C.J. Strike Reservoir Total Maximum Daily Load Dissolved Oxygen Implementation Plan

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Compliance Report

C.J. Strike, FERC Project No. 2055-010 (Article 407)

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(Article 407) Unspecified, Long-term Project Changes

Condition 2 of the Clean Water Act section 401 Water Quality Certification for the project contemplates unspecified, long-term changes to project operations or facilities as determined by the Idaho Department of Environmental Quality for the purpose of achieving pollutant loading allocations assigned to the project consistent with state and federal law. These changes may not be implemented without prior Commission authorization granted after the filing of an application to amend the license.

1. INTRODUCTION

Idaho Power Company (IPC) filed an application with the Federal Energy Regulatory Commission (FERC) for a new license authorizing the continued operation and maintenance of the C.J. Strike Project No. 2055-010, pursuant to the Federal Power Act, on November 18, 1998. Concurrently, IPC requested Clean Water Act section 401 water-quality certification from the Idaho Department of Environmental Quality (IDEQ) that any discharges, which may result from the continued operation of the project, will comply with applicable water quality requirements. IPC subsequently withdrew its application for further analysis and submitted a new request. IPC then again withdrew that application and resubmitted on September 14, 2000. The IDEQ issued certification on September 13, 2001. Certification stipulates that IPC must comply with the following to provide reasonable assurance applicable water quality requirements are met (IDEQ 2001).

1. By January 1 of each year after the date of this certification, and until the C.J. Strike TMDLs are completed, IPC shall pay $50,000 to the Department to assist in the development of the C.J. Strike and Snake River-Succor Creek TMDLs.

2. After the C.J. Strike, Snake River-Hells Canyon and Snake River-Succor Creek TMDLs are completed, IPC shall implement those measures determined by the Department to be necessary to achieve allocations assigned to the C.J. Strike facility consistent with state and federal law requirements. The Department's final determination regarding such measures shall be a condition of this 401 certification. The Department shall attempt to reach agreement with IPC regarding such measures before making its final determination.

FERC issued an order for a new license, pursuant to the Federal Power Act, for continued operation and maintenance of the C.J. Strike Project on August 4, 2004. The order stipulates, among other requirements, compliance with Condition 2 of the Clean Water Act section 401 certification.

The *King Hill-C.J. Strike Reservoir Subbasin Assessment and Total Maximum Daily Load* (King Hill-C.J. Strike TMDL) was approved by the U.S. Environmental Protection Agency in June 2006. The King Hill-C.J. Strike TMDL "requires the addition of 2.2 tons/year of oxygen into the metalimnion of C.J. Strike Reservoir." IPC later received notification from the IDEQ the obligation of C.J. Strike Reservoir section 401 water-quality certification Condition 1 had been fulfilled (Appendix A).

IPC submitted in November 2007 an implementation plan that identified upstream aquatic vegetation removal as the proposed measure to comply with the C.J. Strike Reservoir section 401 water-quality certification Condition 2, the C.J. Strike FERC Project No. 2055-010 Article 407, and the King Hill-C.J. Strike TMDL load allocation. IDEQ reviewed the implementation plan and requested IPC provide "[a] baseline of DO in the reservoir as well as the DO response as a result of macrophyte removal" (IDEQ 2007a). This report has been revised to provide these data and analyses.

2. C.J. STRIKE RESERVOIR POLLUTANT ALLOCATIONS

C.J. Strike Reservoir water quality is listed as being impaired by nutrients and pesticides (IDEQ 2007b). The King Hill-C.J. Strike TMDL provided, among other watershed characteristics, a pollutant source inventory and a statement of loads and supporting analysis for each pollutant of concern. The King Hill-C.J. Strike TMDL recommended de-listing the reservoir for pesticides based on a detailed loading analysis (IDEQ 2006). Dissolved oxygen (DO) was used as an indicator of water quality impairment caused by nutrients. C.J. Strike Reservoir was assigned a DO load allocation of 2.2 tons per year to address the calculated reduction in assimilative capacity. The King Hill-C.J. Strike TMDL stated the DO deficit historically occurred in the metalimnion between the first of July and the first of September and further concluded that most of the DO is needed between July 10 and July 31 with the actual amount varying from 0.01 to 0.8 tons per day. While the IDEQ recommended not listing total dissolved gases as a pollutant of concern on the section 303(d) list, based on the infrequency of spill volume that results in elevated levels and no total dissolved gases induced illness in local aquatic life, they did agree with the FERC's recommendation to monitor levels when spill exceeds 25,000 cubic feet per second (cfs) as required by Article 406 for the C.J. Strike Project.

The King Hill-C.J. Strike TMDL noted that direct oxygenation of the metalimnion is not required (IDEQ 2006). The addition of 2.2 tons DO per year can be accomplished through equivalent reductions in total phosphorus or upstream organic matter, or other appropriate mechanisms that can be shown to result in the required improvement of DO in the metalimnion of C.J. Strike Reservoir. Cost effectiveness of both reservoir and upstream implementation should be considered in all implementation projects in improving aquatic life habitat and support of designated beneficial uses. IDEQ continues to be non-prescriptive in their determination of measures needed to comply with the DO load allocation as evidenced by a letter dated September 26, 2007 (Appendix B).

3. IMPLEMENTATION METHOD AND SCHEDULE

3.1. Proposed Measures

IPC proposes acknowledgement of the total phosphorus target change inflow to and outflow from C.J. Strike Reservoir. The target established in the King Hill-C.J. Strike TMDL (IDEQ 2006) for the Snake River inflow to the reservoir is 0.075 milligrams per liter (mg/L). The target for the Snake River immediately below C.J. Strike Reservoir, as established in the *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Load* (IDEQ 2003), is 0.070 mg/L. The DO deficit in C.J. Strike Reservoir resulting from this total phosphorus target change

is 2.3 tons on July 29. This DO deficit is equal to the DO load allocation (i.e., 2.2 tons) assigned to IPC for the reduced assimilative capacity of C.J. Strike Reservoir.

IPC proposes aquatic vegetation removal at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects to further address reduced DO in C.J. Strike Reservoir. Aquatic vegetation is a nutrient sink as well as a source of oxygen-demanding material when it decays. Removal of this material from the Snake River can be considered a nutrient reduction and equivalent to oxygen additions equal to 0.5-5.7 tons per year; averaging 2.2 tons per year DO to the metalimnion.

Further, IPC is pursuing broad geographic Snake River watershed actions. IPC proposes that water quality improvements resulting from implementation of alternative actions be considered equivalent to oxygen additions. For example, IPC has recently submitted for agency consultation a request that FERC delete articles 401, 407, and 425 from the Milner Project License (IPC 2008a). If approved, IPC has proposed to use its right to store 45,000 acre-feet of water at American Falls Reservoir to pass about 1,500 cfs of water through the Milner Project and downstream during a 14 consecutive-day period between July 1 and July 31 of each year. Modeling and empirical data of increased Snake River flow show DO in the metalimnion increases substantially from sub-standard concentrations to greater than the numeric criteria. As part of the Hells Canyon Complex section 401 water-quality certification application, IPC has proposed a Temperature Enhancement Management Program for the Snake River watershed (IPC 2008b). The program includes watershed improvements aimed at decreasing temperatures through riparian shading and water quality improvement projects and water acquisitions (e.g., leasing, cloudseeding) aimed at increasing Snake River flows, thus further decreasing temperatures. Implementation of these projects throughout the Snake River watershed would have many far-reaching ancillary benefits including reduced sediments and nutrients and increased DO.

IPC proposes to monitor C.J. Strike Reservoir each year until this license term expires. Temperature and DO will be collected through the depth profile at river mile (RM) 494.5, 498.0, 502.0, and 506.0. Monitoring will occur every two weeks during July and August.

Aquatic vegetation removed at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects, as well as temperature and DO monitoring data, will be reported annually at the Article 419: Annual Monitoring Review Meeting. A report will be prepared for the attendees.

3.2. Analysis

3.2.1. C.J. Strike Reservoir Dissolved Oxygen Conditions

IPC has monitored water quality at various locations throughout C.J. Strike Reservoir since 1988. July and August DO profiles at RM 494.5 (i.e., near the dam) and RM 502.0 are provided in Appendix C for 1994, 1995, 1996, 1997, 2006, 2007, and 2008. These locations bound the reservoir's lacustrine zone. Concentrations from about 12-20 m depth indicate conditions in the metalimnion.

DO concentrations at RM 502.0 mostly exceeded 6 mg/L throughout the water column. Infrequently did concentrations fall below the criterion and then only at the deepest depths.

However, DO concentrations at RM 494.5 consistently fell below the criterion. Most of the exceedences occurred throughout the metalimnion and hypolimnion[1]. At times during 2006, the entire water column was less than 6 mg/L. While calendar year 2006 was classified as a medium water year based on a pentile analysis of annual average flows at King Hill, Idaho since records began in 1910, it was preceded by the five lowest water years on record (i.e., 2001-2005) (Figure 1).

During this period of low water conditions, aquatic vegetation was accumulating in the Snake River upstream of C.J. Strike Reservoir. Figure 2 illustrates the bioaccumulation of aquatic vegetation in the river on August 15, 2005 just upstream of an unimproved boat launch at RM 553.8.

During the spring of 2006, above average precipitation was recorded throughout the Middle Snake River from Grand View, Idaho to Twin Falls, Idaho. April rainfall averaged 257% of average (Table 1). As a result, the average April flow at King Hill, Idaho was 148% of average. This high flow scoured aquatic vegetation from the streambed. Figure 3 illustrates the reduced bioaccumulation of aquatic vegetation in the river one year later on August 15, 2006 following the high flows. It is likely to assume this material settled in C.J. Strike Reservoir and contributed to the depressed DO in 2006 as the material decayed and consumed oxygen.

3.2.2. C.J. Strike Reservoir Dissolved Oxygen Modeling

3.2.2.1. Model Selection and Setup

The U.S. Army Corps of Engineers Waterways Experiment Station CE-QUAL-W2 Model was selected for modeling C.J. Strike Reservoir. The CE-QUAL-W2 Model is a two-dimensional, longitudinal and vertical, water-quality model best suited for relatively long and narrow water bodies (Cole and Wells 2002) such as C.J. Strike Reservoir. The model is capable of integrating dynamic hydraulic and water quality analyses in the development of a completely linked evaluation of the inflow boundary conditions, nutrient uptake, and cycling of the biological growth and decay processes to simulate a DO budget. The model has been under continuous development since 1975 and has been successfully applied to over 400 waterbodies worldwide.

Various versions of the CE-QUAL-W2 Model have been used to develop the modeling for C.J. Strike Reservoir. Version 2.0 was applied to originally develop the first reservoir model. This model was converted to version 3.0, which was converted to Version 3.1. The results of each conversion were checked to the previous version to maintain a consistent representation of C.J. Strike Reservoir.

The King Hill-C.J. Strike TMDL is soundly based on the premise that nutrient concentrations are closely linked to organic matter concentrations that are linked to DO concentrations (IDEQ 2006). As such, the DO load allocation for C.J. Strike Reservoir was determined by modeling C.J. Strike Reservoir water quality based on inflow boundary conditions that (1) were set at

[1] In lakes and reservoirs the dissolved oxygen standard does not apply at certain depths and locations (IDAPA 58.01.02 n.d.)

current conditions (i.e., baseline conditions) and (2) met water quality targets for dissolved and particulate constituents (nutrients and algae), DO concentrations, and reduced sediment oxygen demand that would be expected after accumulated pollutants have reduced in the system (Appendix D). IPC began sampling to assess the mass loading of aquatic vegetation to C.J. Strike Reservoir in June 2004. The aquatic vegetation, that is coarse particulate organic matter (CPOM), measured on June 2, 2004 was used to estimate a baseline CPOM boundary condition for simulation of organic matter inflow to C.J. Strike Reservoir (Harrison et al. 2005). The measured value was converted to an annual load and then distributed over the year using estimates of aquatic vegetation removed with a trash rake at the Upper Salmon Falls "B" Project.[2] The CPOM was then evenly divided between labile and refractory fractions and added to the baseline particulate organic matter boundary conditions. CPOM concentrations were then reduced similarly to total phosphorus to simulate water quality targets.

IPC also simulated the effect increased Snake River flow would have on reservoir DO. The premise being that increased flow minimizes the reservoir's reduced assimilative capacity. IPC used the same baseline model scenario as used to simulate water quality changes, that is, inflow boundary conditions were set at current conditions.

3.2.2.2. Nutrient Target

The King Hill-C.J. Strike TMDL established a total phosphorus target of 0.075 mg/L for the Snake River inflow to C.J. Strike Reservoir (IDEQ 2006). Appendix D describes the process of simulating the DO deficit, if any, remaining in C.J. Strike Reservoir after attaining all water quality goals in the inflow Snake River. From the modeling, only on Julian day 210 (July 29) do any DO concentrations below 6.0 mg/L remain in the metalimnion (IDEQ 2006). This mass of DO equates to 2.2 tons per year.

The *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Load*, which receives the King Hill-C.J. Strike TMDL waters, established a total phosphorus target of 0.070 mg/L (IDEQ 2003). This nutrient target was based, in-part, on the *Snake River-Hells Canyon Total Maximum Daily Load (TMDL)* target of 0.070 mg/L (IDEQ and ODEQ 2004). The Mid Snake-Succor Creek reach of the Snake River is directly above the Snake River-Hells Canyon reach and, thus, must meet the most conservative established target where the two reaches meet. In addition, the *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Load* concluded that the total phosphorus target was met in the Snake River immediately below C.J. Strike Reservoir. Using 1999 and 2000 data, the total phosphorus concentration in the Snake River below the dam was 0.070 mg/L (IDEQ 2003).

[2] In 1998, IPC installed an automated trash rake at the Upper Salmon Falls "B" Project to address reduced turbine performance due to head loss caused by accumulated vegetative material on the trash rack (Figure 4). Truckloads of vegetative material have been recorded since installation. In 2005 and 2006, IPC installed similar automated equipment at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects. The particulate organic matter boundary condition adjustment does not account for these projects.

IPC modeled a 0.070 mg/L total phosphorus target inflow to C.J. Strike Reservoir to simulate the concept forwarded in the *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Load* that the most conservative established target must be met where the two reaches meet. That is, a 0.070 mg/L nutrient target is reasonable to assume in the Snake River inflow to C.J. Strike Reservoir in order to meet the 0.070 mg/L nutrient target in the discharge. Appendix E illustrates the DO change in the metalimnion from the reduced total phosphorus target. The CE-QUAL-W2 Model simulation indicated that DO increased 2.3 tons per year in the metalimnion. It can then be stated that accounting for the total phosphorus target change in the Snake River (i.e., from 0.075 to 0.070 mg/L) is equal to the calculated reduced assimilative capacity of 2.2 tons per year DO in C.J. Strike Reservoir.

3.2.2.3. Upstream Aquatic Vegetation Removal

Excessive levels of macrophytes exist in the Snake River upstream of C.J. Strike Reservoir (Falter and Carlson 1994, Falter et al. 1995, Falter and Burris 1996). The macrophytes not only excrete oxygen-demanding materials directly into the water column (Wetzel 2001), but drift into the reservoir and settle to the sediments contributing to reservoir sediment oxygen demand.

The mass of macrophytes provides an estimate of oxygen-demanding materials entering C.J. Strike Reservoir because bacterial decay of the CPOM consumes oxygen from the water column. The oxygen demand assumes all organic matter decays, when in fact, some less digestible does not, and represents a potential oxygen demand. The potential oxygen demand was calculated using an estimate of CPOM from aquatic vegetation removed from the river and stoichiometric conversion factors found in the CE-QUAL-W2 model (Cole and Wells 2002).

The *Idaho Power Company FERC Relicensing of Middle Snake River Hydropower Projects Consent Order*, included as part of the Clean Water Act section 401 water-quality certification, required IPC shall design, install, and operate equipment at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects to remove aquatic vegetation that gathers at the intake structures (State of Idaho 1998). Similar equipment had already been installed at the Upper Salmon Falls "B" Project, and IPC was ordered to continue operation of this equipment. At the time of the King Hill-C.J. Strike TMDL development, the Upper Salmon Falls "B" Project was in operation and baseline model conditions included the effects of this effort. FERC license articles issued on August 4, 2004 ordered the installation and operation of aquatic vegetation removal equipment as required by the consent order. IPC complied with the articles, and aquatic vegetation removal equipment was installed and operation began at Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects between 2005 and 2006.

Reports of the number of truckloads of aquatic vegetation removed at the Upper Salmon Falls "A" Project began in January 2006. Tallies at both the Lower Salmon Falls and Bliss projects began in January 2007. More than 200 truckloads of aquatic vegetation were removed from the Snake River at the Upper Salmon Falls "A" Project in 2006, and to date, more than 100 truckloads in 2007 (Table 2). Fewer amounts were removed from both the Lower Salmon Falls and Bliss projects (Table 3). The mass load of aquatic vegetation can be estimated by multiplying the number of truckloads by the wet weight of a truckload of aquatic vegetation. IPC determined a truckload of aquatic vegetation weighed 4,730 pounds or 2.36 tons.

The aquatic vegetation removed is mostly water. On May 27, 2004, IPC sampled three aliquots of aquatic vegetation removed at the Upper Salmon Falls "B" Project. The percentage wet weight due to moisture on the plants ranged from 10-22% and averaged 18%. Further, IPC has periodically sent samples to analytical laboratories for analysis of nutrient concentrations. Analysis of wet and dry weights indicated about 90% of the aquatic vegetation is comprised of water. Therefore, the mass of aquatic vegetation removed from the river is adjusted to represent dry weight by first multiplying the weight of the truckloads by 0.82 and then multiplying this product by 0.1.

The potential oxygen demand of aquatic vegetation removed from the Snake River is calculated from the amount of dry weight CPOM removed from the Snake River and the CE-QUAL-W2 stoichiometric conversion factor of 1.4 to convert organic matter to oxygen demand (Cole and Wells 2002). It is assumed all truckloads are full, dry weight represents only organic matter, and all organic matter decays. The average annual potential oxygen demand of the aquatic vegetation removed at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects is 80 tons DO per year (Table 4). The King Hill-C.J. Strike TMDL states, "The DO deficit historically occurred in the metalimnion between the first of July and the first of September." The July and August potential oxygen demand totals 20 tons DO. This greatly exceeds IPC's DO load allocation of 2.2 tons DO.

The King Hill-C.J. Strike TMDL also states, "…the actual amount [of DO deficit varies]…from 0.01 to 0.8 tons per day." Evaluation of daily tallies of truckloads of aquatic vegetation removed at the Upper Salmon Falls "A" Project indicate oxygen-demanding aquatic vegetation is removed from the Snake River equivalent up to 0.81 tons DO per day (Table 5). The oxygen demand of aquatic vegetation removed at the Lower Salmon Falls and Bliss projects is in addition and provides reasonable assurance the daily equivalent DO addition exceeds the daily deficit.

The King Hill-C.J. Strike TMDL stated "improvements in DO in the reservoir can be achieved through attainment of growth-limiting concentrations of phosphorus and, ultimately, through long-term reductions in sediment oxygen demand" (IDEQ 2006). Removal of aquatic vegetation from the Snake River that has potential to drift into C.J. Strike Reservoir, settle, and contribute to reservoir sediment oxygen demand reduces long-term oxygen-demanding materials. IPC proposes aquatic vegetation removal at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects as a means to address the DO load allocation of 2.2 tons DO per year. IPC removes aquatic vegetation from the Snake River equivalent to the addition of about 80 tons DO per year. The summer equivalent is about 20 tons DO during July and August. The summer equivalent is nearly ten times IPC's DO load allocation. The proposed measure of aquatic vegetation removal at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects greatly exceeds the load allocation and provides reasonable assurance to address uncertainty relative to assumptions and analysis coefficients and transport and processing in the Snake River from these upstream projects to C.J. Strike Reservoir.

Further, the King Hill-C.J. Strike TMDL "requires the addition of 2.2 tons/year of oxygen into the metalimnion of C.J. Strike Reservoir." The CE-QUAL-W2 Model was used to compare the change in DO levels in the metalimnion of C.J. Strike Reservoir resulting from the proposed aquatic vegetation removal and related CPOM reductions. The annual reduction of CPOM

flowing into the reservoir was estimated to be 57 tons (Table 4). The average monthly CPOM reduction is 0.0069 mg/L (Appendix E).

Because there is uncertainty regarding actual load reductions and typically summer load reductions are greater than winter levels, the estimated average annual CPOM reduction was increased by a factor of 1.3 to better represent average seasonal levels that could occur during the summer. The April-September average CPOM is 0.0087 mg/L (Appendix E). This seasonal average is 1.3 times the annual average of 0.0069 mg/L. The April-September period is likely to be when most of the accumulated organic matter over the year is processed, due to warming water temperatures, and most of the DO demand is realized.

Proposed upstream aquatic vegetation removal with an April-September CPOM reduction increased DO in the metalimnion on July 29 0.29 tons (Appendix E). The July-August average increase in DO was 0.17 tons. C.J. Strike Reservoir has a relatively short retention time, that is, the reservoir typically shows characteristics more similar to run-of-river reservoirs rather than traditional stratified lakes and reservoirs. Using horizontal velocities from the CE-QUAL-W2 Model, retention time was estimated for the metalimnion. The metalimnion has a July-August) retention time of 8.4 days. Therefore, this means that the metalimnetic volume of water in C.J. Strike Reservoir is replaced 7.4 times during the summer (i.e., 62 days ÷ 8.4 days). Multiplying the average DO increase of 0.17 tons by the number of times water is replaced provides an estimate of the mass DO change from the proposed aquatic vegetation removal. The estimated equivalent addition of DO in model year 1995 is 1.3 tons in the metalimnion of C.J. Strike Reservoir.

Aquatic vegetation has been removed at the Upper Salmon Falls “B” Project since 1991. Table 6 illustrates the annual variability of the material removed. Assuming aquatic vegetation varied similarly at the Upper Salmon Fall “A”, Lower Salmon Falls, and Bliss projects, equivalent increases in DO from the proposed aquatic vegetation removal would be estimated to range from 0.5 tons DO in 1998 to 5.7 tons DO in 2008; averaging 2.2 tons DO per year to the metalimnion of C.J. Strike Reservoir.

3.2.2.4. Increased Snake River Flow

IPC has requested that FERC delete articles 401, 407, and 425 from the Milner Project License (IPC 2008a). If approved, IPC has proposed to use its right to store 45,000 acre-feet of water at American Falls Reservoir to pass about 1,500 cfs of water through the Milner Project and downstream during a 14 consecutive-day period between July 1 and July 31 of each year. IPC evaluated the effects of this described action of July flow augmentation on C.J. Strike Reservoir DO.

The greatest increase in DO concentrations were simulated deep in the water column where DO concentrations are currently depressed (Appendix C). At RM 502.0, DO increased as much as 3.5 mg/L near the 18 m depth on both July 4 under the early July flow augmentation simulation and July 29 under the late July flow augmentation simulation (Table 7). In both cases, DO was increased from sub-standard concentrations, that is less than 6 mg/L, to greater than the numeric criteria.

During July 2008, the U.S. Bureau of Reclamation released water from its storage reservoirs to assist with the migration of anadromous fish, species that ascend rivers from oceans to spawn, past the lower Snake River Federal Columbia River Power System projects, established as a reasonable and prudent alternative by the Federal Columbia River Power System biological opinion. Flow increased from about 200 cfs to 4,000 cfs (Figure 5). During this period, IPC measured DO in C.J. Strike Reservoir. DO substantially increased in the metalimnion, that is below about 12 m depth, at RM 502.0 (Figure 6). DO concentrations were always greater than 6 mg/L.

3.3. Implementation Schedule

The *Idaho Power Company FERC Relicensing of Middle Snake River Hydropower Projects Consent Order*, included as part of the Clean Water Act section 401 water-quality certification (State of Idaho 1998), and the FERC license articles issued on August 4, 2004, required IPC shall design, install, and operate equipment at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects to remove aquatic vegetation that gathers at the intake structures. IPC complied with the consent order and articles, and aquatic vegetation removal equipment was installed and operation began between 2005 and 2006.

IPC currently reports on the amount of aquatic vegetation removed at these projects at the Middle Snake and C.J. Strike projects Annual Review Meeting. This reporting will continue for the term of the licenses.

IPC will initiate water quality monitoring every two weeks during July and August in C.J. Strike Reservoir at RM 494.5, 498.0, 502.0, and 506.0 immediately following IDEQ approval of this implementation plan. IPC will report on the monitoring results at the C.J. Strike Project Annual Review Meeting.

4. CONSULTATION

Article 407 does not require IPC consult with other agencies or entities. However, IPC presented the King Hill-C.J. Strike TMDL DO load allocation and proposed measure to interested parties attending the Article 419 Annual Review Meeting on November 28, 2007. IPC also presented the revised proposed measures as described herein to interested parties attending the Article 419 Annual Review Meeting on December 10, 2008.

5. ACKNOWLEDGMENTS

I thank Jack Harrison for his work in supporting the analysis for the C.J. Strike DO load allocation during development of the King Hill-C.J. Strike TMDL. I also thank Scott Zimmerman and Jack Harrison for technical evaluation of feasible measures to address the King Hill-C.J. Strike TMDL DO load allocation.

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Wetzel, R. 2001. Limnology, Lake and River Ecosystems. Academic Press, San Diego, CA.

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Table 1
April average precipitation (BOR 2008) and April 2006 precipitation (WRCC 2008) in inches and the percent of average for Grand View, Glenns Ferry, and Twin Falls, Idaho.

	Grand View	Glenns Ferry	Twin Falls
Average	0.69	0.70	1.10
2006	1.68	2.42	1.99
Percent Average	243%	346%	181%

Table 2
Number of truckloads of aquatic vegetation removed at the Upper Salmon Falls "A" Project in 2006 and 2007.

	2006	2007	Average
January	1	10	6
February	18	5	12
March	10	7	9
April	80	2	41
May	18	11	15
June	9	11	10
July	32	22	27
August	23	18	21
September	7	26	17
October	7	19	13
November	19		19
December	14		14
Total	238	131	201

Table 3
Number of truckloads of aquatic vegetation removed at the Lower Salmon Falls and Bliss project in 2007.

	Lower Salmon Falls	Bliss
January	2	9
February	1	3
March	5	6
April	8	5
May	4	3
June	6	1
July	15	1
August	8	2
September	4	4
October	2	2
November		
December		
Total	55	36

Table 4
Average monthly number of truckloads of aquatic vegetation removed at the Upper Salmon Falls "A", Lower Salmon Falls, and Bliss projects from 2006 to 2007 and the potential oxygen demand (POD) from the decay of the organic matter.

	Average Monthly Truckloads	Wet Weight (ton)	Dry Weight (ton)	POD (ton)
January	17	33	3	5
February	16	31	3	4
March	20	39	4	5
April	54	105	10	15
May	22	43	4	6
June	17	33	3	5
July	43	83	8	12
August	31	60	6	8
September	25	48	5	7
October	17	33	3	5
November*	19	37	4	5
December*	14	27	3	4
Total	295	572	57	80

* November and December values only represent 2006 data.

Table 5
Daily estimates of potential oxygen demand in tons from the decay of the organic matter removed at the Upper Salmon Falls "A" Project during July and August from 2006 to 2007.

	2006		2007	
	July	**August**	**July**	**August**
1	0.27		0.54	0.27
2	0.54		0.27	0.27
3		0.54		0.27
4	0.54	0.27	0.54	0.27
5	0.27	0.27	0.27	0.27
6				0.27
7	0.54	0.54	0.27	
8	0.54	0.27	0.27	
9	0.81	0.27	0.27	0.27
10	0.54	0.27		
11	0.27	0.27	0.27	
12	0.27	0.27	0.27	0.27
13	0.27	0.27	0.27	0.27
14	0.27	0.27	0.27	
15	0.27	0.27		0.27
16	0.27	0.27		0.27
17	0.27		0.27	
18	0.27	0.27		
19	0.27			0.27
20	0.27	0.27	0.27	0.27
21		0.27		
22	0.27		0.27	0.27
23	0.27			
24		0.27		0.27
25	0.27	0.27	0.27	
26	0.27	0.27	0.27	
27	0.27	0.27	0.54	0.27
28		0.27		
29			0.27	0.27
30				
31	0.27		0.27	0.27

Table 6
Annual truckloads of aquatic vegetation removed annually at the Upper Salmon Falls "B" Project (1991-2008) and the associated equivalent potential oxygen demand (POD) of aquatic vegetation at the Upper Salmon Falls "A", Lower Salmon Fall, and Bliss projects based on 1995 CE-QUAL-W2 modeling.

	Annual Truckloads	**POD (ton)**
1991	444	1.8
1992	350	1.5
1993	288	1.2
1994	293	1.2
1995	313	1.3
1996	368	1.5
1997	345	1.4
1998	113	0.5
1999	147	0.6
2000	252	1.0
2001	419	1.7
2002	669	2.8
2003	759	3.2
2004	879	3.7
2005	1260	5.2
2006	503	2.1
2007	693	2.9
2008	1376	5.7
Average	526	2.2

Table 7
CE-QUAL-W2 simulated dissolved oxygen concentrations in milligrams per liter in C.J. Strike Reservoir at river mile 502.0 for two dates in July under (baseline) conditions and the proposed action of 1,500 cubic feet per second flow augmentation. A positive difference value indicates increased dissolved oxygen concentrations.

	July 4				July 29		
Depth (m)	**Baseline**	**Proposed Acton**	**Difference**	**Depth (m)**	**Baseline**	**Proposed Acton**	**Difference**
1.3	8.83	8.87	0.04	1.6	9.06	9.39	0.33
3.5	8.85	8.92	0.07	4.2	9.11	9.38	0.27
5.5	8.72	8.79	0.07	6.2	8.59	8.94	0.35
7.5	8.59	8.65	0.06	8.2	8.31	8.66	0.35
9.5	8.35	8.53	0.18	10.2	7.89	8.36	0.47
11.5	7.86	8.01	0.15	12.2	6.97	7.43	0.47
13.5	7.68	8.04	0.36	14.2	6.49	7.33	0.84
15.5	6.51	7.27	0.76	16.2	4.65	6.47	1.81
17.5	3.14	6.63	3.50	18.2	2.35	6.01	3.66
19.5	0.00	0.72	0.72	20.2	0.00	0.68	0.68

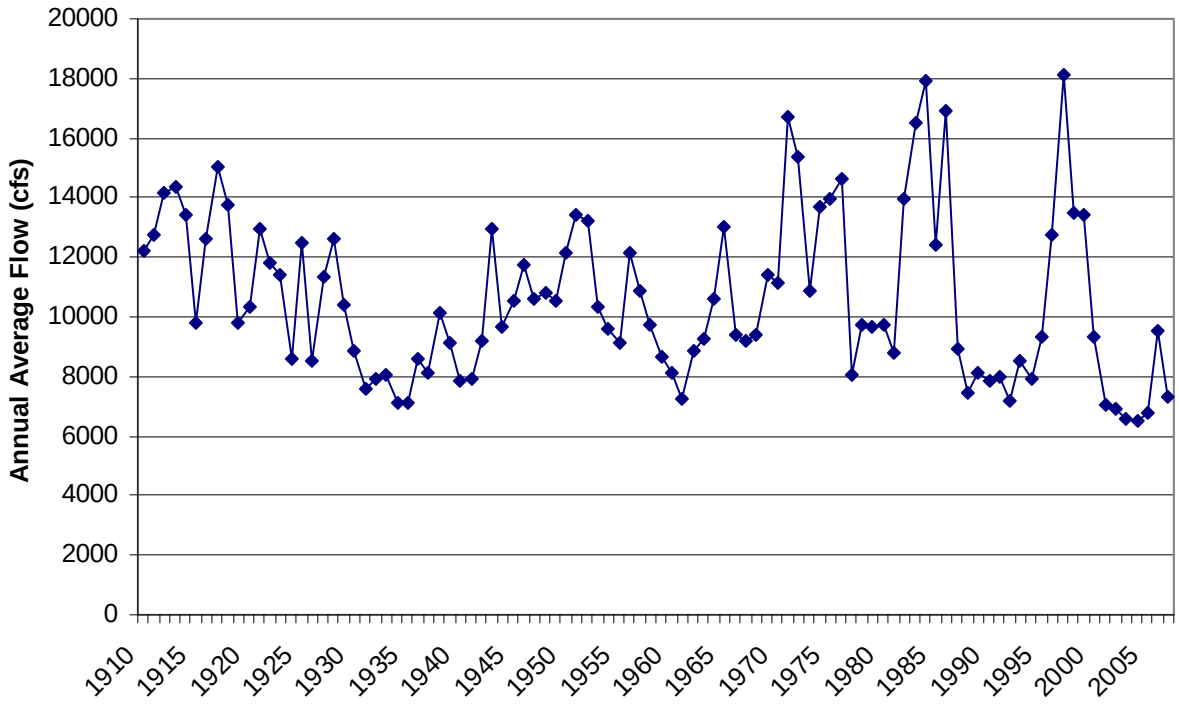


Figure 1
Snake River annual average flow in cubic feet per second (cfs) at King Hill, Idaho from 1910 to 2007.

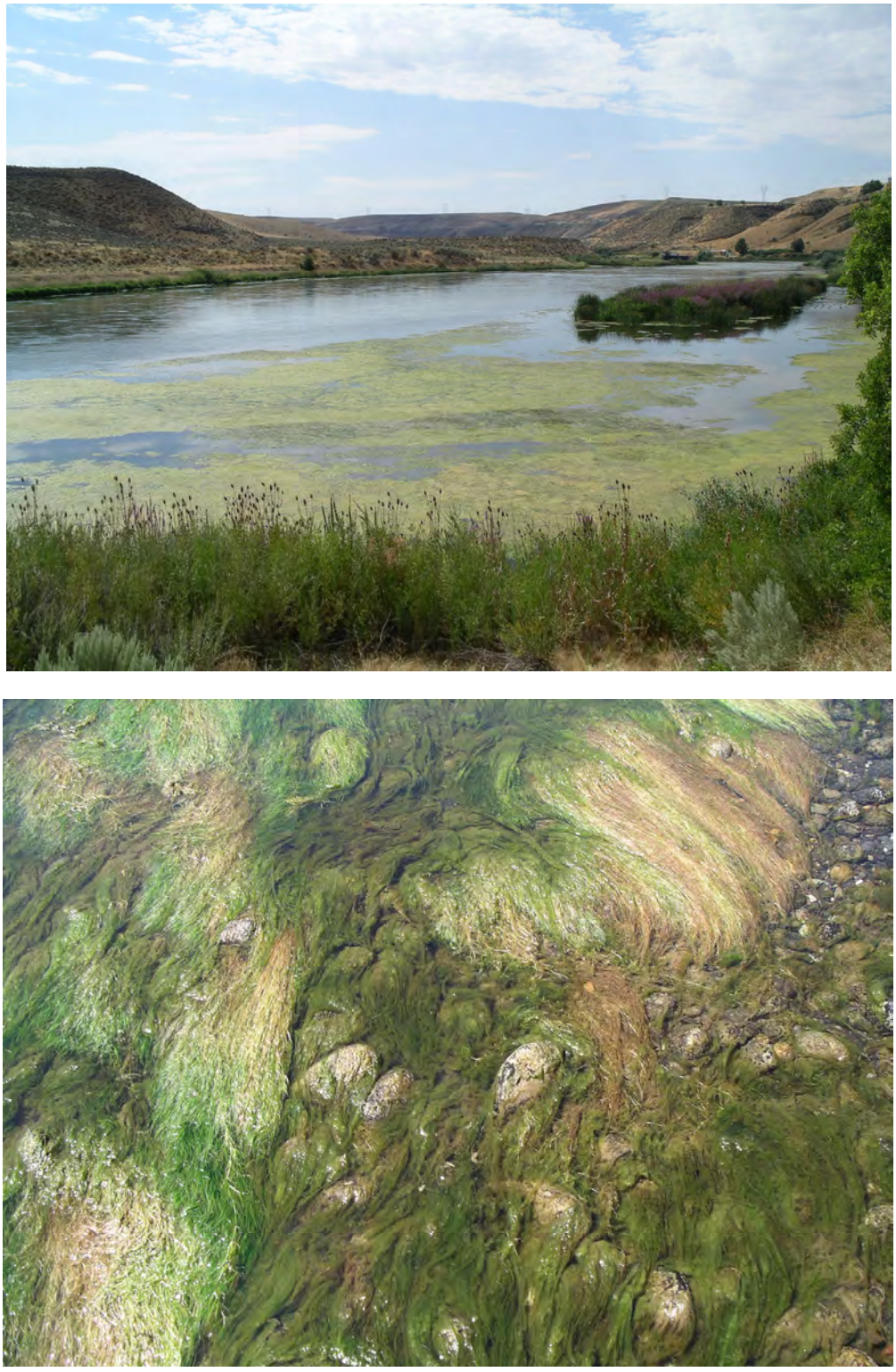


Figure 2
Photographs illustrating the bioaccumulation of aquatic vegetation in the Snake River following five consecutive low water years. Photographs were taken on August 15, 2005 about 33 miles upstream of C.J. Strike Reservoir.



Figure 3
Photographs illustrating the bioaccumulation of aquatic vegetation in the Snake River following high water conditions in April 2006. Photographs were taken on August 15, 2006 about 33 miles upstream of C.J. Strike Reservoir.



Figure 4
Atlas Polar automated rake installed on the Upper Salmon Falls “B” Project trash rack in 1988.

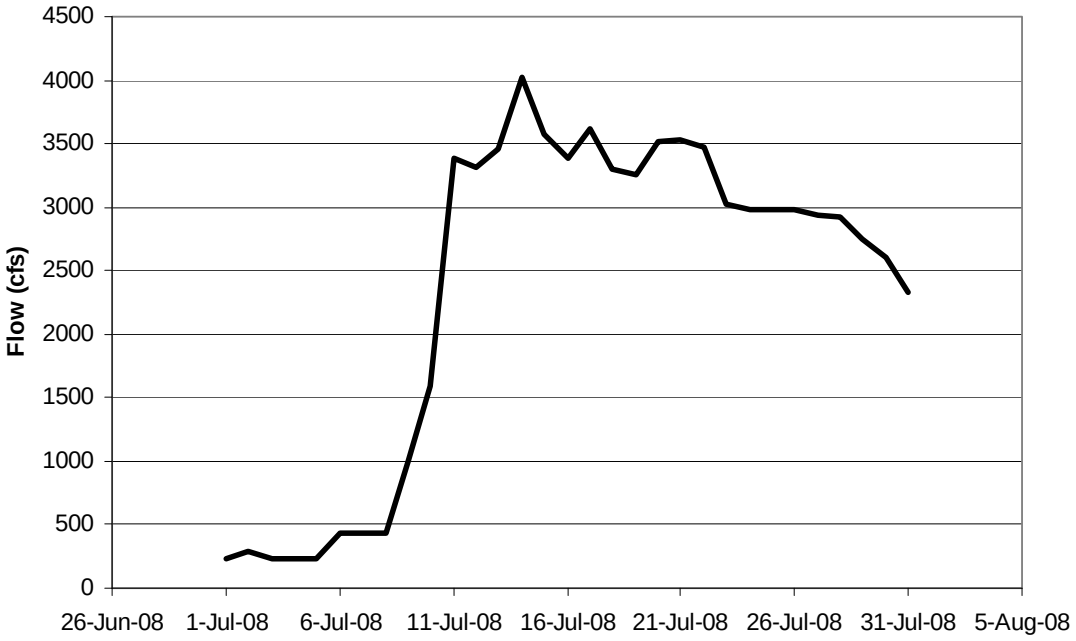


Figure 5
U.S. Bureau of Reclamation Snake River flow augmentation in cubic feet per second (cfs) at Milner during July 2008.

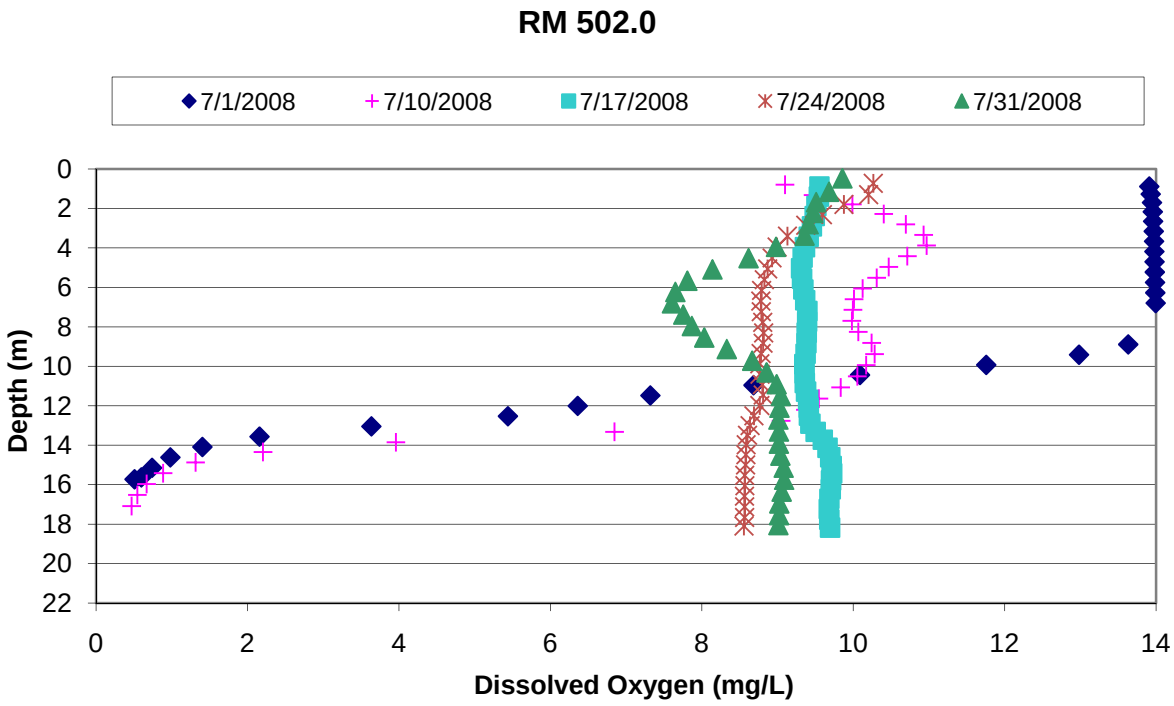


Figure 6
C.J. Strike Reservoir dissolved oxygen concentrations in milligrams per liter (mg/L) at depth in meters (m) at river mile 502.0 during July 2008.

Appendix A
Letter from Idaho Department of Environmental Quality to Idaho Power Company regarding fulfillment of obligations under Condition 1 of the Clean Water Act section 401 water-quality certification.

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STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

1445 North Orchard • Boise, Idaho 83706 • (208) 373-0550

JAMES E. RISCH, GOVERNOR
TOM FRAKES, DIRECTOR

December 14, 2006

Mr. Ralph Meyers
Idaho Power Company
P. O. Box 70
Boise, Idaho 83707

Re: King Hill CJ Strike TMDL Annual Payments

Thank you for your letter of July 19, 2006, regarding the referenced annual payments to the Department of Environmental Quality for completion of the TMDL. Based on the completion of the document and its approval by the U. S. Environmental Protection Agency, the Idaho Power Company had fulfilled the obligations under Condition 1 of the CJ Strike Reservoir Section 401 certification.

We greatly appreciate your contribution to the effort. If we can answer any questions, please contact Craig Shepard at 373-0557.

Sincerely,

J.R. Sandoval

J.R. Sandoval
Administrator
Boise Regional Office

cc: Brenda Malone, DEQ – Financial Office
Craig Shepard, DEQ – Boise Regional Office

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Appendix B
Letter from Idaho Department of Environmental Quality to Idaho Power Company regarding potential dissolved oxygen mitigation measures for C.J. Strike Reservoir.

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STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

1445 North Orchard • Boise, Idaho 83706 • (208) 373-0550

C.L. "Butch" Otter, Governor
Toni Hardesty, Director

September 26, 2007

Brian Hoelscher
Idaho Power Company
P.O. Box 70
Boise, ID 83707

Dear Brian,

As a follow up to our meeting September 13, 2007, I want to provide you with clarification on DEQ's position regarding the use of macrophyte removal to address the C.J. Strike Reservoir dissolved oxygen (DO) allocation identified in the King Hill-C.J. Strike Reservoir Subbasin Assessment and Total Maximum Daily Load. And, depending on the management option Idaho Power Company (IPC) chooses, I would also like to ask that additional reference be provided regarding macrophyte removal and/or the direct oxygenation of the reservoir.

DEQ agrees that the removal of macrophytes may be an appropriate mechanism to reach the TMDL allocation of adding 2.2 tons DO/year.

IPC provided explanation that the upstream macrophyte removal at Upper Salmon "A" was not accounted for in the modeling that resulted in the DO allocation for CJ Strike Reservoir. It is suggested that removing Potential Oxygen Demanding (POD) material at Upper Salmon "A" can be used to meet the downstream DO allocation. While this option may have merit, it would be helpful to provide literature reference to scientifically demonstrate the relationship of removing tons of POD to an actual increase equivalent to 2.2 tons DO/year downstream.

IPC is also considering using a bubble diffuser to inject oxygen into C.J. Strike Reservoir. This management option may also have merit however, there are several variables affecting the gasses ability to transfer into the water. Scott Zimmerman's memo in the *C.J. Strike Reservoir Dissolved Oxygen Analysis* addresses the ability to deliver gasses at depth but does not address other variables, such as air and water temperatures. If this management option is still being considered could you please address any additional variables that may affect the ability of gas transfer into water.

I would be happy to discuss these comments with you and I can be reached at 208-373-0321 or you may call Craig Shepard at 206-373-0557.

Sincerely,

Julia Achabal
Sr. Water Quality Analyst

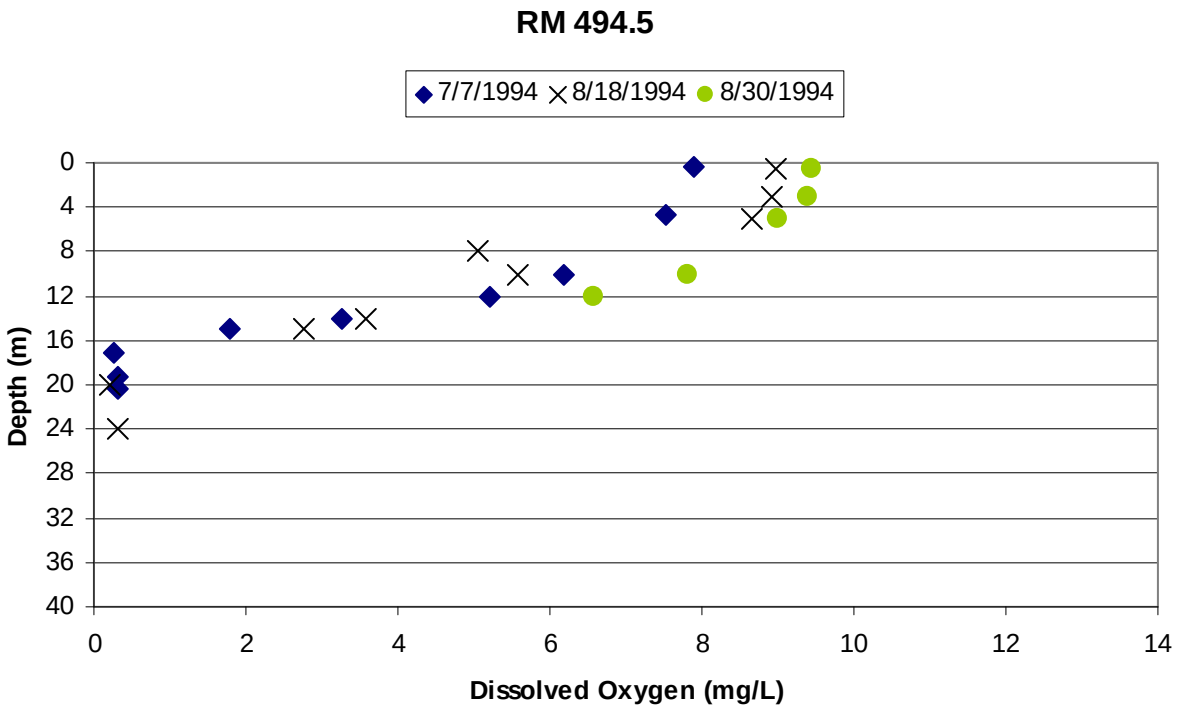
cc. Craig Shepard

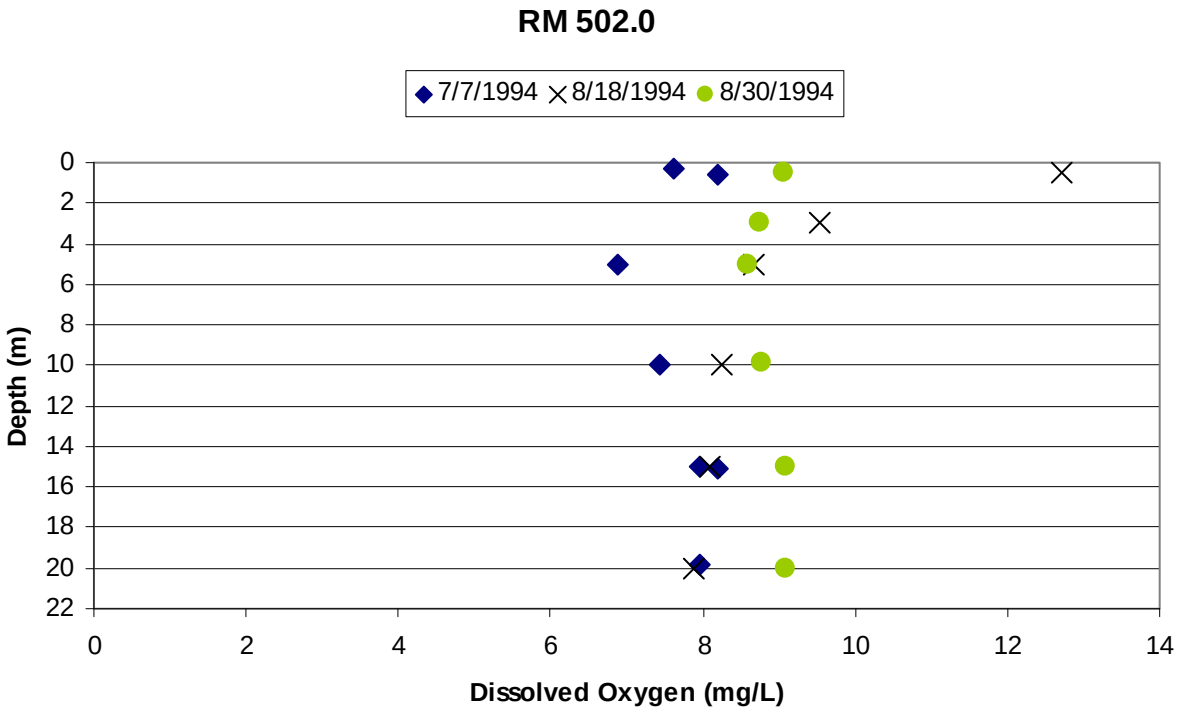
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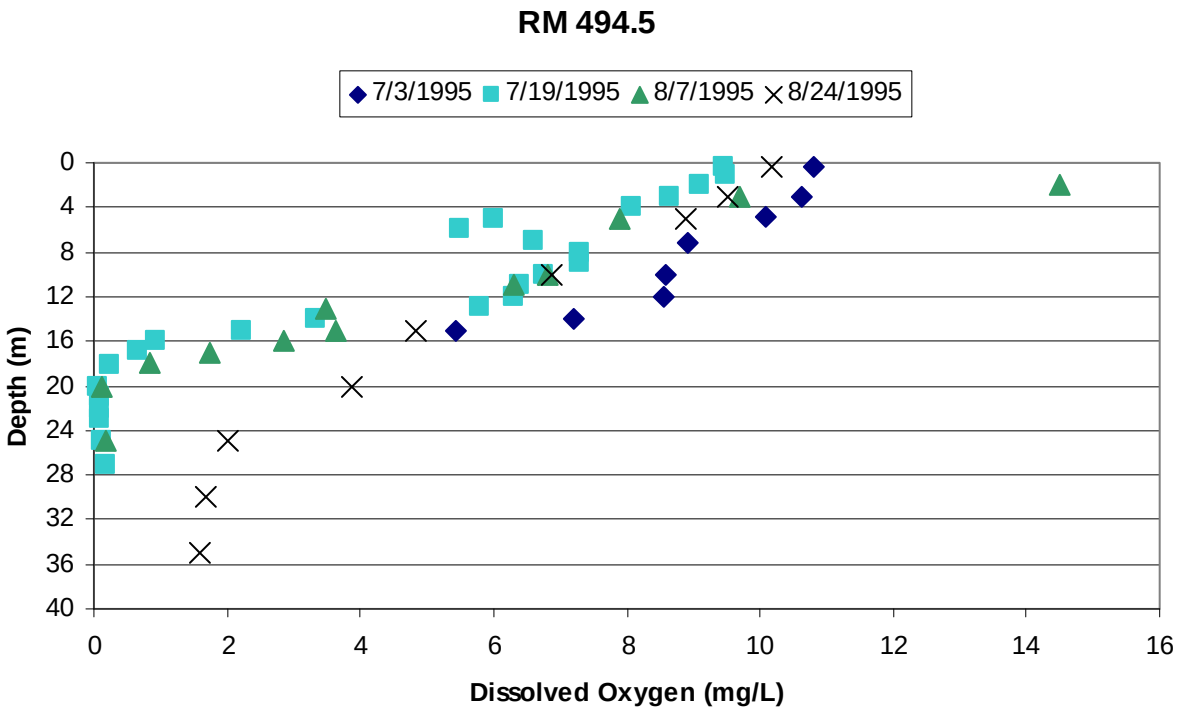
Appendix C

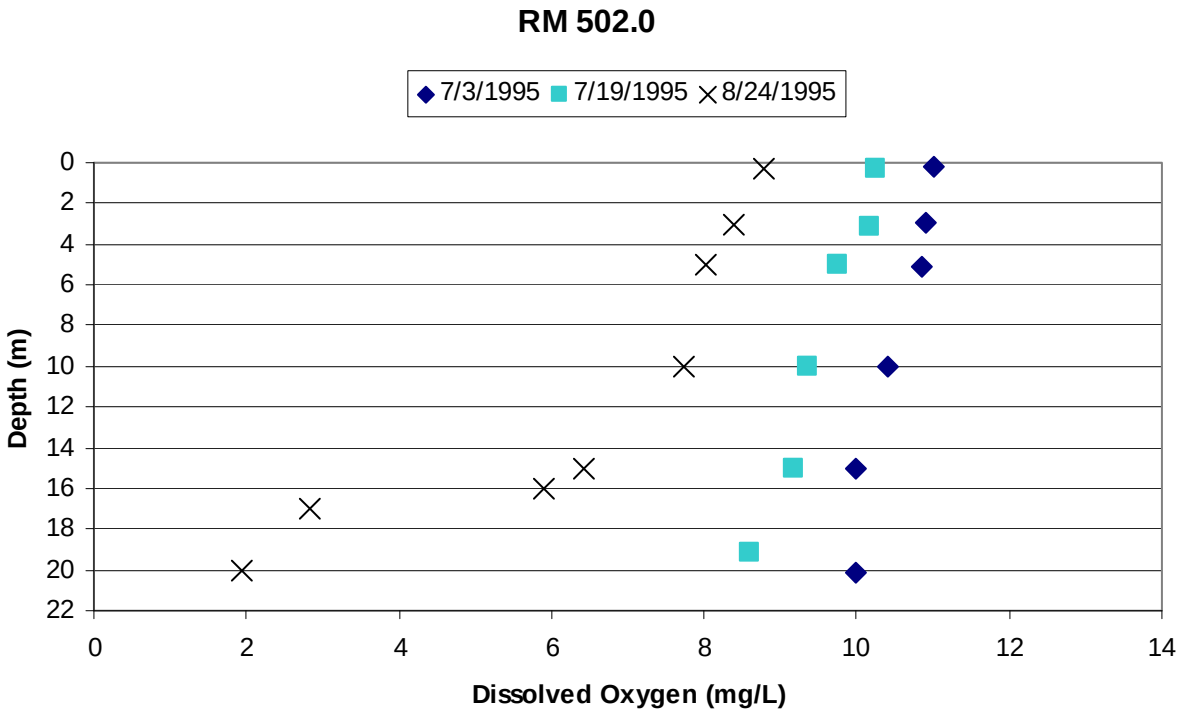
C.J. Strike Reservoir dissolved oxygen concentrations in milligrams per liter (mg/L) by depth in meters (m) at river mile (RM) 494.5 and RM 502.0 during July and August in 1994, 1995, 1996, 1997, 2006, 2007, and 2008.

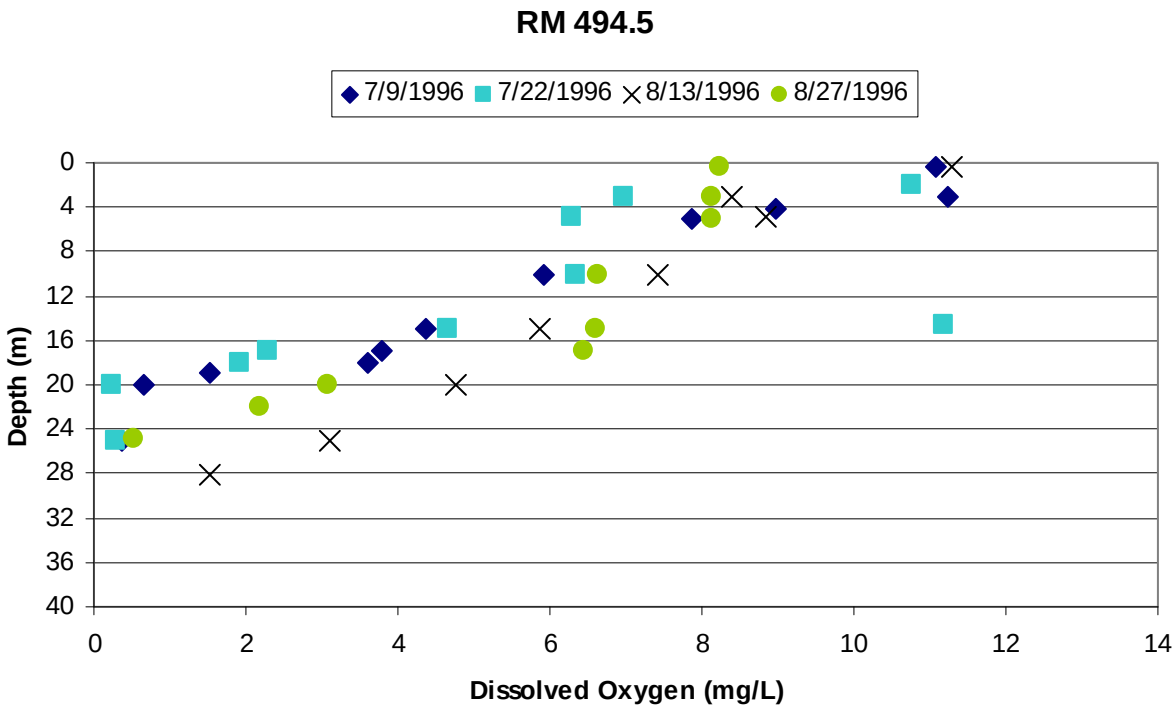
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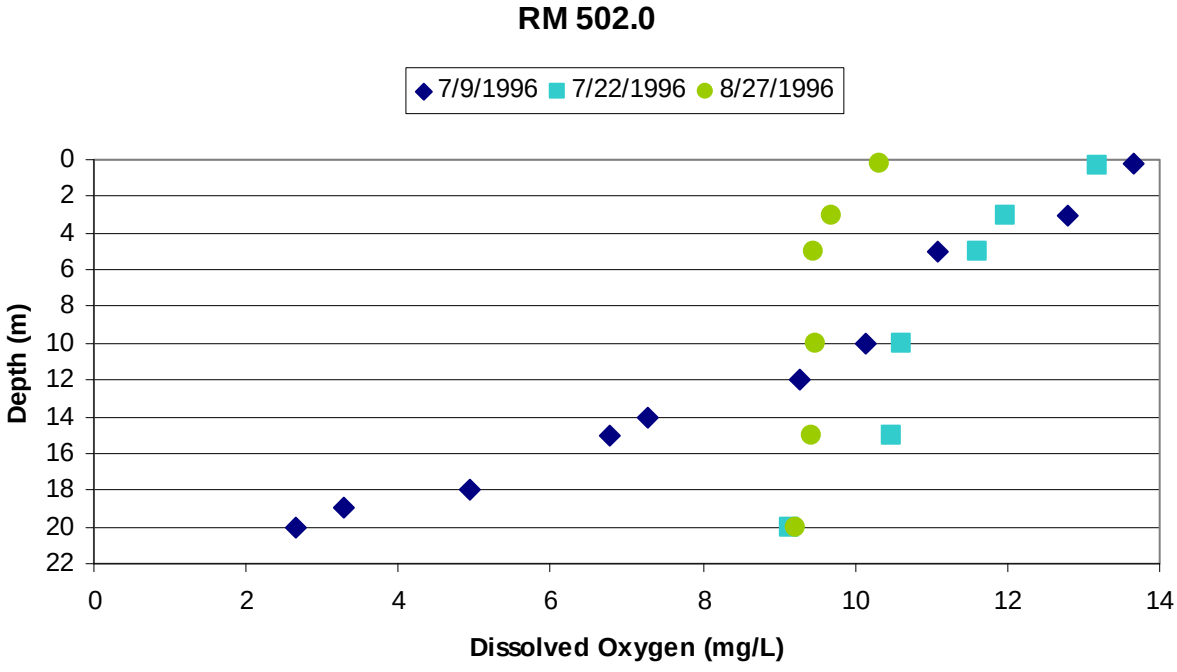

RM 494.5
7/7/1994
8/18/1994
8/30/1994
Depth (m)
0
4
8
12
16
20
24
28
32
36
40
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)

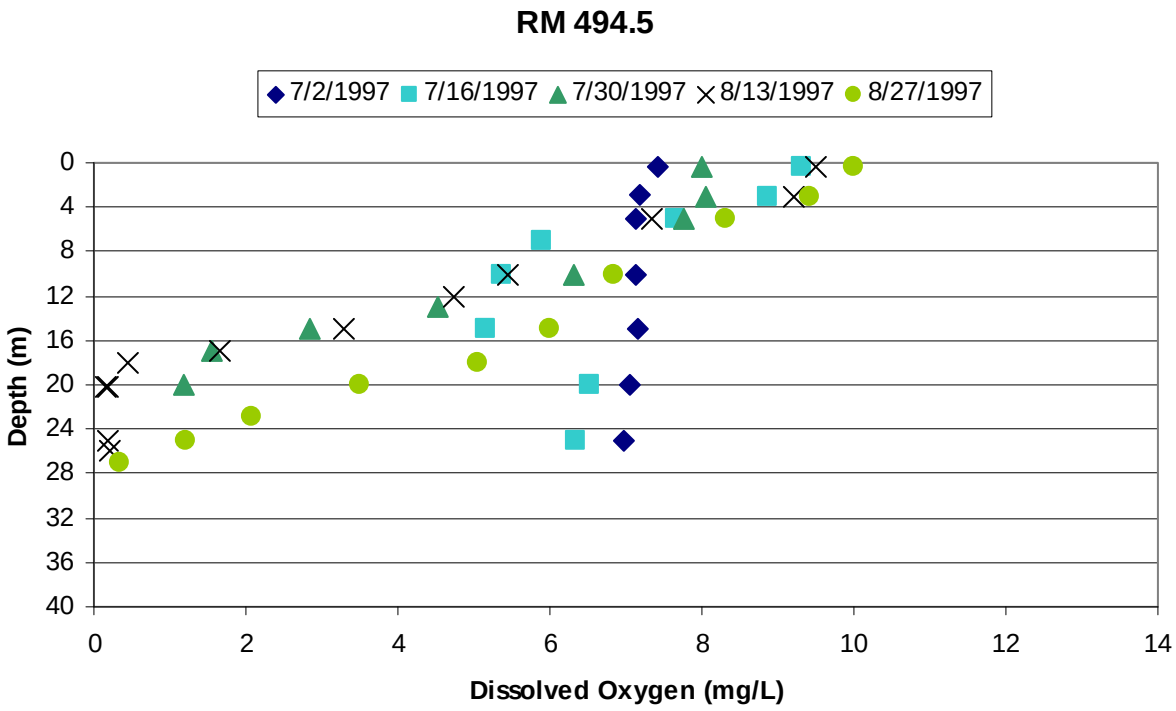

RM 502.0
7/7/1994
8/18/1994
8/30/1994
Depth (m)
0
2
4
6
8
10
12
14
16
18
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22
0
2
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8
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12
14
Dissolved Oxygen (mg/L)

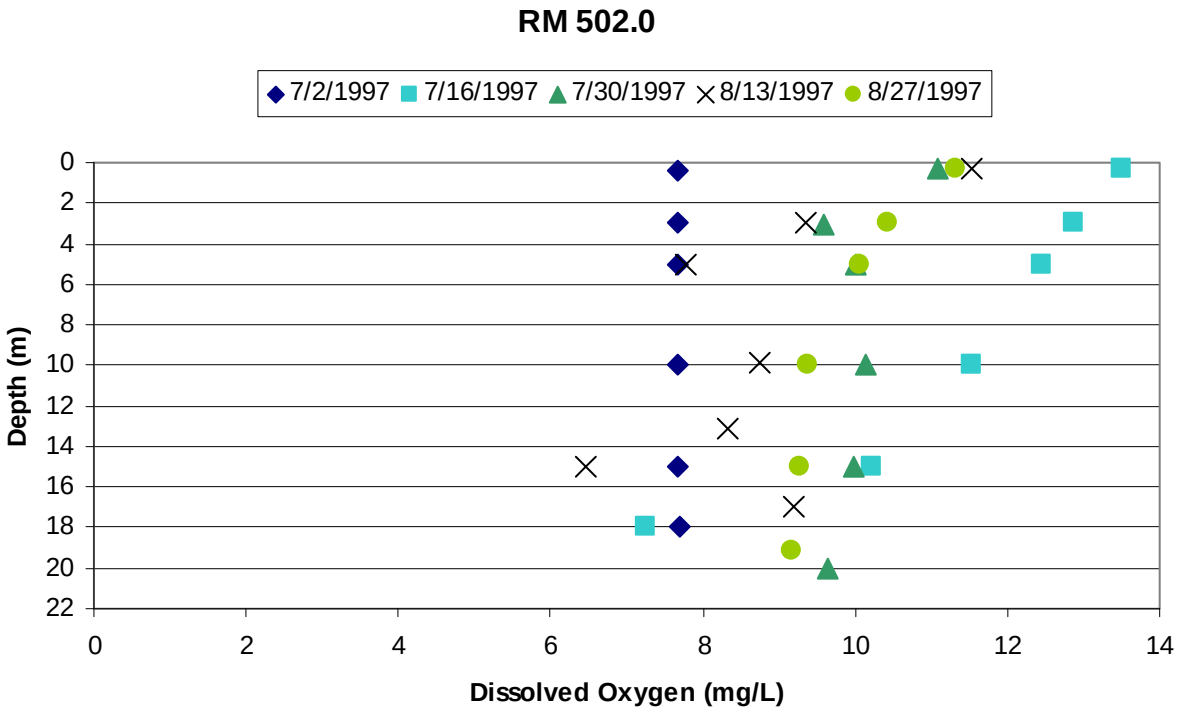

RM 494.5
7/3/1995
7/19/1995
8/7/1995
8/24/1995
Depth (m)
0
4
8
12
16
20
24
28
32
36
40
0
2
4
6
8
10
12
14
16
Dissolved Oxygen (mg/L)


RM 502.0
7/3/1995
7/19/1995
8/24/1995
Depth (m)
0
2
4
6
8
10
12
14
16
18
20
22
0
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8
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12
14
Dissolved Oxygen (mg/L)

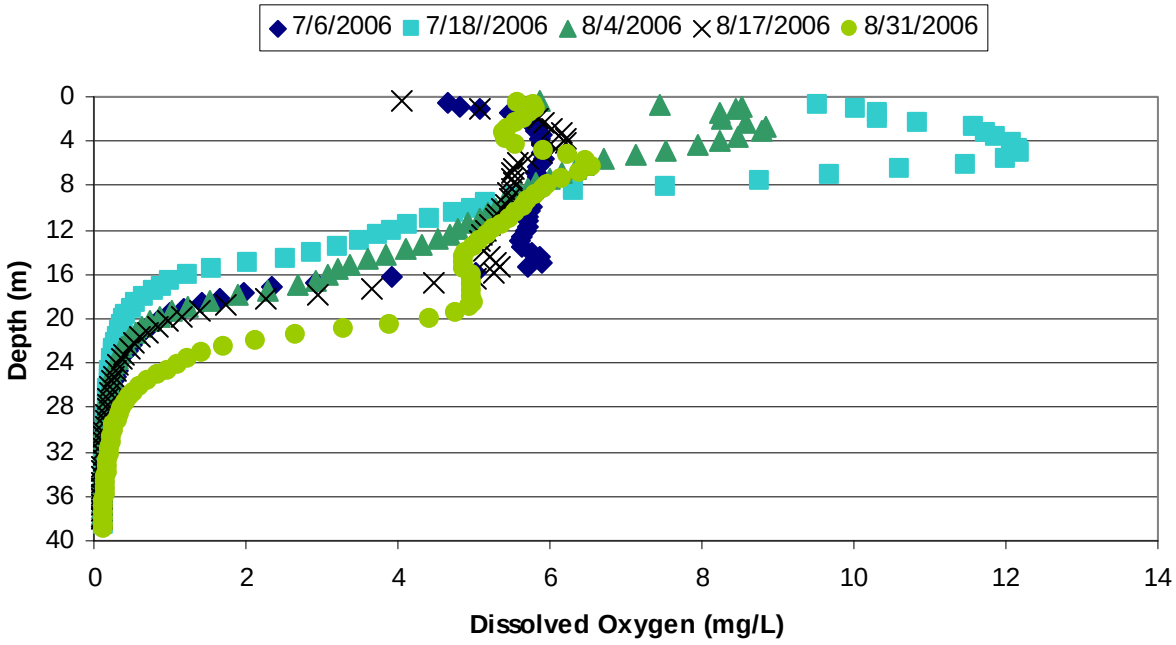

RM 494.5
7/9/1996
7/22/1996
8/13/1996
8/27/1996
Depth (m)
0
4
8
12
16
20
24
28
32
36
40
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)


RM 502.0
7/9/1996
7/22/1996
8/27/1996
Depth (m)
0
2
4
6
8
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14
16
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12
14
Dissolved Oxygen (mg/L)

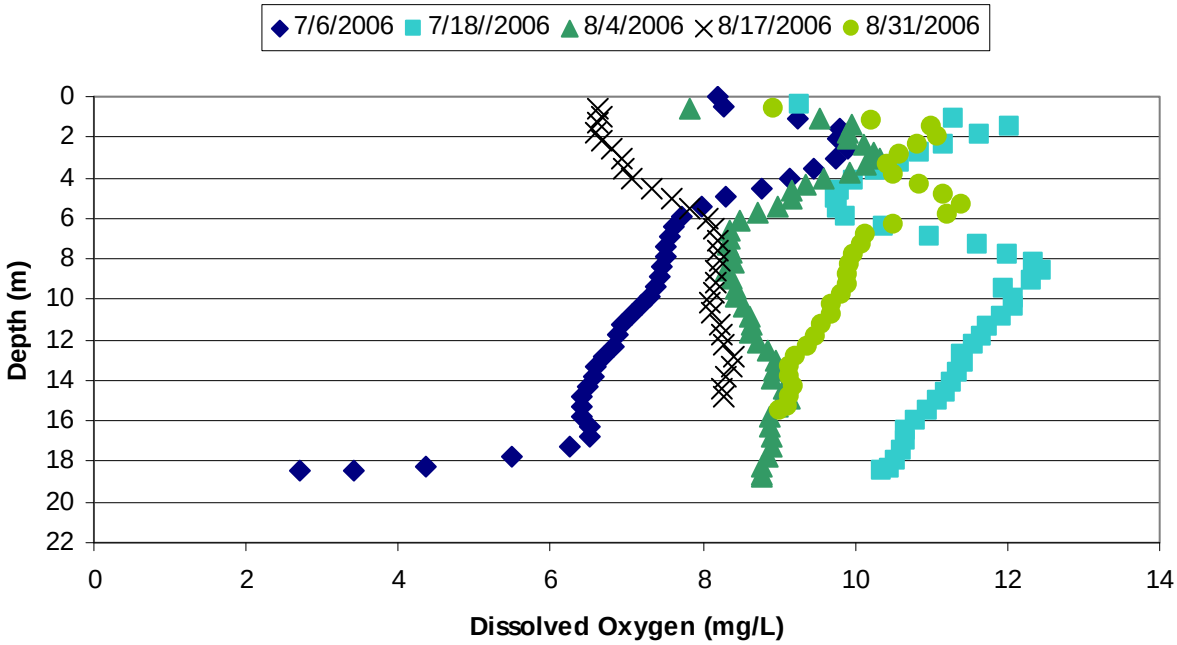

RM 494.5
7/2/1997
7/16/1997
7/30/1997
8/13/1997
8/27/1997
Depth (m)
0
4
8
12
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28
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40
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)

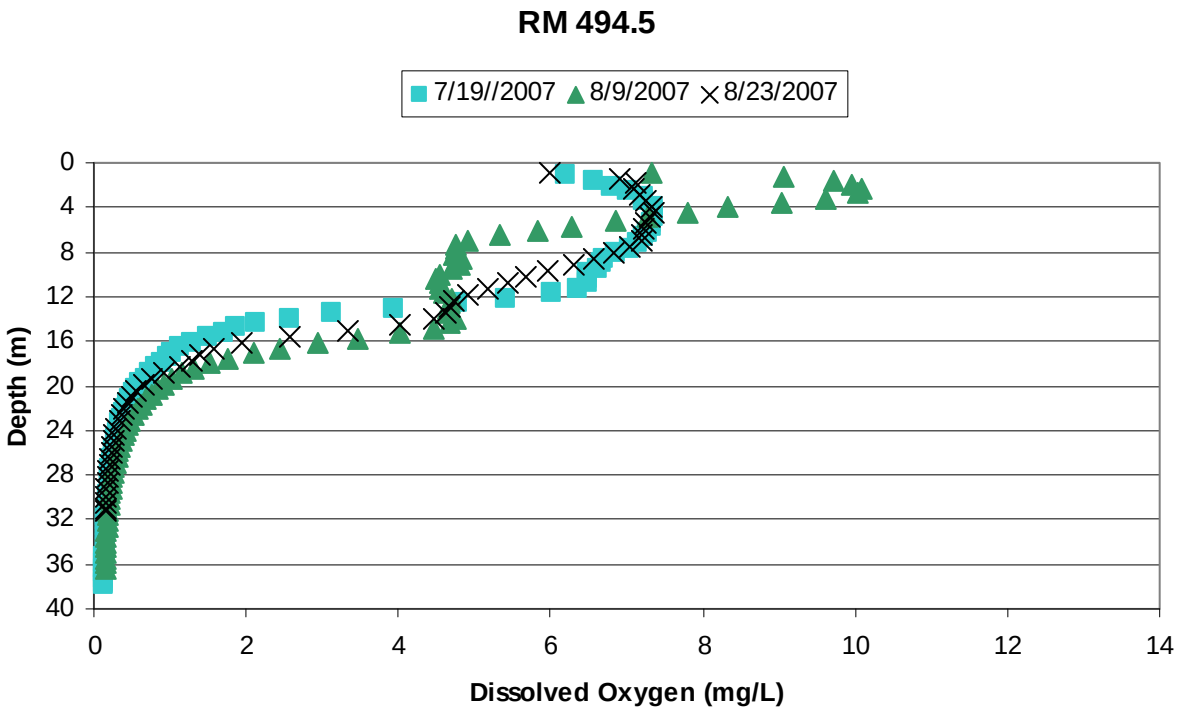

RM 502.0
7/2/1997
7/16/1997
7/30/1997
8/13/1997
8/27/1997
Depth (m)
0
2
4
6
8
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22
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8
10
12
14
Dissolved Oxygen (mg/L)

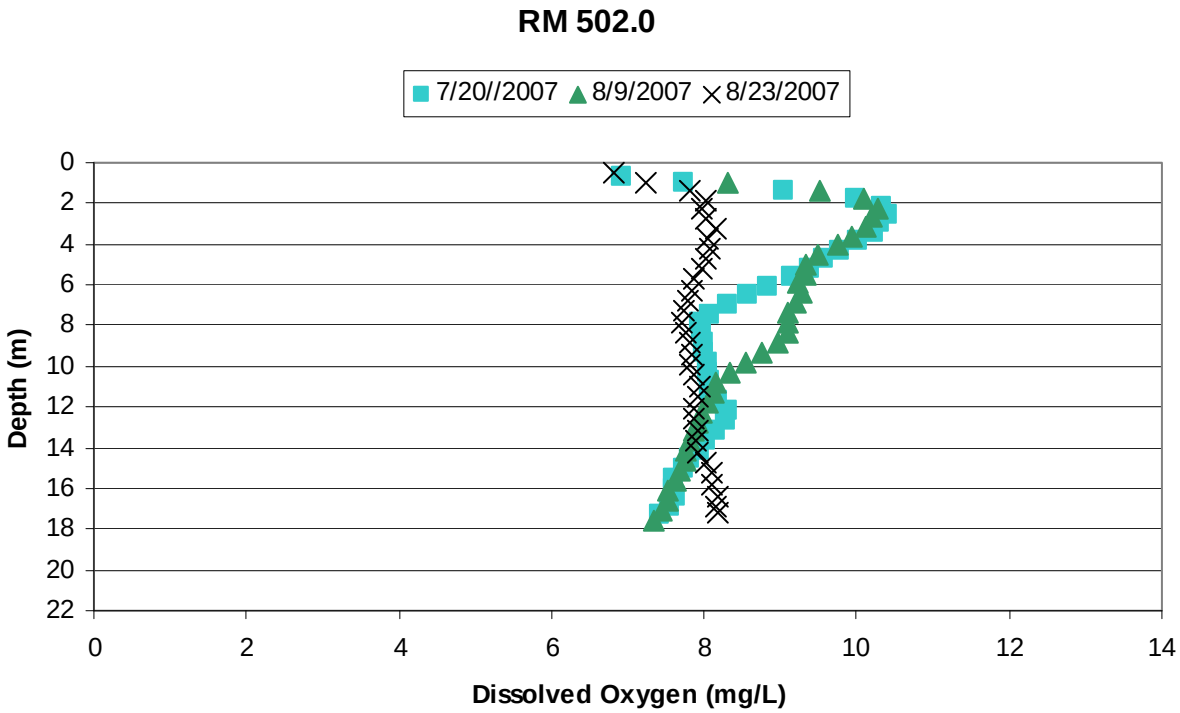
RM 494.5



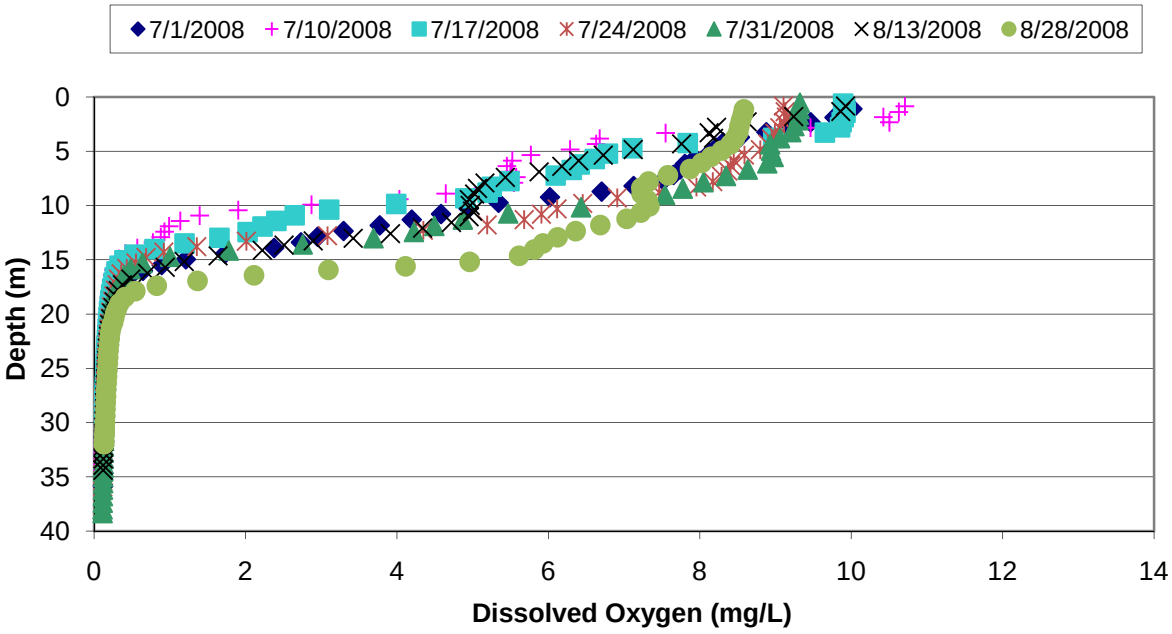
RM 502.0



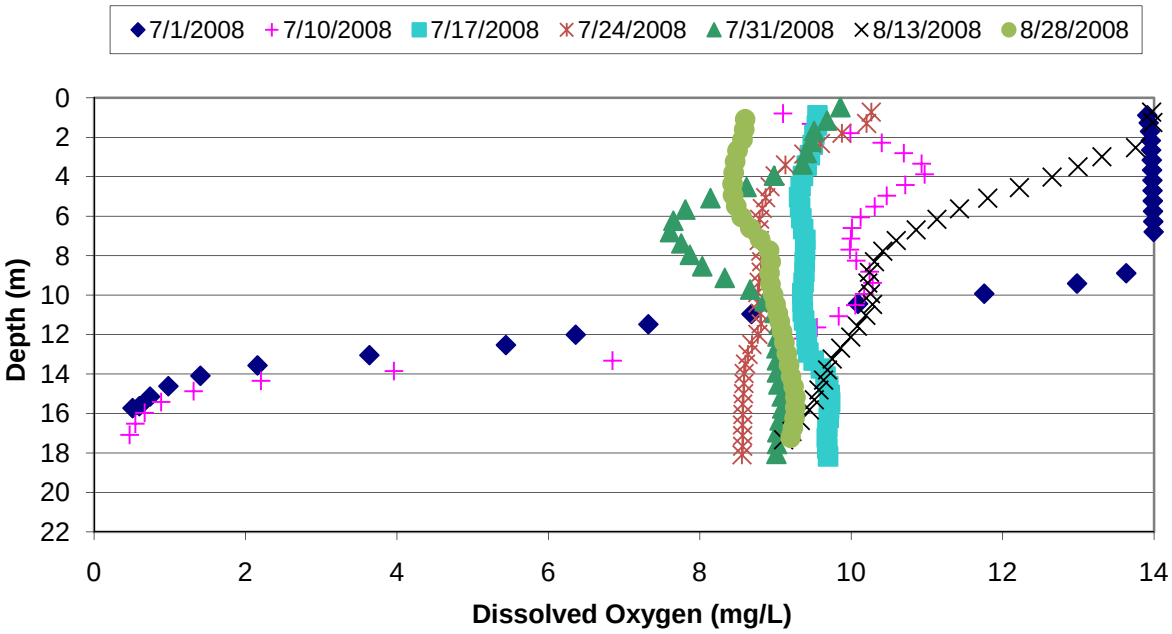

RM 494.5
7/19//2007
8/9/2007
8/23/2007
Depth (m)
0
4
8
12
16
20
24
28
32
36
40
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)


RM 502.0
7/20//2007
8/9/2007
8/23/2007
Depth (m)
0
2
4
6
8
10
12
14
16
18
20
22
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)

RM 494.5



RM 502.0



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Appendix D
Idaho Power Company C.J. Strike Reservoir total maximum daily load modeling report provided to Idaho Department of Environmental Quality.

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Memorandum

Subject 1995 C.J. Strike Reservoir Model Simulations using Draft Subbasin Assessment Target of 75 ug/L

From Brian Hoelscher, Idaho Power Company
Jack Harrison, HyQual
Michael Kasch, HDR
Scott Wells, Portland State University (QC)

Date September 27, 2004

A total phosphorus (TP) target of 75 ug/L has been proposed for the Snake River (above C.J. Strike Reservoir) as part of the King Hill-C.J. Strike Reservoir TMDL (currently being developed). This TP target is being established to address a number of water quality problems in the Snake River related to excess nutrient levels, including the following:

- Nuisance algal conditions (water column and attached) that negatively affect recreational use, including swimming and boating
- Excess organic matter in sediments and subsequent oxygen demand reducing support of aquatic biota
- Potential toxic algal blooms similar to those that have occurred in other areas of Idaho where blue-green algal problems exist
- Production of macrophytes that drift downstream and results on organic matter loads on the reservoir downstream

Additionally, the Idaho Division of Environmental Quality (DEQ) is also proposing a "nutrient-related" dissolved oxygen (DO) allocation for C.J. Strike Reservoir. The intent of the DO allocation is to provide additional Reservoir water quality improvements beyond those that would occur by addressing nutrient related problems upstream. The DO allocation is directed toward increasing DO in the metalimnion.

In this memorandum, we compare the response of the 1995 C.J. Strike Reservoir Model (Harrison, et al, 2004) to the following conditions:

- TP Target—**Short-term improvements** resulting from implementation of the 75 ug/L TP target for the upstream Snake River.
- Improved Sediment Oxygen Demand (SOD) with TP Target—**Long-term water quality improvements**, including reduction in SOD resulting from implementation of TP target.

Methods

To simulate the TP target, we reduced dissolved phosphorus and organic phosphorus (i.e. organic matter, including algae) for the 1995 baseline boundary conditions such that inflowing phosphorus levels did not exceed 75 ug/L (see Attachment A). The DO boundary condition was modified such that DO does not drop below 6 mg/L (Attachment B). Finally, SOD improvements were simulated by replacing baseline SOD values estimated during model optimization with representative values of system with less organic matter loading (see Attachment C).

To facilitate analyses, C.J. Strike Reservoir was divided into three zones: riverine, transition, and lacustrine (Harrison, 2004). The lacustrine zone was further divided into three strata typical of stratified lakes and reservoirs: epilimnion, metalimnion, and hypolimnion (Wetzel, 2001). The locations of these zones are shown in Attachment D.

Changes in DO levels from each of the simulations were compared to baseline conditions using two methods: Comparison with DO Criteria and Volume-Weighted DO. Baseline conditions are represented by the C.J. Strike Model using 1995 measured boundary conditions and optimized to measured in-reservoir water quality data (Harrison, et al, 2004).

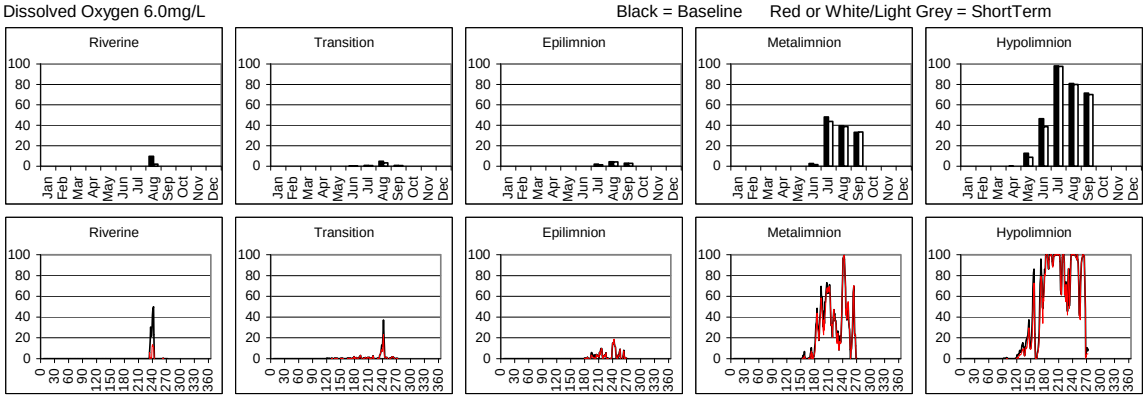
For each time-step, the DO in each cell is compared to the DO criteria of 6.0 mg/L, as proposed in the draft Subbasin Assessment (IDEQ, 2004). If the value was below the criteria, the volume of the cell is added to the "low" volume for its respective zone. The results are then averaged for daily and monthly output. The percent below the criteria is then calculated by dividing the volume below the criteria by the total volume of the zone.

Volume-weighted DO was calculated for the Reservoir and the five zones. The model simulates a DO value for each cell in the model grid. These values were weighted by the volume of the model cell and averaged. The volume-weighted DO calculated for baseline are compared to the simulations for improved conditions and provided in Attachment E.

Simulation Results

Short-Term Improvements: TP Target

This simulation shows C.J. Strike Reservoir's initial response to reductions in TP and organic matter loads based on the TP target of 75 ug/L (Figure 1). When the TMDL is first implemented, SOD will be unchanged from baseline conditions. This limits the initial level of improvement (i.e., increase in DO) in the downstream end of the transition zone and in the lacustrine zone where SOD levels are highest.



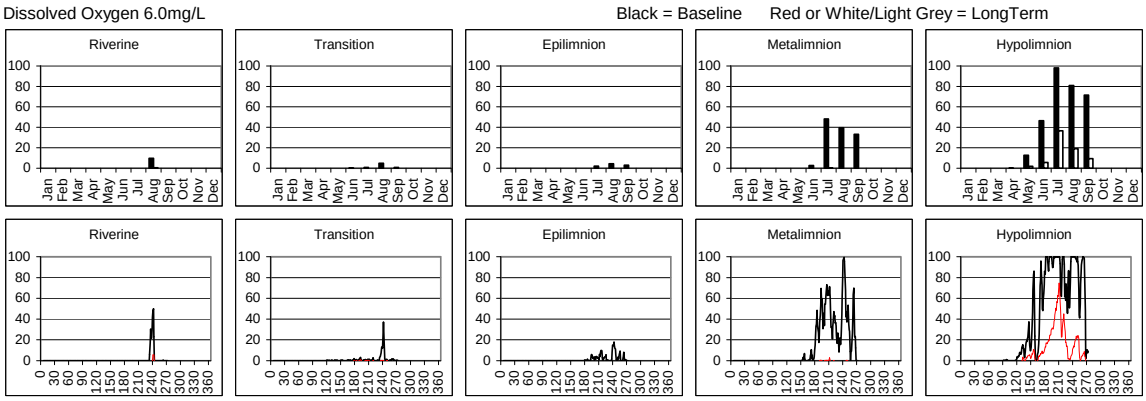
Y-Axis is percent of zone/strata volume below 6 mg/L, X-Axis is Julian day.

Figure 1. Percent of volume below 6 mg/L after short-term improvement resulting from implementation of the 75 ug/L TP target for the Upstream Snake River. Dark line shows percent DO below criteria (6.0 mg/L) for Baseline and light (red) line shows percent DO after TP target implementation.

Long-Term Improvements: Improved SOD with TP Target

Sediment oxygen demand (SOD) is caused by decay of organic matter in bottom sediments. Factors that affect SOD include water temperature (Cole and Wells, 2002) and oxygen content of overlaying waters, and organic matter content sediments (Chapra, 1997). SOD values can range from 0.05 g $m^{-2}d^{-1}$ for mineral soils to 10 g $m^{-2}d^{-1}$ in heavily loaded areas such as near sewage outfalls (Chapra 1997). This is somewhat broader than the range of 0.3 to 5.8 g $m^{-2}d^{-1}$ given in the CE-QUAL-W2 Users Manual (Cole and Wells 2002).

Once the TMDL is implemented, it is anticipated that organic matter loads and sedimentation will decrease. As the loads decrease and existing organic matter decays through natural processes, SOD will decrease. The response to these long-term improvements was simulated by reducing SOD to 0.1 g m^{-2} day^{-1} throughout the Reservoir (Figure 2). This SOD is more typical of levels observed in mineral soils (Chapra 1997). The inflowing boundary conditions are unchanged from the short-term simulation as presented above.



Y-Axis is percent of zone/strata volume below 6 mg/L, X-Axis is Julian day. Metalimnion has a small spike about Julian day 220.

Figure 2. Percent of volume below 6 mg/L after long-term improvements resulting from implementation of the 75 ug/L TP target for the Upstream Snake River and resulting decrease in SOD to 0.1 g m^{-2} day^{-1}. Dark line shows percent DO below criteria (6.0 mg/L) for Baseline and light (red) line shows percent DO with SOD improvement.

The simulation results, as shown above, demonstrate improving conditions from short-term conditions without SOD improvements to long-term conditions with SOD improvements. In general, the simulations show an increase in DO in all zones. The DO improvement is greatest in the metalimnion and hypolimnion.

DO below Criteria with Long-Term Improvements

The mass of DO below the criteria of 6 mg/L with long-term improvements was calculated (Attachment F) to determine DO needed to meet the DO criteria in the metalimnion. The long-term results show a DO mass of 2.2 tons/yr is below the 6 mg/L criteria assuming:

1. Inflow loads are reduced to meet the 0.075 mg/L TP target
2. DO inflow concentrations (e.g. the Snake River boundary conditions) do not fall below 6 mg/L
3. SOD improves over the long-term resulting in a sediment oxygen demand of 0.1 g/m3/day

CONCLUSIONS AND RECOMMENDATIONS

These simulations show substantial improvements in water quality in C.J. Strike Reservoir will occur through implementation of the 75 ug/L TP target proposed for the upstream Snake River after SOD reductions occur (Figure 2). Preliminary simulation results indicate the additional oxygen (approximately 2.2 tons oxygen·yr^{-1}) could further improve DO levels in the metalimnion and increase likelihood of meeting the reservoir DO criteria (6 mg/L) established by Idaho.

References

Chapra, S.C. 1997. Surface Water-Quality Modeling. McGraw-Hill, New York, NY. 844 p.

Cole, T. and S. Wells. 2002. CE-QUAL-W2: A Two Dimensional, Laterally Average, Hydrodynamic and Water Quality Model, Version 3.1. User Manual. Instruction Report EL-02-1. U.S. Army Corp of Engineers. August 2002.

Harrison, J.R. 2004. Memorandum on C.J. Strike Reservoir Zones. Memo to Idaho Power Company.

Harrison, J.R., M.S. Kasch, and S.A. Wells. 2004. C.J. Strike Reservoir CE-QUAL-W2 Water Quality Modeling. Status report to Idaho Power Company.

IDEQ. 2004. Draft Subbasin Assessment for C.J. Strike Reservoir. IDEQ.

Wetzel, R. 2001. Limnology, Lake and River Ecosystems. Academic Press, San Diego, CA.

Attachment A-TP boundary condition (TP less than 75 ug/L)

The baseline boundary condition was developed based on Idaho Power Company (IPC) data as documented in the Water Quality Modeling Report (Harrison, et al, 2004). The reduced boundary condition (Figure A-1) was calculated as follows:

- Calculate total organic matter (TOM) as the sum of LDOM, RDOM, LPOM, RPOM, and Algae
- Calculate organic phosphorus (OP) as TOM divided by 50
- Calculate total phosphorus (TP) as the sum of PO4 and OP
- Find the maximum TP value in the time series
- Divide the target, 75 ug/L by the maximum TP to find the percentage
- Multiply the PO4, LDOM, RDOM, LPOM, RPOM, and Algae in the baseline boundary condition by the percentage to create the reduced boundary condition

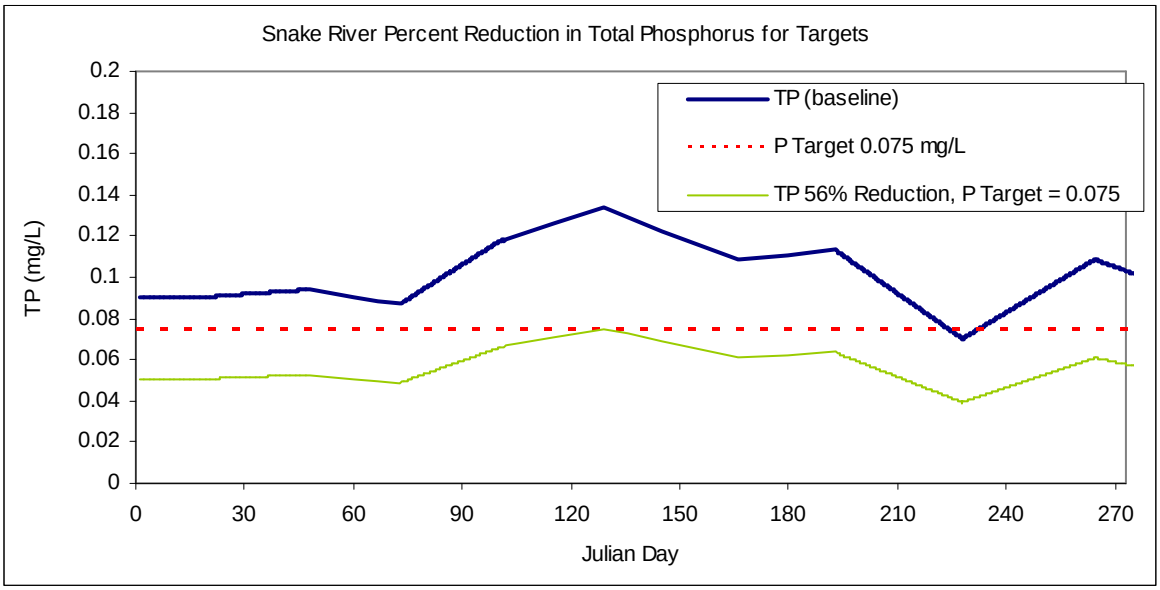
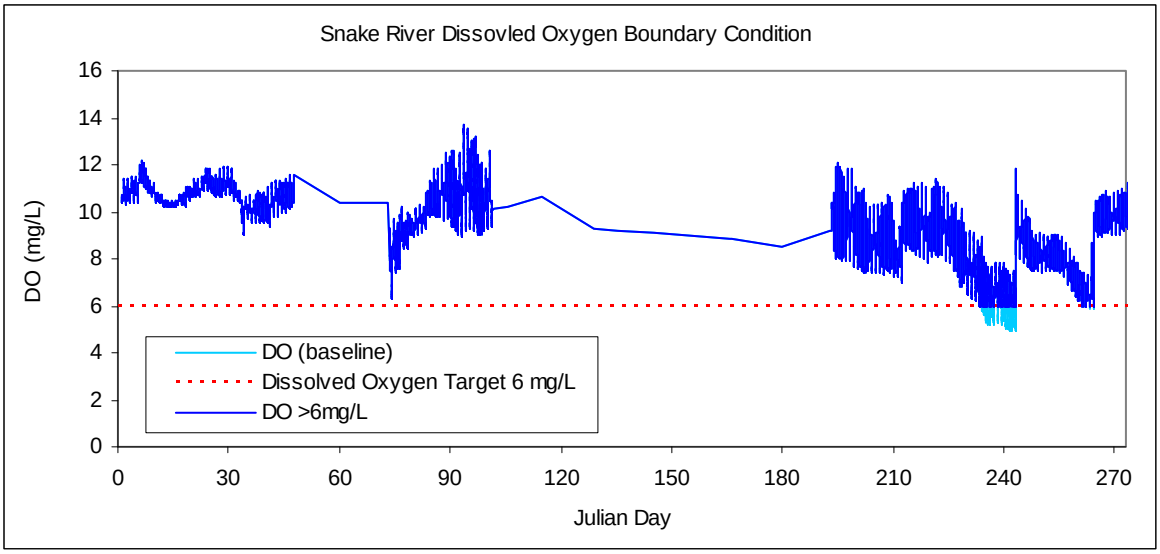


Figure A-1. Snake River Total Phosphorus Reductions

The model boundary conditions and period extends to September 30th. Reservoir profiles, used to optimization kinetic coefficients, are not available after this time. The March through September data are included in this period when temperature and sunlight drive the highest levels of organic matter production and nutrient processing. The January and February data are need to initiate model simulations.

Attachment B-DO Boundary Condition



The short-term and long-term improvements assumed that the inflowing DO would meet the criteria of 6 mg/L.

Attachment C-Optimized Sediment Oxygen Demand

The zero-order model used in the C.J. Strike Reservoir application of CE-QUAL-W2 was set during model optimization based on measured DO levels near the bottom sediment. The optimized (baseline) SOD values (g $m^{-2}d^{-1}$) for each segment, including the Bruneau Arm, are:

S DEMAND	SOD	SOD	SOD	SOD	SOD	SOD	SOD	SOD	SOD
	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	0.50	0.50	0.50	0.50	0.50	0.50	0.60	0.70	0.80
	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	0.50	0.50	0.50	0.50	0.50	0.50			

In the optimized model, a multiplier (FSOD) was used to increase each SOD by a factor of 5, resulting in a variable maximum SOD ranging for 2.5 to 5.0 g $m^{-2}d^{-1}$. The rate applied during the model run is also a function of temperate, as shown in Table C-1. SOD for a FSOD of 1 would range from 0.14 to 0.28 g $m^{-2}d^{-1}$ at 10^{o}C.

Table C-1. SOD for Various Water Temperatures

	SOD	SOD at various temperatures		
Segment	Maximun	5	10	15
Snake River	g O2 / m2-day	g O2 / m2-day	g O2 / m2-day	g O2 / m2-day
2	2.5	0.25	0.70	1.14
3	2.5	0.25	0.70	1.14
4	2.5	0.25	0.70	1.14
5	2.5	0.25	0.70	1.14
6	2.5	0.25	0.70	1.14
7	2.5	0.25	0.70	1.14
8	2.5	0.25	0.70	1.14
9	2.5	0.25	0.70	1.14
10	2.5	0.25	0.70	1.14
11	2.5	0.25	0.70	1.14
12	2.5	0.25	0.70	1.14
13	2.5	0.25	0.70	1.14
14	2.5	0.25	0.70	1.14
15	2.5	0.25	0.70	1.14
16	3	0.30	0.83	1.37
17	3.5	0.35	0.97	1.60
18	4	0.40	1.11	1.82
19	4.5	0.45	1.25	2.05
20	5	0.50	1.39	2.28
21	5	0.50	1.39	2.28
22	5	0.50	1.39	2.28
23	5	0.50	1.39	2.28
24	5	0.50	1.39	2.28
25	5	0.50	1.39	2.28
26	5	0.50	1.39	2.28
27	5	0.50	1.39	2.28
28	2.5	0.25	0.70	1.14
29	2.5	0.25	0.70	1.14

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Attachment D-C.J. Strike Reservoir Zones and Strata

- Snake River

RM beginning	494	495	496	497	498	499	499	500	500	501	501	502	503	504	505	506	506	507	508	509	510	511	512	513	513	514	516	518	520
Segment	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Length:	0.0	2414.0	1609.3	1609.3	841.2	847.3	911.4	992.1	681.2	940.3	1040.9	1152.1	1444.8	1281.7	1249.7	1543.8	752.9	888.5	1609.3	1609.3	1609.3	1609.3	1609.3	1609.3	720.9	923.5	4252.0	3223.3	3223.3	

Layer																														
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Layer Thickness = 2.00 m

Bruneau Arm

RM beginning	0	0.6	1.0	1.6	2.5	3.3	4.0	5.0	6.0	6.7	7.4
Segment	42	41	40	39	38	37	36	35	34	33	32	31
Length:		969.3	640.1	966.2	1379.2	1379.2	1103.4	1609.3	1609.3	1050	1219.2	

Layer												
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17												

Layer Thickness = 2.00 m

Proposed

Zone Limits (rm)

	Begin	End
Riverine	520	513
Transition	513	502
Lacustrine	502	494

Strata Limits (ft-msl)

	Top		Depth to top	
	ft	m	ft	m
Epilimnion	2455	748.3	0	0.0
Metalimnion	2415	736.1	40	12.2
Hypolimnion	2390	728.5	65	19.8

Elevations (msl)	Feet	Meters
Normal maximum pool	2455	748.3
Penstock top	2436	742.5
Penstock centerline	2431	741.0
Penstock bottom	2425	739.1
Reservoir bottom	2316	705.9
Depths (from NMP elevation)		
Maximum depth	139	42.4
Penstock top	19	5.8
Penstock centerline	24	7.3
Penstock bottom	30	9.1

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Attachment E-Volume Weighted DO Results

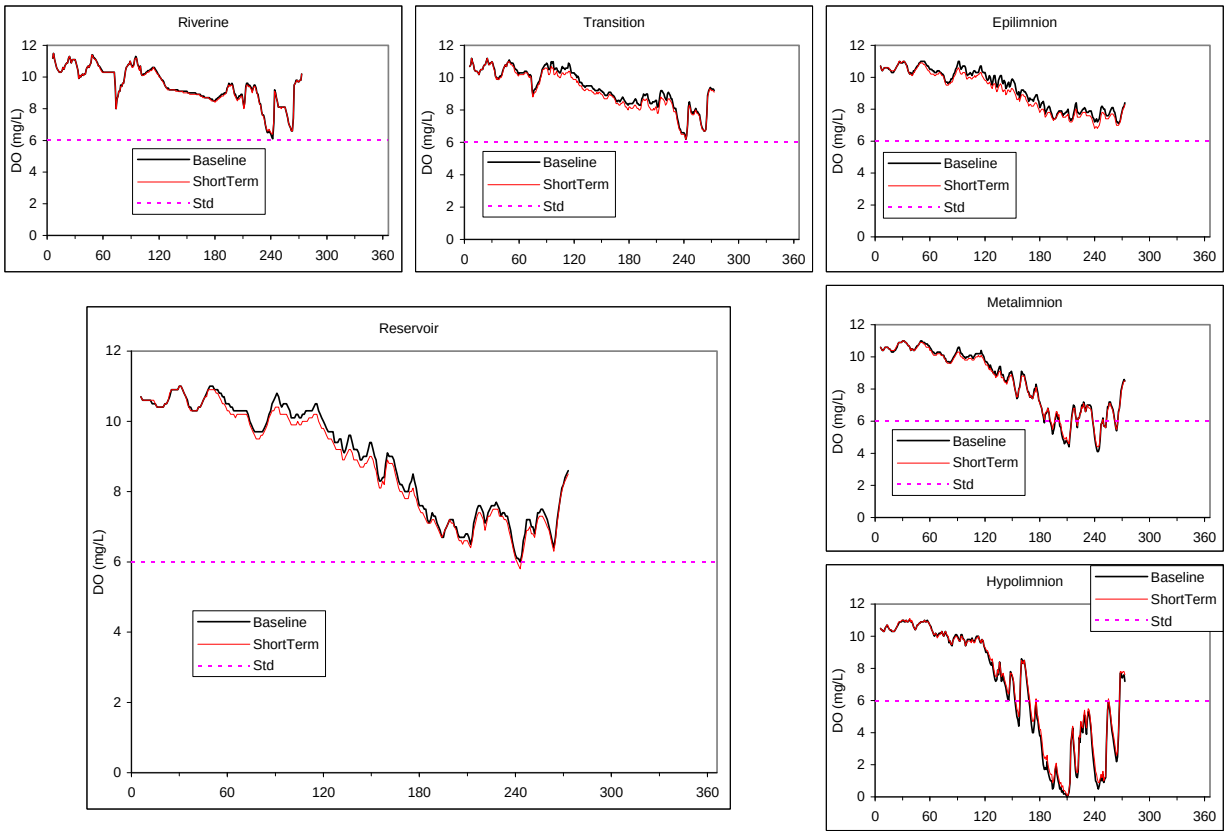


Figure D-1. Simulation results showing short-term improvement resulting from implementation of the 75 ug/L TP target for the Upstream Snake River. Dark line shows volume weighted DO for Baseline and light line shows TP target.

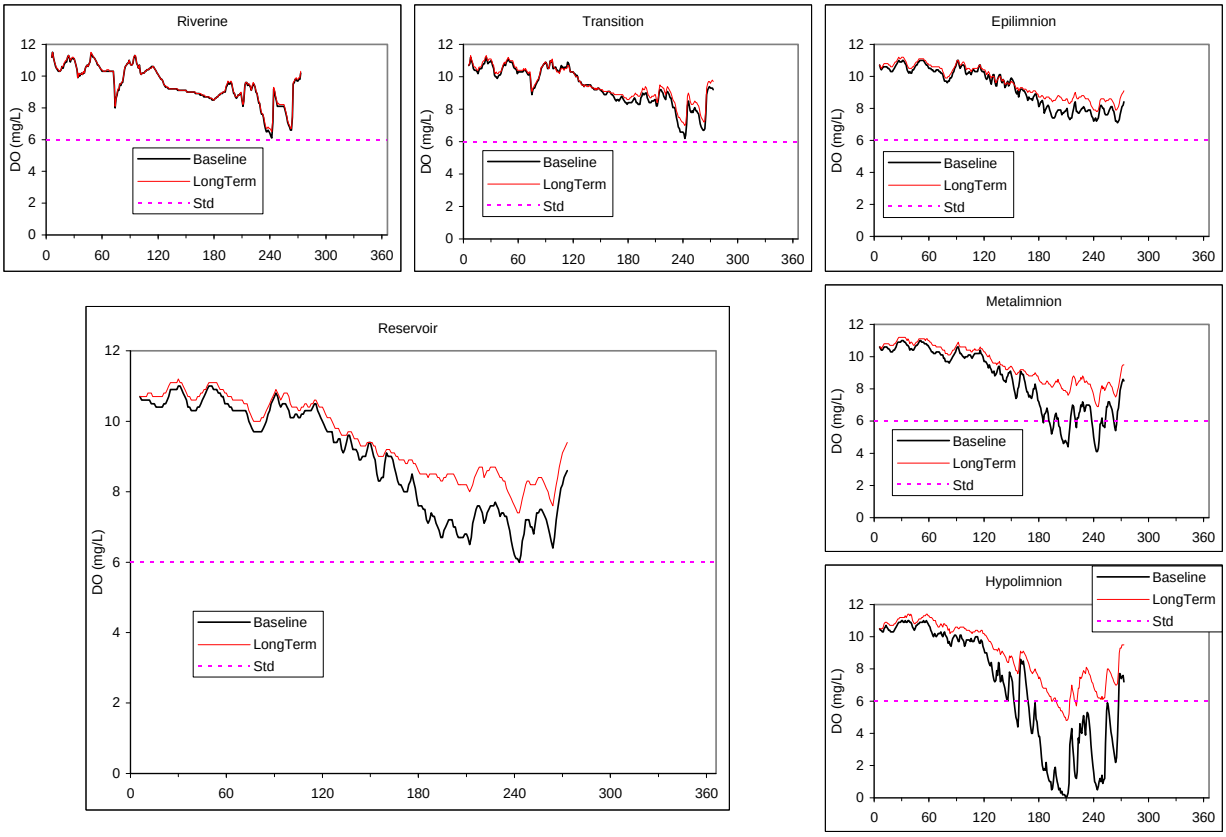


Figure 2. Simulation results showing long-term improvement resulting from implementation of the 75 ug/L TP target for the Upstream Snake River and resulting decrease in SOD. Dark line shows volume weighted DO for Baseline and light line shows TP target with SOD improvement.

Attachment F-Estimation of DO Needed to Meet Target

The volume of the DO below a criteria of 6 mg/L was calculated and used to estimate the mass of DO below 6 mg/L in the metalimnion of C.J. Strike Reservoir. The process involves checking the DO concentration in each cell of the model within the metalimnion and comparing the concentration to the criteria. If the DO concentration is below the criteria, then the volume is summed.

The volume below the DO criteria DO was calculated at 0.5 mg/L increments. The volume difference between each increment is the volume below the different DO concentrations. An example is shown in Table F-1. The volume of DO below the concentration increments is shown in Figure F-1.

Table F-1. Incremental DO Volume Differences July 31,1995 C.J. Strike Metalimnion

DO Conc. (mg/L)	Long-Term (SOD 0.1)	
	Volume Below Conc. (ac-ft)	Difference (ac-ft)
6.0	892.7	686.2
5.5	206.5	116.29
5.0	90.21	90.2
4.5	0	0

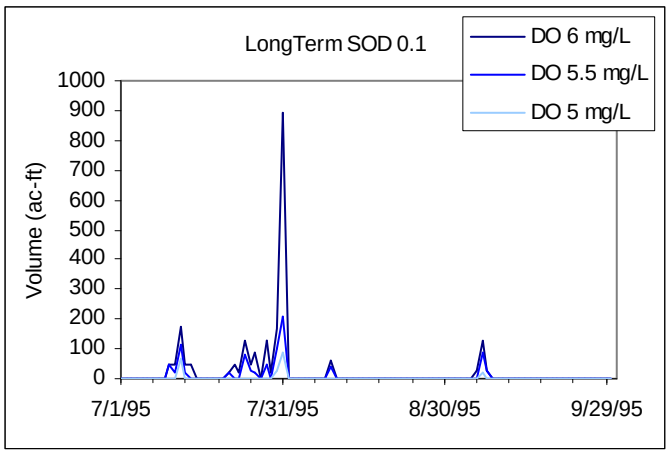


Figure F-1. Metalimnion Volume of DO below each Concentration Increment (ac-ft) for Long-Term (SOD 0.1)

Using this method the DO mass in the epilimnion below the 6 mg/L criteria was estimated for model simulations by multiplying the volume by the DO of increment (i.e., 6, 5.5 and so on). This was then converted to mass of DO in tons per year, with the process applied to various model simulations (Table F-2).

Table F-2. Estimate of C.J. Strike DO Mass

Simulation	Mass of DO (tons/yr)
Baseline	789
Short-Term	750
Baseline (SOD 0.1)	48
Long-Term (SOD 0.1)	2.2
Long-Term (SOD 0.1) with Metalimnion extended down 2m	14.8

Appendix E
Idaho Power Company C.J. Strike Reservoir dissolved oxygen load allocation implementation plan modeling report.

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Technical Memorandum

HyQual
Hydraulics
Hydrology
Water Quality

To: Brian Hoelscher/IPC

From: Jack Harrison/HyQual,PA

Date: July 11, 2008

Subject: CJ Strike Implementation modeling

EPA approved the King Hill-CJ Strike Reservoir TMDL in June 2006. In addition to setting a total phosphorus target of 0.075 mg/L for this reach of the Snake River, an annual 2.2-ton DO load allocation [to be realized between the first of July and the first of September] was established for CJ Strike Reservoir to address water-quality limited waters impaired by nutrients.

An implementation plan was prepared by IPC and submitted to DEQ in November 2007. IPC proposed upstream macrophyte removal as the measure to address the DO load allocation. DEQ responded with a request to provide "[a] baseline of DO in the reservoir as well as the DO response as a result of macrophyte removal."

A water quality model was used to assess dissolved oxygen benefits of the proposed organic matter load reduction. This is the same water quality model (i.e., CE-QUAL-W2) used during development of the King Hill-CJ Strike Reservoir TMDL (see the TMDL for additional information on setup and calibration). To estimate change in reservoir DO levels, simulated reservoir DO levels with the proposed macrophyte removal were compared to simulated DO levels when inflow phosphorus meet the 0.075 mg/L TMDL target, numeric water quality criteria, and long-term sediment oxygen demand (i.e., water quality after implementation of the TMDL).

Additionally, simulated DO levels for inflow water quality meeting a 0.075 mg/L phosphorus target were compared to simulated DO levels when inflow phosphorus levels were set at the downstream phosphorus target of 0.070 mg/L. This represents the difference in reservoir conditions (i.e., reduced assimilative capacity) based on upstream reduction goals for the Mid-Snake (i.e., 0.075 mg/L) compared to downstream reduction goals for the Snake River (i.e., 0.070 mg/L).

Model Setup

Reduced Coarse Particulate Organic Matter

Water quality modeling of CJ Strike Reservoir was used to compare the change in DO levels in the metalimnion of CJ Strike Reservoir resulting from the proposed macrophyte removal and related CPOM reductions. The annual reduction of particulate organic matter (i.e., macrophytes) flowing into the reservoir was estimated at 57 tons (Table 1). This estimate is based on data collected in 2006 and 2007 from upstream projects and does not include macrophyte removal efforts prior to the development of the TMDL. The average monthly CPOM reduction is 0.0069

mg/L, which equates to an average labile coarse particulate organic matter (LCPOM) of 0.0034 mg/L.

Table 1 Estimated monthly CPOM reduction resulting from macrophyte removal.

	Upper Salmon "A" 2006-2007	Lower Salmon Bliss 2007	2007	Total Monthly Truckloads	Macrophyte Wet Weight (ton)	Macrophyte Dry Weight (ton)	(lb/day)	Flow (cfs)	CPOM (mg/L)
January	6	2	9	17	33	3	213	7752	0.0051
February	12	1	3	16	31	3	222	7322	0.0056
March	9	5	6	20	39	4	250	6939	0.0067
April	41	8	5	54	105	10	698	6854	0.0189
May	15	4	3	22	43	4	275	13897	0.0037
June	10	6	1	17	33	3	220	15936	0.0026
July	27	15	1	43	83	8	538	8530	0.0117
August	21	8	2	31	60	6	388	8310	0.0087
September	17	4	4	25	48	5	323	8961	0.0067
October	13	2	2	17	33	3	213	8544	0.0046
November*	19			19	37	4	246	9459	0.0048
December*	14			14	27	3	175	10074	0.0032
Total	204	55	36	295	572	57			
Average							313	9382	0.0069

macrophyte weight per truck (lb)	4730
water on macros in truck	0.18
pound/ton	2000
wet/dry ratio	0.9

* Only 2006 data

LCPOM	**0.5**	**0.0034**
RCPOM	**0.5**	**0.0034**

Because there is uncertainty regarding actual load reductions and typically summer load reductions are greater than winter levels, the estimated average annual CPOM reduction was increased by a factor of 1.3 to better represent average seasonal levels that could occur during the summer. The April-September average CPOM is 0.0087 mg/L. This seasonal average is 1.3 times the annual average of 0.0069 mg/L. The April-September period is likely to be when most of the accumulated organic matter over the year is processed, due to warming water temperatures, and most of the DO demand is realized.

To model potential CPOM reductions, an average CPOM was subtracted from the model boundary (Figure 1).

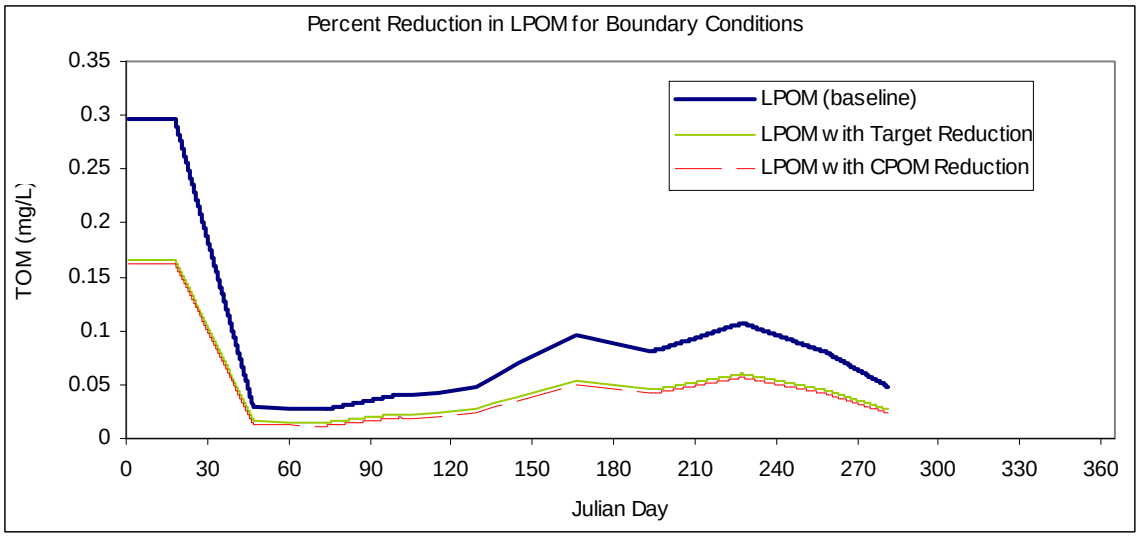


Figure 1 Model boundary conditions (LPOM) for baseline, target reductions (i.e., TP < 0.075 mg/L) and CPOM reductions (i.e., CPOM 0.0069; LPOM 0.0034).

Reduced Snake River Nutrient Target

To compare changes in DO levels for downstream and upstream total phosphorus targets (i.e., 0.070 mg/L versus 0.075 mg/L), the dissolved phosphorus and organic matter boundary conditions were adjusted such that average total phosphorus was less than 0.070 and 0.075 mg/L, respectively.

Simulation Results

Reduced Coarse Particulate Organic Matter

The change in CJ Strike Reservoir DO levels attributable to the proposed macrophyte removal with an April-September CPOM reduction was simulated. The simulated DO levels were compared to simulated DO levels (i.e., baseline) when inflow phosphorus meet the 0.075 mg/L TMDL target (i.e., after implementation of the TMDL). The reservoir DO concentrations on selected dates were converted to tons of DO for each model cell (Attachments A and B). These values were then summed for the metalimnion and the entire reservoir to show change on selected days.

Proposed upstream macrophyte removal with an April-September CPOM reduction increased DO on July 29 0.29 tons and 0.78 tons in the metalimnion and CJ Strike Reservoir, respectively (Table 2). [Note: Modeling conducted to develop the TMDL indicated that metalimnetic sub-standard DO occurred only on July 29. [The July-August seasonal average DO change is 0.17 tons/day and 0.71 tons/day in the metalimnion and reservoir, respectively.]

Table 2 Volume weighted change in DO for the metalimnion and CJ Strike Reservoir for selected days.

		Change in DO (tons)	
Jday	Date	Metalimnion	CJ Strike Reservoir
180	Jun 29	0.18	0.77
190	Jul 9	0.22	0.72
200	Jul 19	0.18	0.64
210	Jul 29	0.29	0.78
220	Aug 8	0.21	0.77
230	Aug 18	0.18	0.68
240	Aug 28	-0.05	0.62
	Average	0.17	0.71

CJ Strike Reservoir has a relatively short retention time, that is, the reservoir typically shows characteristics more similar to run-of-river reservoirs rather than traditional stratified lakes and reservoirs. Using horizontal velocities from the CE-QUAL-W2 model, retention time was estimated for the metalimnion and CJ Strike Reservoir. The metalimnion has a summer (i.e., July-August) retention time of 8.4 days and retention throughout the reservoir is slightly less at 7.8 days. Therefore, this means that the metalimnetic volume of water in CJ Strike Reservoir is replaced 7.4 times during the summer (i.e., 62 days ÷ 8.4 days) and that the entire reservoir volume is replaced 7.9 times. Multiplying the average DO change (Table 2) by the number of times water is replaced provides an estimate of the mass DO change from the proposed macrophyte removal. The estimated mass DO change in model year 1995 is 1.3 tons in the metalimnion and 5.6 tons throughout CJ Strike Reservoir.

Reduced Snake River Nutrient Target

Also assessed was the change in DO with a reduced TP target of 0.070 mg/L. Waters leaving CJ Strike Reservoir must not exceed 0.070 mg/L total phosphorus as established in the Mid Snake-Succor Creek TMDL. The upstream SR-KH target is 0.075 mg/L. IPC reduced inflow boundary conditions to be similar with the downstream target. The change in DO mass between simulated inflow with a target of 0.070 mg/L was compared to simulated DO levels when inflow phosphorus meet the 0.075 mg/L TMDL target (i.e., after implementation of the TMDL). The DO concentration results were converted to tons of DO for each model cell. These values were then summed for the metalimnion and CJ Strike Reservoir to show change on selected days.

The reduced inflow nutrient target of 0.070 mg/L increased DO mass in the metalimnion by 2.34 tons on July 29 (Table 3). The KH-CJ TMDL allocated a DO allocation to IPC of 2.2 tons/year. This allocation was based on IPC modeling. The TMDL concluded:

> After meeting the 0.075 mg/L TP target and achieving a long-term baseline SOD of 0.1 g m^{-2} day^{-1} in the reservoir, there are substantial improvements in metalimnetic dissolved oxygen concentrations.
>
> Only on Julian day 210 (July) do any values below 6.0 mg/L remain in the metalimnion. …

Table 3 Volume weighted change in DO for the metalimnion and CJ Strike Reservoir for selected days.

		Change in DO (tons)	
Jday	Date	Metalimnion	CJ Strike Reservoir
190	Jul 9	0.80	-0.91
195	Jul 14	1.22	1.86
200	Jul 19	1.33	1.66
205	Jul 24	2.04	1.85
210	Jul 29	**2.34**	1.36
	Average	1.54	1.17

CE-QUAL-W2 modeling simulations indicate that a nutrient target of 0.070 mg/L, as established downstream, equals the DO load allocation assigned to IPC for the reduced assimilative capacity of CJ Strike Reservoir.

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Attachment A – Change in DO mass (tons) with 1.3 CPOM reduction

CPOM reduction by 1.3x (i.e., 0.01 mg/L)

Layer	Depth	2	3	4	5	6	8	9	10	11	12	14	16	18	19	20	22	24	25	26	28	29	
2		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
3		0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.003	0.005	
4		0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.007	0.002	0.001	0.002	0.003	0.002	0.003	0.004	
5							0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.002	0.007	0.002	0.002	0.004	0.003	0.003	0.005	0.008	
6										0.000	0.000	0.000	0.001	0.003	0.009	0.003	0.002	0.004	0.005	0.005	0.010	0.016	
7											0.000	0.000	0.001	0.002	0.006	0.002	0.001	0.004	0.005	0.004	0.011	0.020	
8												0.000	0.001	0.002	0.006	0.002	0.001	0.003	0.004	0.004	0.010	0.022	
9												0.000	0.001	0.002	0.003	0.002	0.001	0.002	0.003	0.003	0.008	0.025	
10													0.000	0.002	0.004	0.002	0.001	0.003	0.006	0.003	0.009	0.026	
11														0.003	0.002	0.001	0.001	0.004	0.008	0.004	0.011	0.029	
12														0.002	0.001	0.001	0.001	0.004	0.007	0.004	0.012	0.031	**0.221**
13																0.001	0.001	0.004	0.004	0.003	0.012	0.024	
14																	0.001	0.002	0.003	0.003	0.011	0.018	
15																	0.001	0.001	0.001	0.001	0.004	0.008	
16																			0.000	0.000	0.000	0.000	
	sum	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.002**	**0.002**	**0.003**	**0.005**	**0.003**	**0.006**	**0.019**	**0.050**	**0.018**	**0.015**	**0.038**	**0.054**	**0.040**	**0.109**	**0.236**	**0.602**

Attachment B CJS Strike model geometry and reservoir zones

· **Snake River**

RM beginning	494	495	496	497	498	499	499	500	500	501	501	502	503	504	505	506	506	507	508	509	510	511	512	513	513	514	516	518	520
Segment	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Length:	0.0	2414.0	1609.3	1609.3	841.2	847.3	911.4	992.1	681.2	940.3	1040.9	1152.1	1444.8	1281.7	1249.7	1543.8	752.9	888.5	1609.3	1609.3	1609.3	1609.3	1609.3	1609.3	720.9	923.5	4252.0	3223.3	3223.3	

Layer

Layer																													
1																													
2																													
3																													
4																													
5																													
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14																													
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16																													
17																													

Layer Thickness = 2.00 m

· **Bruneau Arm**

RM beginning	0	0.6	1.0	1.6	2.5	3.3	4.0	5.0	6.0	6.7	7.4
Segment	42	41	40	39	38	37	36	35	34	33	32	31
Length:		969.3	640.1	966.2	1379.2	1379.2	1103.4	1609.3	1609.3	1050	1219.2	

Layer

Layer													
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													

Layer Thickness = 2.00 m

Proposed

Zone Limits (rm)

	Begin	End
Riverine	520	513
Transition	513	502
Lacustrine	502	494

Strata Limits (ft-msl)

	Top ft	Top m	Depth to top ft	Depth to top m
Epilimnion	2455	748.3	0	0.0
Metalimnion	2415	736.1	40	12.2
Hypolimnion	2390	728.5	65	19.8

Elevations (msl)	Feet	Meters
Normal maximum pool	2455	748.3
Penstock top	2436	742.5
Penstock centerline	2431	741.0
Penstock bottom	2425	739.1
Reservoir bottom	2316	705.9
Depths (from NMP elevation)		
Maximum depth	139	42.4
Penstock top	19	5.8
Penstock centerline	24	7.3
Penstock bottom	30	9.1