Parameter: Bacterial
Applicable Rules: OAR 340-01-725, 765, 805, 845 (2)(e)(A)

TMDL Parameter: Mercury
Applicable Rules: OAR 340-41-725, 765, 805, 845 (2)(p)(A)

OAR 340-41-725, 765, 805, 845 (2)(p)(B)
OAR 340-41-725, 765, 805, 845 (2)(p)(A) as interpreted by the Oregon Health Division

TMDL Parameter: Nuisance Algae
Applicable Rules: OAR 340-41-150(1)(b)
OAR 340-41-725, 765, 805, 845 (2)(h-I)

TMDL Parameter: Turbidity
Applicable Rules: OAR 340-41-725-765-805,845 (2)(c)

TMDL Parameter: Total Dissolved Gas
Applicable Rules: OAR 340-41-725, 765, 805, 845 (2)(n)
TMDL Parameter: Pesticides
Applicable Rules: OAR 340-42-725, 765, 805, 845 (2)(p)(A-D); Table 20 criteria

Oregon Forest Practices Act

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forestlands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describes BMPs for forest operations. The Environmental Quality Commission (EQC), Board of Forestry, ODEQ and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards.

ODF and ODEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, and OAR 340-041-0120.

Senate Bill 1010

The Oregon Department of Agriculture has primary responsibility for control of pollution from agriculture sources. This is accomplished through the Agriculture Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010 Adopted by the Oregon State Legislature in 1993. The AWQM Act directs the ODA to work with local farmers and ranchers to develop water quality management plans for specific watersheds that have been identified as violating water quality standards and have agriculture water pollution contributions. The agriculture water quality management plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct the problems. ODA statutes and rules include provisions relating to water quality on agricultural lands applicable to the SR-HC TMDL; specifically OAR 603-095-0900 through 0960 and OAR 603—95-1800 through 1860.

Local Ordinances

Within the Implementation Plans in the appendices, the DMAs are expected to describe their specific legal authorities to carry out the management measures they choose to meet the TMDL allocations. Legal authority to enforce the provisions of a City’s NPDES permit would be a specific example of legal authority to carry out management measures.

Appendix 1 – Oregon Department of Forestry

Implementation Plan for
Non-Federal Forest Lands in Oregon

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Non-Federal Forest Lands

The purpose and goals of Oregon's Water Protection Rules (OAR 629-635-100) include protecting, maintaining, and improving the functions and values of streams, lakes, wetlands, and riparian management areas. Best management practices (BMPs) in the Oregon Forest Practices Act (FPA), including riparian zone protection measures and a host of other measures described below, are the mechanism for meeting State Water Quality Standards (WQS).   There is a substantial body of scientific research and monitoring that supports an underlying assumption of the FPA, that maintaining riparian processes and functions is critical for water quality and fish and wildlife habitat. These riparian processes and functions include: Shade for stream temperature and for riparian species; large wood delivery to streams and riparian areas; leaf and other organic matter inputs; riparian microclimate regulation; sediment trapping; soil moisture and temperature maintenance; providing aquatic and riparian species dependent habitat; and nutrient and mineral cycling. The FPA provides a broad array of water quality benefits and contributes to meeting water quality standards for water quality parameters such as temperature, sediment, phosphorus, dissolved oxygen, nutrients, aquatic habitat and others.

Currently, many streams within the Snake River – Hells Canyon Subbasin significantly exceed the WQSs for the parameters of concern. The water quality impairments in the Snake River – Hells Canyon Subbasin clearly do not result solely from current forestry activities. Agricultural areas, and especially the extensive urban areas, contribute significantly to water quality impairment within the basin. It is also important to note that historic forest practices such as splash dam activities, use of log puncheon culverts, abandoned forest roads, and the widespread removal of wood from streams may continue to influence current stream conditions and riparian functions. In addition, current forest practices occur on forestlands that simultaneously support non-forestry land uses that can affect water quality, such as recreation, grazing and public access roads.

Water quality parameters are influenced in a number of ways. For example, it is recognized that increasing the level of riparian vegetation retained along forested reaches of these streams reduces solar loading, potentially preventing a substantial amount of stream heating. While providing high levels of shade to streams is an important aspect of meeting instream temperature standards it needs to be considered within the context of past management, stream morphology and flows, groundwater influences, site-productivity, insects, fire, and other disturbance mechanisms that vary in time and space across the landscape.

The amount of sediment reaching streams can also affect water quality. For example, it is recognized that, proper road construction and culvert placement, good road maintenance, appropriate road surfacing, locating side-cast and soil waste materials in stable locations, properly placing and removing temporary stream crossings, establishing appropriate water-bars on skid trails, using appropriate harvesting systems and techniques, proper site preparation (including slash disposal), among other sound forestry practices, can reduce or eliminate sediment from entering streams. The FPA deals with these and other forest activities.

As described below, ODF and DEQ are involved in several statewide efforts to analyze the existing FPA measures and to better define the relationship between TMDL load allocations and the FPA measures designed to protect water quality. How water quality parameters are affected, as established through the TMDL process as well as other monitoring data, will be an important part of the body of information used in determining the adequacy of the FPA.

Forest practices on non-federal land in Oregon are regulated under the FPA and implemented through administrative rules that are administered by the Oregon Department of Forestry (ODF). The Oregon Board of Forestry (BOF), in consultation with the Environmental Quality Commission (EQC), establish BMPs and other rules to ensure that, to the extent practicable, non-point source (NPs) pollution resulting from forest operations does not impair the attainment of water quality standards.

With respect to the temperature standard, surface water temperature management plans are required according to OAR 340-041-0026 when temperature criteria are exceeded and the waterbody is designated as water-quality limited under Section 303(d) of the Clean Water Act. In the case of state and private forestlands, OAR 340-041-0120 identifies the FPA rules as the surface water management plan for forestry activities. The DEQ recognizes (through a Memorandum of Understanding with ODF) that the FPA provide the Best Management Practices (BMPs) for forest activities on non-federal forestland in Oregon.

ODF and DEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, and OAR 340-041-0120. Current adaptive management efforts under several of the above statutes and rules are described in more detail following the discussion below on the roles of the BOF and EQC in developing BMPs that will achieve water quality standards.

ORS 527.765 Best management practices to maintain water quality.

(1) The State Board of Forestry shall establish best management practices and other rules applying to forest practices as necessary to insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state. Such best management practices shall consist of forest practices rules adopted to prevent or reduce pollution of waters of the state. Factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:

(a) Beneficial uses of waters potentially impacted;
(b) The effects of past forest practices on beneficial uses of water;
(c) Appropriate practices employed by other forest managers;
(d) Technical, economic and institutional feasibility; and
(e) Natural variations in geomorphology and hydrology.

ORS 527.770 Good faith compliance with best management practices not violation of water quality standards; subsequent enforcement of standards.

A forest operator conducting, or in good faith proposing to conduct, operations in accordance with best management practices currently in effect shall not be considered in violation of any water quality standards. When the State Board of Forestry adopts new best management practices and other rules applying to forest operations, such rules shall apply to all current or proposed forest operations upon their effective dates.

There are currently extensive statutes and administrative rules that regulate forest management activities in the Snake River – Hells Canyon Subbasin, which address the key water quality issues of stream temperatures, riparian aquatic functions, and sediment dynamics. The following is a list of specific administrative rules describing the purpose and goals of the FPA towards the achievement and maintenance of water quality standards established by the EQC.

OAR 629-635-100 - Water Protection Rules; Purpose and Goals

(3) The purpose of the water protection rules is to protect, maintain and, where appropriate, improve the functions and values of streams, lakes, wetlands, and riparian management areas. These functions and values include water quality, hydrologic functions, the growing and harvesting of trees, and fish and wildlife resources.

(4) The water protection rules include general vegetation retention prescriptions for streams, lakes and wetlands that apply where current vegetation conditions within the riparian management area have or are likely to develop characteristics of mature forest stands in a "timely manner." Landowners are encouraged to manage stands within riparian management areas in order to grow trees in excess of what must be retained so that the excess may be harvested.

(5) The water protection rules also include alternative vegetation retention prescriptions for streams to allow incentives for operators to actively manage vegetation where existing vegetation conditions are not likely to develop characteristics of mature conifer forest stands in a "timely manner."

(6) OARs 629-640-400 and 629-645-020 allow an operator to propose site-specific prescriptions for sites where specific evaluation of vegetation within a riparian management area and/or the condition of the water of the state is used to identify the appropriate practices for achieving the vegetation and protection goals.

(7) The overall goal of the water protection rules is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met.

(a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, non-point source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of the water quality standards.

(b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-000 (streams), OAR 629-645-000 (significant wetlands), and OAR 629-650-000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients.

OAR 629-640-000 - Vegetation Retention Goals for Streams; Desired Future Conditions

(1) The purpose of this rule is to describe how the vegetation retention measures for streams were determined, their purpose and how the measures are implemented. The vegetation retention requirements for streams described in OAR 629-640-100 through OAR 629-640-400 are designed to produce desired future conditions for the wide range of stand types, channel conditions, and disturbance regimes that exist throughout forestlands in Oregon.

(2) The desired future condition for streamside areas along fish use streams is to grow and retain vegetation so that, over time, average conditions across the landscape become similar to those of mature streamside stands. Oregon has a tremendous diversity of forest tree species growing along waters of the state and the age of mature streamside stands varies by species. Mature streamside stands are often dominated by conifer trees. For many conifer stands, mature stands occur between 80 and 200 years of stand age. Hardwood stands and some conifer stands may become mature at an earlier age. Mature stands provide ample shade over the channel, an abundance of large woody debris in the channel, channel-influencing root masses along the edge of the high water level, snags, and regular inputs of nutrients through litter fall.

(3) The rule standards for desired future conditions for fish use streams were developed by estimating the conifer basal area for average unmanaged mature streamside stands (at age 120) for each geographic region. This was done by using normal conifer yield tables for the average upland stand in the geographic region, and then adjusting the basal area for the effects of riparian influences on stocking, growth and mortality or by using available streamside stand data for mature stands.

(4) The desired future condition for streamside areas that do not have fish use is to have sufficient streamside vegetation to support the functions and processes that are important to downstream fish use waters and domestic water use and to supplement wildlife habitat across the landscape. Such functions and processes include: maintenance of cool water temperature and other water quality parameters; influences on sediment production and bank stability; additions of nutrients and large conifer organic debris; and provision of snags, cover, and trees for wildlife.

(5) The rule standards for desired future conditions for streams that do not have fish use were developed in a manner similar to fish use streams. In calculating the rule standards, other factors used in developing the desired future condition for large streams without fish use and all medium and small streams included the effects of trees regenerated in the riparian management area during the next rotation and desired levels of instream large woody debris.

(6) For streamside areas where the native tree community would be conifer dominated stands, mature streamside conditions are achieved by retaining a sufficient amount of conifers next to large and medium sized fish use streams at the time of harvest, so that halfway through the next rotation or period between harvest entries, the conifer basal area and density is similar to mature unmanaged conifer stands. In calculating the rule standards, a rotation age of 50 years was assumed for even-aged management and a period between entries of 25 years was assumed for uneven-aged management. The long-term maintenance of streamside conifer stands is likely to require incentives to landowners to manage streamside areas so that conifer reforestation occurs to replace older conifers over time.

(7) Conifer basal area and density targets to produce mature stand conditions over time are outlined in the general vegetation retention prescriptions. In order to ensure compliance with state water quality standards, these rules include requirements to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(8) For streamside areas where the native tree community would be hardwood dominated stands, mature streamside conditions are achieved by retaining sufficient hardwood trees. As early successional species, the long-term maintenance of hardwood streamside stands will in some cases require managed harvest using site specific vegetation retention prescriptions so that reforestation occurs to replace older trees. In order to ensure compliance with state water quality standards, these rules include requirements in the general vegetation retention prescription to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(9) In many cases the desired future condition for streams can be achieved by applying the general vegetation retention prescriptions, as described in OAR 629-640-100 and OAR 629-640-200. In other cases, the existing streamside vegetation may be incapable of developing into the future desired conditions in a "timely manner." In this case, the operator can apply an alternative vegetation retention prescription described in OAR 629-640-300 or develop a site-specific vegetation retention prescription described in OAR 629-640-400. For the purposes of the water protection rules, "in a timely manner" means that the trees within the riparian management area will meet or exceed the applicable basal area target or vegetation retention goal during the period of the next harvest entry that would be normal for the site. This will be 50 years for many sites.

(10) Where the native tree community would be conifer dominant stands, but due to historical events the stand has become dominated by hardwoods, in particular, red alder, disturbance is allowed to produce conditions suitable for the re-establishment of conifer. In this and other situations where the existing streamside vegetation is incapable of developing characteristics of a mature streamside stand in a "timely manner," the desired action is to manipulate the streamside area and woody debris levels at the time of harvest (through an alternative vegetation retention prescription or site specific vegetation retention prescription) to attain such characteristics more quickly.

The Water Protection Rules are an important component of the rules that are designed to achieve and maintain water quality standards. The rules identify seven geographic regions and distinguish between streams, lakes, and wetlands. The rules further distinguish each stream by size and type. Stream size is distinguished as small, medium, or large, based on average annual flow. Stream type is distinguished as fish use, domestic use, or neither.

Generally, no tree harvesting is allowed within 20 feet of all fish bearing, all domestic-use, and all other medium and large streams unless stand restoration is needed. In addition, all snags and downed wood must be retained in every riparian management area. Provisions governing vegetation retention are designed to encourage conifer restoration on riparian forestland that is not currently in the desired conifer condition. Future supplies of conifer on these sites are deemed desirable to support stream functions and to provide fish and wildlife habitat. The rules provide incentives for landowners to place large wood in streams to immediately enhance fish habitat. Other alternatives are provided to address site-specific conditions and large-scale catastrophic events.

The goal for managing riparian forests along fish-use streams is to grow and retain vegetation so that, over time, average conditions across the riparian landscape become similar to those of mature unmanaged riparian stands. This goal is based on the following considerations:

(1) Mature riparian stands can supply large, persistent woody debris necessary to maintain adequate fish habitat. A shortage of large wood currently exists in streams on non-federal forestlands due to historic practices and a wide distribution of young, second growth forests. For most streams, mature riparian stands are able to provide more of the functions and inputs of large wood than are provided by young second-growth trees.

(2) Historically, riparian forests were periodically disturbed by wildfire, windstorms, floods, and disease. These forests were also impacted by wildlife such as beaver, deer, and elk. These disturbances maintained a forest landscape comprised of riparian stands of all ages ranging from early successional to old growth. At any given time, however, it is likely that a significant proportion of the riparian areas supported forests of mature age classes. This distribution of mature riparian forests supported a supply of large, persistent woody debris that was important in maintaining quality fish habitat.

The overall goals of the riparian vegetation retention rules along Type N and Type D streams are the following:

- Grow and retain vegetation sufficient to support the functions and processes that are important to downstream waters that have fish;
- Maintain the quality of domestic water; and
- Supplement wildlife habitat across the landscape.

These streams have reduced Riparian Management Area (RMA) widths and reduced basal area retention requirements as compared to similar sized Type F streams (Table 1). In the design of the rules this was judged appropriate based on a few assumptions. First, it was assumed that the amount of large wood entering Type N and D channels over time was not as important for maintaining fish populations within a given stream reach. And second, it was assumed that the future stand could provide some level of "functional" wood over time in terms of nutrient inputs and sediment storage. The validity of these assumptions needs to be evaluated over time through monitoring.

Table 1. Riparian Management Area widths for streams of various sizes and beneficial uses (OAR 629-635-310).

	Type F	Type D	Type N
LARGE	100 feet	70 feet	70 feet
MEDIUM	70 feet	50 feet	50 feet
SMALL	50 feet	20 feet	Apply specified water quality protection measures, and see OAR 629-640-200

For all streams that require an RMA, basal area targets are established that are used for any type of management within the RMA. These targets were determined based on the data that was available at the time, with the expectation that these targets could be achieved on the ground. There is also a minimum tree number requirement of 40 trees per 1000 feet along large streams (11-inch minimum diameter at breast height), and 30 trees per 1000 feet along medium streams (8-inch minimum diameter at breast height). The specific levels of large wood inputs that the rules are designed to achieve are based on the stream size and type. The biological and physical characteristics specific to a given stream are taken into account in determining the quantity and quality of large wood that is functional for that stream. Given the potential large wood that is functional for a given stream, a combination of basal area targets, minimum tree retention, buffer widths, and future regenerated stands and ingrowth are used to achieve the appropriate large wood inputs and effective shade for a given stream.

The expectation is that these vegetation retention standards will be sufficient towards maintaining stream temperatures that are within the range of natural variability. In the design of the Water Protection Rules shade data was gathered for 40 small non-fish-bearing streams to determine the shade recovery rates after harvesting. One to two years after harvest, 55 percent of these streams were at or above pre-harvest shade levels due to understory vegetation regrowth. Most of these streams had a bankfull width averaging less than six feet, and most shade was provided by shrubs and grasses within 10 feet of the bank. Since 1991 there has also been a 120-acre limit on a single clearcut size, which is likely to result in a scattering of harvested area across a watershed over time. In the development of the rules it was assumed that this combined with the relative rapid shade recovery along smaller non-fish-bearing streams would be adequate in protecting stream temperatures and reduce possible cumulative effects. For fish bearing streams it is assumed that a 20-foot no-harvest area, combined with the tree retention requirements for the rest of the RMA, will be adequate to maintain shade levels necessary to achieve stream temperature standards. The monitoring program is currently collecting data to test these assumptions, evaluate the effectiveness of the rules, and evaluate whether or not water quality standards for temperature are being achieved.

In terms of sediment issues specific to forest roads, there are BMPs within the FPA specifically designed to regulate road design, construction and maintenance. The bulk of the BMPs are directed at minimizing sediment delivery to channels. The primary goals of the road rules are to: (1) protect the water quality of streams, lakes, and wetlands; (2) protect fish and wildlife habitat; and (3) protect forest productivity.

The Board of Forestry revised several BMPs related to road design when the new Water Protection Rules were adopted in the fall of 1994. Significant changes made to the road construction rules include the following:

- The requirement for operators not to locate roads in riparian management areas, flood plains, or wetlands unless all alternative locations would result in greater resource damage.
- The requirement for operators to design stream crossings to both minimize fill size and minimize excavation of slopes near the channel. A mandatory written plan is required for stream crossing fills over 15 feet deep.
- The requirement to design stream-crossing structures for the 50-year flow with no ponding, rather than the 25-year storm with no specification of allowable ponding.
- The requirement that stream crossing structures be passable by juvenile fish as well as adult fish.
- The requirement that fish must be able to access side channels.
- The requirement that stream structures constructed under these rules must be maintained for fish passage.

In determining the location of a new road, operators are required to avoid steep slopes, slides and areas next to channels or in wetlands to the extent possible. Existing roads should be used when possible, and stream crossings should be used only when essential. The design of the road grade must vary to fit the local terrain and the road width must be minimized. The operator must also follow specific guidelines for stream-crossing structures (listed above). Cross-drainage structures must be designed to divert water away from channels so that runoff intercepted by the road is dispersed onto the hillslope before reaching a channel. The specific method used is up to the operator, but the end result should be the dispersal of water running off of the road and the filtering of fine sediment before the water reaches waters of the state.

Construction and maintenance activities should be done during low water periods and when soils are relatively dry. Excavated materials must be placed where there is minimal risk of those materials entering waters of the state, and erodible surfaces must be stabilized. Landings must be built away from streams, wetlands and steep slopes.

Road maintenance is required on all active and inactive roads. Regardless of when a road was constructed, if the road has been used as part of an active operation after 1972, it is subject to all maintenance requirements within the current rules. Culverts must be kept open, and surface road drainage and adequate filtering of fine sediment must be maintained. If the road surface becomes unstable or if there is a significant risk of sediment running off of the road surface and entering the stream, road activity must be halted and the erodible area must be stabilized. Abandoned roads constructed prior to 1972 and not used for forest management since that time are not subject to Forest Practices regulatory authority.

All roads in use since 1972 must either be maintained or vacated by the operator. Vacated roads must be effectively barricaded and self-maintaining, in terms of diverting water away from streams and off of the former road surface, where erosion will remain unlikely. Methods for vacating roads include pulling stream-crossing fills, pulling steep side cast fills, and cross ditching. It is up to the landowner to choose between vacating a road and maintaining a road. If a road is not vacated, the operator is required to maintain the road under the current rules whether it is active or inactive, however they are not required to bring the design up to current standards outside of the normal maintenance and repair schedule.

The ODF has a monitoring program that is currently coordinating separate projects to monitor the effectiveness of the forest practice rules with regard to landslides, riparian function, stream temperature, chemical applications, sediment from roads, BMP compliance, and shade. The results from some of these projects have been released in the form of final reports and other projects will have final reports available in the spring of 2000, 2001 and beyond.

Voluntary measures are currently being implemented across the state under the Oregon Plan for Salmon and Watersheds (OPSW) to address water quality protection. These measures are designed to supplement the conifer stocking within riparian areas, increase large wood inputs to streams, and provide for additional shade. This is accomplished during harvest operations by (1) placing appropriate sized large wood within streams that meet parameters of gradient, width and existing wood in the channel; and (2) relocating in-unit leave trees in priority areas[1] to maximize their benefit to salmonids while recognizing operational constraints, other wildlife needs, and specific landowner concerns.

The measures include the following:

ODF 8S: Riparian Conifer Restoration

Forest practice rules have been developed to allow and provide incentives for the restoration of conifer forests along hardwood-dominated RMAs where conifers historically were present. This process enables sites capable of growing conifers to contribute conifer LWD in a timelier manner. This process will be modified to require an additional review process before the implementation of conifer restoration within core areas.

ODF 19S: Additional Conifer Retention along Fish-Bearing Streams in Core Areas

This measure retains more conifers in RMAs by limiting harvest activities to 25 percent of the conifer basal area above the standard target. This measure is only applied to RMAs containing a conifer basal area that is greater than the standard target.

ODF 20S: Limited RMA for Small Type N Streams in Core Areas

This measure provides limited 20 foot RMAs along all perennial or intermittent small Type N streams for the purpose of retaining snags and downed wood.

ODF 21S: Active Placement of large wood during Forest Operations

This measure provides a more aggressive and comprehensive program for placing large wood in streams currently deficient of large wood. Placement of large wood is accomplished following existing ODF/ODFW placement guidelines and determining the need for large wood placement is based upon a site-specific stream survey.

ODF 22S: 25 Percent In-unit Leave Tree Placement and Additional Voluntary Retention

This measure has one non-voluntary component and two voluntary components:

(1) The State Forester, under statutory authority, will direct operators to place 25 percent of in-unit leave trees in or adjacent to riparian management areas on Type F and D streams.
(2) The operator voluntarily locates the additional 75 percent in-unit leave trees along Type N, D or F streams, and
(3) The State Forester requests the conifer component be increased to 75 percent from 50 percent.

ODF 61S: Analysis of "Rack" Concept for Debris Flows

OFIC members will conduct surveys to determine the feasibility and value of retaining trees along small type N streams with a high probability of debris flow in a "rack" just above the confluence with a Type F stream. The rack would extend from the RMA along the Type F stream up the Type N stream some distance for the purpose of retaining trees that have a high likelihood of delivery to the Type F stream.

ODF 62S: Voluntary No-Harvest Riparian Management Areas

[1] The Executive Order replaced the concept of “core areas” with “priority areas”. See (1)(f) of the Executive Order (p.5).

Establishes a system to report and track, on a site-specific basis, when landowners voluntarily take the opportunity to retain no-harvest RMAs.

The voluntary management measures are implemented within priority areas. Several of the measures utilize in-unit leave trees and are applied in a "menu" approach to the extent in-unit leave trees are available to maximize their value to the restoration of salmonid habitat. The choice of menu measures is at the discretion of the landowner, but one or more of the measures is selected.

The measures can be described as either active restoration measures, or passive restoration measures that provide long-term large wood recruitment. Voluntary measures ODF 8S and 21S are active restoration activities. ODF 8 restores hardwood-dominated riparian areas back to a conifer-dominated condition, where appropriate, using a site-specific plan. Site-specific plans require additional consultation with the ODFW to minimize potential damage to the resource. They often result in conditions that are more protective of the resources than would occur without the site-specific plan. ODF 21S addresses large wood placement if stream surveys determine there is a need. Measures ODF 19S, 20S, 22S, and 62S provide future large wood recruitment through additional riparian protection. This additional protection is accomplished by retaining in-unit leave trees, snags, and downed wood within and along RMAs, and by changing the ratio of in-unit leave trees to 75 percent conifer.

The following application priority has been developed for OPSW voluntary measures for harvest units containing more than one stream type. The list establishes the general priority for placement of in-unit leave trees.

(1) Small and medium Type F streams.
(2) Non-fish bearing streams (Type D or Type N), especially small low-order headwater stream channels, that may affect downstream water temperatures and the supply of large wood in priority area streams.
(3) Streams identified as having a water temperature problem in the DEQ 303(d) list of water quality limited waterbodies, or as evidenced by other available water temperature data; especially reaches where the additional trees would increase the level of aquatic shade.
(4) Potentially unstable slopes where slope failure could deliver large wood.
(5) Large Type F streams, especially where low gradient, wide floodplains exist with multiple, braided meandering channels.
(6) Significant wetlands and stream-associated wetlands, especially estuaries and beaver pond complexes, associated with a salmon core area stream.

The Oregon Plan also has voluntary measures addressing sediment issues related to forest roads. Many forest roads built prior to the development of the FPA or prior to the current BMPs continue to pose increased risk to fish habitat. Industrial forest landowners and state forest lands are currently implementing the Road Hazard Identification and Risk Reduction Project, measures ODF 1S and ODF 2S, to identify risks to salmon from roads and address those risks. The purposes of this project are:

(1) Implement a systematic process to identify road-related risks to salmon and steelhead recovery.
(2) Establish priorities for problem solution.
(3) Implement actions to reduce road related risks.

The Road Hazard Identification and Risk Reduction Project is a major element of the Oregon Plan. The two major field elements of this project are (1) the surveying of roads using the Forest Road Hazard Inventory Protocol, and (2) the repairing of problem sites identified through the protocol. Road repairs conducted as a result of this project include improving fish passage, reducing washout potential, reducing landslide potential, and reducing the delivery of surface erosion to streams.

Roads assessed by this project include all roads on Oregon Forest Industry Council member forestland, plus some other industrial and non-industrial forestland, regardless of when they were constructed. Industrial forest landowners have estimated spending approximately $13 million a year, or $130 million over the next 10 years, on this project for the coastal ESUs alone. However, the effort is not limited to nor bound by this funding estimate. Funding for the implementation for this measure within the other ESUs will be reflective of road problems found.

Under ODF 2S, the State Forest Lands program has spent over $2.5 million during the last biennium (1997-1999) for the restoration of roads, replacement of culverts and other stream crossing structures damaged by the 1996 storm. State Forest Lands are also proposing to spend an additional $2.5 million dollars in each of the next two biennia to improve roads, including stream-crossing structures. This effort will upgrade approximately 130 miles of road in each biennium.

In addition to ODF 1S & 2S, there are additional measures under the Oregon Plan that address road management concerns:

ODF 16S - Evaluation of the Adequacy of Fish Passage Criteria: Establish that the criteria and guidelines used for the design of stream crossing structures pass fish as intended under the goal.
ODF 34S - Improve Fish Passage BMPs on Stream Crossing Structures: Ensure that all new stream crossing structures on forestland installed or replaced after the fall of 1994 will pass both adult and juvenile fish upstream and down stream.

Adaptive Management Process

By statute, forest operators conducting operations in accordance with the BMPs are considered to be in compliance with Oregon's water quality standards. The 1994 Water Protection Rules were adopted with the approval of the Environmental Quality Commission as not violating water quality standards. However, there are several provisions within the FPA and rules that require adaptive management.

The ODF is currently in the process of reviewing the effectiveness of the forest practice rules. In January of this year the Governor of Oregon signed Executive Order no. EO 99-01 that directed the Oregon Board of Forestry, with the assistance of an advisory committee, to determine to what extent changes to forest practices are needed to meet state water quality standards and protect and restore salmonids. The committee is directed to consider both regulatory and non-regulatory approaches to water quality protection. To carry out this charge, an ad hoc advisory committee is in the process of developing four separate issue papers on the following topics:

(1) Fish passage restoration and water classification
(2) Forest roads
(3) Riparian functions
(4) Landslides

The committee represents diverse interests, including environmental, industrial, non-industrial, county, and public advocates. In addition to ODF technical staff, the Oregon Department of Environmental Quality (DEQ) and Oregon Department of Fish and Wildlife (ODFW) have technical staff participating in the process. The committee expects to make recommendations to the Board of Forestry in early 2000. The Board will then consider the recommendations in determining whether revisions to the FPA and additional voluntary approaches are necessary consistent with ORS 527.710.

As the designated management agency (DMA) for water quality management on nonfederal forestlands, ODF is also working with the DEQ through a memorandum of understanding (MOU) signed in June of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the forest practice rules as part of the Total Maximum Daily Load process. The purpose of the MOU is also to guide coordination between the ODF and DEQ regarding water quality limited streams on the 303d list. An evaluation of rule adequacy will be conducted (also referred to as a "sufficiency analysis") through a water quality parameter by parameter analysis. This statewide demonstration of forest practices rule effectiveness in the protection of water quality will address the following specific parameters and will be conducted in the following order[2]:

(1) Temperature (estimated draft report target completion date Spring, 2000)
(2) Sediment and turbidity (estimated date Fall, 2000)
(3) Aquatic habitat modification (estimated date Spring, 2001)

[2] The estimated completion dates listed here differ from those dates listed in the MOU. Due to unforeseen circumstances the DEQ and ODF have agreed to revise the dates.

(4) Bio-criteria (estimated date Fall, 2001)
(5) Other parameters (estimated date Spring, 2002)

These sufficiency analyses will be reviewed by peers and other interested parties prior to final release. The analyses will be designed to provide background information and techniques for watershed-based assessments of BMP effectiveness and water quality assessments for watershed with forest and mixed land uses. Once the sufficiency analyses are completed, they will be used as a coarse screen for common elements applicable to each individual TMDL to determine if forest practices are contributing to water quality impairment within a given watershed and to support the adaptive management process.

There may be circumstances unique to a watershed or information generated outside of the statewide sufficiency process that need to be considered to adequately evaluate the effectiveness of the BMPs in meeting water quality standards. Information from the TMDL, ad hoc committee process, ODF Water Protection Rule effectiveness monitoring program, and other relevant sources may address circumstances or issues not addressed by the statewide sufficiency process. This information will also be considered in making the FPA sufficiency determination. ODF and DEQ will share their understanding of whether water quality impairment is due to current forest practices or the long-term legacy of historic forest management practices and/or other practices. The two agencies will then work together and use their determinations to figure out which condition exists (a, b, c, or d in the MOU). The MOU describes the appropriate response depending on which condition exists.

Currently ODF and ODEQ do not have adequate data to make a collective determination on the sufficiency of the current FPA BMPs in meeting water quality standards within the Snake River - Hells Canyon Subbasin. This situation most closely resembles the scenario described under condition c of the ODF/DEQ MOU. Therefore, the current BMPs will remain as the forestry component of the TMDL. The draft versions of the statewide FPA sufficiency analyses for the various water quality parameters will be completed as noted above. The proposed Snake River - Hells Canyon TMDLs will be completed December 31, 2001. Data from an ODF/DEQ shade study will be collected over the summer of 1999 and a final report will be completed in the summer of 2000. Information from the ad hoc committee advisory process may be available by summer of 2000. Information from these efforts, along with other relevant information provided by the DEQ, will be considered in reaching a determination on whether the existing FPA BMPs meet water quality standards within the Tualatin basin.

The above adaptive management process may result in findings that indicate changes are needed to the current forest practice rules to protect water quality. Any rule making that occurs must comply with the standards articulated under ORS 527.714(5). This statute requires, among other things, that regulatory and non-regulatory alternatives have been considered and that the benefits provided by a new rule are in proportion to the degree that existing forest practices contribute to the overall resource concern.

Appendix 2 – Oregon's Agricultural Water Quality Management Plan and Rules

In Oregon agricultural water quality management plans (1010 Plans) will be submitted according to the schedule set forth by the Oregon Department of Agriculture. ODA statutes and rules include provisions relating to water quality on agricultural lands applicable to the SR-HC TMDL, specifically OAR 603-095-0900 through 0960 and OAR 603—95-1800 through 1860.

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Appendix 3 – Oregon Department of Transportation

TMDL Implementation Plan for Oregon's State Transportation System

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ODOT TMDL Watershed Management Plan

The Oregon Department of Transportation (ODOT) plan addresses the requirements of a Total Maximum Daily Load (TMDL) allocation for pollutants associated with the ODOT system. This statewide approach for an ODOT TMDL watershed management plan would address specific pollutants, but not specific watersheds. Instead, this plan would demonstrate how ODOT incorporates water quality into project development, construction, and operations and maintenance of the state and federal transportation system, thereby meeting the elements of the National Pollutant Discharge Elimination System (NPDES) program, and the TMDL requirements.

ODOT has partnered with DEQ in the development of several watershed management plans. By presenting a single, statewide, management plan, ODOT:

- Streamlines the evaluation and approval process for the watershed management plans
- Provides consistency to the ODOT highway management practices in all TMDL watersheds.
- Eliminates duplicative paperwork and staff time developing and participating in the numerous TMDL management plans.

Temperature and sediment are the primary concerns for pollutants associated with ODOT systems that impair the waters of the state. DEQ is still in the process of developing the TMDL water bodies and determining pollutant levels that limit their beneficial uses. As TMDL allocations are established by watershed, rather than by pollutants, ODOT is aware that individual watersheds may have pollutants that may require additional consideration as part of the ODOT watershed management plan. When these circumstances arise, ODOT will work with DEQ to incorporate these concerns into the statewide plan.

ODOT Limitations

The primary mission of ODOT is to provide a safe and effective transportation system, while balancing the requirements of environmental laws. ODOT is a dedicated funding agency, restricted by the Oregon Constitution in its legal authority and use of resources in managing and operating the state and federal highway system. ODOT can only expend gas tax resources within the right of way for the operation, maintenance and construction of the highway system.

ODOT and DEQ recognize that the ODOT system has the potential to negatively impact the beneficial uses of the waters of the state, primarily through surface water runoff. However, removal of vegetative cover to provide for safety, and undermining of the road associated with bank failure may impact temperature and sediment allocations.

As defined in the TMDL program, ODOT is a Designated Management Agency (DMA) because highways have the potential to pollute waterways and negatively impact watershed health. With this definition of a DMA, ODOT is required to participate in developing and implementing watershed management plans that will reduce the daily pollutant loads generated from ODOT highways to acceptable TMDL levels.

ODOT is not a land use or natural resource management agency. ODOT has no legal authority or jurisdiction over lands, waterways, or natural resources that are located outside of its right of way. ODOT's contribution to the TMDL management plan can only be directed at the development, design, construction, operations and maintenance of the ODOT system.

Related Clean Water Regulations

There are various water quality laws and regulations that overlap with the TMDL program. In a TMDL Memorandum of Agreement with the Environmental Protection Agency (EPA) (July 2000), DEQ states that; “DEQ will implement point source TMDLs through the issuance or re-issuance of National Pollutant Discharge Elimination System (NPDES) permits”. The DEQ NPDES municipal permit program was established in 1994 and requires owners and operators of public stormwater systems to reduce or eliminate stormwater pollutants to the maximum extent practicable.

On June 9, 2000, ODOT received an NPDES permit from DEQ that covers all new and existing discharges of stormwater from the Municipal Separated Storm Sewer associated with the ODOT owned and maintained facilities and properties located within the highway right of way and maintenance facilities for all basins in Oregon. This permit required the development of a statewide ODOT stormwater management plan.

Other environmental regulations that overlap with the intent of the TMDL program include the federal and state Endangered Species Act, Corps of Engineers Wetland 404 permit regulations, state cut and fill removal laws, erosion control regulations, ground water protection rules, etc. Many federal, state, and local agencies join DEQ in administering and enforcing these various environmental regulations related to water quality.

ODOT Programs

ODOT established a Clean Water program in 1994 that works to develop tools and processes that will minimize the potential negative impacts of activities associated with ODOT facilities on Oregon's water resources. The ODOT Clean Water program is based on developing and implementing Best Management Practices (BMPs) for construction and maintenance activities. ODOT has developed, or is developing the following documents, best management practices, or reviews, that reduce sediment and temperature impacts:

- **ODOT Routine Road Maintenance Water Quality and Habitat Guide, Best Management Practices, July 1999 (ESA 4(d) Rule)**

ODOT has worked with National Marine Fisheries Service (NMFS) and Oregon Department of Fish and Wildlife (ODFW) to develop Best Management Practices (BMPs) that minimize negative environmental impacts of routine road maintenance activities on fish habitat and water quality. The National Marine Fisheries Service has determined that routine road maintenance, performed under the above mentioned guide, does not constitute a 'take' of anadromous species listed under the federal Endangered Species Act, and therefore additional federal oversight is not required. This determination has been finalized as part of the Federal Register, Volume 65, Number 132, dated Monday, July 10, 2000, pages 42471-42472. In addition, the Oregon Department of Fish and Wildlife has determined that the guide, and BMPs are adequate to protect habitat during routine maintenance activities.

- **NPDES Municipal Separated Storm Sewer System (MS4) Permit**

ODOT worked with DEQ to develop a statewide NPDES MS4 permit and stormwater management program that reduces pollutant loads in the ODOT stormwater system. The permit was issued to ODOT on June 9, 2000.

- **NPDES 1200CA Permit**

ODOT has developed an extensive erosion control program that is implemented on all ODOT construction projects. The program addresses erosion and works to keep sediment loads in surface waters to a minimum. ODOT currently holds 5 regional permits that cover highway construction.

- **Erosion and Sediment Control Manual**

ODOT Geotechnical/Hydraulic staff have developed erosion and sediment control manuals and training for construction and maintenance personnel. Included in the manual are designs for different types of erosion control measures.

- **National Environmental Policy Act (NEPA) Reviews**

ODOT is an agent of the Federal Highway Administration; consequently, ODOT must meet NEPA requirements during project development. Included in the project development process are reviews to avoid, minimize and mitigate project impacts to natural resources, including wetlands and waters of the state.

- **Integrated Vegetation Management (IVM) District Plans**

ODOT works with the Oregon Department of Agriculture and other agencies to develop activities that comply with regulations that pertain to the management of roadside vegetation. Vegetation management BMPs can directly effect watershed health. Each ODOT district develops an integrated vegetation management plan.

- **Forestry Program**

ODOT manages trees located within its right of way in compliance with the Oregon Forest Practices Act and other federal, state, and local regulations. Temperature, erosion, and land stability are watershed issues associated with this program. ODOT is currently working with ODFW on a prototype for managing hazardous trees along riparian corridors.

- **Cut/Fill Slope Failure Programmatic Biologic Assessment**

ODOT has been in formal consultation with the National Marine Fisheries Service, the US Fish and Wildlife Service and the Oregon Department of Fish and Wildlife Service in the development of a programmatic biological assessment for how ODOT will repair cut/fill slope failures in riparian corridors. The draft document outlines best management practices to be used in stabilizing failed stream banks, and bio-engineered design solutions for the failed banks.

- **Disposal Site Research Documentation and Programmatic Biological Assessment**

ODOT has been working with DEQ in researching alternatives and impacts associated with the disposal of materials generated from the construction, operation and maintenance of the ODOT system. ODOT has begun the process of entering into formal consultation with NMFS, USFWS, and ODFW on disposing of clean fill material.

ODOT TMDL Pollutants

ODOT and DEQ have identified temperature and sediment as the primary TMDL pollutants of concern associated with highways. While DEQ may identify other TMDL pollutants within the watershed, many historical pollutants, or pollutants not associated with ODOT activities, are outside the control or responsibility of ODOT. In some circumstances, such as historical pollutants within the right of way, it is expected that ODOT will control these pollutants through the best management practices associated with sediment control. ODOT is expecting that by controlling sediment load these TMDL pollutants will be controlled. Research has indicated that controlling sediment also controls heavy metals, oils and grease, and other pollutants.

Oregon’s limited summer rainfall makes it highly unlikely that ODOT stormwater discharges elevate watershed temperatures. Management of roadside vegetation adjacent to waterways can directly effect water temperature. ODOT has begun to incorporate temperature concerns into its vegetation management programs and project development process.

Other TMDL concerns, such as dissolved oxygen, or chlorophyll A, can be associated with increased temperature. These TMDLs are not associated with the operation and maintenance of the transportation system, and are outside the authority of ODOT. Specific TMDL concerns that are directly related to the transportation system will be incorporated into the ODOT management plan.

ODOT NPDES characterization monitoring indicates ODOT pollutant levels associated with surface water runoff are below currently developed TMDL standards. This indication is based on ODOT 1993-95 characterization monitoring and current TMDLs.

Requirements of a TMDL Implementation Plan (IP)

Designated Management Agencies appointed by DEQ are required to develop a watershed management plan once the TMDL for the watershed is defined. EPA and DEQ have listed the following requirements as essential elements of a watershed TMDL Plan:

1) Proposed management measures tied to attainment of the TMDL. This will include a list of sources by category or sub-category of activity;
2) Timeline for implementation, including a schedule for revising permits, and a schedule for completion of measurable milestones (including appropriate incremental, measurable water quality targets and milestones for implementing control actions);
3) Timeline for attainment of water quality standards, including an explanation of how implementation is expected to result in the attainment of water quality standards;

4) Identification of responsible participants demonstrating who is responsible for implementing the various measures;
5) Reasonable assurance of implementation;
6) Monitoring and evaluation, including identification of parties responsible for monitoring, and a plan and schedule for revision of the TMDL and/or implementation plan;
7) Public involvement;
8) Maintenance of effort over time;
9) Discussion of cost and funding;
10) Citation to legal authorities under which the implementation will be conducted.

1) Proposed Management Measures tied to attainment of TMDLs.
ODOT has two business lines: project development and construction, and maintenance. There are management measures, processes, requirements and reviews included with each business line that are tied to the TMDL programs. These include:

- The ODOT MS4 NPDES permit and permit application: addresses sediment and temperature TMDL, includes project development and construction, and maintenance.
- The ODOT NPDES 1200 CA Permit: addresses sediment TMDL for construction.
- The ODOT Erosion and Sediment Control Manual: addresses sediment TMDL for construction and maintenance.
- The ODOT Routine Road Maintenance Water Quality and Habitat Guide, Best Management Practices, July 1999: addresses sediment and temperature TMDL.
- National Environmental Policy Act: addresses sediment and temperature TMDL, and habitat issues.
- Endangered Species Act requirements for project development: addresses sediment and temperature TMDL, and habitat issues.

2) Timeline for Implementation
ODOT already implements many water quality management measures as directed by state and federal law. Implementation timelines for currently developing measures are described in ODOT's MS4 NPDES permit. The ODOT MS4 permit was recently issued and is valid until May 31, 2005. ODOT's regional construction permits (1200 CA) are scheduled for renewal in December 2000.

3) Timeline for Attainment of Water Quality Standards
The complete attainment of load allocations applicable to ODOT corridors may not be feasible, certainly in the short term, and likely in the long term due to safety concerns and other important factors. However, ODOT expects to implement every practicable and reasonable effort to achieve the load allocations when considering new or modifications to existing corridors, and changes in operation and maintenance activities.

4) Identification of Responsible Participants
Implementing the ODOT best management measures is the responsibility of every ODOT employees. ODOT Managers are held accountable for ensuring employees and actions meet agency policy, and state and federal law, including the Clean Water Act.

5) Reasonable Assurance of Implementation
ODOT is required by its state NPDES MS4 permit to implement a stormwater management plan. In addition, as a federally funded agency, ODOT is required to comply with the Endangered Species act and the Clean Water Act as part of project development. Recent agreements with NMFS require ODOT to implement best management practices for routine road maintenance.

6) Monitoring and Evaluation (see MS4 Permit Application)
ODOT's monitoring and evaluation program is tied to performing research projects that address best management practices and effectiveness of the practices.

7) Public Involvement
DEQ held public hearings on the ODOT MS4 Stormwater Management Plan throughout Oregon. In addition, NMFS held a series of public hearings on the ESA 4(d) rule, which included the ODOT Routine Road

Maintenance Best Management Practices. ODOT project development under goes a public involvement process that includes review by regulating agencies, and public hearings and meetings.

8) Maintenance of Effort Over Time
The elements of the ODOT water quality and habitat programs are bound in state and federal law, and state and agency directives. Consequently, the ODOT programs are standard operating practice.

9) Discussion of Cost and Funding
ODOT revenue comes primarily from dedicated funds collected as state and federal gasoline taxes. The Oregon Constitution dedicates taxes associated with motor vehicle fuel, and the ownership, operation and use of motor vehicles for the construction, reconstruction, improvement, repair, maintenance, operation and use of public highways. Consequently, ODOT is unable to expend resources outside its rights of way, or on activities not directly related to ODOT highways. ODOT construction projects are funded through a variety of Federal Highway Administration funding programs, including the Transportation Equity Act (TEA-21), state gas tax dollars, local and matching funds and bond.

ODOT budgets are identified the preceding year for the following biennium. Each ODOT section or district budgets as necessary to fulfill the requirements of its identified programs. ODOT determines the budget for its MS4 permit as program needs develop and as agency funds allow. ODOT Office of Maintenance, through the Clean Water/Salmon Recovery Program allocates funds to maintenance forces for betterment projects that improve water quality and salmon habitat.

The Oregon Transportation Commission and the Oregon State Legislature approve the ODOT budget.

10) Citation to Legal Authorities - See MS4 Permit Application
ODOT has legal authority only over ODOT right of way.

Conclusion

ODOT programs are adaptive and are expected to change as new information becomes available. ODOT will continue to work with the ODEQ, NMFS, USFWS, and ODFW in best management practices, research opportunities, training, etc. The ODOT program meets the requirements of the TMDL management plans, and will be attached as appropriate to individual watershed plans.

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Appendix 4 – Federal Land Management Agencies TMDL Implementation Plan

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Standards and Guidelines and Best Management Practices in Use on Lands Administered by the U.S. Forest Service in the Snake River/Hells Canyon Drainage Area

Federal Forest Lands

All management activities on federal lands managed by the U.S. Forest Service (USFS) in the Snake River/Hells Canyon drainage area must follow standards and guidelines (S&Gs) as listed in the respective Forest Land Use and Management Plans (LRMPs), as amended, for the Wallowa-Whitman, Payette, and Nez Perce National Forests. Additionally, forest management activities will use Best Management Practices (BMPs) as defined in various Federal and State laws such as the Implementation Plan for 208 (Water Pollution Control Act, PL 92-500, as amended). Specific Stand Management Unit (SMU) Constraints and Mitigation Measures identified in the Wallowa-Whitman NF Watershed Management Handbook are used when various situations are encountered during project layout.

A significant LRMP amendment affecting USFS land management was the implementation of interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California; otherwise known as PACFISH (USFS 1995). This amendment added further protection to anadromous fish and their habitat following their listing under the Federal Endangered Species Act (ESA).

Other sources of guidance for managing the National Forests are derived from the USFSs obligations under ESA. Because the Forests manage ESA listed species and critical habitat, any activity the Forest authorizes is reviewed by the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (FWS), or both. On-going Forest actions and LRMPs are also reviewed by NMFS and/or FWS whenever a new species receives Federal listing status under ESA as in the case of the recent Bulltrout and Steelhead listings (NMFS, FWS 1998). After review of proposed actions, management guidance to the USFS can be either Conservation Recommendations or non-discretionary Terms and Conditions when a Biological Opinion is issued by the regulatory agencies.

PACFISH

The PACFISH revision to the Wallowa-Whitman LRMP provides interim direction for establishment and management of Riparian Habitat Conservation Areas (RHCAs) and S&Gs for Key Watersheds. All National Forest Service (NFS) Watersheds in the Grande Ronde River Basin have been designated as Key Watersheds. The PACFISH RHCAs include traditional riparian corridors, wetlands, intermittent streams, and other areas that help maintain the integrity of aquatic ecosystems by: (1) influencing the delivery of coarse sediment, organic matter, and woody debris to streams, (2) providing root strength for channel stability, (3) shading the stream, and (4) protecting water quality. Interim buffer widths are described as follows:

1. <u>Fish-bearing streams</u>: Includes the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge; or to the outer edges of the 100-year floodplain; or to the outer edges of riparian vegetation; or to the distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet, including both sides of the stream channel), whichever is greatest.

2. <u>Permanently flowing non-fish bearing streams</u>: Includes the stream and the areas of the active stream channel of the 100-year flood plain; or a distance equal to the height of one site-potential tree; or 150 feet slope distance (300 feet, including both sides of the stream channel), whichever is greatest.

3. <u>Ponds, lakes, reservoirs, and wetlands greater than 1 acre</u>: Includes the waterbody and the area to the outer edges of the riparian vegetation, or to the extent of the seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of one site potential tree, or 150 feet slope distance from the edge of the maximum pool elevation of constructed ponds and reservoirs or from the edge of the wetlands pond or lake, whichever is greatest.

4. <u>Seasonally flowing or intermittent streams, wetlands less than 1 acre, landslides, and landslide-prone</u>

areas: At a minimum, these widths must include: The extent of landslides and landslide-prone areas; the intermittent stream channel and the area to the top of the inner gorge; the intermittent stream channel or wetland and the area to the outer edges of the riparian vegetation; the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one site-potential tree; or 100 feet slope distance, whichever is greatest.

Standards and Guidelines

Specific and general S &Gs found in the Forest LRMP, PACFISH, and Biological Opinions are applied to various National Forest management activities such as Timber Management, Roads Management, Range Management, and Fire and Fuels Management. Primary S&Gs are listed by management activity and include:

Timber Management:

1. Prohibit timber harvest or fuelwood cutting in RHCAs, except as described (see below). Do not include RHCAs in the land base used to determine the allowable sale quantity (ASQ), but any volume harvested can contribute to the timber sale program (USFS 1995). Exceptions to harvesting timber in RHCAs include:

   - Where catastrophic events such as fire, flooding, volcanic, wind, or insect damage result in degraded riparian conditions, allow salvage and fuelwood cutting in RHCAs only where present and future woody debris needs are met, where cutting would not retard or prevent attainment of other riparian management objectives (RMOs), and where adverse effects on listed anadromous fish can be avoided. For watersheds with listed salmon or designated critical habitat, complete a Watershed Analysis prior to salvage cutting in RHCAs (USFS 1995).

   - Apply silviculture practices for RHCAs to acquire desired vegetation characteristics where needed to attain RMOS, and in a manner that does not retard attainment of RMOs and that avoids adverse effects on listed anadromous fish.

2. Watershed analysis is required (PACFISH) prior to salvage cutting within RHCAs in watersheds with designated critical habitat. If management activities are planned within a Priority Watershed, the NMFS suggests that the potential significance of adverse effects to salmon and their habitat is heightened. Any proposed salvage or silvicultural activities within RHCAs that pose more than a *de minimis* (the least) risk of adverse effects to listed salmon or critical habitat need to demonstrate clearly that the actions will avoid adverse effects to salmon and their habitat and will not retard or prevent attainment and maintenance of ecological goals and RMOS. Examples of actions that pose more than a *de minimis* risk in RHCAs include: a) machinery-related ground disturbance; b) cutting of live fire-resistant tree species (e.g. ponderosa pine, Douglas western larch and lodgepole pine); c) cutting of any native species of trees or shrubs that are contributing shade to the stream; and d) cutting or removal of any large trees (defined as any tree species older than 150 years or with a diameter at breast height of greater than 20 inches) from RHCAs that could contribute to maintaining or restoring a natural regime of large woody debris recruitment (NMFS 1995).

3. For new/proposed timber sales, it is recommended the USFS should evaluate equivalent clearcut area (ECA) in Priority Watersheds. If the existing ECA exceeds 15% of the potentially forested area, a watershed analysis should be conducted prior to initiating actions that would increase ECA. Actions that would increase ECA should proceed after watershed analysis only if there is low to de minimis risk of adversely affecting fish habitat and if attainment and maintenance of ecological goals and RMOs will not be retarded or prevented. For proposed/new actions, watershed analysis should be conducted prior to reducing RHCA widths in Priority Watersheds (NMFS 1995).

Roads Management:

1. For each existing or planned road, meet RMOs and avoid adverse effects on listed anadromous fish by: completing Watershed Analysis or site specific analysis prior to construction of new roads or landings in

RHCAs, minimizing road and landing locations ins, initiating development and implementation of a Road Management Plan or a Transportation Management Plan. At a minimum, address the following items in the plan:

a. Road design criteria, elements, and standards that govern construction and reconstruction, road management objectives for each road, criteria that govern road operation, maintenance, and management, requirements for pre-, during-, and post-storm inspections and maintenance, regulation of traffic during wet periods to minimize erosion and sediment delivery and to accomplish other objectives, implementation and effectiveness monitoring plans for road stability, drainage, and erosion control, and mitigation plans for road failures;

b. Avoid sediment delivery to streams from road surfaces; outsloping of the roadway surface is preferred, except in cases where outsloping would increase sediment delivery to streams or where outsloping is infeasible or unsafe, route road drainage away from potentially unstable stream channels, fills and hillslopes. Avoiding disruption of natural flow paths; and

c. Avoid sidecasting of soils or snow. Sidecasting of road material is prohibited on road segments within or abutting RHCAs in watersheds containing designated critical habitat for listed anadromous fish.

2. Determine the influence of each road on the RMOS. Meet RMOs and avoid adverse effects on listed anadromous fish by:

   a. Reconstructing road and drainage features that do not meet design criteria or operation and maintenance standards, or that have been shown to be less effective than designed for controlling sediment delivery, or that retard attainment of RMOS, or do not protect designated critical habitat for listed anadromous fish from increased sedimentation;

   b. Prioritize reconstruction based on current and potential damage to listed anadromous fish and their designated critical habitat, the ecological value of the riparian area affected, and the feasibility of options such as helicopter logging and road relocation out of RHCAs;

   c. Close and stabilize, or obliterate and stabilize roads not needed for future management. Prioritize these actions based on the current and potential damage to listed anadromous fish and their designated critical habitat, and the ecological value of the riparian resources affected; and

   d. Construct new, and improve existing culverts bridges, and other stream crossings to accommodate a 100-year flood, including associated bedload and debris, where those improvements would/do pose a substantial risk to riparian conditions.

3. Design, construct, operate, and maintain roads and trails of the forest transportation system based on resource objectives and intended uses, considering safety, total cost of transportation and impacts on the land.

4. Reestablish vegetative cover on obliterated roads by natural processes, where possible, or supplement by such means as scarifying, ditching, contouring, and seeding.

5. Design and maintain road drainage to prevent the influx of significant amounts of road sediment runoff into streams.

6. Avoid the use of heavy equipment within riparian ecosystems. When such use is unavoidable the activity will include mitigation measures designed to minimize adverse effects on the riparian zone and downstream values. Ground disturbing activities will normally be limited to 10% exposed soil or less within riparian ecosystems.

7. Protect water quality in all aspects of road and trail system management. Use practices, which will avoid or minimize sediment production from new road construction and will correct existing sediment sources.

8. Road drainage should be discharged where sediment can settle out before reaching a stream channel.

9. Road closure objectives include closures to prevent casual use in order to minimize sediment production and to effectively mitigate past impacts in order to put the area back into vegetative production.

10. The Biological Opinion (NMFS 1995) states that PACFISH guidelines for road management generally were adequate. Guidelines prioritize road restoration and management actions for Priority watersheds.

    - For proposed/new roads, where road density is greater than 2 miles/square mile in Priority Watersheds, the USFS should reduce road mileage and emphasize road closure, obliteration, and revegetation. (NMFS 1995)

    - For ongoing road development actions, the USFS should demonstrate that new roads are being offset by concomitant reductions in road mileage and road restoration in Priority Watersheds. (NMFS 1995)

11. Road Management Plans and Transportation Management Plans required by the interim PACFISH guidance should be completed and implemented in Priority Watersheds as soon as feasible. The status of these plans, schedules for completion, and effects of not completing these plans should be analyzed and described in the EISs for ecosystem management. The EISs should include a strategy for completing these plans. (NMFS 1995).

Fire Management

- Design fuel treatment and fire suppression strategies, practices, and actions as not to prevent attainment of RMOs, and to minimize disturbance of riparian ground cover and vegetation. Strategies should recognize the role of fire in ecosystem function and identify those instances where fire suppression or fuel management actions could perpetuate or be damaging to long-term ecosystem function, listed anadromous fish, or designated critical habitat.

- Design prescribed burn projects and prescriptions to contribute to the attainment of the RMOs.

- Re-establish vegetation following wild fire or management activities where necessary to prevent excessive erosion.

Range Management

- Adjust grazing practices (e.g. length of grazing season, stocking levels, timing of grazing, etc.) to eliminate impacts that are inconsistent with attainment of Riparian Management Objectives. If adjusting practices is not effective, eliminate grazing (GM-1).

- Locate new livestock handling and/or management facilities outside Riparian Habitat Conservation Areas. For existing livestock handling facilities inside the Riparian Habitat Conservation Areas, assure that Riparian Management Objectives are met. Where these objectives cannot be met, require relocation or removal of such facilities (GM-2).

- Limit livestock trailing, bedding, watering, salting, loading, and other handling efforts to those areas and times that will assure Riparian Management Objectives are met (GM-3).

- Adjust wild horse and burro management to eliminate impacts that are inconsistent with attainment of Riparian Management Objectives (GM-4).

Recreation Management

- Design, construct, and operate recreation facilities, including trails and dispersed sites, within Riparian Habitat Conservation Areas in a manner that contributes to attainment of the Riparian Management Objectives. For existing recreation facilities inside Riparian Habitat Conservation

Areas, assure that Riparian Management Objectives are met. Where Riparian Management Objectives cannot be met, require relocation or closure of recreation facilities (RM-1).

- Adjust dispersed and developed recreation practices that are inconsistent with attainment of Riparian Management Objectives. Where adjustment measures such as education, use limitations, traffic control devices, increased maintenance, relocation of facilities, and/or specific site closures are not effective, eliminate the practice or occupancy (RM-2).

- Wild and Scenic Rivers, Wilderness, and other Recreation Management plans will address attainment of Riparian Management Objectives (RM-3).

Minerals Management

- If the Notice of Intent indicates a mineral operation could affect attainment of Riparian Management Objectives, require a reclamation plan, approved Plan of Operations (or other such governing document), and reclamation bond. Impacts that cannot be avoided will be reclaimed after operations to as near the pre-mining condition as practicable to meet Riparian Management Objective. Reclamation Plans will contain measurable attainment and bond release criteria for each reclamation activity (MM-1).

- Locate structures, support facilities, and roads outside Riparian Habitat Conservation Areas. Where no alternative to siting facilities in Riparian Habitat Conservation Areas exists, locate in a way compatible with Riparian Management Objectives. Road construction will be kept to the minimum necessary for the approved mineral activity. When a road is no longer required for mineral or land management activities, it will be closed, obliterated, and stabilized (MM-2).

- Prohibit solid and sanitary waste facilities in Riparian Habitat Conservation Areas. If no practicable alternative to locating mine waste (waste rock, spent ore, tailings) facilities in Riparian Habitat Conservation Areas exists, and releases can be prevented and stability can be ensured, then (MM-3):

    a. analyze the waste material using the best conventional sampling methods and analytic techniques to determine its chemical and physical stability characteristics.

    b. locate and design the waste facilities using best conventional techniques to ensure mass stability and prevent the release of acid or toxic materials. If the best conventional technology is not sufficient to prevent such releases and ensure stability over the long term, prohibit such facilities in Riparian Habitat Conservation Areas.

    c. monitor waste and waste facilities to confirm predictions of chemical and physical stability, and make adjustments to operations as needed.

    d. reclaim waste facilities after operations to assure chemical and physical stability and to meet the Riparian Management Objectives.

    e. require reclamation bonds adequate to ensure long-term chemical and physical stability of mine waste facilities.

- For leasable minerals, prohibit surface occupancy within Riparian Habitat Conservation Areas for oil, gas, and geothermal exploration and development activities where contracts and leases do not already exist, unless there are no other options for location and Riparian Management Objectives can be met. Adjust the operating plans of existing contracts to eliminate impacts that are inconsistent with attainment of Riparian Management Objectives (MM-4).

- Sand and gravel mining and extraction within Riparian Habitat Conservation Areas will occur only if Riparian Management Objectives can be met (MM-5).

- Develop inspection and monitoring requirements for mineral activities. Evaluate the results of inspection and monitoring to modify mineral plans, leases or permits as needed to eliminate impacts that are inconsistent with attainment of Riparian Management Objectives (MM-6).

General Management:

The S&G and BMPs that generally apply to all categories of Forest management include:

- Maintain natural large woody debris, plus tree needed for future supply, to protect or enhance stream channel and bank structure, enhance water quality, and provide structural fish habitat within all Streamside Management Unit (SMU) classes.

- Enhance streambank vegetation and/or large woody debris where it can be effective in improving channel stability of fish habitat.

- Give areas in which water quality or channel stability are being adversely impacted high Priority for treatment to minimize the effects of the impact or to correct the impacting activity.

- Give maintenance of soil productivity and stability priority over uses described or implied in all other management direction, standards, or guidelines.

- Give management and enhancement of water quality**,** protection of watercourses and streamside management units, and fish habitat priority over other uses described or implied in other management standards, or guidelines.

- In all project environmental analyses address the presence of, and the potential impacts to, any wetlands within the project area. Particular attention will be paid to protection of springs during road location, timber sale plans, and range allotment management plans. Adverse impacts to wetlands will be avoided or mitigated.

- Give preferential consideration to resources such as fish, wildlife and vegetation and water that are dependent upon riparian areas over other resources in action within or affecting riparian areas.

- Meet Water Quality Standards for waters of the State of Oregon (Oregon Administrative Rules, Chapter 340-41) through planning, application, and monitoring of BMPs in conformance with the Clean Water Act, regulations, and federal guidance issued thereto.

- Minimize detrimental soil conditions with total acreage impacted (compaction, puddling, displacement, and severe burning) not to exceed 20 percent of the total acreage within the activity area including landings and system roads.

- Down trees that influence or will eventually influence stream channel dynamics should not be removed.

- Acceptable erosion control means only minor deviation from established standards, provided no major or lasting damage is caused to soil or water.

- Equipment shall not be operated when conditions are such that soil and/or water damage will result. Contract provisions must be met. Erosion control work done by the purchaser shall be adjusted by the ground and weather conditions and the need for controlling runoff. Erosion control work shall be kept current.

- Revegetation measures, including grass seeding must be supplemental to other stabilization measures such as mulching, pitting, scarifying, subsoiling, waterbars, and dips. Hold soil in place on constructed roads and prevent silt movement into streams.

References Cited in the Oregon Snake River – Hells Canyon Water Quality Management Plan

USDA Forest Service and USDI BLM. 1995c.
Environmental assessment for implementation of interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California (PACFISH).

National Marine Fisheries Service. 1995.
Biological Opinion for the implementation of interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California (PACFISH).

National Marine Fisheries Service. 1998.
Biological Opinion for the Land and Resource Management Plans for National Forest and Bureau of Land Management Resource Areas in the Upper Columbia River Basin and Snake River Basin Evolutionarily Significant Units.

U.S. Fish and Wildlife Service. 1998.
Biological Opinion for the Effects to Bulltrout From Continued Implementation of Land and Resource Management Plans and Resource Management Plans as Amended by the Interim Strategy for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada (Infish) and the Interim Strategy for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). U.S. Fish and Wildlife Service, Regions 1 and 4, Portland, OR and Denver, CO.

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6.2 State of Idaho General Implementation Plan

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Idaho Department of Environmental Quality

State of Idaho General Implementation Plan (Water Quality Management Plan)

for the

Snake River – Hells Canyon Total Maximum Daily Load (TMDL)

July 2003

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Purpose

The Snake River - Hells Canyon (SR-HC) Total Maximum Daily Load (TMDL) is a joint effort between the Idaho Department of Environmental Quality (IDEQ) and the Oregon Department of Environmental Quality (ODEQ), with participation by the US Environmental Protection Agency (US EPA) and local stakeholders.

The purpose of this water quality management plan document is to act as a general outline for implementation of the SR-HC TMDL. According to IDEQ guidance (IDEQ, 1999a), an implementation plan "provides details of the actions needed to achieve load reductions (set forth in a TMDL), a schedule of those actions, and specifies monitoring needed to document actions and progress toward meeting state water quality standards." This TMDL has been prepared as a bi-state process between Idaho and Oregon. To fulfil the requirements of the State of Oregon TMDL process, an implementation plan must be submitted to the US EPA with the SR-HC TMDL. IDEQ guidance states that a TMDL implementation plan should be developed within eighteen months of the approval of the TMDL it is intended to support and supplement. Because of this difference in procedure, this general plan is being submitted with the SR-HC TMDL and other, more specific implementation plans will be prepared and submitted according to the IDEQ procedure.

Overview/Background

The scope of this TMDL effort extends from where the river intersects the Oregon/Idaho border (Snake River mile (RM) 409) to immediately upstream of the inflow of the Salmon River (RM 188) (Hydrologic Unit Codes (HUCs) 17050115, 17050201 and 17060101, and a small corner of 17050103). This scope includes the Hells Canyon Complex reservoirs: Brownlee, Oxbow and Hells Canyon. For the purposes of this document, the SR-HC reach has been divided into five segments: Upstream Snake River (RM 409 to 335); Brownlee Reservoir (RM 335 to 285); Oxbow Reservoir (RM 285 to 272.5); Hells Canyon Reservoir (RM 272.5 to 247); and Downstream Snake River (RM 247 to 188).

The Snake River Basin includes areas of Idaho, Nevada, Oregon, Utah, Washington and Wyoming. The Snake River is the 10th longest river system in the United States, extending over 1000 miles from its headwaters in Yellowstone National Park, Wyoming, to its confluence with the Columbia River near Pasco, Washington. The Snake River is the major tributary in the Columbia River system. It drains about 87 percent of the State of Idaho (about 73,000 square miles) and approximately 17 percent of the State of Oregon (about 16,900 square miles). In addition, over 18 percent of the State of Washington (approximately 19,600 square miles) is also located in the Snake River Basin. The Snake River stretches across nearly 760 miles of southern and southwestern Idaho, with about 270 miles of this segment acting as the border between Oregon and Idaho. Near Lewiston the Snake River leaves Idaho (having left Oregon upstream near China Garden Creek), traveling the remainder of its length westward across Washington toward its confluence with the Columbia River.

Conditions within this system vary ecologically, geologically, and hydrologically between upstream and downstream segments. Ecological variations within the river system are evident in the changes in climate, vegetation, animal populations and fisheries throughout the listed segments. Geologic variation such as changes in elevation, soil, rock type, landforms and relative impact of naturally occurring erosive processes are observed upstream to downstream. Equally evident are the hydrologic variations that occur with distance traveled from the fast-flowing upstream section of the river, through the slower-flowing, more lacustrine (lake-like) reservoir systems, to the rapid, white-water section downstream of Hells Canyon Dam. In addition to changes in flow and velocity, hydrologic variations include differences in relative ground and surface-water inflows and channel morphology throughout the listed segments. Variations in water quality and quantity also occur over time. Temporal variations cover a wide range of factors including historical vs. current land use and river management conditions, changes induced by differences in flow and precipitation in a wet year vs. a dry year, and seasonal variation in both water quality and quantity.

For more information on the characterization of the Snake River basin watershed, see section 2.1 of the Snake River - Hells Canyon Subbasin Assessment.

Designated Beneficial Uses

Designated surface water beneficial use classifications are intended to protect the various uses of each state's surface water. The specific designated beneficial uses for the SR-HC TMDL reach differ slightly between Oregon and Idaho, but the basic concepts are consistent. Numeric and narrative water quality standards are designed to protect the most sensitive of each state's beneficial uses. The designated beneficial uses for the SR-HC TMDL reach are listed in the table below. Segment-specific designated beneficial use information is available in Tables 2.2.3 a and 2.2.3 b of the SR-HC Subbasin Assessment.

Designated Beneficial Uses for the Snake River – Hells Canyon TMDL Reach

Oregon Beneficial Use	*Idaho Beneficial Use*	*Bi-State Beneficial Use Category*
Public Domestic Water Supply	Cold Water Biota	Aquatic Life
Private Domestic Water Supply	Primary Contact Recreation	Recreation
Industrial Water Supply	Domestic Water Supply	Water Supply
Irrigation	Special Resource Water	Wildlife habitat
Livestock Watering	Salmonid Spawning	Aesthetics
Fishing and Boating		
Resident Fish and Aquatic Life		
Anadromous Fish Passage		
Wildlife and Hunting		
Fishing		
Water Contact Recreation		
Salmonid Rearing and Spawning		
Hydropower		
Salmonid Fish Rearing		
Commercial Navigation and Transport		
Aesthetic Quality		

Listed Pollutants

The mainstem Snake River from where the river intersects the OR/ID border at river mile 409 downstream to immediately above the Salmon River at river mile 188 has been identified as water quality limited due to violations of water quality standards. The table below outlines listed pollutants from the SR-HC TMDL reach. Segment-specific pollutant information is available in Tables 2.2.3 a and 2.2.3 b of the SR-HC Subbasin Assessment.

303(d) listed pollutants for the Snake River – Hells Canyon TMDL Reach

Oregon 303(d) Listed Pollutants	Idaho 303 (d) Listed Pollutants
Mercury	Bacteria
Temperature	Dissolved Oxygen
	Mercury
	Nutrients
	pH
	Sediment
	Temperature

Total dissolved gas is not listed on either State's 303(d) lists but was addressed due to direct requests from members of the public advisory team (PAT) during the SR-HC TMDL process. The following parameters have been identified as causing violations of Oregon and Idaho water quality standards in the section of the Snake River covered in this TMDL:

BACTERIA

Violations of bacteria in surface waters can result in health risks for primary contact recreation such as swimming, water skiing and skin diving where there is a risk of ingestion of small quantities of water. Elevated bacteria counts also represent a risk (to a lessor degree) for secondary contact recreation such as boating. The following is a listing of possible bacteria sources in the subbasin; it is not meant to be comprehensive, but it does contain the most probable sources of bacteria in the subbasin:

- Improperly treated sewage and septic waste
- Animal wastes

Available data show that bacteria counts (*E. coli* and fecal coliform) have not exceeded water quality criteria for primary or secondary contact recreation within the Upstream Snake River segment of the SR-HC reach during recent years. Based on these data, the SR-HC TMDL process recommends that the mainstem Snake River (RM 409 to RM 347, OR/ID border to Scott Creek inflow) be delisted for bacteria by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent to the currently approved 1998 listing.

DISSOLVED OXYGEN

Dissolved oxygen (DO) is important for fish and other aquatic life. Low DO levels in the SR-HC TMDL reach are caused primarily by oxygen-demanding pollutants and by respiration effects of algae. The following is a listing of possible sources of low dissolved oxygen in the subbasin:

- High nutrient, algal or organic loading and degradation

NUTRIENTS

Nutrients help promote the growth of algae. Respiring algae consume oxygen. During the day, when sunlight drives photosynthesis, the effects of respiration are offset by the production of oxygen. At night, however, when the sun cannot drive photosynthesis, the algae consume oxygen from the water column. In addition, decomposition of algae and other detritus can deplete oxygen from the water and sediment. Excess nutrients, primarily phosphorus in the SR-HC TMDL reach, cause nuisance aquatic growth that can adversely affect aquatic life and recreational uses. Although phosphorus is naturally occurring in the Snake River basin, there are also anthropogenic sources. The following is a listing of some phosphorus sources in the subbasin:

- Urban runoff
  - Roadways
  - Stormwater
- Rural runoff
  - Roadways
  - Rural stormwater
  - Ranchettes
- Agricultural runoff
  - Applied fertilizers in farming and landscaping
  - Livestock grazing
  - Irrigation practices
- Forestry runoff
  - Roadways
  - Grazing on forested lands
- Algae and detritus
- Instream and near-stream erosion
- Sewage and septic waste

MERCURY

The Snake River - Hells Canyon reach is under a human fish consumption advisory due to mercury levels. Historical agricultural chemicals, industrial and municipal source inputs, and air deposition from local and distant sources of mercury are generally considered to be minor sources of mercury within the section of the Snake River basin covered by this TMDL. Primary mercury sources include:

- Legacy mining
- Natural geologic inputs

The SR-HC mercury TMDL has been postponed until The SR-HC mercury TMDL has been postponed until 2006 pending collection of water column data that will allow determination of mercury loading. Data collection and improved modeling capability will be undertaken in the interim so that accurate loading assessments can be arrived at.

PH

pH is the measure of acidity or alkalinity in a system. Extreme levels of pH can be toxic to aquatic life. In the Snake River - Hells Canyon subbasin reach variations in pH are buffered by naturally occurring minerals. The photosynthetic process of algae can drive the pH up to levels that are toxic. Available data show that pH levels have not exceeded water quality criteria for primary or secondary contact recreation within the Upstream Snake River segment of the SR-HC reach during recent years. Based on these data, the SR-HC TMDL process recommends that the mainstem Snake River from RM 409 to RM 347 (OR/ID border to Scott Creek inflow) and from

RM 335 to RM 285 (Brownlee Reservoir) be delisted for pH by the State of Idaho as part of the first 303(d) list submitted by the State of Idaho subsequent to the currently approved 1998 listing.

SEDIMENT

Suspended sediment and bedload sediment can have a negative impact on aquatic life, including deposition and transport of adsorbed toxic materials, interfering with feeding behavior, gill damage, reduced growth rates, smothering eggs and fry, and death. The following is a listing of some sediment sources in the subbasin:

- Erosion from roadways
- Erosion from agricultural lands
- Urban and suburban stormwater run-off
- Landslides
- Forest fires
- High flow events

TEMPERATURE

Temperature is a key factor in determining water quality, particularly in regards to fish health and aquatic habitat. High temperatures can be harmful to fish at all stages of life, especially if they occur in combination with other habitat limitations. In the Snake River - Hells Canyon reach environmental factors such as a hot, dry climate and sparse, low growing native vegetation play a major role in determining water temperature. The following is a listing of some factors affecting temperature in the subbasin:

- Industrial inputs
- Sewage treatment plant discharges
- Agricultural inputs
- Riparian vegetation disturbance
- Natural temperature influences

TOTAL DISSOLVED GAS

Supersaturation of total dissolved gas can lead to gas bubble trauma disease in sub-yearling and yearling salmon. The primary cause of supersaturation of total dissolved gas in the water column is:

- Spillway releases from impoundments

Goals and Objectives

The overall goal of this general Water Quality Management Plan and the associated specific implementation plans is to achieve compliance with water quality standards for each of the 303(d) listed parameters and streams in the SR-HC TMDL reach. The specific goal of this general Water Quality Management Plan is to describe a basic strategy for the source specific implementation plans that will be prepared within 18 months of the approval of the SR-HC TMDL. When completed, the source-specific implementation plans will identify specific measures designed to reduce discharges from nonpoint sources to the level of the load allocations and discharges from point sources to the level of the waste load allocations described in the TMDL. As discussed above, this plan is preliminary in nature and is designed to be adaptive as more information and knowledge is gained regarding the pollutants, allocations, management measures, and other related areas.

Current Regulatory Framework

Under Section 303(d)(1) of the Clean Water Act, states are required to prepare a list of waters not meeting state water quality standards. For waters on this list, the "303(d) list," states must then prepare pollution control plans that allocate acceptable pollutant loads (or load reductions) to point and nonpoint sources contributing to the water quality violation. These plans are referred to as Total Maximum Daily Loads (TMDLs). The statute requires further, that TMDLs "be established at a level necessary to implement the applicable water quality standard" (33U.S.C. §1313(d)(1)(C)).

US EPA has determined that States should develop TMDL "implementation plans" to describe the tools, methods, and authorities that will be used to achieve water quality standards, schedules and milestones for implementing the called-for actions, and a specific plan to monitor progress toward water quality standards attainment and correct the TMDL if it is found to be ineffective. Implementation plans rely on existing local, state, and federal authorities (e.g., NPDES permitting authorities for point sources and requirements associated with financial assistance agreements under the Farm Bills enacted by Congress) and in no way create new enforcement authorities or result in more enforceable TMDLs.

In Idaho, implementation plans are not currently submitted to the US EPA for approval as part of the TMDL. In Idaho, implementation plans are approved by the IDEQ Regional and State Offices and submitted to EPA for their information and record keeping. In Idaho, implementation plans are also to be incorporated into the State's Water Quality Management Plan.

Revisions to the Water Quality Planning and Management Regulations, including the TMDL regulations, at 40 CFR Parts 9 et al. (65 Fed. Reg. 43586-43670) were signed on July 11, 2000 and published in the Federal Register on July 13, 2000. The revised TMDL regulations assert that TMDLs must include implementation plans on submission as one of eleven required minimum elements. However, Supplemental Appropriations provisions attached to the fiscal year (FY) 2001 Military Construction, Family Housing, and Base Realignment and Closure for the Department of Defense (MilCon) Appropriations Bill, prohibited EPA from spending any FY 2000 or FY 2001 funds to implement, or prepare to implement, these regulatory provisions. Additionally, a change in federal administration has resulted in the revisions being reviewed by the new (incoming) administration and a decision on "activation" of the proposed rule changes being delayed yet again. Therefore, this document, and the associated 18 month schedule for completion of the specific implementation plans have been drafted under the existing TMDL rules outlined in Section 303(d) of the Clean Water Act and associated 1992 TMDL program regulations (40 CFR Part 130, Section 130.7).

Responsibility and Plan Development

It is expected that the compilation of specific implementation plans for the SR-HC TMDL will proceed under the existing practice established for the State of Idaho, namely, implementation plans will be cooperatively developed by IDEQ, local Watershed Advisory Group(s) (WAGs), and other 'designated agencies' with input from the established public process. It is envisioned that the Public Advisory Team (PAT) which functions as the WAG for the SR-HC TMDL, will also have the opportunity to be involved in this process as a group or on a member-specific basis as they choose. Their experience with the SR-HC TMDL process will be invaluable to the identification of effective, productive measures to attain the targets identified in the TMDL.

WAGs may be created in separate drainages where they do not already exist to assist IDEQ in completion of these specific implementation plans. Where WAGs are already in place, they will also act as an integral part of the implementation planning process to identify appropriate implementation measures. Other individuals may also be identified to assist in the development of the site-specific implementation plans as their areas of expertise are identified as beneficial to the process. Together, these entities will recommend specific control actions and will then, with the Basin Advisory Group (BAG), review the specific implementation plan before submitting it to IDEQ. IDEQ will act as a repository for approved implementation plans.

Designated state agencies are responsible for assisting with preparation of specific implementation plans, particularly for those sources for which they have regulatory authority or programmatic responsibilities. Idaho's designated state management agencies are:

- Idaho Department of Lands (IDL): timber harvest, oil and gas exploration and development, mining
- Idaho Soil Conservation Commission (ISCC): grazing and agriculture
- Idaho Department of Transportation (IDT): public roads
- Idaho Department of Agriculture (IDA): aquaculture
- Idaho Department of Environmental Quality (IDEQ): all other activities

To the maximum extent possible, specific implementation plans will be developed with the participation of federal partners and land management agencies (i.e. the Natural Resource Conservation Service, US Forest Service, US Bureau of Land Management, and US Bureau of Reclamation, etc.). In Idaho, these agencies, and their federal and state partners, are charged by the Clean Water Act to lend available technical assistance and other appropriate support to local efforts/projects for water quality improvements.

All stakeholders in the SR-HC reach have a responsibility for implementation of the TMDL. IDEQ and the "designated agencies" in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. Their general responsibilities are outlined below.

- **IDEQ** will oversee and track overall progress on the specific implementation plan and monitor the watershed response. IDEQ will also work with local governments on urban/suburban issues.
- **IDL** maintains and updates approved best management practices (BMPs) for forest practices and mining. IDL is responsible for ensuring use of appropriate best management practices BMPs on state and private lands.
- **ISCC**, working in cooperation with local Soil and Water Conservation Districts and the Natural Resource Conservation Service (NRCS), will provide technical assistance to agricultural landowners. These agencies help landowners design BMP systems

appropriate for their property, and identify and seek appropriate cost-share funds. They also provide periodic project reviews to ensure BMPs are working effectively.
- **IDT** is responsible for ensuring appropriate BMPs are used for construction and maintenance of public roads.
- **IDA** is responsible for working with aquaculture to install appropriate pollutant control measures. Under a Memorandum of Understanding with EPA and IDEQ, IDA also inspects dairies to ensure compliance with NPDES requirements.

The expectations of all designated agencies, WAGs and other appropriate public process participants are to:
- Develop BMPs to achieve Load Allocations (LAs) and Waste Load Allocations WLAs);
- Give reasonable assurance that management measures will meet load allocations through both quantitative and qualitative analysis of management measures;
- Adhere to measurable milestones for progress;
- Develop a timeline for implementation, with reference to costs and funding; and
- Develop a monitoring plan to determine if BMPs are being implemented, individual BMPs are effective, load and wasteload allocations are being met and water quality standards are being met.

In addition to the designated agencies, the public, through the WAG and other equivalent processes, will be provided with opportunities to be involved in implementation plan development to the maximum extent practical. It is recognized that public participation will significantly affect public acceptance of the document and the proposed control actions. The public (land owners, local governing authorities, tax payers, industries, and land managers) are the ones who know the pollutant sources best and will be responsible for implementing the control actions identified in the plan. Experience has shown that the best and most effective implementation plans are those that are developed with substantial public cooperation and involvement.

Adaptive Management

The goal of the Clean Water Act and associated administrative rules for Oregon and Idaho is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where non-point sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

TMDLs are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met and designated beneficial uses are supported. ODEQ and IDEQ recognize that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and some other analytical techniques are simplifications of these complex processes and, while they are useful in interpreting data and in predicting trends in water quality, they are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

For the purposes of the SR-HC TMDL, a general Water Quality Management Plan (Implementation Plan) will be written and submitted to EPA as part of the TMDL document. Following this submission, in accordance with approved state schedules and protocols, specific implementation plans will be prepared for pollutant sources in both Oregon and Idaho. If specific implementation plans are available at the completion of the TMDL, they will be referenced in the general Water Quality Management Plan. Appropriate agencies and/or entities as designated by the states will assist in the development and oversight of the specific plans. These specific implementation plans will be designed to reduce pollutant loads to meet the TMDLs established for listed pollutants.

For point sources, it is the initial expectation that sources will meet their specific waste load allocations in five years or sooner if feasible. During this time frame, each source will prepare a facilities plan (the point source version of an implementation plan) that will investigate alternatives for meeting allocations. If the facilities plan documents that achieving waste load allocations within the 5-year time frame is not feasible, the source may request an extension. The request may be considered by the Director, but, in the case of Oregon, may also be referred to the Oregon Environmental Quality Commission.

For nonpoint sources, ODEQ and IDEQ also expect that implementation plans be implemented as soon as practicable. ODEQ and IDEQ recognize, however, that it may take some period of time, from several years to several decades, to fully implement the appropriate management practices. ODEQ and IDEQ also recognize that it may take additional time after implementation has been accomplished before the management practices identified in the general Water Quality Management Plan or specific implementation plans become fully effective in reducing and controlling pollution. In addition, ODEQ and IDEQ recognize that technology for controlling nonpoint source pollution is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated targets and surrogates cannot be achieved as originally established. Nevertheless, it is the expectation of both ODEQ and IDEQ that nonpoint sources make a good faith effort to achieving their respective load allocations in the shortest practicable time.

Both ODEQ and IDEQ recognize that expedited implementation of TMDLs will be socially and economically challenging. Further, there is a desire to minimize economic impacts as much as possible consistent with protecting water quality and beneficial uses.

ODEQ and IDEQ further recognize that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated targets and surrogates. Such events could be, but are not limited to floods, fire, insect infestations, and drought.

For some pollutants in the SR-HC TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDLs. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. It is the expectation, however, that the general Water Quality Management Plan and the associated specific implementation plans will address how human activities will be managed to achieve the water quality targets and surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, the specific implementation plans should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

If a non-point source that is covered by the TMDLs complies with its finalized implementation plan or applicable forest practice rules, it will be considered in compliance with the TMDL.

ODEQ and IDEQ intend to regularly review progress of this general Water Quality Management Plan and the associated specific implementation plans to achieve TMDLs. If and when ODEQ and IDEQ determine the general Water Quality Management Plan and the associated specific implementation plans have been fully implemented, that all feasible management practices have reached maximum expected effectiveness, and a TMDL or its interim targets have not been achieved, the DEQs shall reopen the TMDL and adjust it or its interim targets and the associated water quality standard(s) as necessary.

The implementation of TMDLs and the associated plans is enforceable under the applicable provisions of the water quality standards for point and nonpoint sources by ODEQ, IDEQ, and other state agencies and local governments in both Oregon and Idaho. However, it is envisioned that sufficient initiative exists on the part of local stakeholders to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. This could occur first through direct intervention from state or local land management agencies, and secondarily through ODEQ or IDEQ. The latter may be based on departmental orders to implement management goals leading to water quality standards.

If a source is not given a load allocation, it does not necessarily mean that the source is prohibited from discharging any wastes. A source may be permitted to discharge by ODEQ or IDEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when site temperature is achieved. Alternatively, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source may be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

In employing an adaptive management approach to the TMDLs, the general Water Quality Management Plan, and the associated specific implementation plans, ODEQ and IDEQ have the following expectations and intentions:

- Subject to available resources, ODEQ and IDEQ intend to review the progress of the TMDLs, general Water Quality Management Plan and the associated specific implementation plans, on a five-year basis.
- In conducting this review, ODEQ and IDEQ will evaluate the progress towards achieving the TMDLs (and water quality standards) and the success of implementing the general Water Quality Management Plan and associated specific implementation plans.
- ODEQ and IDEQ expect that designated agencies in each state will also monitor and document their progress in implementing the provisions of the specific implementation plans for those pollutant sources for which they are responsible. This information will be provided to ODEQ and IDEQ respectively for use in reviewing the TMDL.
- ODEQ and IDEQ expect that designated agencies will identify benchmarks for the attainment of TMDL targets and surrogates as part of the specific implementation plans being developed. As implementation of the general Water Quality Management Plan and the associated specific implementation plans proceeds, these established benchmarks will be used to measure progress toward the goals outlined in the SR-HC TMDL.
- Where implementation of the specific implementation plans or effectiveness of management techniques are found to be inadequate, ODEQ and IDEQ expect designated agencies to revise the components of their implementation plan to address these deficiencies.
- If ODEQ and IDEQ, in consultation with the designated agencies, conclude that all feasible steps have been taken to meet the TMDL and its associated targets and surrogates, and that the TMDL, or the associated targets and surrogates are not practicable, the TMDL may be reopened and revised as appropriate. ODEQ and IDEQ would also consider reopening the TMDL should new information become available indicating that the TMDL or its associated targets and/or surrogates should be modified.

Proposed General Management Measures

The proposed general management measures designed to meet the wasteload allocations and load allocations of each TMDL are laid out in the Load Allocation section of the SR-HC TMDL. A summary of these general actions is outlined by listed pollutant in the tables below. The timelines for achieving these measures will be specified in the specific implementation plans prepared within 18 months of the approval of the SR-HC TMDL. Due to the spatially expansive, and hydrologically complex nature of the SR-HC watershed, these timelines are expected to extend for several decades.

General Actions Outlined for Bacteria in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Data support delisting	Data support delisting
Brownlee Reservoir	Not listed	Not listed
Oxbow Reservoir	Not listed	Not listed
Hells Canyon Reservoir	Not listed	Not listed
Downstream Snake River	Not listed	Not listed

General Actions Outlined for Mercury in the Snake River – Hells Canyon TMDL*

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Total SR-HC TMDL reach (RM 409 to 188)	Data collection to determine loading	- Data collection to determine loading - Sediment/erosion control measures from other SR-HC TMDLs - Identification and remediation of legacy mining

* The SR-HC mercury TMDL has been postponed until 2006 pending collection of water column data that will allow determination of mercury loading.

General Actions Outlined for Nutrients and Dissolved Oxygen in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	- Biological nutrient removal or equivalent reduction for mechanical plants - Lagoons will conduct feasibility study to determine effectiveness of alternative treatments in long term planning	- Implementation of BMPs in a tributary or drainage specific fashion to meet ≤ 14 ug/L chlorophyll *a* and ≤0.07 mg/L at discharge or inflow to the Snake River
Brownlee Reservoir	No point sources carrying a nutrient load discharge directly to Brownlee Reservoir	- Implementation of BMPs in a tributary or drainage specific fashion to meet ≤ 14 ug/L chlorophyll *a* and ≤0.07 mg/L at discharge or inflow to Brownlee Reservoir - Dissolved oxygen augmentation by Idaho Power Company
Oxbow Reservoir	No point sources carrying a nutrient load discharge directly to Oxbow Reservoir	- Implementation of BMPs in a tributary or drainage specific fashion to meet ≤ 14 ug/L chlorophyll *a* and ≤0.07 mg/L at discharge or inflow to Oxbow Reservoir
Hells Canyon Reservoir	Not listed – will benefit from	Not listed – will benefit from

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
	upstream improvements	upstream improvements
Downstream Snake River	Not listed – will benefit from upstream improvements	Not listed – will benefit from upstream improvements

General Actions Outlined for Sediment in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Existing NPDES limits or ≤ 50 mg/L as a monthly average if limits are not identified in existing permit	≤ 50 mg/L monthly average, ≤ 80 mg/L for acute events lasting no more than 14 days applied at the point of discharge to the Snake River
Brownlee Reservoir	No point sources carrying a sediment load discharge directly to Brownlee Reservoir	≤ 50 mg/L monthly average, ≤ 80 mg/L for acute events lasting no more than 14 days applied at the point of discharge to the Snake River
Oxbow Reservoir	No point sources carrying a sediment load discharge directly to Oxbow Reservoir	≤ 50 mg/L monthly average, ≤ 80 mg/L for acute events lasting no more than 14 days applied at the point of discharge to the Snake River
Hells Canyon Reservoir	Not listed – will benefit from upstream improvements	Not listed – will benefit from upstream improvements
Downstream Snake River	Not listed – will benefit from upstream improvements	Not listed – will benefit from upstream improvements

General Actions Outlined for Pesticides in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Not listed, acts as source for listed segment Bulk load allocation	- Not listed, acts as source for listed segment - Bulk load allocation - Sediment/erosion control
Brownlee Reservoir	No point sources carrying a pesticide load discharge directly to Brownlee Reservoir	- Not listed, acts as source for listed segment - Bulk load allocation - Sediment/erosion control
Oxbow Reservoir	No point sources carrying a pesticide load discharge directly to Oxbow Reservoir	- Bulk load allocation - Sediment/erosion control
Hells Canyon Reservoir	not listed – will benefit from upstream improvements	not listed – will benefit from upstream improvements
Downstream Snake River	not listed – will benefit from upstream improvements	not listed – will benefit from upstream improvements

General Actions Outlined for pH in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Data support delisting	Data support delisting
Brownlee Reservoir	Data support delisting	Data support delisting
Oxbow Reservoir	Not listed	Not listed
Hells Canyon Reservoir	Not listed	Not listed
Downstream Snake River	Not listed	Not listed

General Actions Outlined for Temperature in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Existing load at design flows	- Natural and unquantifiable conditions exceed criteria, anthropogenic loading less than 0.14 ^{o}C - Temperature assessments on a tributary drainage basis
Brownlee Reservoir	Existing load at design flows	- Natural and unquantifiable conditions exceed criteria, anthropogenic loading less than 0.14 ^{o}C - Temperature assessments on a tributary drainage basis
Oxbow Reservoir	Existing load at design flows	- Natural and unquantifiable conditions exceed criteria, anthropogenic loading less than 0.14 ^{o}C - Temperature assessments on a tributary drainage basis
Hells Canyon Reservoir	Existing load at design flows	- Natural and unquantifiable conditions exceed criteria, anthropogenic loading less than 0.14 ^{o}C - Temperature assessments on a tributary drainage basis
Downstream Snake River (cold water aquatic life and salmonid rearing)	Existing load at design flows	- Natural and unquantifiable conditions exceed criteria, anthropogenic loading less than 0.14 ^{o}C - Temperature assessments on a tributary drainage basis
Downstream Snake River (Salmonid spawning, fall chinook, October 23 to March 30)	Existing load at design flows	- Temperature load allocation to Idaho Power Company to meet water temperature at RM 345 (thermal potential surrogate) or $\leq$ 13 ^{o}C maximum weekly maximum temperature at the outflow of Hells Canyon Dam during

Segment	Point Source Allocations/Appropriate Actions	Nonpoint Source Allocations/Appropriate Actions
		critical period

General Actions Outlined for Total Dissolved Gas in the Snake River – Hells Canyon TMDL

Segment	Point Source Allocations/Appropriate Actions*	Nonpoint Source Allocations/Appropriate Actions
Upstream Snake River	Not applicable	Not applicable
Brownlee Reservoir	Not applicable	Not applicable
Oxbow Reservoir	Not to exceed 110% saturation at flows less than 72,500 cfs, or other loading determined to be appropriate in the 401 Certification or FERC relicensing processes	Not applicable
Hells Canyon Reservoir	Not to exceed 110% saturation at flows less than 72,500 cfs, or other loading determined to be appropriate in the 401 Certification or FERC relicensing processes	Not applicable
Downstream Snake River	Not to exceed 110% saturation at flows less than 72,500 cfs, or other loading determined to be appropriate in the 401 Certification or FERC relicensing processes	Not applicable

* Actions are specific to the operation of Brownlee and Hells Canyon Dams

Point Sources

All individual point sources that were assigned a wasteload allocation in the TMDL will have the allocations incorporated in their NPDES permits as new effluent limits. Categories of sources that are regulated by general permits will also have such allocations.

WASTEWATER TREATMENT PLANTS

The wasteload allocations assigned to wastewater treatment plants (WWTP) will be implemented through modifications to their National Pollutant Discharge Elimination System (NPDES) permits. Permit modifications, however, will likely be preceded by the establishment of a compliance schedule between IDEQ/EPA and individual sources that will provide sources a schedule for meeting waste load allocations. Once facilities plans are completed and a source has selected an option for meeting its waste load allocations, the permits will be modified to incorporate effluent limits that are consistent with the waste load allocations and the selected option. The modified permits may also include provisions to implement management plans, if appropriate.

NPDES PERMITTED SOURCES

All general NPDES permits will be reviewed and, if necessary, modified to ensure compliance with load allocations. Either numeric effluent limits will be incorporated into the permits or specific management measures and plans will be developed.

Nonpoint Sources

All nonpoint sources that were assigned a load allocation in the TMDL will have the allocations incorporated into their specific implementation plans. The specific implementation plans will also describe by source, source category, or source subcategory the nonpoint source pollutant reduction measures, or BMPs, that are planned to achieve the TMDL load allocation. The implementation plan will describe the existing pollutant loads, the BMPs that will be applied to reduce loads, and the estimated pollutant reductions.

LAND-USE MANAGEMENT CATEGORIES

For nonpoint source discharges, ODEQ and IDEQ have assembled an initial listing of management categories. This listing, given below, is designed to be used by the designated agencies as guidance for selecting management measures to be included in the specific implementation plans. This listing is not comprehensive and other sources and management measures will most likely be added where appropriate. For each source or measures deemed applicable, a listing of the frequency and extent of application should also be provided. In addition, each of the designated agencies is responsible for source assessment and identification, which may result in additional categories. It is crucial that management measures be directly linked with their effectiveness at reducing pollutant loading contributions.

COUNTY AND CITY GOVERNMENT

Public Awareness/Education

- General and Targeted Outreach

New Development and Construction

- Planning, permitting, and design procedures
- Education and outreach
- Construction and post construction control procedures
- Storm drain system construction

Existing Development

- Storm drain system operation and maintenance and retrofitting
- Street and road sweeping and maintenance
- Septic system inspection and enforcement
- Parking lot sweeping
- Commercial and industrial facilities controls
- Urban and commercial source controls (i.e. fertilizers and pet waste)

Riparian Area Management

- Revegetation
- Streambank stabilization

Community Facility Management

- Parks, public water bodies, public buildings and facilities

Best Management Practices

- Implementation and monitoring

Rules and Ordinances

- Creation of local rules and ordinances to meet load allocations and water quality standards

FOREST PRACTICES

- Riparian Area Management
- Road and Culvert Management
- BMP implementation and monitoring
- Public awareness and education

AGRICULTURAL PRACTICES

- Riparian area management
- Erosion control
- Animal waste control
- Nutrient management
- BMP implementation and monitoring
- Public awareness and education

TRANSPORTATION

- Road construction, maintenance, and repair
- BMP implementation and monitoring
- Public Awareness and education

Other Potential Mechanisms for Restoration of Water Quality

IDEQ and ODEQ recognize the desire of stakeholders to equalize the economic burden of meeting the TMDL.

One way to achieve this is to allocate loads based upon costs so that everyone pays the same per unit of reduction. Unfortunately, there is insufficient time and information to base allocations on equal cost. This could only be done after each allocated source completed a facilities plan to determine various means and the associated costs of reducing loads. This could take months if not longer and the current court appointed TMDL schedule will not support this delay.

Effluent Trading

A second approach to equalizing costs is effluent trading. Currently, a policy framework is available for effluent trading between point sources. A draft framework for joint point source – nonpoint source has been developed as part of the Lower Boise River Pollutant Trading Pilot Project. This framework may be modified to be appropriate to the SR-HC TMDL process. This could be accomplished within the first or second five-year phase of the implementation of the SR-HC TMDL. Until this framework is in place, IDEQ and ODEQ recommend that point sources with allocations expand their facilities planning efforts to consider means and costs of reducing their loads further than necessary to meet allocations. Sources could then market their additional load reductions to others under the existing point source to point source trading framework and, if their load reductions were cheaper to achieve, sell them. IDEQ and ODEQ are willing to adjust allocations after the TMDL is established provided the parties involved have enforceable contracts, permits, or other instruments to ensure that effluent trades can and will be implemented.

IDEQ and ODEQ will further support the construction (or modification) of a trading framework to allow nonpoint sources to participate in pollutant trading within the SR-HC TMDL watershed.

General Timeline and Steps for Implementation Plan Development

The purpose of this element of the general Water Quality Management Plan is to demonstrate a strategy for implementing and maintaining the plan and the resulting water quality improvements over the long term. Included in this section are timelines for the implementation of ODEQ and IDEQ activities. Each specific implementation plan will also include timelines. Timelines should be as specific as possible and should include a schedule for BMP installation and/or evaluation, monitoring schedules, reporting dates and milestones for evaluating progress.

The specific implementation plans will be designed to reduce pollutant loads from sources to meet TMDLs, their associated loads, and water quality standards. IDEQ recognizes that where implementation involves significant habitat restoration or reforestation, water quality standards may not be met for decades. In addition, IDEQ recognizes that technology for controlling nonpoint source pollution is, in some cases, in the development stages and will likely take one or more iterations to develop effective techniques.

For some SR-HC TMDLs, pollutant surrogates have been defined as alternative targets for meeting the TMDL for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the subbasin or its riparian areas. It is the expectation, however, that the specific implementation plans will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, the specific implementation plans should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

IDEQ intends to regularly review progress of the specific implementation plans. The specific implementation plans, this overall general Water Quality Management Plan, and the TMDLs are part of an adaptive management process. Modifications to the general Water Quality Management Plan and the specific implementation plans are expected to occur on an annual or more frequent basis. Review of the TMDLs are expected to occur approximately five years after the final approval of the TMDLs, or whenever deemed necessary by ODEQ or IDEQ.

A preliminary timeline is outlined on the following page for activities related to the general Water Quality Management Plan and associated specific implementation plans.

Reasonable Assurance

Reasonable assurance has recently been described as a “high degree of confidence that wasteload allocations and/or load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or voluntary actions.” (Preamble to proposed TMDL regulation, FR64 No.162, August 23, 1999). According to IDEQ guidance (IDEQ, 1999a), “reasonable assurance applies only to situations in which load reductions necessary to meet the load capacity for a particular pollutant are split among both and nonpoint sources.” The SR-HC TMDL meets this qualification as nonpoint sources represent the dominant source of pollutants to the SR-HC TMDL reach.

Preliminary timeline for activities specific to the first phase of implementation for the Snake River - Hells Canyon TMDL (Dates in Table assume that the SR-HC TMDL will be approved in 2002. If approval is later, the initiation of implementation will reflect this delay.)

<table>
<tr><th>Activity</th><th colspan="2">2003</th><th colspan="2">2004</th><th colspan="2">2005</th><th colspan="2">2006</th><th colspan="2">2007</th></tr>
<tr><td>ODEQ/IDEQ Establishment of Mutual Agreements and Orders to Require Facilities to prepare Facilities Plans for meeting WLAs and NPDES Permits</td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>ODEQ/IDEQ Issuance of MS4 Permits (if appropriate)</td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>ODEQ/IDEQ Modification of General Permits to meet WLAs</td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Development and Submittal of Source Specific Implementation and Monitoring Plans</td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NPDES Permit Holders Develop Facilities Plans</td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Implementation of Source Specific Plans</td><td></td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td>ODEQ/IDEQ Modification of WWTP Permits to meet WLAs</td><td></td><td></td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NPDES Permit Holders Implement Facilities Plans for Meeting WLAs</td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td>ODEQ/IDEQ/Agency/Public Review of TMDL and general Water Quality Management Plan</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td>Submittal of Annual Reports</td><td colspan="10">Sept. 30 of Each Year</td></tr>
</table>

<u>Please note:</u> Only the first phase of implementation is outlined in this table. December 2007 marks the end of the first five-year “phase” of implementation (assuming TMDL approval occurs in 2002). Consecutive five-year phases will follow with assessment of system wide progress at the end of each phase (i.e. 2012, 2017, 2022, etc.) If TMDL approval occurs later than 2002, five-year phases will be reflective of time frames starting the year following approval.

For point sources, reasonable assurance is achieved through the establishment of NPDES permits (including general permits) that are consistent with established wasteload allocations contained in the TMDL. Other permits and licenses, such as FERC relicensing, stormwater permits, or Endangered Species Act Section 10 incidental take permits, may also provide adequate reasonable assurance.

For nonpoint sources that rely, generally, on voluntary or incentive-based mechanisms to achieve loading reductions, IDEQ guidance (IDEQ, 1999a) states that the agency provides reasonable assurance for nonpoint sources through its Nonpoint Source Management Plan (which has been approved by EPA and certified by the Attorney General to have adequate authorities to be implemented in Idaho). This guidance points out, that if necessary, “injunctive or other judicial relief may be sought against the operator of a nonpoint source activity in accordance with the IDEQ Director's authorities provided by Idaho Code 39-108."

Monitoring and the 'Feedback Loop'

Monitoring will be conducted to ensure that nonpoint source reduction mechanisms are operating effectively, and to give some quantitative indication of the reduction efficiency for in-place BMPs. The monitoring proposed for this plan includes both implementation monitoring and water quality monitoring. Implementation monitoring consists of a variety of methods such as spot checks, periodic project reviews and photographic documentation to demonstrate that pollutant reduction measures have been properly installed, are being properly maintained and are performing as designed. Implementation monitoring methods have been summarized in the sections describing implementation measures and are described in more detail in the appropriate appendices.

Generally, water quality monitoring will not be carried out on a project-specific basis but rather as a suite of indicator analyses monitored at critical points within the system. For example, a decrease in total phosphorus over time as monitored at Farewell Bend (RM 335) indicates that BMPs emplaced within the Upstream Snake River segment watershed were effective in reducing total phosphorus levels within the mainstem water column. This data will be used, in conjunction with flow measurements, to evaluate the overall increase in water quality indicators through the decrease in total pollutant mass being contributed to the system.

If in-stream monitoring indicates a decreasing water quality trend (not directly attributable to environmental conditions) or a violation of standards despite use of approved BMPs or knowledgeable and reasonable efforts, then BMPs for nonpoint source activities must be modified by the appropriate agency to ensure protection of beneficial uses (IDAPA Section 16.01.02.350.02.b.ii). This process is known as the "feedback loop" in which BMPs or other efforts are periodically monitored and modified if necessary to ensure protection of beneficial uses. With continued instream monitoring, SR-HC TMDL implementation will initiate the feedback loop process and will evaluate the success of BMP implementation and its effectiveness in controlling nonpoint source pollution.

State Programs and Authorities

Under Section 319 of the Clean Water Act (CWA), each state is required to develop and submit a nonpoint source management plan. Idaho's Nonpoint Source Management Program (IDEQ, 1999a) was submitted and approved by the EPA. The nonpoint source management program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. Since the development of the original Nonpoint Source Management Program in 1989, revisions of the water quality standards have occurred. Many of these revisions have adopted provisions for public involvement, such as the formation of Basin Advisory Group (BAGs) and Watershed Advisory Groups (WAGs) (IDAPA 16.01.02052). The WAGs are established in high priority watersheds to assist IDEQ and other state agencies in developing TMDLs, Watershed Management Plans and specific implementation plans for those segments.

The State of Idaho water quality standards refer to other programs whose mission is to control nonpoint pollution sources. Some of these programs and responsible agencies are listed in the following table.

The State of Idaho uses a voluntary approach to control agricultural nonpoint sources. However, regulatory authority can be found in the state water quality standards (IDAPA 16.01.02350.01 through 16.01.02350.03). IDAPA 16.01.02054.07 refers to the Idaho Agricultural Pollution Abatement Plan (IAPAP) that provides direction to the agricultural community for approved BMPs. The IAPAP outlines responsible agencies or elected groups (local Soil and Water Conservation Districts) that will take the lead if nonpoint pollution problems need addressing. For agricultural activity it assigns the local soil conservation districts to assist the landowner/operator to develop and implement BMPs to abate nonpoint pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may provide injunctive relief for those situations determined to be an imminent and substantial danger to public health or environment (IDAPA 16.01.02350.02 (a)).

State of Idaho Regulatory Authority for Nonpoint Pollution Sources

Citation	IDAPA Citation	Responsible Agency
Rules governing forest practices	16.01.02350.03(a)	Idaho Department of Lands
Rules governing solid waste management	16.01.02350.03(b)	Idaho Department of Health and Welfare
Rules governing subsurface and individual sewage disposal systems	16.01.02350.03(c)	Idaho Department of Health and Welfare
Rules and standards for stream channel alteration	16.01.02350.03(d)	Idaho Department of Water Resources
Rules governing exploration and surface mining operations	16.01.02350.03(e)	Idaho Department of Lands
Rules governing placer and dredge mining	16.01.02350.03(f)	Idaho Department of Lands
Rules governing dairy waste	16.01.02350.03(g) or IDAPA 02.04.14	Idaho Department of Agriculture

If a nonpoint pollutant(s) is determined to be impacting beneficial uses and the activity already has in-place referenced BMPs, or knowledgeable and reasonable practices, the state may request the BMPs be evaluated and/or modified to determine appropriate actions. If evaluations and/or modifications do not occur, injunctive relief may be requested (IDAPA 16.01.02350.2, ii (1)).

A voluntary approach is expected to be able to achieve the nonpoint source reduction goals. Strong public involvement coupled with the eagerness of the agricultural community demonstrates a willingness to implement BMPs and protect water quality. In the past, cost-share projects have provided the agricultural community technical assistance, information and education (I & E), and the cost share incentives to implement BMPs. The continued funding of these projects will be critical for the load allocations to be achieved in the Snake River watershed.

Reasonable Assurance for Forestry BMP Implementation

The major forest landowners and land managers in the watershed have been working together throughout development of the SR-HC TMDL and this implementation plan. All the major forestland managers have generally committed to achieving TMDL related goals on forested lands. In addition to this commitment, various federal and state requirements and regulations will ensure that the forest landowners continue to maintain and improve road systems and riparian management. Forestry is one of the few regulated land uses in the watershed. All owners will continue to abide by the rules and regulations of the State under the Forest Practices Act that require monitoring of BMP effectiveness and update of BMPs when they are found to be inadequate.

Additionally, the Forest Service will continue to follow land and resource management plans to implement activities. Activities include: timber harvest, road management, livestock grazing, prescribed fire, watershed improvements, fish habitat improvements, recreation management, and others. Sources of pollutants of concern will be identified and treatments implemented concurrent with activities. Activity plans are finalized and implemented as funds become available. National Environmental Protection Act and Endangered Species Act analyses will be required prior to implementation. Projects are scheduled based on funding and priorities on each forest. Partnership and cooperative efforts will be developed on a project-by-project basis.

For federal lands, funding for projects will rely in part upon fees taken in on timber sales and/or special federal allocations to address water quality problems. Funding sources include: collection agreements, soil and water improvements, road maintenance, ecosystem management, Capital Investment Project (CIP), 5 percent funds, and Knutsen-Vanderburg (K-V) funds, and other grants (CWA Section 319, National Forest Foundation, etc). Future direction from the Natural Resource Agenda, and Clean Water Action Plan may also provide future sources of funding.

Idaho Department of Lands relies largely on funds received from timber sales.

Reasonable Assurance for Agricultural BMP Implementation

BMP implementation for agriculture in the State of Idaho is achieved through voluntary incentive-based programs. Historically, cost-share incentives have been available to producers from state and federal conservation programs. The state incentive program was the SAWQP program. This program was established to assist agricultural producers in watersheds where critical acres are identified as contributing to a defined problem associated with a decline in water quality. The SAWQP program has been historically funded through the Idaho Pollution Control Account. That fund was projected to deplete financial resources in 1999. All funds from this account have been allocated and the ability to write new contracts has been frozen. A SAWQP replacement program administered by the Idaho Soil Conservation Commission is expected to be in place in the near future, and will act as a funding source to projects similar to those funded by the original SAWQP program.

A new statewide cost-share program known as the Water Quality Program for Agriculture (WQPA) was approved and funded by the Idaho Legislature for the state fiscal year 2000. Funds for this program became available in July of 2000 and BMPs were installed starting in 2001. Federal programs have been available to landowners or producers for the implementation of BMPs or practices that will have a positive impact on the land and water quality. These programs historically include the Conservation Reserve Program (CRP), as well as Habitat Improvement Program (HIP), Wildlife Habitat Incentive Program (WHIP), Wetland Reserve Program (WRP), and the most recent program, Environmental Quality Incentives Program (EQIP). Federal programs are developed outside of the State of Idaho. Availability of funds, longevity, and rules of the programs are not subject to local management. Federal cost-share programs are expected to continue to be available in the future to assist meeting the reductions required by the SR-HC TMDL.

Reasonable Assurance for Urban/Suburban BMP Implementation

Successful implementation of recommended BMPs and management practices to reduce pollutant loading within the urban/suburban arena will require the availability of cost share funding, loans, grants, or other sources of funding. Full-scale implementation cannot be expected to occur prior to the identification of such funding sources, and is expected to proceed on an intermittent basis, as funding becomes available. The adoption of a countywide erosion and sediment control ordinance and implementation of specific programs recommended for the municipalities depends on action by the County Commission and elected city officials.

There are many voluntary, non-regulatory, watershed improvement programs that are in place and are addressing water quality concerns in the Snake River-Hells Canyon Subbasin. Both technical expertise and partial funding are provided through these programs. Examples of activities promoted and accomplished through these programs include: planting of conifers, hardwoods, shrubs, grasses and forbs along streams; relocating legacy roads that may be detrimental to water quality; replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems. These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues.

Landowner Assistance Programs

A variety of grants and incentive programs are available to landowners in the SR-HC TMDL watershed. These incentive programs are aimed at improving the health of the watershed, particularly on private lands. They include technical and financial assistance, provided through a mix of state and federal funding. Local natural resource agencies administer this assistance, including the Idaho Department of Lands, Idaho Department of Fish and Game, IDEQ, Idaho Soil Conservation Commission and the National Resources Conservation Service.

Field staff from the administrative agencies provide technical assistance and advice to individual landowners, watershed councils, local governments, and organizations interested in enhancing the subbasin. These services include on-site evaluations, technical project design, stewardship/conservation plans, and referrals for funding as appropriate. This assistance and funding is further assurance of implementation of the general Water Quality Management Plan and associated specific implementation plans.

Financial assistance is provided through a mix of cost-share, tax credit, and grant funded incentive programs designed to improve on-the-ground watershed conditions. Some of these programs, due to source of funds, have specific qualifying factors and priorities. Cost share programs include the Forestry Incentive Program (FIP), Stewardship Incentive Program (SIP), Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentive Program (WHIP).

Monitoring and Evaluation

The objectives of this monitoring effort are to demonstrate long-term recovery, better understand natural variability, track implementation of projects and BMPs, and track effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the "reasonable assurance of implementation" for the SR-HC TMDL general Water Quality Management Plan and the associated source specific implementation plans.

The specific implementation plans will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. The mechanism for tracking specific implementation efforts will be annual reports to be submitted to ODEQ and IDEQ.

The "monitoring and evaluation" component has two basic categories:

- Tracking the implementation progress of specific implementation plans; and
- Tracking the progress of improving water quality through monitoring of physical, chemical and biological parameters.

Monitoring plans will provide information on progress being made toward achieving TMDL allocations and achieving water quality standards, and will help in the interim evaluation of progress as described under Adaptive Management.

Implementation Plan Monitoring

Implementation plan monitoring also has two major components:

- Watershed monitoring, and
- BMP monitoring.

IDEQ has primary responsibility for the former, while designated agencies have primary responsibility for the latter. Watershed monitoring measures the success of the implementation measures in accomplishing the overall TMDL goals and includes both in-stream and in-reservoir monitoring. BMP monitoring measures the success of individual pollutant reduction projects. Implementation plan monitoring may also supplement the watershed information available during development of the TMDL and fill data gaps.

WATERSHED MONITORING

Watershed monitoring of the SR-HC TMDL reach has the following objectives:

- Evaluate of watershed pollutant sources, refine of baseline conditions and pollutant loading;
- Evaluate trends in water quality data;
- Establish pollutant storage and recycling capacity in the SR-HC TMDL reach;

- Evaluate the collective effectiveness of implementation actions in reducing pollutant loading to the mainstem and/or tributaries; and
- Gather information and fill data gaps in order to more accurately determine pollutant loading to the SR-HC TMDL reach.

BMP/Project Effectiveness Monitoring

Site or BMP-specific monitoring may be included as part of specific treatment projects if determined appropriate and justified, and will be the responsibility of the designated project manager or grant recipient. The objective of an individual project monitoring plan is to verify that BMPs are properly installed, being maintained and working as designed. Monitoring for pollutant reductions at individual projects will consist of spot checks, annual reviews and evaluation of advancement toward reduction goals. Evaluation of advancement toward reduction goals will be accomplished using the project tracking system (described in more detail on page 30) and annual reports.

Individual entities and source groups constructing BMP projects should include budget allowances for a monitoring program (qualitative and/or quantitative) for the project site. The information generated by each of the agencies/entities gathering data in the SR-HC TMDL reach will be pooled and used to determine whether management actions are having the desired effects or if changes in management actions and/or TMDLs are needed. Results will be used to recommend or discourage similar projects in the future and to identify specific watershed or reach, monitoring information that indicates the implementation plan is not achieving expected results. This detailed evaluation will typically occur on a 5-year cycle. If progress is not occurring then the appropriate management agency will be contacted with a request for action.

Evaluation of Effort Over Time

Annual reports on progress toward TMDL implementation will be prepared to provide the basis for assessment and evaluation of progress. Documentation of TMDL implementation activities, actual pollutant reduction effectiveness, and projected load reductions for planned actions will be included. If water quality goals are being met, or if trend analysis shows that implementation activities are resulting in benefits that indicate that water quality objectives will be met in a reasonable period of time, then implementation of the plan will continue. If monitoring or analyses show that water quality goals are not being met, the TMDL implementation plan will be revised to include modified objectives and a new strategy for implementation activities.

Public Involvement

In Idaho, implementation plans are subject to public involvement requirements similar to those for TMDLs. Idaho Code Section 39-3611 states that TMDLs shall be developed in accordance with Section 39-3614 (duties of the BAG), Section 39-3616 (duties of each WAG) and the federal Clean Water Act. Idaho Code Section 39-3612 states that after a TMDL is completed the Director shall, subject to the provisions of Idaho Code Section 67-5200, adopt the processes as part of the state's water quality management plan pursuant to the federal Clean Water Act. Federal regulations also require public participation in Clean Water Act decisions (40 CFR Part 25).

Idaho Code identifies WAGs as the entity responsible for recommending actions needed to effectively control sources of pollution. While a general framework for pollution control actions has been considered during development of the loading analysis, and this water quality management plan, the source specific implementation plans that will be prepared after the SR-HC TMDL is approved are the principal documents that specify the recommended actions needed to control pollutants. In developing these specific implementation plans, the WAGs and the Director will employ appropriate means of public involvement deemed necessary or required under Idaho Code Section 67-5200 and shall cooperate fully with the public involvement or planning processes of other appropriate public agencies. The BAG is also expected to review the specific SR-HC TMDL implementation plans. In meeting these various requirements, IDEQ will seek public involvement as follows:

1. At the minimum, drafts of the specific implementation plan will be presented to the WAG, if applicable, representing the geographic area covered. All WAG and BAG meetings will be open to the public.

2. IDEQ will publish notice in newspapers covering the TMDL geographic area advertising at least a thirty (30) day period for interested persons to review the draft specific implementation plans and present comments to IDEQ. The notice will be published with enough lead-time to reasonably advise the public of the meeting. The notice will indicate where the public may obtain a copy of the draft specific implementation plans prior to any public meetings; information about public meetings, if any are planned; when comments are due; a contact person for questions; and an address for submitting written comments.

IDEQ generally holds a public information meeting early in the comment period. At the meeting, IDEQ will present information on how the specific implementation plans were developed and answer questions from the public. Comments will be accepted in writing if postmarked by the last day of the public comment period.

If a WAG is involved in the development of the specific implementation plans, the thirty (30) day public comment period is still required but a public meeting is not. However, even in this situation a public meeting is strongly recommended. All public comments will be considered in preparing the final specific implementation plan.

Public Information and Education

Public information and education efforts are an important part of ensuring full and timely implementation of the measures proposed in this plan. Information and education will generally take two forms: general information about the plan directed to all residents and interests in the watershed and source-specific information and education efforts targeted to sources who may be involved in implementing pollutant reduction measures. General information and education measures will include a public meeting sponsored by the WAG or appropriate designated agency to explain the draft plan, an opportunity for public review and comment, and distribution of the final plan to interested parties. Ongoing information about implementation progress will be provided at WAG or appropriate designated agency meetings, which are open to the public.

Forestry Information and Education Efforts

Load reduction information, BMP locations, and performance/efficacy values obtained during the course of implementation will be available to the public through a variety of public forums including reports to the WAG or appropriate designated agency, Implementation Plan Source Groups and other organizations and agencies.

Agriculture Information and Education Efforts

Local Soil and Water Conservation Districts (SCDs) have been involved in various efforts to increase the knowledge and awareness of conservation practices for agricultural landowners. This has been advanced with methods such as with newsletters, workshops, articles and conservation planning.

In many SCDs, newsletters are mailed out to producers, landowners and interested residents of the district. Often these newsletters are produced by the SCD and provide general information about conservation practices as well as current events. Workshops are often held annually cover agriculture and other natural resource topics of special interest in the SCDs. These workshops have been well attended by the general public. The SCDs also often provide local media with articles about issues of interest to local agricultural landowners. Education also occurs on a personal level when district planners visit landowners and producers to develop conservation plans.

Urban/Suburban Information and Education Efforts

Load reduction information, BMP emplacement mechanisms and performance/efficacy values obtained during the course of implementation will be available to the public through a variety of public forums including reports to the WAG or appropriate designated agency, Implementation Plan Source Groups and other organizations and agencies.

Costs and Funding

Specific implementation plans will include a cost analysis for the resources needed to develop, execute and maintain the programs described. The purpose of conducting an economic analysis of project costs is to compare options and their effectiveness. Life cycle cost analysis allows projects of varying capital and operations costs to be compared. When combined with pollutant removal efficiencies, project costs can be compared in terms of their economic benefit per unit of pollutant removed ($/kg or $/kg/year).

Projects may be prioritized for implementation according to their unit costs of pollutant removal to maximize cost effectiveness. Another purpose of including a cost analysis is to describe estimated costs and demonstrate there is sufficient funding available to begin implementation. A final purpose may be to identify potential future funding sources for project implementation.

There are many natural resource enhancement efforts and projects occurring in the subbasin that are relevant to the goals of the plan. Funding is essential to implementing projects associated with this general Water Quality Management Plan. There are many sources of local, state, and federal funds. Several are discussed in the Reasonable Assurance section above.

Evaluation of Progress/Reporting

Annual reports from each source work group, detailing pollutant reduction measures implemented, observed emplacement and operation efficiencies, and projected load reductions will be submitted to the DEQs.

Project Tracking System

A tracking system will be prepared to serve as a master summary of all projects and BMPs constructed for the purpose of reducing the pollutant load to the SR-HC TMDL reach. The system will be used as a management tool to assess pollutant load reduction, to analyze cost effectiveness, and to assess performance of each BMP either individually or as a whole. The tracking system should include the following project characteristics:

- Project or BMP Identification and Description;
- Project Schedule;
- Project Inspection Responsibilities,
- Location of BMP or Project (watershed, source group);
- Project Priority;
- Estimated and Actual Pollutant Control Effectiveness;
- Estimated Costs (capital, annual operation and maintenance, unit costs for pollutant removal);
- Sources of Funding; and
- Collateral Watershed Benefits (in-stream flows, temperature, fisheries, aesthetics, flood control, etc.).

The tracking system will provide a database summary of all projects and BMPs in the SR-HC TMDL reach. Individual projects, tributary watersheds, and the SR-HC TMDL reach will be assessed for pollutant load reductions and cost effectiveness from the information available in the database. The tracking system will be used to support the preparation of annual reports and to document projects completed. Since the database also tracks projects yet to be completed, it will provide an aid to developing a funding strategy and project construction schedule. Finally, the database will be linked to a geographic information system (GIS) mapping system to locate each project within the SR-HC TMDL reach.

Management actions in response to implementation plan tracking may include revisions to the plan, revised project schedules, modified priorities for projects, identification of funding needs, and feedback to improve the pollutant reduction effectiveness of BMPs and projects. Field inspection and confirmation of the application of appropriate BMPs is an important element of overall program management. Field inspection may provide useful feedback to improve the implementation and effectiveness of future projects. Field inspections may also be a required component of other programs that support watershed management plans, such as state agricultural cost share grants.

Due to the complexity of the SR-HC TMDL, which will involve many projects and multi-year implementation, pursuit of project funding may be a significant challenge. Implementation plan tracking tools will provide financial planning information to support the systematic pursuit of funding support from diverse sources including local funds, grants, and cost-share programs. Watershed benefits beyond the basic pollutant reduction objectives of individual projects and BMPs will be important to define. These collateral benefits may include enhancements to habitat, fisheries, flood control, sustained in-stream flows, and so on. These features may provide important information for prioritization of projects, with higher priority given to projects with multiple benefits. Collateral benefits may also be important in pursuit of implementation funding and may help projects qualify for outside funding support.

Annual Reports

Annual reports detailing pollutant reduction measures implemented, observed emplacement and operation efficiencies, and projected load reductions will be submitted to the DEQs. The tracking system will be used to support the preparation of annual reports and to document projects completed. These reports are tentatively scheduled to be submitted on or before 30 September of each year.

Implementation Plan Revision

The SR-HC TMDL will utilize monitoring data to evaluate progress in attaining water quality standards in the SR-HC TMDL reach and full support of designated beneficial uses. If goals are being reached, or if trend analysis shows that implementation activities are resulting in benefits that indicate that water quality objectives will be met within a reasonable time, the implementation plan will not be revised. If analysis, or other information indicates that water quality goals will not be met, the specific implementation plans will be revised to include new objectives and a new strategy for implementation actions.

The following conditions could indicate a need to revise the specific implementation plans:

- Monitoring data indicate water quality standards will not be attained by continued execution of the specific implementation plans.
- Actual effectiveness and efficiency of pollutant reduction BMPs/projects falls short of or exceeds projections used in the specific implementation plans.
- Pollutant reduction BMPs/projects are not executed according to the specific implementation plans due to lack of funding or other factors.
- Monitoring data indicate that natural background loadings of pollutants differ from historical data and revisions to reduction targets for manageable loadings are required.

Implementation Plan Revision vs. TMDL Revision

Careful consideration of the need for revisions is required to distinguish between the need to modify the implementation plan or the TMDL itself. Revisions to the specific implementation plan may be undertaken as a management approach to more effectively target activities to accomplish the water quality goals set in the TMDL. Revisions to the TMDL itself imply the need to revisit the basis for water quality impairment, the basic relationships associated with the maximum available loading capacity, and the load allocation to point and nonpoint sources. TMDL revision may have broader implications in terms of both stakeholder commitments and regulatory requirements.

A sustained effort in reduction of external pollutant loadings will be needed to improve water quality in SR-HC TMDL reach. Natural weather conditions may affect the rate of progress in meeting the SR-HC TMDL objectives for water quality improvement. Increased snowpack and precipitation is expected to benefit short-term water quality condition. Extended low water years are expected to delay beneficial improvements in water quality.

Land Use Changes

The SR-HC TMDL and this general implementation plan in some cases address loading issues and implementation strategies on a land-use basis. However, land-use distributions are not static. Data collected within the State of Idaho show diminishing agricultural and forestry land use and increasing urban/suburban land-use trends (Idaho Department of Commerce, 2000).

Land Use Change Scenarios

It is acknowledged that changes in land use will continue to occur throughout the implementation process and into the future. The following discussion is therefore intended to address this potential and ensure that land-use changes will not result in non-attainment of the required load reductions. This discussion is not intended as a mechanism to address current loading. Three generalized scenarios have been considered in evaluating the potential impact of land use changes on implementation of the SR-HC TMDL. These scenarios have been outlined as follows:

- Move High Load to Low Load Situation
    - Example: Convert developable land to a conservation easement
- Move Low Load to High Load Situation
    - Example: Convert developable land to residential
- Transition/Construction Impacts
    - Example: Construction erosion and sedimentation

If pre-development and post-development pollutant loadings can be quantified, three approaches may be considered with regard to the management of new development impacts. These approaches are outlined as follows:

- Apply BMPs to achieve reduction goal;
- Apply BMPs to maintain pre-development loads (no net increase); and
- Compensate for increased load with other reductions.

New Development

New development represents a unique aspect of loading and reduction considerations within the watershed as it commonly represents a change in land-use from within the existing nonpoint source categories. The dominant trend in land-use change within the State of Idaho is the conversion of agriculture and forested land to urban/suburban development. Features such as view, topography, recreation potential, and access by public roads drives development decisions. Income from property sales often supplements or replaces more limited income derived from agricultural land use.

It is recognized that in order to effectively meet pollutant reductions throughout the watershed, all contributing sources must participate in the reduction effort. Limiting reductions to existing land uses alone will place an unfair burden for pollutant reduction on established practices. This burden will increase over time with occurrence of land use changes within the watershed.

Primary responsibility for review and approval of new development rests with local authorities. Zoning within the watershed is administered by County Planning and Zoning Commissions and the municipalities. The Counties administer the majority of the watershed area where land use can change from agriculture. Where not already in-place, efforts should be made to control the impact of construction on water quality. Adoption of the "State of Idaho Catalog of Storm Water Best Management Practices for Idaho Cities and Counties" along with stringent site grading requirements to mitigate erosion and sedimentation during construction have proven successful in other areas of the state. Site grading permits are subject to review by county engineers and other designated officials, and can be reviewed by interested agencies and the public during the formal review process. This provides a link between water quality management considerations and the review and approval process for new development.

An assessment of projected water quality impacts (both positive and negative) incorporated within the existing process for review of proposed new developments, would allow an equitable and effective distribution of the required pollutant reductions to all land uses. This incorporation of TMDL requirements, BMPs, mitigation, and reduction mechanisms as part of this review process will further assure the success of the SR-HC TMDL and specific implementation plans at a local level.

On a state level, permit applications submitted to IDEQ for new development within the watershed of an impaired water body will be evaluated as to potential water quality impacts, and will be reviewed with TMDL load and reduction allocations in mind.

Specific Implementation Plans

According to IDEQ guidance (IDEQ, 1999a), the specific implementation plans associated with the SR-HC TMDL are expected to be completed and on file at IDEQ within 18 months of EPA approval of the TMDL. This 18-month timeline includes the public comment period. These specific implementation plans will include detailed information on steps to be taken to meet pollutant targets as appropriate within the SR-HC TMDL reach, timelines for implementation, milestones and interim goals for implementation, and reasonable assurance that the plans will be implemented.

While each specific implementation plan process associated with the SR-HC TMDL and the inflowing tributaries will be different, the major steps in implementation plan development will be fairly consistent overall. A general overview of the State of Idaho implementation planning process has been laid out below.

This schedule assumes that either a WAG is already in place or the current public process (i.e. the SR-HC PAT, etc) will be appropriate and that the implementation plan will be reviewed by the BAG. If a new WAG is formed to develop the implementation plan, an additional early task should be to select and brief new members on the TMDL.

1. Work groups may be formed as appropriate representing identified sources. Work group members will be familiarized with the nonattainment issue and any available TMDL content proposals. The most effective organization will depend on the watershed. It is projected that source groups will be organized around similar land uses or source types (e.g., municipalities, agriculture, forestry) as appropriate. However, it is recognized that other organizational structures may make more sense.

2. Source load estimates from the TMDL will be refined as necessary. This will be especially applicable to inflowing tributary loads. Tributary load allocations will be identified at the mouth, therefore, the TMDL process in place for these drainages may need to assign loads to specific land uses or land areas within each drainage.

3. Measures to reduce pollutant loads will be identified, cost effectiveness of available pollutant control measures will be assessed as appropriate, and the amount of control necessary to achieve the TMDL goal will be determined. For point sources this will be identification of one or more control technologies that will achieve the wasteload allocation (WLA). For nonpoint sources this will be identification of best management practices (BMPs) and the amount needed (acres to be treated, miles of road to be treated, etc.) to implement the load allocation (LA).

4. A draft monitoring plan will be prepared.

5. A schedule with appropriate milestones and interim goals will be established. The approach for monitoring and responsibilities for tracking, managing and reporting on implementation progress will be identified.

6. Load reductions from all sources will be evaluated collectively to ensure TMDL targets are met (this step should be completed within 12 months of the TMDL approval to ensure sufficient time for public review and timely submission).

7. Estimate of control measures needed and associated load reductions will be refined if/as necessary to achieve TMDL targets.

8. Cost estimates for load reduction measures will be developed as appropriate.

9. A review of the draft document by the WAG (or other appropriate public stakeholder group), by IDEQ, and by other designated agencies will be completed.

10. Public review and comment period will be held.

11. The implementation plan will be revised and finalized using comments and review responses.

12. The final implementation plan will be submitted to IDEQ.

Idaho implementation plans will follow the TMDL schedule as identified for the State of Idaho. The following table identifies the currently scheduled completion dates for TMDLs related to the SR-HC TMDL.

Schedule for TMDLs related to the Snake River - Hells Canyon TMDL.

Location	Listed Pollutant (1998 303(d) list)	TMDL Due Date
Snake - American Falls to Milner (Lake Walcott TMDL)	DO, pest, sed	1999
Snake - Milner to King Hill (Mid-Snake and Upper-Snake Rock TMDLs)	amm, bac, DO, nut, Qalt, sed, temp, therm	1997, 2000
Snake - King Hill to Hwy 51	sed	2004
CJ Strike Reservoir	nut, pest	2004, 2000
CJ Strike Dam to Castle Creek	sed	2002
Castle Creek to Swan Falls	sed	2002
Owyhee River		
North Fork (TMDL completed)	temp	1999
South Fork (TMDL completed)	temp	1999
Middle Fork (TMDL completed)	temp	1999
Middle Fork	temp	2006
Lower	bac, chl *a*, DDT, Diel, DO, Hg, temp	2006
Mainstem Tribs	bac, sed, Qalt, temp	2001
Tribs	temp	1999
Tribs	temp, Hg	2006
Boise River		
North Fork	sed	2000
South Fork	sed	2000
Lower* (Lucky Peak to Snake River) (TMDL completed)	bac, nut, Qalt, sed, temp	1998*
Tribs	DO, nut, OG, sed, unk	2001, 2006
* Nutrient TMDL pending SR-HC TMDL allocations		
Malheur River		
Upper	bac, Qalt, temp	2003
Lower	bac, chl *a*, DDT, Diel	2003
Tribs	bac, chl *a*, temp	2003
Payette River		
North Fork	DO, nut, pH	1998, 2004
Middle Fork	temp	2003
Black Canyon Reservoir	nut, OG, sed	1999
Black Canyon Dam to Snake (TMDL completed)	bac, nut, temp	1999
Tribs	Halt, nut, Qalt, sed, temp	2003
Weiser River	bac, DO, nut, sed, temp	2003
Tribs	bac, nut, Qalt, sed, temp	2003, 2006
Burnt River and Tribs	chl *a*, Halt, Qalt, sed, temp	2005

Location	Listed Pollutant (1998 303(d) list)	TMDL Due Date
Powder River and Tribs	bac, DO, Qalt, sed, temp	2005
Pine Creek	temp	2005
Imnaha River	temp	2001
Tribs	Halt, temp	2001
Dennett Creek	Qalt, sed, temp	2001
Warm Springs Creek	nut, sed	2001
Hog Creek	nut, sed	2001
Scott Creek	nut, sed	2001
Divide Creek	sed	2005
Wolf Creek	sed	2005
Getta Creek	sed	2005

Key Elements of State of Idaho Source-Specific Implementation Plans

According to IDEQ June 8, 1999 guidance (IDEQ, 1999a), specific implementation plans prepared for the State of Idaho will include the following elements:

- key load reduction activities (e.g., permit modifications);
- responsible parties (either designated agencies or specific sources, where possible);
- anticipated or potential start and finish dates for activities;
- key milestones (to provide the basis and checkpoints for assessing implementation progress);
- time required for load reduction measures to reach maturity (to give a sense of individual measures' impact on reduction goals); and
- time required to reach water quality objectives (attainment with applicable water quality standards).

The specific implementation plans should also identify an individual who will oversee the schedule, monitor implementation progress, and determine when (if at all) the implementation plan and TMDL must be modified to reach water quality goals.

As stated earlier, the source-specific implementation plans will include detailed information on steps to be taken to meet pollutant targets as appropriate within the SR-HC TMDL reach, timelines for implementation, milestones and interim goals for implementation, and reasonable assurance that the plans will be implemented. Implementation plans to meet SR-HC TMDL load allocations for the inflowing tributaries will be completed and submitted according to their specific TMDL schedule. In the case of tributaries with TMDLs currently in place, the 18 month time period from the US EPA approval of the SR-HC TMDL will apply. In the case of tributaries where a tributary TMDL is scheduled to be completed following the submittal of the SR-HC TMDL, the implementation plan to meet load allocations from the SR-HC TMDL will be completed according to the tributary TMDL schedule. State-specific policy on timing of implementation submission will apply (i.e. State of Oregon tributary TMDLs will follow Oregon practice with implementation plan timing and State of Idaho tributary TMDLs will follow Idaho practice with implementation plan timing.

While each specific implementation plan process for the State of Idaho associated with the SR-HC TMDL and the inflowing tributaries will be different, the major steps in implementation plan development will be consistent with State of Idaho requirements as outlined above.

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7.1 REFERENCE INFORMATION

7.1.1 GLOSSARY

Word	**Definition**
Adsorption	The adhesion of one substance to the surface of another.
Aeration	A process by which a water body secures oxygen directly from the atmosphere. The gas can then enter the biochemical oxidation reactions in the water.
Aerobic	Life forms or processes that require the presence of molecular oxygen.
Alluvium	The deposition of sediment by a river at any point along its course.
Ambient	Surrounding, external or unconfined conditions.
Anaerobic	Processes that occur in the absence of molecular oxygen.
Anoxia	The condition of oxygen deficiency.
Anthropogenic	Caused or produced through the agency of humans.
Assimilative Capacity	The rate at which an aquatic system must consume and remove impurities from water to maintain water quality.
Autotrophic organisms	Organisms that produce their own energy from inorganic compounds (usually photosynthesis).
Biomass	The weight of biological matter, often measured in terms of grams per square meter of surface area.
Chlorophyll a	A photosynthetic pigment reflecting green light and imparting the typical green color to plants; chlorophyll a is found in all autotrophic plants.
Coliform Bacteria	A group of bacteria predominately inhabiting the intestines of man and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.
Colluvium	Material transported to a site by gravity.
Designated Beneficial Uses	Any of the various uses of water, including, but not limited to domestic water supplies, industrial and agricultural water supplies, cold water biota, recreation, wildlife habitat and aesthetics. This is often shortened to either "designated uses" or "beneficial uses."
Dissolved Oxygen	Oxygen that is dissolved in the water of a stream, lake, or reservoir. It is the oxygen used by aquatic organisms for respiration.
Effluent	Treated or untreated wastewater that flows out of a treatment plant, sewer or industrial outfall. Generally refers to wastes discharged into surface waters.
Epilimnion	The warm, top-water zone above the thermocline in a lake or reservoir.
Eutrophic	A body of water of high photosynthetic activity and low transparency, usually

Word	Definition
	rich in nutrients.
Fauna	The entire animal life of a given region, habitat or geological stratum.
Fecal Streptococci	A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.
Flora	The plant life of a given region, habitat or geological stratum.
Hydrology	The science dealing with the properties, distribution and circulation of water.
Hypolimnion	The cold, bottom-water zone below the thermocline in a lake or reservoir.
Igneous	Rocks formed by solidification of molten magma.
Influent	A tributary stream to an industrial or wastewater treatment plant.
Infusion	The continuous slow introduction of one content into another.
Intergravel D.O.	Dissolved oxygen found in the substrate (usually gravel) of a stream, which is needed to support fish and macro invertebrates during early life stages.
Limnology	Scientific study of fresh water, especially the history, geology, biology, physics and chemistry of lakes and reservoirs.
Load Allocation	The portion of a receiving water's loading capacity that is allocated either to one of its existing or future nonpoint sources of pollution or to natural background sources.
Loading Capacity	The greatest amount of loading that a waterbody can receive without violating water quality standards.
Mesotrophic	A trophic region in which a lake or reservoir tends to be moderately productive, but nuisance algae blooms do not occur because the nutrient supply is limited.
Nonpoint Source	Discharges to waterbodies from diffuse sources as opposed to point sources which discharge from a single point.
Noxious	Physically or chemically harmful or destructive.
Orthophosphate	A form of soluble inorganic phosphorus that is directly utilizable biological processes including algal growth.
Pelagic	The open areas of lakes or reservoirs.
Photic Zone	The surface zone of the sea or a lake having sufficient light penetration for photosynthesis.
Phytoplankton	Microscopic algae and microbes that float freely in open water of lakes and oceans.
Point Source Pollution	The type of water quality degradation resulting from the discharges into receiving waters from sewers and other identifiable "points".
Residuum	The by-product of a geological process.
Riparian	Living or located on the banks of a natural watercourse.

Word	Definition
Secchi Disc	A black and white disc, 20 cm in diameter, used to measure the transparency of water. Used as an indicator of turbidity in a water body.
Selective Withdrawal	The ability to draft water from a reservoir from differing dam elevations.
SNOTEL	Snow survey telemetry which uses the principle of radio transmissions by meteor burst. Radio signals are aimed skyward where trails of meteorites reflect or re-radiate the signals back to earth.
Stagnation	The absence of mixing in a waterbody.
Stratification	Organization of a lake into horizontal layers due to differences in temperature.
Thermocline	A horizontal temperature discontinuity layer in a lake in which the temperature falls by at least 1^{o}C per meter of depth.
Total Maximum Daily Load (TMDL)	A measurement establishing the total amount of pollutant(s) allowed in a water body while maintaining the water body at or above water-quality standards. In practice a TMDL is the sum of all the Load Allocations, Waste Load Allocations, and the Margin of Safety.
Total Suspended Solids (TSS)	The material retained on a 45-micron filter after filtration.
Trophic State	Level of growth or productivity of a lake as measured by phosphorus content, chlorophyll a concentrations, amount of aquatic vegetation, algal abundance and water clarity.
Trophic State Index	A system used by many states for classification of the degree of eutrophication exhibited by a lake or reservoir. The index combines measures of phosphorus, chlorophyll a levels and water clarity (transparency) to provide a frame of reference for comparing measurements over time.
Turbidity	A measure of the extent to which light passing through water is reduced to suspended materials.
Waste Load Allocations	The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution.
Water Quality Modeling	The input of variable sets of water quality data to predict the response of a lake or stream to different management or climatic variables.
Watershed	A region bounded peripherally by the surrounding topography that ultimately drains to a common lake or stream.

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7.1.2 Acronyms

Acronym	Description
303(d)	Comprehensive listing of water quality limited stream segments
AFO	Animal Feeding Operation
AWQMAP	Agricultural Water Quality Management Area Plan (Oregon DEQ terminology)
BAG	Basin Advisory Group (Idaho DEQ terminology)
BCC	Boise Cascade Corporation
BETTER	Box, Exchange, Transport, Temperature & Ecology of a Reservoir
BLM	US Bureau of Land Management
BNR	Biological Nutrient Removal or Biological Nutrient Reduction
BMP	Best Management Practice
BOR	US Bureau of Reclamation
BOD	Biochemical Oxygen Demand
BU	Beneficial Use
^{o}C	Degrees Celsius
CES	Cooperative Extension System
CFR	Code of Federal Register
CFS	Cubic Feet per Second
CFU	Colony Forming Unit
COE	US Army Corps of Engineers
CRP	Conservation Reserve Program
CWA	Clean Water Act (Federal)
DBU	Designated Beneficial Use
DMA	Designated Management Agency
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DOP	Dissolved Ortho-phosphate
EPA	US Environmental Protection Agency
ESA	Endangered Species Act (Federal)
^{o}F	Degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FLIR	Forward Looking Infrared Radiometry (a remote sensing technique for temperature)
FPA	Forest Protection Act
FWPCA	Federal Water Pollution Control Act
GIS	Geographical Information System
HCNRA	Hells Canyon National Recreation Area
HCC	Hells Canyon Complex
HUA	Hydrologic Unit Area
HUC	Hydrologic Unit Code
Hg	Mercury
IDA	Idaho Department of Agriculture
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Division of Environmental Quality
IDFG	Idaho Department of Fish & Game
IDHW	Idaho Depart of Health & Welfare
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources

Acronym	Description
IFPA	Idaho Forest Practices Act
IPCo	Idaho Power Company
ISCC	Idaho Soil Conservation Commission
ISDA	Idaho Department of Agriculture
Kg	Kilogram (one thousand grams)
L	Liter
LA	Load Allocation
LAC	Local Advisory Committee
LC	Loading Capacity
MAF	Million Acre-Feet
Mg	Milligram (one thousandth of a gram)
Mg/L	Milligrams per Liter
MOS	Margin of Safety
MSL	Mean Sea Level
MUSLE	Modified Unified Soil Loss Equation
MW	Megawatt
NEDC	
Ng	Nanogram (one billionth of a gram)
Ng/L	Nanograms per Liter
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
NTR	National Toxics Rule
NTU	Nephelometric Turbidity Units
NURP	National Urban Runoff Program
NWDA	
OAR	Oregon Administrative Rule
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODHW	Oregon Department of Health and Welfare
ODSL	Oregon Department of State Lands
ODH	Oregon Division of Health
OFPA	Oregon Forest Practices Act
ODWR	Oregon Department of Water Resources
OP	Ortho-phosphate
ORS	Oregon Revised Statutes
P	Phosphorus
PAG	Public Advisory Group
PAT	Public Advisory Team
PIR	Phosphorus Index Rating
PM&E	Protection, Mitigation and Enhancement
POC	Particulate Organic Carbon
PON	Particulate Organic Nitrogen
POP	Particulate Organic Phosphorus
QA/QC	Quality Assurance and Quality Control (for sampling and analysis of data)
RM	River Mile
RMO	Riparian Management Objectives
RHCA	Riparian Habitat Conservation Areas
RUSLE	Revised Universal Soil Loss Equation

Acronym	Description
SAWQP	State Agricultural Water Quality Program (Idaho program)
SBA	Sub-Basin Assessment
SR-HC	Snake River – Hells Canyon
SRP	Soluble Reactive Phosphorus
SRPA	Snake River Plain Aquifer
SSC	Suspended Sediment Concentration (also referred to as Total Suspended Sediment)
STORM	Storage, Treatment, Overflow & Runoff Model
SCD	Soil Conservation District
SWCD	Soil and Water Conservation District
SWMM	Stormwater Management Model
TAC	Technical Advisory Committee
TDG	Total Dissolved Gas
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TSSed	Total Suspended Sediment
Ug	Microgram (one millionth of a gram)
Ug/L	Micrograms per liter
USBR	US Bureau of Reclamation
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFS	US Forest Service
USFWS	US Fish & Wildlife Service
USGS	US Geological Survey
USLE	Universal Soil Loss Equation
UTM	Universal Transverse Mercator
WAG	Watershed Advisory Group (Idaho terminology)
WEQ	Wind Erosion Quotient
WHIP	Wildlife Habitat Incentives Program
WLA	Waste Load Allocation
WPCA	Water Pollution Control Act
WQI	Water Quality Index
WQLS	Water Quality Limited Segment
WQPA	Water Quality Program for Agriculture
WRP	Wetlands Reserve Program
WWTP	Wastewater Treatment Plant
WY	Water Year

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7.1.3 Other TMDLs in the General Area of the Snake River – Hells Canyon Reach

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Scheduling of TMDLs in the Snake River - Hells Canyon Drainage

Bolded entries are part of the Snake River - Hells Canyon TMDL

Location	Listed Pollutant (1998 303(d) list)	TMDL Due Date	State Responsible	HUC Number
Snake River				
Snake - American Falls to Milner (Lake Walcott TMDL)	DO, pest, sed	1999	Idaho	17040209
Snake - Milner to King Hill (Mid-Snake and Upper-Snake Rock TMDLs)	amm, bac, DO, nut, Qalt, sed, temp, therm	1997, 1999(?)	Idaho	17040212
Snake - King Hill to Hwy 51	sed	2004	Idaho	17050101
CJ Strike Reservoir	nut, pest	2004, 2000	Idaho	17050101, 17050102
CJ Strike Dam to Castle Creek	sed	2002	Idaho	17050103
Castle Creek to Swan Falls	sed	2002	Idaho	17050103
Swan Falls to Boise River Inflow*	**bac, DO, nut, pH, Qalt, sed**	**2002**	**Idaho**	**17050103***
Snake River - Mainstem (RM 409 to 168)	**Hg, temp**	**2007**	**Oregon**	**17050115, 17050201, 17060101, 17050103****
Boise River to Weiser River	**bac, nut, pH, sed**	**2001**	**Idaho**	**17050115**
Middle Snake - Payette (OR)	**Hg, temp**	**2003**	**Oregon**	**17050115**
Weiser River to Brownlee Dam	**DO, nut, pH, sed**	**2001**	**Idaho**	**17050201**
Brownlee Reservoir	**Hg, temp**	**2005**	**Oregon**	**17050201**
Brownlee Dam to Oxbow Dam	**nut, pest, sed**	**2001**	**Idaho**	**17050201**
Oxbow Dam to above Salmon River	**not listed**	**2001**	**Idaho**	**17060101**
Lower Snake - Asotin**	Hg, temp	2005	Oregon	17060103**
* Mainstem Snake downstream from OR/ID border only ** Mainstem Snake downstream to OR/WA border only				
Owyhee River				
North Fork (TMDL completed)	temp	1999	Idaho	17050107
South Fork (TMDL completed)	temp	1999	Idaho	17050105

Location	Listed Pollutant (1998 303(d) list)	TMDL Due Date	State Responsible	HUC Number
Middle Fork (TMDL completed)	temp	1999	Idaho	17050107
Middle Fork	temp	2006	Oregon	17050107
Lower	bac, chl a, DDT, Diel, DO, Hg, temp	2006	Oregon	17050110
Mainstem tribs	bac, sed, Qalt, temp	2001	Idaho	17050104
Tribs	temp	1999	Idaho	17050107
Tribs	temp, Hg	2006	Oregon	17050107, 17050110
Boise River				
North Fork	sed	2000	Idaho	17050111
South Fork	sed	2000	Idaho	17050113
Lower* (Lucky Peak to Snake River) (TMDL completed)	bac, nut, Qalt, sed, temp	1998*	Idaho	17050114
Tribs	DO, nut, OG, sed, unk	2001, 2006	Idaho	17050113, 17050114
* Nutrient TMDL pending SR-HC TMDL allocations				
Malheur River				
Upper	bac, Qalt, temp	2003	Oregon	17050116
Lower	bac, chl a, DDT, Diel	2003	Oregon	17050117
Tribs	bac, chl a, temp	2003	Oregon	17050116, 17050117
Payette River				
North Fork	DO, nut, pH	1998, 2003	Idaho	17050123
Middle Fork	temp	2003	Idaho	17050123, 17050122
Black Canyon Reservoir	nut, OG, sed	1999	Idaho	17050122
Black Canyon Dam to Snake (TMDL completed)	bac, nut, temp	1999	Idaho	17050122
Tribs	Halt, nut, Qalt, sed, temp	2003	Idaho	17050122, 17050123
Weiser River	bac, DO, nut, sed, temp	2003	Idaho	17050124
Tribs	bac, nut, Qalt, sed, temp	2003, 2006	Idaho	17050124

Location	**Listed Pollutant (1998 303(d) list)**	**TMDL Due Date**	**State Responsible**	**HUC Number**
Burnt River and Tribs	chl a, Halt, Qalt, sed, temp	2005	Oregon	17050202
Powder River and Tribs	bac, DO, Qalt, sed, temp	2005	Oregon	17050203
Pine Creek	temp	2005	Oregon	17060101
Imnaha River	temp	2001	Oregon	17060102
Tribs	Halt, temp	2001	Oregon	17060102
Salmon River				
North Fork	sed, temp, unk	2000, 2001	Idaho	17060201, 17060203
South Fork	sed	2000	Idaho	17060208
Lower	sed	2004	Idaho	17060209
Mainstem tribs	Qalt, sed, temp	2005	Idaho	17060205, 17060206
Tribs	bac, DO, Halt, mtu, nut, pH, Qalt, sed, temp, unk	2000, 2001, 2004, 2005, 2006	Idaho	17060201, 17060202, 17060203, 17060204, 17060205, 17060207, 17060208, 17060209, 17060210
Dennett Creek	Qalt, sed, temp	2001	Idaho	17050201
Warm Springs Creek	nut, sed	2001	Idaho	17050201
Hog Creek	nut, sed	2001	Idaho	17050201
Scott Creek	nut, sed	2001	Idaho	17050201
Divide Creek	sed	2005	Idaho	17060101
Wolf Creek	sed	2005	Idaho	17060101
Getta Creek	sed	2005	Idaho	17060101

algae = nuisance algae growth
amm = ammonia (NH_3)
bac = bacteria or pathogens
chl a = chlorophyll a
DDT = pesticide listing for the presence of DDT and associated metabolites (DDD, DDE)
Diel = pesticide listing for the presence of the insecticide Dieldrin
DO = low dissolved oxygen
Halt = habitat alteration
Hg = metals listing for the presence of mercury
mtu = metals listing for the presence of unidentified (unknown) metals
nut = listing for excessive nutrients
pH = pH outside of the identified range (6.5 to 9.5 in Idaho waters, 7.0 to 9.0 in Oregon waters)
pest = listed for the presence of pesticides
Qalt = flow alteration
sed = presence of excessive sediment
temp = temperature exceedences
therm = thermal alteration
unk = listed because of non-support of designated beneficial uses due to unknown pollutants/pollution