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# Response to FERC Additional Information Request WQ-2 Part (a)

## Conceptual Design Report

## Temperature Control

## Part (a)
## Conceptual Design Report

Hells Canyon Project
FERC No. P-1971-079

February 2005

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# SCHEDULE A: ADDITIONAL INFORMATION REQUEST WQ-2 TEMPERATURE CONTROL

*Time Required: 9 months*

Nearly all of the agencies, Tribes, and NGOs involved in this proceeding have requested that you evaluate the potential benefits of modifying the Brownlee intake to allow the depth of withdrawal to be adjusted to provide some control over the temperature of water that is discharged from the project. Your application, however, provides little information about this potential enhancement measure. In our EIS on this licensing action, we will need to consider the costs and benefits of this and other measures that could protect and enhance aquatic resources. Therefore, you should evaluate this measure and provide the information that is listed below. We will use this information to examine the effects of variable level releases in terms of improving the reproductive success and growth of fall chinook and effects on other aquatic resources downstream of the project.

Since low oxygen levels frequently occur in the deeper parts of the water column at Brownlee reservoir, your evaluation will need to consider the effects of installing and operating a temperature control structure on downstream DO levels and, if it is needed to avoid adverse effects, the oxygenation of water that is withdrawn at depth from the reservoir. Your evaluation should also consider improvements expected from implementation of the reservoir aeration and turbine venting measures that you proposed in your license application.

To allow us to evaluate this measure, please provide the following information with your evaluation:

(a) Conceptual design report.

Within 3 months of the date of this AIR, please prepare and file with the Commission a conceptual design report on alternative designs for temperature control structures that could be installed at the Brownlee intake. The first part of this report should identify seasonal temperature and DO objectives designed to enhance conditions for fall chinook spawning, incubation, rearing, and migration in the Hells Canyon reach. These objectives should encompass: (1) providing cooler water during the early part of the fall chinook spawning season; (2) accelerating the warming of water temperatures in the spring to promote growth and early emigration; and (3) providing adequate DO levels. The second part of the report should provide conceptual designs and costs of alternative temperature control structures, including any oxygenation measures that may be needed to meet DO objectives.

Your report should include conceptual designs and costs (capital and operation and maintenance [O&M] separately) for at least the following alternatives:

(i) Full depth control (to a depth of approximately 250 feet below full pool) for at least 10,000 cfs of intake capacity. This would entail construction of a full height, gated intake tower and a conduit leading to the intake for unit 5 (11,800-cfs capacity) or to multiple units (units 1 through 4 have a 5,675-cfs capacity for each unit).

(ii) Depth control for all units within the range that is possible using the existing intake channel (up to approximately 150 feet below full pool). This could entail a gated structure across the entrance of the intake channel.

(iii) A combination of Subparts (i) and (ii).

(iv) Full depth control (to a depth of approximately 250 feet below full pool) for all units. This could be accomplished using a control structure constructed across the entrance of the intake channel with a large conduit leading to a gated intake tower.

(b) Preliminary screening of alternative designs to meet temperature objectives.

Within 6 months of the date of this AIR, prepare and file a report that lists each alternative design and evaluates the potential effectiveness of each alternative design for meeting the temperature objectives identified in part (a). Your assessment should include modeling of conditions in each of the 5 representative years (1992, 1994, 1995, 1999, and 1997) under proposed operations and for the flow augmentation scenario described in Scenario 2 of AIR OP-1, *Operational Scenarios*. This report should identify a preferred design that is considered to be the best suited for meeting the temperature objectives that were defined in Part 1 of AIR WQ-2.

*Schedule A (continued)*

(c) Detailed evaluation of the preferred design.

Within 9 months of the date of this AIR, prepare and file a report that provides a detailed evaluation of the potential effectiveness of the preferred design that was identified in part (b) of AIR WQ-2. This report should include modeling of the temperature and DO levels of waters discharged from Hells Canyon dam for each of the 5 representative years (1992, 1994, 1995, 1999, and 1997) under proposed operations and for the flow augmentation scenario described in Scenario 2 of AIR OP-1, *Operational Scenarios*. Your evaluation should include multiple model runs as needed to develop and refine a seasonal strategy for withdrawing water from selected depth(s), including blends of water drawn from more than one depth, to meet the seasonal temperature objectives identified in part (a) of AIR WQ-2. Your report should identify a preferred seasonal withdrawal strategy and determine the timing and amount of oxygen that would need to be added to outflows from the Brownlee development to meet the DO objectives identified in part (a) of AIR WQ-2. In addition, please provide a qualitative evaluation of the potential effects of that strategy on ammonia levels, pH levels, and concentrations of mercury and organo-chlorine compounds in the waters discharged from Hells Canyon dam. In your simulations, please assume implementation of aeration of Brownlee reservoir as you have proposed, as well as venting of Brownlee units 1 through 5. Also provide a proposed implementation schedule and a detailed estimate of design, construction, and operation costs (including any oxygen augmentation measures that are needed to meet DO objectives that are not explicitly addressed in AIR WQ-1, *Dissolved Oxygen Augmentation*) and any effects on project generation or dependable capacity from implementing the preferred alternative. Please provide your estimate of capital and operating costs and any effects on project generation or dependable capacity by year over the term of the next license, assuming a 30-year license.

For your proposed withdrawal strategy, please provide plots of the following information for both proposed operations and for the flow augmentation scenario:

(i) A plot of simulated hourly water temperatures below Hells Canyon dam from January 1 through December 31 for each of the 5 representative years (1992, 1994, 1995, 1999, and 1997).

(ii) A plot of simulated hourly DO levels below Hells Canyon dam from January 1 through December 31 for each of the 5 representative years (1992, 1994, 1995, 1999, and 1997).

(iii) Semi-monthly plots (February, April, June, August, October and December) of simulated temperature and DO isopleths in Brownlee reservoir for each of the 5 representative years (1992, 1994, 1995, 1999, and 1997). These plots should be similar in format to the plots that you provided in figures 13 and 26 of Technical Appendix E.2.2-2, except that each plot should be provided in a full-page, black-and-white format.

(iv) A qualitative evaluation of the potential effects on ammonia levels, pH levels, and concentrations of mercury and organo-chlorine compounds in the waters discharged from Hells Canyon dam for each of the 5 representative years (1992, 1994, 1995, 1999, and 1997).

Each of these graphs should be provided in a full-page black-and-white format to ensure that all data series are visible both in hard copy and electronic formats. To facilitate side-by-side comparisons, please provide the same graphs for your current and proposed operations[1] using the existing intake configuration and the current depth of withdrawal.[2] Please use the same scale and format that you use in the graphs that you provide in your response to parts (e)(i) through (e)(iv) of AIR OP-1.

Include comments from NOAA Fisheries, FWS, IDFG, IDEQ, ODFW, ODEQ, CRITFC, NPT, SBT, SPT, BPT, CTUIR, and CTWS on the information identified in parts (a), (b), and (c) of this AIR and your response to their comments with your filing.

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[1] In AIR OP-2, Current Operations Scenarios, we ask you to determine whether your proposed operations are the same as your current operations.

[2] If agreement can be achieved with the consulted agencies, the number of alternatives, scenarios, and time-steps (days and months) that are modeled in parts (a) and (b) of this request can be reduced.

# 1. INTRODUCTION

In accordance with FERC AIR WQ-2, this report provides conceptual designs and estimated costs for alternative temperature control structures that "could be installed at the Brownlee intake" [3]. AIR WQ-2 requires that the first part of the report identify "seasonal temperature and DO objectives designed to enhance conditions for fall chinook spawning, incubation, rearing, and migration in the Hells Canyon reach", specifying that these objectives should encompass: (1) providing cooler water during the early part of the fall chinook spawning season; (2) accelerating the warming of water temperatures in the spring to promote growth and early emigration; and (3) providing adequate DO levels. IPC addresses these objectives in this report. However, factual issues remain as to whether the measures contemplated by AIR WQ-2 would provide any benefits to the fall chinook resource below Hells Canyon Dam. Idaho Power Company believes, based on extensive scientific evidence, that the HCC, under its current configuration and operations, adequately protects and supports fall chinook spawning and rearing.[4] This protection and support includes adequate water temperature and dissolved oxygen conditions below the project.[5] Legal issues also remain relating to whether implementation of the measures that are the subject of AIR WQ-2 would "enhance" the fall chinook resource within the meaning of the Federal Power Act.[6] By completing AIR WQ-2 and submitting this report, IPC neither waives nor abandons its previous objections or the factual and legal defenses to AIR WQ-2.

The second part of this report provides conceptual designs and costs, including conceptual oxygenation measures to meet DO objectives, for alternatives with the characteristics specified by FERC in AIR WQ-2. To comply with AIR WQ-2, several potentially feasible selective withdrawal concepts were developed, and reconnaissance level plans and construction cost estimates for most of the potentially feasible structures were prepared. From these conceptual and reconnaissance level plans and estimates, five alternatives have been selected for further evaluation. Tables 1 and 2 identify the alternatives selected for further evaluation, along with reconnaissance level construction and operation cost estimates.

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[3] Although IPC's preliminary review indicates that the submitted alternative designs "could" be installed at the Brownlee intake, substantial issues related to the technical and economical feasibility of installing such alternatives remain for later review and analysis.

[4] Support for this position is contained in the FLA and is summarized in the Request of Idaho Power Company for Rehearing and Request for Stay Pending Decision ("IPC's Request") dated July 29, 2004.

[5] The best available information indicates that current water temperature and DO conditions below the HCC adequately support salmonid uses. See generally the FLA, IPC's Request, and IPC's Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River, August, 2004, Appendix D.

[6] IPC maintains that such measures cannot be considered "enhancement" under the FPA, because the purpose of such measures is to mitigate for the effects of the downstream federal projects, not for the effects of the HCC. See: IPC's Request.

The five alternatives selected for further evaluation in accordance with AIR WQ-2 were selected because, based on our preliminary evaluations, they best complied with the descriptions of the selective withdrawal alternatives provided by FERC in AIR WQ-2, and because they were identified to be the most effective, least cost methods to achieve the downstream water temperature and DO objectives in AIR WQ-2. There are three other alternatives that might achieve the objectives even more efficiently; however, the short time period available to respond to this AIR precluded further assessment of these alternatives at this time. These three alternatives are: a pump-and-pipe system to lift hypolimnion water into the intake channel, air bubble upwelling of the hypolimnion in the powerhouse forebay, and construction of a selective withdrawal curtain across the width of the reservoir upstream of the powerhouse intake.

Four considerations are critical to the evaluation of the adequacy of any potential alternatives. The first critical consideration is that the cooling potential of selective withdrawal structures at Brownlee is principally limited by the amount of inflows and spring flood control operations. In a high inflow year, with a corresponding flood control draft, the average reservoir temperature will be substantially warmer in late summer and fall than it will be in a low inflow year. Thus, in a high flow year, it may not be possible to attain the fall temperature targets with any type of selective withdrawal structure. In low and moderate inflow years, with much more limited flood control drafts, it is more feasible to minimize the hypolimnion water temperature and thus have a greater potential impact on downstream temperatures in the fall.

A second critical consideration is that the amount of cold water that can be stored in Brownlee is limited, which correspondingly limits the amount of cooling of water downstream that can be accomplished through selective withdrawal at Brownlee Reservoir.

A third critical consideration is that the amount of cold water available in Brownlee Reservoir below the sill of the existing intake is even more limited than the total amount of cold water that can be stored in the reservoir. Thus, deep withdrawal structures may have a lower benefit versus cost ratio than structures in the intake channel.

A fourth consideration critical for assessment of the effectiveness of the alternatives is an understanding of the typical operations of Brownlee powerhouse and reservoir in the fall. Although IPC reduces the flows below Hells Canyon Dam each fall to aid successful downstream salmon spawning and incubation, it remains very important during this period for IPC to be able to ramp flows through Brownlee powerhouse up and down each day to meet system needs, even during the fall chinook spawning period. Currently, IPC is able to efficiently increase flows through Brownlee powerhouse at any time of year to meet the daily load peaks, and to reduce powerhouse flows during the off-peak hours, using the downstream Oxbow and Hells Canyon Reservoirs to regulate flows to maintain relatively constant flows below Hells Canyon Dam during the salmon spawning period. Even though average flows through Brownlee are low during the fall chinook spawning period, it is important to retain the powerhouse peak flow capacity during this period. If a selective withdrawal structure installed at Brownlee requires that high flows be drawn through relatively small channels, with corresponding high energy loss, it will inhibit the ability of the HCC to efficiently use the inflows to meet system needs and regional power demands.

This report is being mailed to the organizations listed in FERC AIR WQ-2 (NOAA Fisheries, FWS, IDFG, IDEQ, ODFW, ODEQ, CRITFC, NPT, SBT, SPT, BPT, CTUIR, and CTWS). In consideration of the limited time allowed to respond to this AIR, during the organization review period, and pending receipt of comments, IPC is proceeding with performance evaluations of the five alternatives considered by IPC to have the best potential to comply with the characteristics described by AIR WQ-2. These five alternatives are those shown in Table 2.

It is emphasized that the costs and concept plans contained in this report are reconnaissance level plans and estimates, and that further refinement of any of the concepts might result in significant variations from the cost estimates and concept plans shown herein.

# 2. RESPONSES

## 2.1. Response to Part (a)—Conceptual Design Report

*(a) Conceptual design report*

Within 3 months of the date of this AIR, please prepare and file with the Commission a conceptual design report on alternative designs for temperature control structures that could be installed at the Brownlee intake. The first part of this report should identify seasonal temperature and DO objectives designed to enhance conditions for fall chinook spawning, incubation, rearing, and migration in the Hells Canyon reach. These objectives should encompass: (1) providing cooler water during the early part of the fall chinook spawning season; (2) accelerating the warming of water temperatures in the spring to promote growth and early emigration; and (3) providing adequate DO levels. The second part of the report should provide conceptual designs and costs of alternative temperature control structures, including any oxygenation measures that may be needed to meet DO objectives.

Your report should include conceptual designs and costs (capital and operation and maintenance [O&M] separately) for at least the following alternatives:

(i) Full depth control (to a depth of approximately 250 feet below full pool) for at least 10,000 cfs of intake capacity. This would entail construction of a full height, gated intake tower and a conduit leading to the intake for unit 5 (11,800-cfs capacity) or to multiple units (units 1 through 4 have a 5,675-cfs capacity for each unit).

(ii) Depth control for all units within the range that is possible using the existing intake channel (up to approximately 150 feet below full pool). This could entail a gated structure across the entrance of the intake channel.

(iii) A combination of Subparts (i) and (ii).

(iv) Full depth control (to a depth of approximately 250 feet below full pool) for all units. This could be accomplished using a control structure constructed across the entrance of the intake channel with a large conduit leading to a gated intake tower.

### 2.1.1. Temperature and DO Objectives

Consistent with FERC AIR WQ-2 and subject to the qualifications set forth herein, IPC is assessing the feasibility, cost, and effectiveness of alternative designs to achieve the following general objectives for temperature and DO in the discharge from Hells Canyon Dam.

#### 2.1.1.1. General Objectives:

- Accelerate the warming of water temperatures in the spring to promote growth and early migration;
- promote cooler fall temperatures in the discharge from Hells Canyon Dam during the early part of the fall chinook spawning period;

- provide adequate DO levels in the river downstream of Hells Canyon Dam during fall chinook spawning, incubation, rearing and migration downstream of Hells Canyon Dam.

### 2.1.1.2. Specific Targets

In an effort to assess the effectiveness of the alternatives considered in achieving those objectives, IPC has established the following targets.

#### *2.1.1.2.1. Target Water Temperatures in Hells Canyon Dam Discharge*

- Daily temperature of water being discharged from Hells Canyon Dam equals daily temperature of water flowing into Brownlee Reservoir from the time in January when inflow temperatures are warmer than discharge through the time that inflow temperatures rise above 18 °C.

    - Rationale: The general objective is to accelerate the warming of water temperatures [below the HCC] in the spring to promote growth and early migration.[7] The HCC moderates the temperature influences of the upstream Snake River, generally keeping discharge temperatures cooler in the spring and early summer, and warmer in the early fall, than inflow water temperatures. In the spring of the year, this moderating effect keeps discharges within water quality standards.

      This specific target is intended to achieve the general objective of accelerating the warming of Hells Canyon Dam discharges in the spring while recognizing that the ability of the HCC to provide warmer water is limited by the temperature of inflows to the project. In early January, outflow temperatures are often warmer than inflows to Brownlee Reservoir, however, later in the month inflow begins to warm and become warmer than outflow temperatures. As such, inflow temperatures to Brownlee Reservoir in early spring represent the maximum potential warming for Hells Canyon outflows.

    - Daily temperature in Hells Canyon Dam discharges on October 23 through the period when discharge temperatures fall to 13 °C without temperature modification not to exceed 13° C or daily temperature of water inflowing into Brownlee Reservoir, whichever is greater.

[7] IPC questions the need to increase the temperature of discharges from the HCC in the spring, but notes that NOAA Fisheries has posited in comments filed with FERC that warmer late winter and early spring temperatures in the discharge from the HCC may aid in the outmigration of juvenile fall Chinook through the lower Snake River. While an increase in water temperature may hasten the growth and emergence of juvenile fish, IPC contends that since the construction of the HCC, fall chinook smolts in the Snake River below the HCC are emerging earlier than fish did historically in the same reach, and that fish from below Hells Canyon Dam would be out-migrating through the lower Snake River earlier than what occurred historically were it not for the construction of Lower Granite Dam and Reservoir. (See: Technical Appendix E.3.1-2 chapter 5 of the HCC FLA).

- ° Rationale: The general objective to be analyzed under AIR WQ-2, with regard to fall temperatures, is to provide "cooler water during the early part of the fall chinook spawning season." October 23 represents the initiation date of the period defined for fall chinook spawning (IDEQ and ODEQ 2003) for the Snake River below Hells Canyon Dam. A literal reading of WQ-2 imposes the assumption in the analysis that water cooler than existing conditions below the HCC is necessary on or after October 23rd to promote or protect fall chinook spawning below the HCC. While IPC has accepted this assumption for the purposes of its analysis of this objective, it neither agrees with it nor believes that existing data and information support it. Because IPC believes that existing water temperature conditions below the HCC support fall chinook spawning, the target temperature it chose to use to assess the effectiveness of the alternatives considered is not based on the needs of the species. A 13 °C target temperature is consistent with the fall chinook spawning season temperature identified in the Snake River-Hells Canyon TMDL (IDEQ and ODEQ 2003). However, a single salmonid spawning temperature criterion is not equally appropriate in all waters, at all latitudes, in all years, or even for the entire spawning season in a single year.[8] The 13 °C temperature criteria are overly simplistic and were developed based on studies of constant temperature regimes.

#### *2.1.1.2.2. Target Dissolved Oxygen in Hells Canyon Dam Discharge*

AIR WQ-2 requires IPC to identify seasonal DO objectives "designed to enhance conditions for fall chinook spawning, incubation, rearing and migration in the Hells Canyon reach", with the specific objective of providing "adequate DO levels". Because of the size and complexity of the Snake River watershed and the effect of upstream anthropogenic influences on downstream water quality, responsibility for water quality issues that manifest themselves below the Hells Canyon Dam cannot be allocated solely to the HCC. In 2003, the Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ) jointly developed the "Snake River-Hells Canyon Total Maximum Daily Load" (SR-HC TMDL) for the Snake River between river miles (RM) 409 and

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[8] IPC has recently submitted a draft petition to IDEQ seeking to establish a fall salmonid temperature criteria that more closely approximates the temperature requirements of the Snake River fall chinook salmon. (See Appendix D.) Evaluations of the declining temperature regime in the Columbia River demonstrate that healthy fall chinook salmon populations initiate spawning at temperatures above 13 °C. In an in-river environment, fall salmon spawning typically begins at temperatures near 16 °C under a declining thermal regime. A temperature decline of approximately 0.2 °C per day during this fall spawning period is typical in (1) historical water temperature measurements (pre-project measured at Oxbow), (2) present day inflowing waters to the HCC, and (3) present day waters below Hells Canyon Dam. IPC is also currently conducting studies that examine the Snake River fall chinook salmon survival at various declining temperature regimes. Preliminary results suggest no significant differences in egg-to-fry survival between the existing standard and a declining thermal regime with initial temperatures at 15 °C. Other studies also suggest no significant difference in survival at initial temperatures of 16.1 °C and less under a declining thermal regime.

188. IPC participated in the SR-HC TMDL process and the TMDL contains load allocations for the HCC for various water quality parameters, including dissolved oxygen. The SR-HC TMDL recognizes that nutrient concentrations are closely linked to dissolved oxygen concentrations. As a consequence, the TMDL, in implementing a watershed approach, assigned total phosphorus load allocations to pollutant sources for the Snake River upstream of the HCC (RM 409–335) and a dissolved oxygen load allocation for Brownlee Reservoir (RM 335–285). In this manner, the SR-HC TMDL recognized that pollutant sources upstream of the HCC were responsible for those water quality problems occurring upstream and not for water quality problems that would occur if the waters flowing into the HCC met water quality standards. Conversely, the TMDL recognized that the HCC was responsible for those water quality problems related exclusively to impoundment effects that would occur if inflowing water met water quality standards.[9] While the TMDL contemplates that measures to address respective load allocations would be implemented concurrently, it also recognized that due to the size and complexity of the watershed that several decades will be required to achieve full implementation and significant water quality improvement.[10]

Notwithstanding the foregoing, in an effort to assess the feasibility, cost, and effectiveness of measures intended to meet this objective, IPC has developed the following specific objectives for DO. These objectives are considered to be protective of salmonid uses below the HCC and are consistent with proposed site-specific water quality standard criteria submitted for the consideration of IDEQ and ODEQ by IPC's Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River, August 2004, Appendix D.

A DO target of 10 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from January 1 through May 10.

- Rationale: Existing spawning dissolved oxygen standards are based on water column levels needed to sustain a minimum of 8.0 mg/L intergravel DO levels. Site specific data (IPC unpublished data; IPC 2004) indicates that intergravel DO levels in newly constructed redds are no more than 2 mg/L lower than water column DO levels. Therefore, a 10 mg/L DO target in the water column will ensure adequate oxygen levels for eggs in newly constructed redds.

[9] SR-HC TMDL [July 2003], page 450.

[10] "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, 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." *Id.*, pg. 448.

A DO target of 8.0 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from May 10 through October 23.

- Rationale: This target is consistent with existing state standards to protect cold water biota (IDEQ and ODEQ 2003).

A DO target of 6.0 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from October 23 through November 2, 8.0 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from November 3 through December 12, and 10 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from December 13 to December 31.

- Rationale: Site specific data documenting the differential between water column and intergravel DO in fall Chinook redds below Hells Canyon Dam and best available scientific information related to the oxygen needs of different salmonid egg stages indicate that these DO levels in the water column are adequate for protecting developing fall Chinook eggs (Olson and Foster 1955; IPC 2004).

### *2.1.2. Conceptual Designs and Cost Estimates*

Table 1 identifies five alternative selective withdrawal concepts that IPC believes best comply with those characteristics specified by FERC in AIR WQ-2, and which IPC intends to evaluate for the purposes of developing a preferred design that is considered to be “best suited”, i.e. most effective and economical, to achieve the temperature objectives defined in Part 1 of AIR WQ-2. Table 2 shows reconnaissance level cost estimates for the associated direct construction costs, oxygenation costs, indirect construction costs, reduced power production costs, and operation and maintenance (O&M) costs for each of the five listed alternatives. Pending completion of additional modeling, the lost power and oxygen demands for each alternative are speculative. The lost power estimates are based on conceptual designs prepared for IPC by Washington Group International (WGI). During the power loss calculations, however, it was identified that further design improvements, to reduce energy losses in the spring, would be advisable should IPC proceed with further design refinements. Thus, the estimated costs for oxygenation, the indirect construction, lost power, O&M, and overall estimated annual costs shown in Table 3 should be considered preliminary pending further evaluation. Because the estimates were based on consistent assumptions for each alternative, the estimates are principally useful as a gauge to assess the probable relative cost of each alternative.

#### 2.1.2.1. Estimated Direct Construction Costs

The direct construction cost estimates for each of the alternatives were prepared by WGI based on the concept plans and text descriptions shown in Appendix A. WGI's detailed cost estimate for each alternative is shown in Appendix B.

#### 2.1.2.2. Estimated Oxygenation Costs

The joint state and federal TMDL for the Hells Canyon reach of the Snake River ("Snake River–Hells Canyon Total Maximum Daily Load") of July 2003, identifies pollutant allowances for the Hells Canyon reach of the Snake River. The TMDL determined that much of the DO deficiency in the Hells Canyon reach of the Snake River results from upstream pollutant discharges into the river. Based on this determination, the Hells Canyon reach TMDL assigns IPC only a limited responsibility for remedying the DO deficiency in the Hells Canyon reach based upon the water quality impacts caused by the project. The balance of the responsibility was assigned to upstream dischargers based on causation.

The cost of oxygenation needed to reach the DO targets through measures at Brownlee Dam and Reservoir will depend upon the extent to which upstream dischargers implement measures to improve water quality based upon the allocations made to them in the TMDL process. The cost of such measures at Brownlee Dam and Reservoir would be greatest in the absence of any such upstream improvements. However, since IPC's TMDL allocation is based upon water quality impacts caused by the HCC, IPC's share of the cost of such measures at Brownlee Dam and Reservoir should not exceed the cost of measures to satisfy IPC's TMDL allocation. Although IPC's cost responsibility is limited by the TMDL allocation, IPC has prepared an estimate of the total costs of oxygenation based upon the conservative assumption that none of the upstream improvements are implemented.

Note that the following oxygenation cost estimates are based on oxygenating the maximum possibly accessible hypolimnion for each of the alternatives, to mitigate potential reductions in downstream dissolved oxygen associated with operation of a selective withdrawal structure. By definition, the following aeration costs do not address oxygen deficiencies in the upper levels of the reservoir (metalimnion and epilimnion) that currently occur principally due to degraded inflowing water quality conditions. Significantly more oxygen could be required to also remedy the dissolved oxygen deficiencies that currently occur in the metalimnion and epilimnion of Brownlee Reservoir or consistently meet state water quality standards if upstream water quality improvements are not implemented, or do not result in improved oxygen conditions in Brownlee Reservoir.

The quantity of oxygenation needed in the absence of the specified upstream improvements exceeds the current market availability of liquid oxygen in the northwest United States. Thus, the oxygenation cost estimate must to some extent rely on speculative market costs and/or estimates for the cost of generating oxygen at Brownlee Dam.

In light of the above considerations, Table 2 shows estimated costs for the following range of assumptions:

- Add an amount of oxygen equal to 4 mg/l of the amount of cold water “available” and/or likely to be withdrawn via each selective withdrawal structure
- Add an amount of oxygen equal to 8 mg/l of the amount of cold water “available” and/or likely to be withdrawn via each selective withdrawal structure

The two oxygen addition targets of adding 4 mg/l or 8 mg/l were selected to provide a reasonable perspective of potential oxygenation costs. Initially, oxygenation estimates were prepared based on an assumption that enough oxygen would be added to raise the hypolimnion DO up to the expected level in the epilimnion on a “typical” year. In October, the difference in DO in the hypolimnion and the epilimnion has historically averaged approximately 5.5 mg/l; however, the difference has ranged from zero to 8 mg/l and changes fairly quickly each fall. Ultimately, estimated costs for adding amounts equivalent to 4 and 8 mg/l of the total accessible hypolimnion were calculated to provide a reasonable range of potential oxygenation costs. It should be noted that the amounts of oxygen calculated would not redress oxygen deficiencies currently encountered in the epilimnion and in the discharge from Brownlee powerhouse. In the absence of upstream water quality improvements, it is expected that oxygen addition well in excess of 8 mg/l of the hypolimnion would be needed to ensure that the discharge below Brownlee powerhouse would not fall below 6 mg/l.

Also, as is identified in Appendix C, Mobley Engineering’s report on oxygenation concepts for temperature control structure alternatives in Brownlee Reservoir, accessing the cold-water hypolimnion may involve more water quality concerns than just low dissolved oxygen. Discharges from the bottom of Brownlee Reservoir would be expected to contain methane, ammonia, and possibly sulfide at levels that may not be oxidized before being released to the tailwater, causing greenhouse gas releases, odors, and potentially toxic levels of sulfide, dependent on pH and sulfide concentrations. Methylmercury could also occur in the discharges and might not be oxidized before being released to the tailwater. As identified in Appendix C, prior oxygenation of part of the hypolimnion might be required to control anoxic products.

Two oxygenation estimates were prepared for each of the two alternatives shown above. One estimate was based on purchasing liquid oxygen and injecting the oxygen into the reservoir upstream of the penstock intakes. A second estimate was based on constructing and operating a gaseous oxygen production plant at Brownlee Dam and similarly injecting gaseous oxygen into the reservoir upstream of the penstock intakes. For selective withdrawal alternatives 1, 2, 5, and 12, the estimated cost of constructing and operating an oxygen generating plant at Brownlee was lower than the projected liquid oxygen purchase costs. For Alternative 8, because this alternative does not allow creation of a large, deep hypolimnion, and thus limits the amount of hypolimnion water available that would have to be oxygenated, the estimated cost of purchasing and injecting liquid oxygen is lower than the estimated cost of providing gaseous oxygen using an on-site oxygen generating plant. Because of necessary conservatism in the projected future cost of buying extraordinarily large quantities of liquid oxygen, and doubts about the relative economics of actually constructing an oxygen generating plant at Brownlee Dam, both estimates are shown in Table 2 as a range of potential oxygenation costs for each selective withdrawal alternative.

To derive estimated costs for purchasing or generating oxygen at Brownlee Reservoir, and efficiently injecting it into the powerhouse flow, IPC retained both Mobley Engineering and NORCO Incorporated to assist preparation of these estimates. Based on information provided by Mobley Engineering (see Appendix C) and NORCO Incorporated, the following costs were used in the derivation of the oxygenation cost estimates:

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|---|---|---|
| Initial capital cost to construct in-reservoir oxygen injection systems, with or without storage tank(s) and evaporators: | | $1,000,000 |
| Cost of purchasing liquid oxygen: | | $300/TN |
| Purchase and construction costs of VPSA type oxygen generating plants: | | |
| 42-TN/day VPSA oxygen generating plant with injection system: | | $4,300,000 |
| Energy demand for 42-TN/day VPSA plant: | 620 kWh/TN | |
| 75-TN/day VPSA oxygen generating plant with injection system: | | $6,173,000 |
| Energy demand for 75-TN/day VPSA plant: | 610 kWh/TN | |
| 100-TN/day VPSA oxygen generating plant with injection system: | | $7,170,000 |
| Energy demand for 100-TN/day VPSA plant: | 680 kWh/TN | |
| 175-TN/day VPSA oxygen generating plant with injection system: | | $9,360,000 |
| Energy demand for 175-TN/day VPSA plant: | 580 kWh/TN | |

Because the oxygen generating plant and injection system capital costs are relatively minor compared to the capital cost of most of the selective withdrawal structures, a simplified blended capital cost of approximately 11% of the capital cost per year was used to calculate the equivalent annualized cost of the oxygen generating and injection equipment and installation. Similarly, the cost of energy to operate a conceptual oxygen generating plant was based on an approximate 2005 fall average energy cost of $55/MWh.

The estimated O&M cost of the oxygenation facilities was based on estimates of the amount of labor and parts necessary to operate and maintain each facility each year. The O&M cost for the oxygen generating and injection equipment was added to the annual estimated oxygenation costs, and was not included in the estimated O&M cost of each of the selective withdrawal structures. Information from NORCO Incorporated indicated very high typical capacity factors and net availability for VPSA gaseous oxygen generating plants, and it is expected that the plant would only need to be operated for a few months each year, so no excess plant capacity to account for equipment outage time was explicitly included in the capital estimates.

The oxygenation cost estimates shown do not take into account other methods available to enhance the oxygen concentration downstream of the Brownlee powerhouse, such as aerating turbine runners and/or draft tube aeration or implementation of effective water quality measures upstream of Brownlee Reservoir. It is probable that other oxygenation methods would be less expensive than oxygen injection into the reservoir upstream of powerhouse intakes. However, the potential cost savings available via other oxygenation methods cannot be defined until the terms and conditions of the water quality certifications have been determined.

#### 2.1.2.3. Estimated Indirect Construction Costs

Indirect construction costs are composed of two separate costs—the cost of reservoir drafts to accommodate construction of the selective withdrawal structures, and the Allowance for Funds Used During Construction (AFUDC) for each of the selective withdrawal structures.

The estimated cost of reservoir drafts for construction was derived using a spreadsheet that calculated an estimated value of the power lost due to low reservoir elevation each hour of the median (1995) flow year, with monthly peak and off-peak hourly power value estimates for 2005. The duration, depth, and time of year of reservoir drafts necessary to accommodate construction of each of the selective withdrawal structures was based on the concept plans and text descriptions shown in Appendix A.

The estimated Allowance for Funds used During Construction (AFUDC) for each of the alternatives was based on the predicted construction cost and duration of each of the structures from the text descriptions of the alternatives shown in Appendix A. An annual AFUDC rate of 7.24% was used to estimate the interest that would be capitalized for each of the alternatives.

#### 2.1.2.4. Estimated Lost Power Costs

The estimated annual lost power costs were derived using a variety of methods. Hydraulic modeling has been done at the University of Iowa for the weir structure (Alternative 1), which provided an approximate mathematical relationship between flows and head losses for this structure. To derive annual expected energy losses for this structure, a spreadsheet was used that calculated the expected energy loss and associated power value for each hour of flow for an entire calendar year. These calculations were performed for five proposed operation flow years: 1992 (low flow year); 1994 (medium low flow year); 1995 (approximate median flow year); 1999 (medium high flow year); and 1997 (high flow year). The 15-minute flows for proposed operations for each of these inflow years were the flows calculated by the CHEOPS model for the other HCC relicensing studies currently underway. The 15-minute power values were based on a monthly peak and off-peak wholesale power cost projection for 2005.

A significant complicating factor for each of the lost power estimates was the discovery during analyses that much of the annual energy loss caused by the conceptual structures in the intake channel occurs in the spring, before placement of the stoplogs or gates, due to the reduction in channel cross-section caused by the weir and/or gate permanent structural components during spring flood control drafts. Should there be cause to continue with these studies, it is expected that the selective withdrawal structures in the intake channel would be re-designed to reduce these springtime energy losses. However, the time allowed for completion of the studies specified in AIR WQ-2 is not adequate to accommodate redesign and re-analysis of the intake channel structure at this time. Thus, the expected head losses due to the existing design of these structures are shown in this report, with the knowledge that design refinements would likely reduce these losses should the structures ever be built.

The expected energy losses for the gate structure in the intake channel (Alternative 2) were more difficult to accurately estimate due to the absence of modeled energy loss versus flow relationships. Thus, the expected energy losses for the gate structure were presumed to roughly equal the energy losses for the weir structure in low flow years, and were estimated at 170% of the weir structure in high flow years. The 170% estimate was based on the smaller cross section of the upper part of the gate structure, relative to the weir structure, and also in consideration of the contemplated mode of operation of the gate structure, which anticipates that head losses would be deliberately created in the fall, using the variable height gates, to induce flow from the colder, denser hypolimnion. As with the weir structure, this estimate is quite speculative because if a gate structure were to be constructed, the design would undoubtedly be refined prior to construction to reduce expected energy losses.

The expected energy cost for Alternative 5, which contemplates both a gate structure in the intake channel and re-opening of the old diversion tunnel into the intake channel, was based on the estimates for the gate structure by itself, with additional allowance for the increase in friction losses for the flow that would be drawn from the bottom of the reservoir via the tunnel. A simple calculation, based on the energy needed to extract 10,000 cfs via the tunnel, for 10 hours per day for 30 days per year in a low flow year, for 16 hours per day for 30 days in a medium flow year, and for 24 hours per day for 30 days in a high flow year, with an estimated average power cost of $55/MWh, and a 65% average pump efficiency, was used to calculate the expected additional energy cost to extract more cold water via the tunnel than would be available if drawn through the gate structure by itself.

Alternative 8 contemplates construction of a new gated, 10,000 cfs to 12,000 cfs tower with tunnels directly to the Unit 5 penstock. Head losses at the design flow were calculated by Washington Group International for these structures, which are briefly summarized in Appendix A.

Because of the increased head losses associated with drawing generating flows into the powerhouse via the conceptual small intake tower, the powerhouse operations, and even the reservoir operations to some extent, would likely be different than the operations described in the license application. To calculate expected energy losses from Alternative 8, assumptions had to be made about the allocation of powerhouse flows between generating units. To derive expected energy losses, an annual water balance was developed to estimate the amount of flow that would be drawn through the small tower in a low flow year and a high flow year. For the low flow year, all of the inflow could be passed via the four small generators, so it was assumed that flows would be drawn via the small tower for only one month at a rate of 10,000 cfs, 24 hours per day, for a 30-day period. The associated energy cost of this, with an expected head loss of 4-foot and an average energy cost of $55/MWh, amounted to $130,000.

For Alternative 8 for a high flow year, it was assumed that a peak flow of 12,000 cfs would be passed through Unit 5 24 hours per day for a full 30 days in the fall, resulting in lost energy worth approximately $190,000 during that peak flow month. The balance of the 7,000,000 AF of inflows that could not be passed via the small units was assumed to be passed through Unit 5 at the minimum practical average flow, 24 hours per day over the balance of the year. This equated to an average flow of 9,460 cfs, 24 hours per day, for 335 days, with an associated head loss of approximately 3.5-foot. This led to a lost energy cost estimate for the balance of the year of $1,240,000, for a total of $1,430,000, which was subsequently rounded up to $1,500,000 to account for machine outage time, unaccounted-for machine efficiency reductions, and the relative roughness of the estimating method.

For Alternative 12, the same energy loss spreadsheet used to calculate the value of lost energy for Alternative 1 was used with mathematical head loss equations that were provided by WGI for the 35 kcfs tower and tunnels to the existing powerhouse intake. Because Alternative 12 would accommodate the proposed project operations, the CHEOPS-generated flows for a low and a high flow year were used in the spreadsheet, along with current 2005 wholesale power cost projections.

### 2.1.2.5. Estimated Operations and Maintenance Costs

The projected O&M costs for each of the selective withdrawal alternatives are expected to be relatively minor in comparison to the other costs associated with the selective withdrawal alternatives. The estimated O&M costs of each of the facilities was based on estimates of the amount of labor and parts necessary to operate and maintain each facility each year. The O&M costs for the oxygen generating and injection equipment were added to the annual estimated oxygenation costs, and were not included in the estimated O&M cost of each of the selective withdrawal structures.

The annual O&M estimates were escalated at a current trend forecast rate of consumer price inflation (2.5%). To annualize the values, the 30-year escalated stream of expenses was averaged. Annual estimates for property insurance and property taxes were included in the annual cost estimates as well. All of the expense components for each alternatives are listed in Table 3**.**

### 2.1.2.6. Estimated Total Costs

The 30-year total and annualized costs for each of the selective withdrawal structures include estimates for the following items that were mentioned previously: operation and maintenance expenses, property taxes, insurance costs, oxygenation costs, and lost energy (opportunity) costs. In addition to these cost components, the annual cost of capital for each alternative is included in the overall cost estimates listed in Table 4. The annual cost of capital represents levelized costs over an assumed 30-year period, and is the Applicant's estimated annual revenue requirement. A discount rate of 7.20%, per IPC's 2004 Integrated Resource Plan was used to calculate the levelized cost of capital for the various selective withdrawal structures.

As noted in the introduction, it is emphasized that the overall cost estimate shown for each of the alternatives is by necessity based on reconnaissance level concept designs and very generalized assumptions regarding projected inflows, future power costs, actual operating characteristics and predicted oxygenation costs. Thus, the actual cost of any of the alternatives might vary significantly from the estimates shown in Table 2, Table 3, and Table 4.

#### *2.1.2.6.1. Conclusion*

Tables 1 and 2 identify five alternatives that IPC believes best comply with those characteristics specified by FERC in AIR WQ-2, and which IPC intends to consider and/or evaluate further for the purposes of developing a preferred design that is considered to be "best suited", i.e. most effective and economical, to achieve the temperature objectives defined in Part 1 of AIR WQ-2. Tables 3 and 4 summarize the cost estimates for each of the five alternatives.

## *2.1.3. Part (a) Consultation*

IPC received two consulting organization letters regarding the draft Part (a), Conceptual Design Report. One letter was from the US Department of Commerce, NOAA, National Marine Fisheries Service, dated January 10, 2005. The second letter was from the Oregon Department of Environmental Quality, Eastern Region, Bend Office, dated January 10, 2005. Copies of these letters are attached (Appendix E). Paraphrased restatements of each of the comments received, along with IPC's response, are as follows:

### 2.1.3.1 NOAA Fisheries letter dated January 10, 2005

NOAA comments "1" and "2" do not suggest report modifications, but rather indicate NOAA's willingness to work with IPC to identify cost effective measures to achieve the desired temperatures, and concur with IPC's identification of critical considerations in the draft report. The text regarding these critical considerations has not been changed from the draft.

NOAA comment 3: NOAA advises IPC to proceed with the assumption that 20°C is the maximum water temperature that is protective of migrating fish, and urges IPC to consider the ability of the proposed structures to release 18°C water throughout the summer and early fall—even though this may be cooler than that minimally required to meet state temperature criteria.

> IPC response to NOAA comment 3: For the reasons that 1) FERC does not specifically request a summer temperature objective, 2) IPC's proposed summer maximum temperature target has raised concerns with NOAA and ODEQ, 3) the daily temperature of water inflowing into Brownlee Reservoir during the summer normally exceeds the summer maximum temperature targets proposed by IPC in its draft response to FERC, and by NOAA and ODEQ in their comments on the draft response to FERC, and 4) Brownlee Reservoir generally has a cooling effect on water inflowing into Brownlee Reservoir during the summer, IPC is deleting its temperature objective/target for the summer in its final response to FERC. Also, to address comments of NOAA and ODEQ, the spring temperature target will only apply until inflow temperatures rise above 18°C.
>
> However, IPC's approach to evaluating the structures in WQ-2(b) will allow identification of the approximate minimum summer temperature that can be maintained throughout the summer in each flow year and with each structure, while ensuring that enough cold water would be available to meet the fall target.

NOAA comment 4: NOAA recommends adoption of higher downstream dissolved oxygen targets for the fall salmon spawning period of October 23 through November 2. IPC identified a target downstream DO concentration for this period of 6.0 mg/L or the DO concentration of inflows, whichever is less, as adequate for protecting fall Chinook eggs. NOAA recommends an alternate target of 8.0 mg/L.

> IPC response to NOAA comment 4: As described in the rationale for the October 23-November 3 DO target in section 2.1.1, site specific data documenting the differential between water column and intergravel DO in fall Chinook redds below Hells Canyon Dam and best available scientific information related to the oxygen needs of different salmonid egg stages indicate that the DO targets proposed by IPC for this period are adequate for protecting developing fall Chinook eggs.
>
> It is noted that at this preliminary stage in the analyses, the DO targets and methods/cost for oxygenation are somewhat separate. Considerable uncertainty remains in what the resulting discharge DO levels would be with the conceptual addition of oxygen equating to a 4 or 8 mg/L increase in the “available” cold water volume (see section 2.1.2.2).
>
> However, IPC’s approach to evaluating DO levels in WQ-2 (b) is similar to the approach for temperature impact evaluations described above and should allow visualization of predicted DO levels under each of the temperature control scenarios.

NOAA comment 5: In Section 2.1.2.4 of the draft response, IPC noted that the current design of Alternatives 1 and 2 lead to unnecessary energy losses during spring flood control periods, and that if construction of alternatives such as these is ever pursued, design refinements would likely be made to reduce these energy losses. NOAA suggests that IPC continue to refine the estimates of the projected lost power costs associated with these structures in the final response.

> IPC response to NOAA comment 5: IPC concurs that prior to proceeding with final design and construction of any of these alternatives, further design refinements and lost power estimates would be necessary. However, IPC believes that doing so at this stage would be premature, especially in light of the relatively small percentage (less than 10% in each case) of the cost of each structure that is represented by the estimated power losses.

NOAA comment 6: NOAA recommends discontinuing further analyses of Alternative 1 (and presumably Alternative 2 also) because it does not provide access to the water in the bottom of the reservoir, and NOAA Fisheries has identified the ability to extract the water in the deeper strata of the reservoir as a capability necessary for reducing downstream summer and fall water temperatures to enhance migration conditions for juvenile and adult salmon and steelhead.

> IPC response to NOAA comment 6: IPC disagrees with this recommendation. As noted in the introduction to the draft response to AIR WQ-2, the amount of cold water available in Brownlee

Reservoir below the sill of the existing intake would amount to approximately a quarter of the maximum amount of cold water that could conceptually be retained in Brownlee Reservoir with a selective withdrawal structure (all of the conceptual structures, with the exception of Alternative 8, have the potential to store additional cold water by raising the thermocline). The significantly greater costs and risks necessary to access the bottom strata of the reservoir, relative to the expected benefits, may lead to the conclusion that attempting to extract water from the bottom strata of the reservoir is not justified.

#### 2.1.3.2. Oregon Department of Environmental Quality, Eastern Region, Bend Office, letter dated January 10, 2005

ODEQ First Comment, re: draft response Section 1: Based on the information currently available to ODEQ, ODEQ does not concur that the HCC, under its current configuration and operations, adequately protects and supports fall chinook spawning and rearing, including adequate water temperature and dissolved oxygen conditions, and considers the statements to this effect in the introduction of the draft response to be positions of IPC rather than proven statements of fact, and requests that the introduction be rewritten to reflect this status.

IPC response to ODEQ's First Comment: In accord with ODEQ's suggestion, the introduction has been revised to indicate that it is Idaho Power Company's belief, based on extensive scientific evidence, that the HCC, under its current configuration and operations, adequately protects and supports fall chinook spawning and rearing, and that this protection and support includes adequate water temperature and dissolved oxygen conditions below the project.

ODEQ Second Comment, re: draft response Section 2.1.1: The temperature and dissolved oxygen targets identified by IPC should be based on the existing Oregon and Idaho water quality standards, instead of the site specific water quality standards which IPC has proposed as appropriate for the river below Hells Canyon Dam.

IPC response to ODEQ's Second Comment: FERC AIR WQ-2 Part (a) directed IPC to identify seasonal temperature and DO objectives designed to enhance conditions for fall chinook spawning, incubation, rearing, and migration in the Hells Canyon reach. The targets identified by IPC are based on the FERC direction contained in AIR WQ-2 and the best available scientific biological data for the Snake River and its biota below Hells Canyon Dam. IPC recognizes that the existing state water quality standards take legal precedence over IPC's proposed site-specific standards.

For the reasons that: 1) FERC does not specifically request a summer temperature objective; 2) IPC's proposed summer maximum temperature target has raised concerns with NOAA and ODEQ; 3) the daily temperature of water inflowing into Brownlee Reservoir during the summer normally exceeds the summer maximum temperature targets proposed by IPC in its draft response to FERC, and by NOAA and ODEQ in their comments on the draft response to FERC; and 4) Brownlee Reservoir generally has a cooling effect on water inflowing into Brownlee Reservoir during the summer, IPC is deleting its temperature objective/target for the summer in its final response to FERC. Also, to address comments of NOAA and ODEQ, the spring temperature target will only apply until inflow temperatures rise above 18°C.

However, IPC's approach to evaluating the structures in WQ-2 (b) should allow for identification of the minimum summer temperature that can be maintained throughout the summer, in each flow year and with each structure, while ensuring that enough cold water would be available to meet the fall cooling target.

Also, IPC's approach to evaluating DO levels in WQ-2 (b) is similar to the approach for temperature and should allow visualization of simulated DO levels under each of the temperature control scenarios.

ODEQ Third Comment, re: draft response Section 2.1.2: The conceptual designs and costs should be revisited and revised in the context of compliance with current state water quality standards, not the targets identified by IPC.

IPC response to ODEQ's Third Comment: As discussed in IPC's response to ODEQ's second comment, IPC's approach to evaluating the structures in WQ-2 (b) will predict the minimum summer temperature and downstream DO attainable with each structure while still meeting the fall temperature targets. This will provide a basis for comparisons with any other temperature and DO targets.

More importantly, different temperature and DO targets or objectives would not lead to new or different conceptual designs or cost estimates. The conceptual designs prepared by IPC were directed by FERC in AIR WQ-2 and/or were developed based on what is believed to be physically feasible. Development of these alternatives was not, and is not, being limited by the specific temperature and DO targets identified.

ODEQ Fourth Comment, re: Consultation: IPC did not, prior to drafting the draft response to AIR WQ-2, provide a forum for stakeholder discussion and input, and the draft response did not contain a section for reporting on the requisite consultation.

IPC response to ODEQ's Fourth Comment: Given the limited time allowed by FERC to respond to the AIRs, there was not adequate time available to engage in more comprehensive discussions as suggested by ODEQ. Nevertheless, IPC has followed FERC guidelines with respect to consultation relative to this AIR response, and this section regarding the requisite consultation has been added to the final response to AIR WQ-2 Part (a). Further, IPC has taken action addressing both of the ODEQ concerns described above. As noted by ODEQ, settlement discussions are underway, and have been underway for some time, which explicitly provide a forum for more involved discussions, input and negotiation regarding water quality issues.

ODEQ Fifth Comment, re: ODEQ Comment Conclusion: The IPC response to FERC AIR WQ-2 should be revised pending re-evaluation of alternatives developed for compliance with appropriate temperature and DO objectives and in consideration of consultation.

IPC response to ODEQ's Fifth Comment: This is largely a reiteration of ODEQ's second and third comments. As noted in IPC's response to ODEQ's second and third comments, the range of selective withdrawal alternatives being evaluated was not constrained by the targets selected. Thus, adopting different targets would not change the selective withdrawal and oxygenation alternatives being evaluated.

# 3. LITERATURE CITED

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IPC. 2004. Petition to initiate a process for site specific criteria for Hells Canyon Snake River. Letter from Chris Randolph (IPC) to Larry Koenig (IDEQ).

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. EPA 910-R-99-010. Environmental Protection Agency, Region 10, Seattle, WA. 279pp.

Olson, P. A. and R. F. Foster. 1955. Temperature tolerance of eggs and young of Columbia River Chinook salmon. Transactions of the American Fisheries Society 104:111–121.

Table 1. Alternatives that comply with the characteristics specified by FERC in AIR WQ-2, and/or would most effectively and economically achieve the overall objectives

| No. | Description |
|---|---|
| 1 | Overflow stoplog weir in existing intake channel (See AIR Part (a) subpart (ii)) |
| 2 | Variable height gate structure in the existing powerhouse intake channel (See AIR Part (a) subpart (ii)) |
| 5 | Variable height gate structure in the existing intake channel, re-open the original, existing, plugged, diversion tunnel and connect it to the existing intake channel, with cold water uplift provided by elevation control at the channel gate structure and uplift pumping at the vertical access shaft (See AIR Part (a) subparts (i) and (ii), and (iii)) |
| 8 | New 10 - 12 kcfs variable-height-gated intake tower with trashracks above re-opened original diversion tunnel, new vert shaft and tunnels from old diversion tunnel directly to Unit 5 penstock (See AIR Part (a) subpart (i)) |
| 12 | New 35-kcfs variable-height-gated intake tower above enlarged old diversion tunnel to vertical shaft to new tunnel into existing intake channel, plus concrete dam across existing intake channel (See AIR Part (a) subpart (iv)) |

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Table 2. Costs of Alternatives Directed by FERC or Considered to be Most Feasible and Competitive

| No. | Description | Estimated Direct Construction Cost | Estimated Oxygenation Cost (See Notes 2 and 3) | Estimated Indirect Construction Cost | Estimated Annual Lost Power Costs (Notes 4 and 5) | Estimated Annual O&M Costs (Note 6) | Estimated Annual Cost (30 year) (Note 7) |
|---|---|---|---|---|---|---|---|
| 1 | Overflow stoplog weir in existing intake channel.<br>Would not significantly restrict powerhouse flows, would allow raising the thermocline to store more cool water, however, does not provide access to 180 kAF of low level hypolimnion water below existing sill at elev 1930 | $24,000,000 | $1,200,000 to $1,600,000 per year to inject 4 mg/l DO into the maximum possibly accessible hypolimnion, 620,000 AF. $1.4MM avg<br>$1,600,000 to $3,000,000 per year to inject 8 mg/l DO into the maximum possibly accessible hypolimnion, 620,000 AF, $2.3MM avg | $3,700,000 lost power during construction.<br>$2,200,000 allowance for funds used during construction | Low Flow Year (1992): $110,000<br>Median Low Flow Year (1994): $210,000<br>Median Flow Year (1995): $280,000<br>Median High Flow Year (1999): $660,000<br>High Flow Year (1997): $870,000<br>Avg of 5 tested years: $430,000 | $30,000 | $5,600,000 |
| 2 | Variable height gate structure in the existing powerhouse intake channel.<br>Would not significantly restrict powerhouse flows, would allow raising the thermocline to store more cool water, however, does not provide access to 180 kAF of low level hypolimnion water below existing sill at elev 1930. (A gate structure has two minor advantages over the weir – the ability to select from a range of reservoir levels and the ability to exclude surface water from the intake channel) | $32,000,000 | Same as Alt 1:<br>$1.2MM to $1.6MM/yr to inject 4 mg/l DO into 620 kAF, $1.4MM avg.<br>$1,6MM to $3MM/yr to inject 8 mg/l DO into 620 kAF, $2.3MM avg. | $3,700,000 lost power during construction.<br>$3,000,000 allowance for funds used during construction | Similar to overflow weir in Low Flow Year ($110,000). Substantially higher than weir in medium and high flow years. Estimated to range from a minimum of $110,000 in a low flow year to a maximum of $1,500,000 during a high flow year.<br>For estimating purposes, assume 30% higher than the weir on average, $550,000. | $20,000 | $6,600,000 |
| 5 | Variable height gate structure in the existing intake channel, re-open the original, existing, plugged, diversion tunnel and connect it to the existing intake channel, with cold water uplift provided by elevation control at the channel gate structure and by pumping.<br>Would not significantly restrict powerhouse flows, would allow raising the thermocline to store more cool water, provides limited access to additional 180 kAF of low level hypolimnion water below existing sill at elev 1930 | $48,000,000 | $1,200,000 to $1,600,000/yr to inject 4 mg/l DO into the maximum possibly accessible hypolimnion, 800,000 AF, $1.4MM avg.<br>$1.6 to $3.0 MM/yr to inject 8 mg/l DO into the maximum possibly accessible hypolimnion, 800 kAf, $2.3MM avg | $3,700,000 lost power during construction.<br>$8,200,000 allowance for funds used during construction | Same as gate structure, plus energy demand in fall to draw bottom water into the intake via the re-opened diversion tunnel. Total estimated to range from a minimum in a low flow year of $150,000 to maximum in a high flow year of $1,600,000. For estimating purposes, assume $50k higher than Alt 2, $600,000/yr. | $30,000 | $8,900,000 |

Table 2. (Cont.)

| No. | Description | Estimated Direct Construction Cost | Estimated Oxygenation Cost (See Notes 2 and 3) | Estimated Indirect Construction Cost | Estimated Annual Lost Power Costs (Notes 4 and 5) | Estimated Annual O&M Costs (Note 6) | Estimated Annual Cost (30 year) (Note 7) |
|---|---|---|---|---|---|---|---|
| 8 | New 10–12 kcfs variable-height-gated intake tower above re-opened original diversion tunnel, new vertical shaft with trashrack in shaft and tunnels from old diversion tunnel *directly to Unit 5 penstock.*<br>This alternative would reduce the existing powerhouse hydraulic capacity and efficiency. Would not normally allow raising the thermocline to store more cool water. Would provide limited access to additional 180 kAF of low level hypolimnion water below existing sill at elev 1930. | $217,000,000 | $470,000 to $710,000 per year to inject 4 mg/l DO into the probably accessible hypolimnion, 180,000 AF. $590,000 avg<br>$790,000 to $960,000 per year to inject 8 mg/l DO into the probably accessible hypolimnion, 180,000 AF, $870,000 avg | Conceptual construction plan assumes that no special reservoir draft would be needed for construction. A 2-month draft at elev 2020 in late fall would cost apprx $8,200,000 in lost power.<br>$35,300,000 allowance for funds used during construction | This Alternative would significantly reduce the powerhouse operating flexibility and would cause substantial head losses. Est min in very low flow years of $130,000. Est max in highest flow years of $1,500,000. Est average for comparison purposes of $400,000/yr (losses increase slightly exponentially with flows). | $60,000 | $28,200,000 |
| 12 | New 35-kcfs variable-height-gated intake tower above enlarged old diversion tunnel to vertical shaft to new tunnel into existing intake channel, plus *concrete da*m across existing intake channel.<br>Would not significantly restrict powerhouse flows, would allow raising the thermocline to store more cool water, would provide access to additional 180 kAF of low level hypolimnion water below existing sill at elev 1930 | $286,000,000 | <u>Same as Alt 5</u>:<br>$1.2 to $1.6MM/yr to inject 4 mg/l DO into 800 kAF, $1.4MM avg.<br>$1.6 to $3.0MM/yr to inject 8 mg/l DO into 800 kAF, $2.3MM avg. | Conceptual construction plan assumes that no special reservoir draft would be needed for construction. A 2-month draft at elev 2020 in late fall would cost apprx $8,200,000 in lost power.<br>$66,200,000 allowance for funds used during construction | $400,000 in a very low flow year (1992), $600,000 in med low flow year (1994), $1,200,000 in medium flow year (1995), $1,600,000 in med high flow year (1999), $2,000,000 in very high flow year (1997).<br>For comparison purposes, average assumed to be $1,200,000 (1995 flows) | $60,000 | $41,100,000 |

Note 1: All Year 2005 costs.

Note 2: Oxygenation cost estimates are based on two feasible alternatives: 1) the cost of buying and injecting liquid oxygen, and 2) an estimate for the cost of buying and operating a gaseous oxygen generating plant and injection system. Based on estimates provided by NORCO Incorporated and Mobley Engineering, the projected cost of buying and injecting liquid oxygen is typically higher than the estimated cost of manufacturing oxygen on site for alternatives 1, 2, 5, and 12. The estimate for each of these alternatives is shown for two reasons. First, because this provides a logical range of expected costs, and second, because for smaller, and possibly more reasonable, quantities of oxygenation, it would likely be non-economic for IPC to construct an oxygen generating plant on site.

Note 3: The maximum possibly accessible cold hypolimnion water available via Alternatives 5 and 12 is approximately 30% greater than that available via Alternatives 1 and 2. Despite this, the estimated oxygenation costs for Alternatives 5 and 12 are not significantly higher because the projected oxygen transfer efficiency for Alternatives 5 and 12 was coincidentally approximately 30% better than that estimated for Alternatives 1 and 2, as a result of being able to inject into deep, confined, intake tunnels.

Note 4: Lost Power Costs: The annual lost power cost estimates are based on the existing designs. Hydraulic modeling done subsequent to completion of the preliminary designs and construction cost estimates indicates that the lost power costs could be reduced substantially with modifications to the design of the selective withdrawal structures. For each of the existing alternatives, a substantial portion of the energy losses occur due to reduction of the cross sectional area of the mouth of the intake channel in the spring concurrent with high flows and spring flood control reservoir drafts. The reduction of the intake channel cross section results from the permanent structural components, not from the stoplogs and/or gates. The lost power costs do not include the estimated cost of operating oxygen generating plants. The power demands of oxygen generating plants are included in the oxygenation cost estimates.

Note 5: The lost power cost estimates are based on projected 2005 monthly peak and off-peak power costs.

Note 6: Estimated annual O&M costs are for the operations and maintenance of the selective withdrawal structure(s) only. O&M costs for oxygen injection methods are included in the estimated oxygenation costs.

Note 7: The estimated annual costs are made up of the annual average expenses plus the levelized cost of capital for each of the selective withdrawal alternatives.

Table 3. Expenses for Alternatives Directed by FERC or Considered to be Most Feasible and Competitive—in millions (MM)

| Alt No. | Expense Components | | | | | Totals | |
|---|---|---|---|---|---|---|---|
| | 30 Year Oxygenation Cost | 30 Year Lost Power | 30 Year O&M | 30 Year Property Taxes | 30 Year Insurance | 30 Year Total Expenses | Average Annual Expenses |
| 1 | $69.0MM | $12.9MM | $1.3MM | $6.1MM | $0.8MM | $90.1MM | $3.0MM |
| 2 | $69.0MM | $16.5MM | $0.9MM | $8.1MM | $1.1MM | $95.6MM | $3.2MM |
| 5 | $69.0MM | $18.0MM | $1.3MM | $13.1MM | $1.7MM | $103.1MM | $3.4MM |
| 8 | $26.1MM | $12.0MM | $2.7MM | $58.7MM | $7.8MM | $107.2MM | $3.6MM |
| 12 | $69.0MM | $36.0MM | $2.7MM | $81.9MM | $10.8MM | $200.4MM | $6.7MM |

Table 4. Overall Costs for Alternatives Directed by FERC or Considered to be Most Feasible and Competitive—in millions (MM)

| No. | Cost of Capital | | | Expenses | | Total |
|---|---|---|---|---|---|---|
| | Total Investment (including AFUDC) | Present Value Cost of Capital | Levelized Cost of Capital | 30 Year Total Expenses | Average Annual Expenses | Annualized Costs |
| 1 | $26.2MM | $33.3MM | $2.6MM | $90.1MM | $3.0MM | $5.6MM |
| 2 | $35.0MM | $44.5MM | $3.4MM | $95.6MM | $3.2MM | $6.6MM |
| 5 | $56.2MM | $71.4MM | $5.5MM | $103.1MM | $3.4MM | $8.9MM |
| 8 | $252.3MM | $320.9MM | $24.6MM | $107.2MM | $3.6MM | $28.2MM |
| 12 | $352.2MM | $447.8MM | $34.4MM | $200.4MM | $6.7MM | $41.1MM |

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Appendix A. Brownlee selective withdrawal alternatives assessed by Washington Group International; descriptions and concept drawings, October 2004; Alternatives 1, 2, 5, 8, and 12

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# 4.0 ALTERNATIVES IDENTIFIED

## 4.1 ALTERNATIVE 1 – OVERFLOW WEIR WITH STOPLOGS IN THE EXISTING POWER INTAKE CHANNEL

### 4.1.1 Description

This alternative operates as a simplified overflow weir, using stoplogs to set the crest of the overflow weir in the existing power intake channel of the Brownlee Project. The required crest of overflow weir elevation can be adjusted by removing stoplogs from the stoplog slots as the Brownlee reservoir water surface changes, the power intake flows change, and/or the desired water temperature within the range of Reservoir El. 2077 down to El. 1930 dictates. Steel fabricated stoplogs are 28 feet long by 9 inches in depth, and are either 10 feet or 5 feet in height. The 10-foot stoplogs are for use at lower depths and 5-foot-high stoplogs are used at upper elevations for smaller height adjustments. The stoplogs are constructed of a steel frame that utilizes plates and tees in built-up members, angles and ½ inch steel plate for the face area. The plates are designed for a blow-off pressure equal to the design hydrostatic differential (5 feet) plus 20 percent of the maximum hydrodynamic pressure. Therefore, if the upstream to downstream head differential is greater than 6 feet, spring activated releases would allow water to pass through the weir, thus avoiding over stressing the structure. At the blow-off pressure, the connection of the plate to the frame would fail and, therefore, higher pressures that would otherwise transfer larger loads to the pier support structure would not form.

This alternative requires installation of the new Weir Structure across the existing power intake channel "in the wet", because the minimum reservoir level cannot be practically reduced below about El. 1976. Most of the foundation and non-flow through portions of the structure would consist of hollow precast concrete sections that are fabricated in a casting yard and transported to the site for installation. After the precast sections are lowered in place and anchored together, concrete would be placed inside the precast sections, which act as forms. Structural steel embeds and rock anchors would require divers to install these components underwater. Once installation of the new components reaches the reservoir water surface level, the remaining structure and bridge super structure can be installed without the use of divers.

### 4.1.2 Operation and Hydraulic Performance

Operation of the overflow weir (technically a submerged weir) involves removing stoplogs as required by the reservoir water surface elevations in the channel and desired temperature levels in the reservoir. The top of weir elevation needs to be set to allow a flow through surface area that results in an operating head loss of two feet or less. If the head differential exceeds six feet, spring activated releases would allow water to pass through the weir, thus avoiding over stressing the structure. Divers would need to be used to "reset" or re-install the blow off plates for resuming normal operation.

### 4.1.3 Construction Issues

Construction of an overflow weir barrier in the intake channel would require substantial underwater work. Much of the underwater construction is based upon the use of precast concrete shell elements that would be filled with tremie concrete, built-up from the bottom of the channel layer by layer. Use of post tensioning tendons is required to reduce the amount of reinforced concrete and ensure stability of the completed structure for all loading conditions. Piers containing the stoplog guides would extend from the bottom of the power intake channel to the bridge deck level at El. 2100 to allow stoplogs to be inserted and removed from the guides above water. Construction procedures anticipate the use of a crane mounted on "flexi-float" modules that would be anchored to prevent horizontal movement while supporting the placement of structures. Another large crane would be required at the staging/loading area to load precast concrete segments, structural steel, reinforcing steel and other construction materials for transport to the overflow weir barrier construction area.

### 4.1.4 Construction Cost Estimate

The estimated cost to construct the Overflow Weir with Stoplogs scheme is about **$24 million**, including engineering, project management, permits, and a contingency allowance. This figure does not include sales tax, loss of power generation during construction, allowance for funds used during construction (AFUDC), and the value of lost generation due to head losses occurring during operation of new facilities

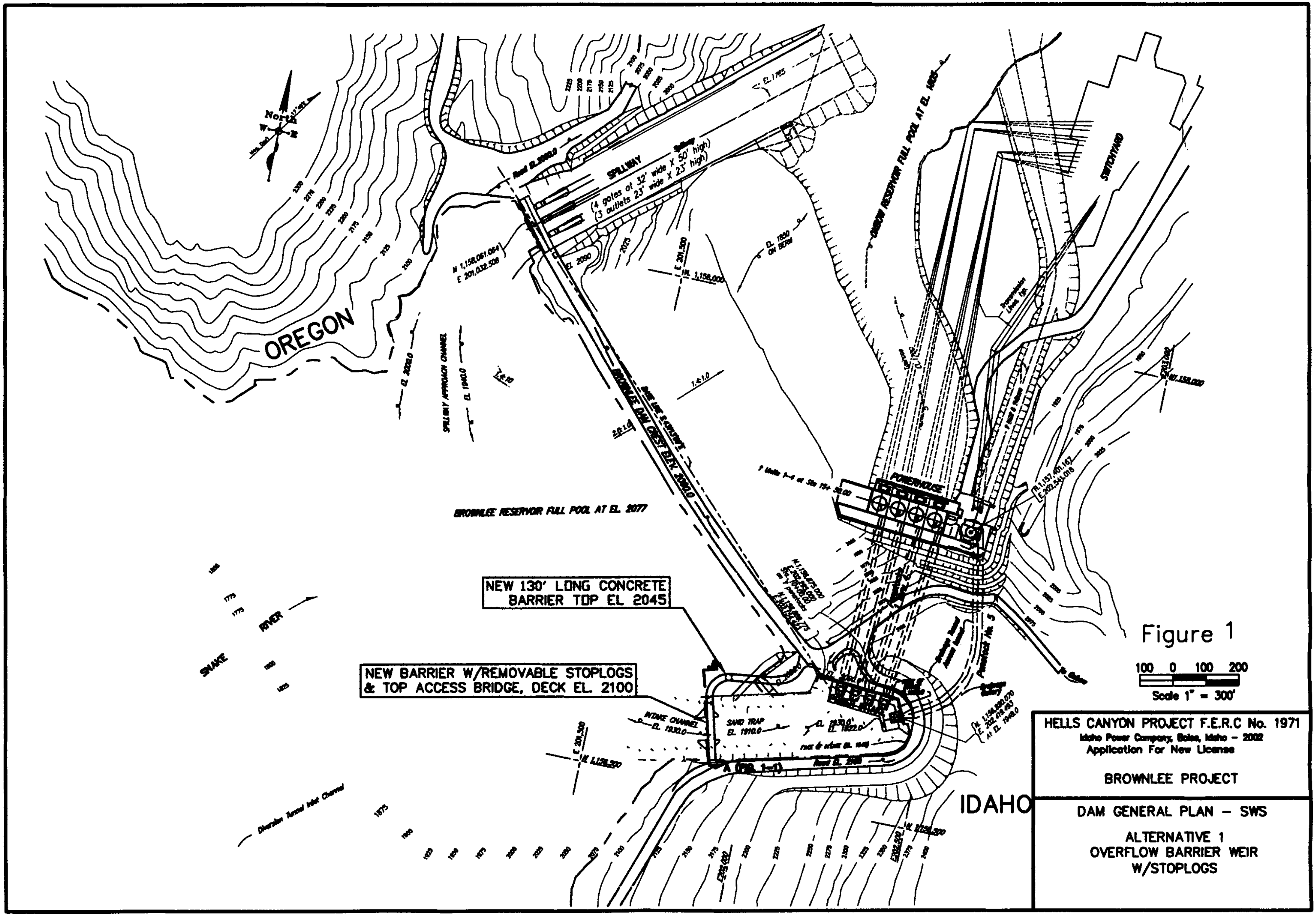
### 4.1.5 Construction Schedule

The Overflow Weir with Stoplogs facility could be constructed over a period of about 25 to 30 months, depending on the time of year the project is started and plant shutdown allowances for construction activities. The reservoir would need to be drawn down to below El. 2045 continuously for a period of three months to allow tendons to be installed. The construction schedule and its interface with plant operation needs further study to achieve a viable, practical, and cost effective schedule solution.

### 4.1.6 Drawings

The following plan, sections and profile figures depict the layout and general details of various features of Alternative 1:

Figures 1 and 1-1.



North
OREGON
IDAHO
SNAKE RIVER
SPILLWAY
(4 gates at 32' wide X 50' high)
(3 outlets 23' wide X 23' high)
SPILLWAY APPROACH CHANNEL
BROWNLEE DAM CREST ELEV. 2080.0
BROWNLEE RESERVOIR FULL POOL AT EL. 2077
POWERHOUSE
SWITCHYARD
NEW 130' LONG CONCRETE
BARRIER TOP EL 2045
NEW BARRIER W/REMOVABLE STOPLOGS
& TOP ACCESS BRIDGE, DECK EL. 2100
INTAKE CHANNEL
EL. 1930.0
SAND TRAP
EL. 1910.0
Figure 1
100 0 100 200
Scale 1" = 300'
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Idaho Power Company, Boise, Idaho - 2002
Application For New License
BROWNLEE PROJECT
DAM GENERAL PLAN - SWS
ALTERNATIVE 1
OVERFLOW BARRIER WEIR
W/STOPLOGS

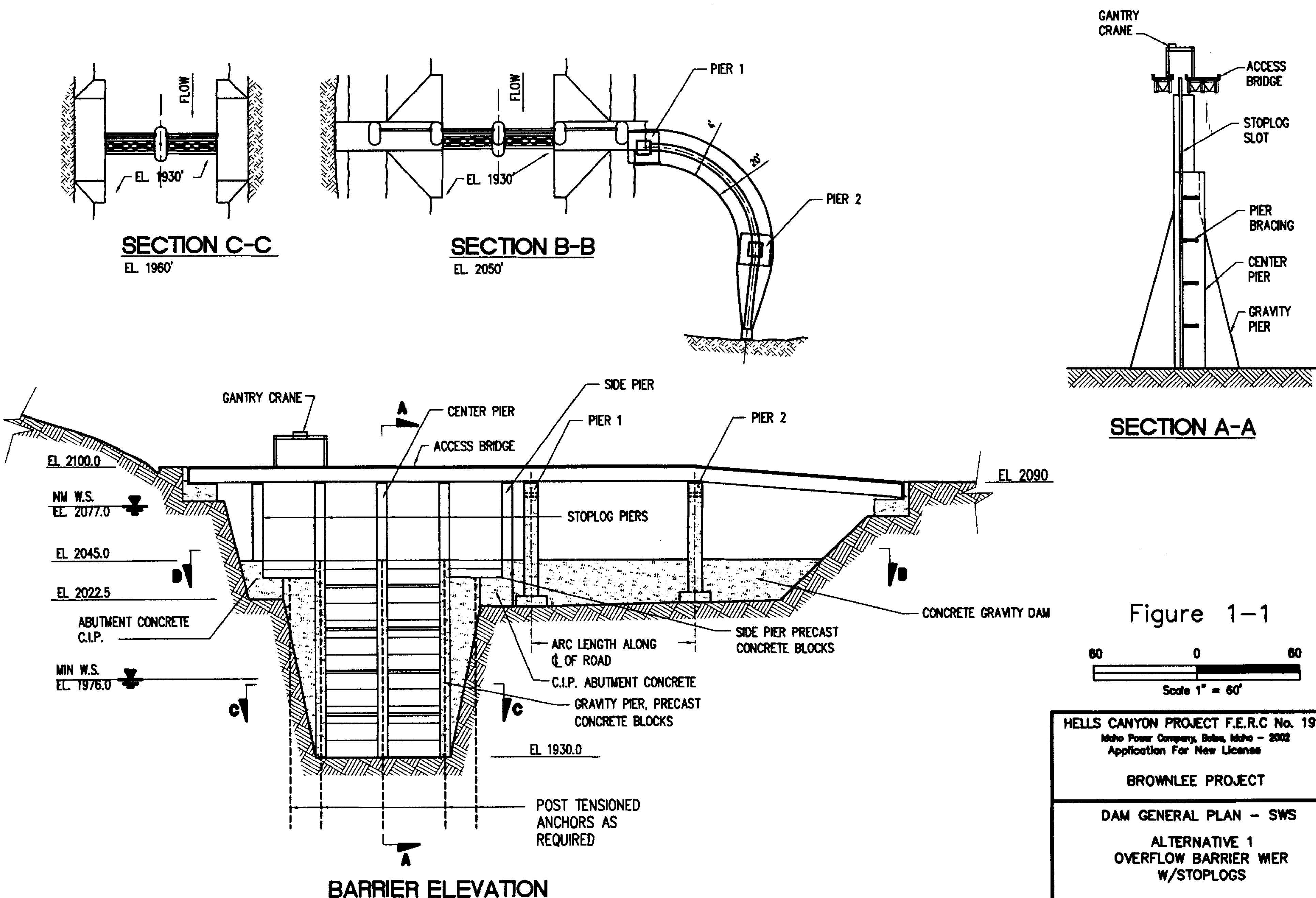


Figure 1-1

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BROWNLEE PROJECT

DAM GENERAL PLAN – SWS

ALTERNATIVE 1
OVERFLOW BARRIER WIER
W/STOPLOGS

## 4.2 ALTERNATIVE 2 - SELECTIVE WITHDRAWAL BARRIER WITH VARIABLE HEIGHT GATES IN THE EXISTING POWER INTAKE CHANNEL

### 4.2.1 Description

This alternative requires installation of the Gated Barrier Structure across the existing power intake channel and it works as a barrier with variable height gates as depicted in Figure 2-2. The barrier with variable height gates would consist of the following:

- Two center bays, each bay containing six gates, each gate would be 25 feet wide by 25 feet high.
- Two side bays each with one gate 35 feet wide by 25 feet high, and
- The position of each gate is controlled by its own independent hoisting mechanism, so that numerous opening combinations are available for operation of the Brownlee Project.

This alternative requires installation of the new Gated Barrier Structure across the existing power intake channel "in the wet", because the minimum reservoir level cannot be practically reduced below about El. 1976. Most of the foundation and non-flow through portions of the structure would consist of hollow steel shell or precast concrete sections that are fabricated in a casting yard and transported to the site for installation. After the fabricated sections are lowered in place and anchored together, concrete would be placed inside the shell or precast sections, which act as forms. Structural steel and embedded metals would be built into the forms to be joined together underwater by divers, and installation of foundation rock anchors would also be done by underwater divers. Once installation of the new components reaches the reservoir level, the remaining structure, bridge super structure, hoists, and gantry crane electrical and control components can be installed by conventional methods.

### 4.2.2 Operation and Hydraulic Performance

With this configuration, water can be drawn from any reservoir level from El. 1930 up to El. 2077. As the Brownlee reservoir water surface fluctuates, or intake flows change, and/or the desired water temperature within the range of Reservoir El. 2077 down to El. 1930 dictates, the size and level of openings in the Barrier can be adjusted to provide the desired selective withdrawal between El. 1930 and El. 2077. This alternative is designed to operate with a normal maximum head differential of about two feet, depending upon the total gated opening provided for flow passage. If the upstream to downstream head differential is greater than 5 feet, spring activated releases or designed non-damaging failure of the gates would allow water to pass through the Barrier, thus avoiding over stressing the structure. Another method of handling the hydrodynamic loading imparted on the barrier structure and the gates involves designing a spring loaded or hydraulic shock absorbing guide system that would allow gate and guide assembly displacement to defuse the hydrodynamic loading. After the hydrodynamic load is dissipated the gates and guide system would automatically be restored to their original position.

The combination of opening gates at different levels and different discharge rates between El. 1930 and 2077 would determine the tier of water that would enter the intake structure area, thus affecting the water temperature entering Brownlee intakes. If all of the gates were fully raised to their open position, the flow area provided would be over 9,000 $ft^2$. For a discharge flow of

35,000 cfs to not exceed the differential head of 2 feet, a cross-sectional flow area of only 5,140 $ft^2$ is required.

The following are some selected variations of flow through the variable height gates at the barrier resulting from a head differential of 2.0 feet between the reservoir and the water level downstream of the barrier in the intake channel.

**Table 4.2-1**
**Discharge Rating at the Power Intake Channel Barrier**
**Equipped with Variable Height Gates**

| Gates Open | Flow Area ($ft^2$) | Q (cfs) |
|---|---|---|
| 2 gates raised (open) in center bay | 1,250 | 8,500 |
| 4 gates raised (open) in center bay | 2,500 | 17,000 |
| 6 gates raised (open) in center bay | 3,750 | 25,500 |
| 8 gates raised (open) in center bay | 5,000 | 34,050 |
| Note: Total flow area (for Q = 35,000 cfs) = 5,140 $ft^2$<br>Total flow area available when all gates are raised (open) = 9,000 $ft^2$ | | |

### 4.2.3 Construction Issues

Construction of a gated barrier in the intake channel would require substantial underwater work. Much of the underwater construction is based upon the use of hollow steel shell or pre-constructed steel or precast concrete shell elements that would be filled with tremie concrete, built-up from the bottom of the channel layer by layer. Use of some post tensioning tendons is required to reduce the amount of reinforced concrete and ensure stability of the completed structure for all loading conditions. Piers containing the gate guides would extend from the bottom of the power intake channel to the bridge deck level at El. 2100 to allow gates to be moved up and down to achieve the desired size and level of openings. Construction procedures anticipate the use of a crane mounted on "flexi-float" modules that would be anchored to prevent horizontal movement while supporting the placement of structures. Another large crane would be required at the staging/loading area to load pre-constructed steel or precast concrete shells, structural steel, reinforcing steel and other construction materials for transport to the gated barrier construction area.

Construction of the non-gated side concrete gravity dam barrier, located on the north bank of the power intake channel, could be performed in the dry while the reservoir level is at or below the bottom the barrier, El. 2014.25. If this option is not practical due to construction schedule or higher reservoir water levels, construction of the gravity dam barrier could be done using tremie concreting. Construction of the gated barrier across the existing channel would require under water excavation, abutments and foundation preparation and under water concrete placement. These construction activities would require periodic and complete Plant Shutdown. Operating the plant in a peaking mode may allow operating the plant for 12 hours or so each day while the construction activities are shut down. Other construction related environmental issues, such as water quality, impact on fishery resources during construction activities also need to be addressed. The existing spillway is located on the north abutment of the Brownlee dam, approximately 1,400 feet north of the new channel barrier construction location. During a flood event flows through the spillway may result in creating high cross-flow currents at the barrier construction location. This issue and the potential impact on construction activities from reservoir level fluctuation during flood events require further consideration.

### 4.2.4 Construction Cost Estimate

The estimated cost to construct the Barrier with Variable Height Gates in the existing power intake channel scheme is about **$32 million**, including engineering, project management, permits, and a contingency allowance. This figure does not include sales tax, loss of power generation during construction, allowance for funds used during construction (AFUDC), and the value of lost generation due to head losses occurring during operation of new facilities

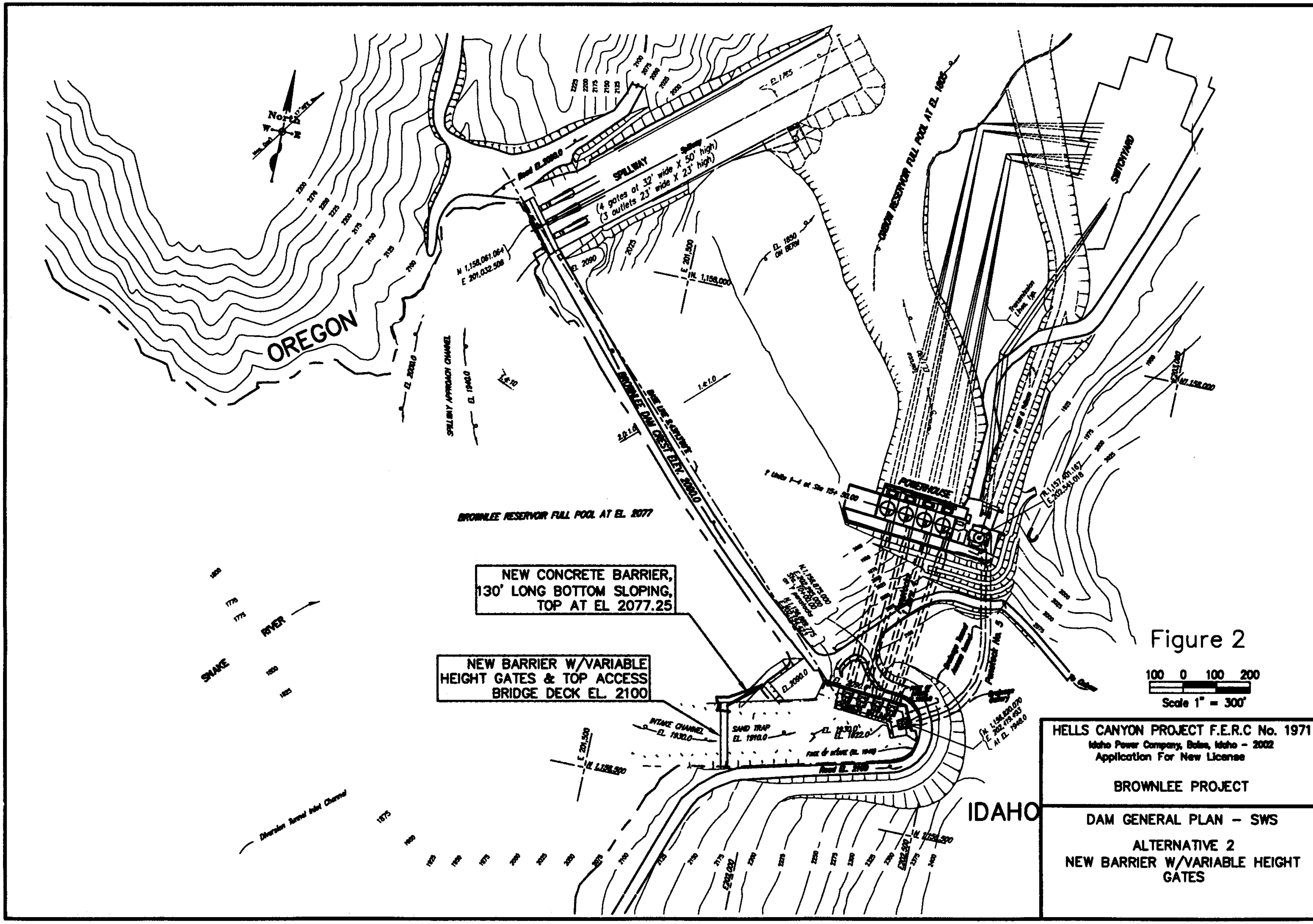
### 4.2.5 Construction Schedule

The Barrier with Variable Height Gates in the existing power intake channel facility could be constructed over a period of about 25 to 30 months, depending on the time of year the project is started and plant shutdown allowances for construction activities. The reservoir would need to be drawn down to below El. 2045 continuously for a period of three months to allow tendons to be installed. This construction schedule and its interface with plant operations needs further consideration and study to achieve a viable, practical, and cost effective schedule solution.

### 4.2.6 Drawings

The following plan, sections and detail figures depict the layout and general details of various features of Alternative 2:

Figures 2, 2-1, 2-2 and 2-3


OREGON
IDAHO
North
SPILLWAY
(4 gates at 32' wide X 50' high)
(3 outlets 23' wide X 23' high)
SPILLWAY APPROACH CHANNEL
BROWNLEE DAM CREST ELEV. 2080.0
BROWNLEE RESERVOIR FULL POOL AT EL. 2077
OXBOW RESERVOIR FULL POOL AT EL. 1805
SWITCHYARD
POWERHOUSE
SNAKE RIVER
NEW CONCRETE BARRIER, 130' LONG BOTTOM SLOPING, TOP AT EL 2077.25
NEW BARRIER W/VARIABLE HEIGHT GATES & TOP ACCESS BRIDGE DECK EL. 2100
INTAKE CHANNEL EL. 1930.0
SAND TRAP EL. 1910.0
Diversion Tunnel Inlet Channel
100 0 100 200
Scale 1" = 300'
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Idaho Power Company, Boise, Idaho - 2002
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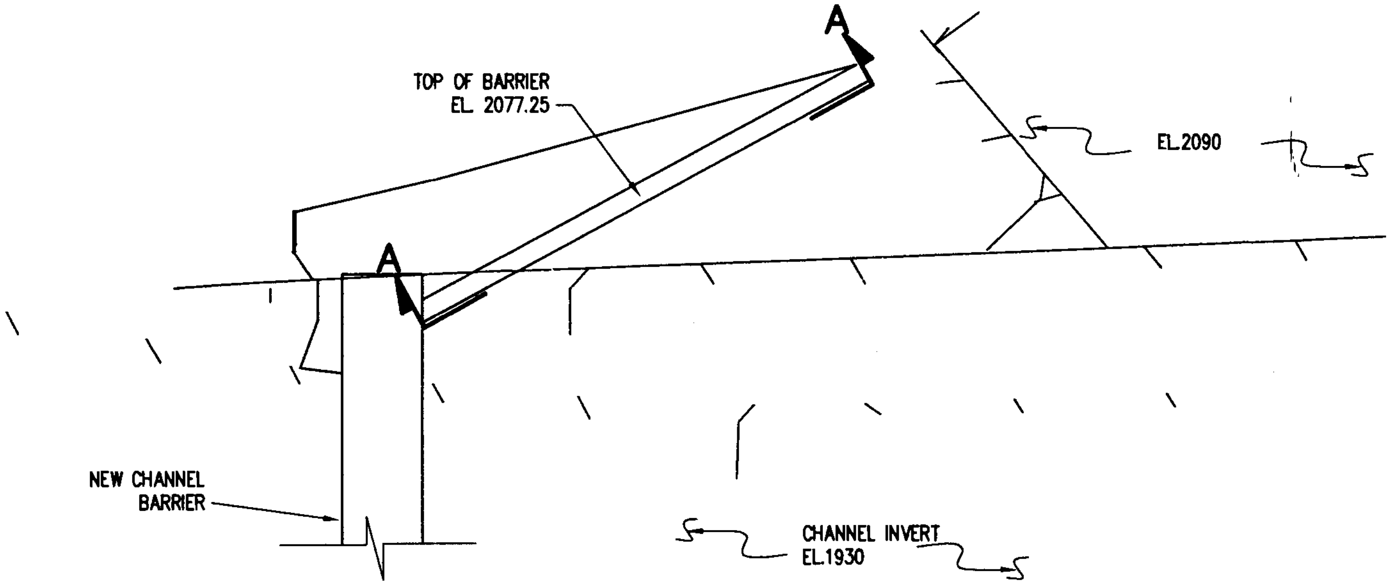
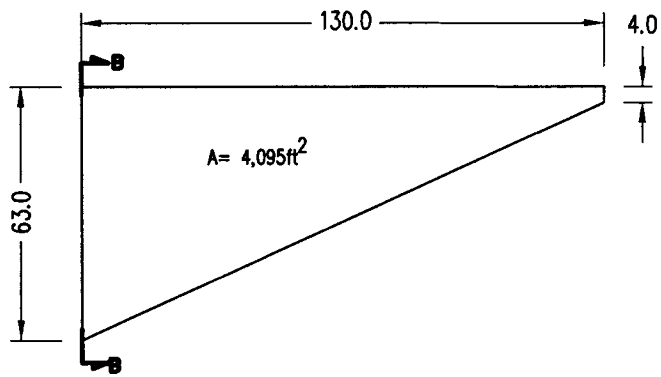
BROWNLEE PROJECT
DAM GENERAL PLAN - SWS
ALTERNATIVE 2
NEW BARRIER W/VARIABLE HEIGHT GATES

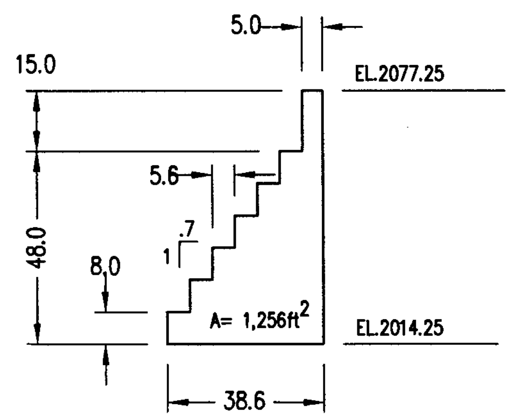
Figure 2




PLAN VIEW - EXISTING CHANNEL - CONCRETE SIDE BARRIER




VIEW A-A




SECTION B-B

Figure 2-1

40 0 40

Scale 1" = 40'

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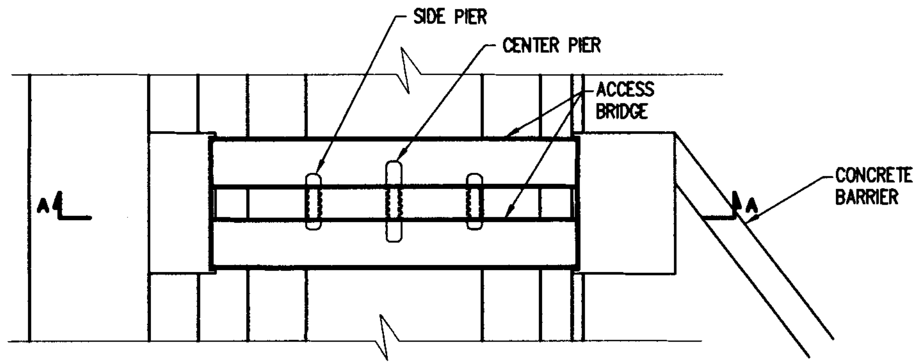
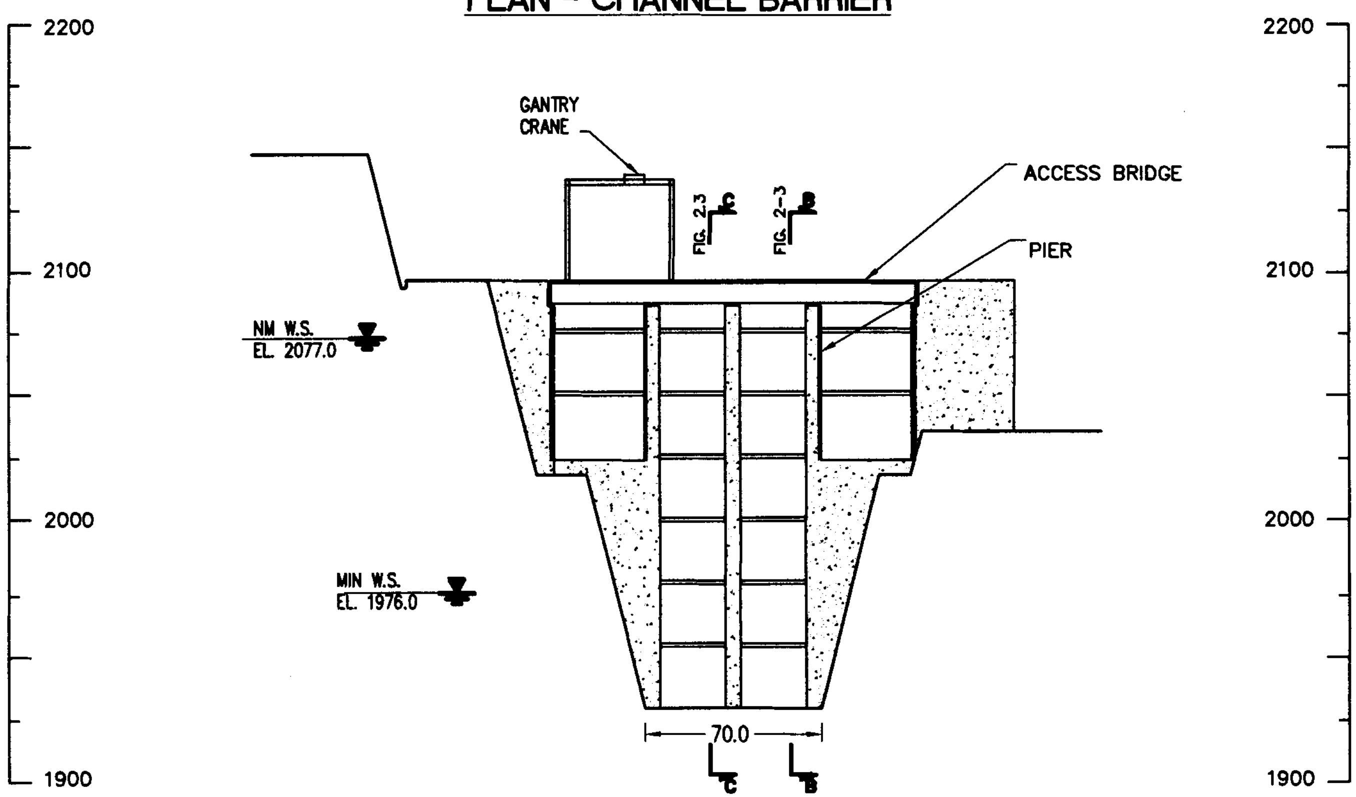
DAM GENERAL PLAN - SWS

ALTERNATIVE 2
NEW BARRIER W/VARIABLE HEIGHT GATES




PLAN - CHANNEL BARRIER




SECTION A-A

Figure 2-2

60 0 60

Scale 1" = 60'

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DAM GENERAL PLAN - SWS

ALTERNATIVE 2
NEW BARRIER W/VARIABLE HEIGHT GATES

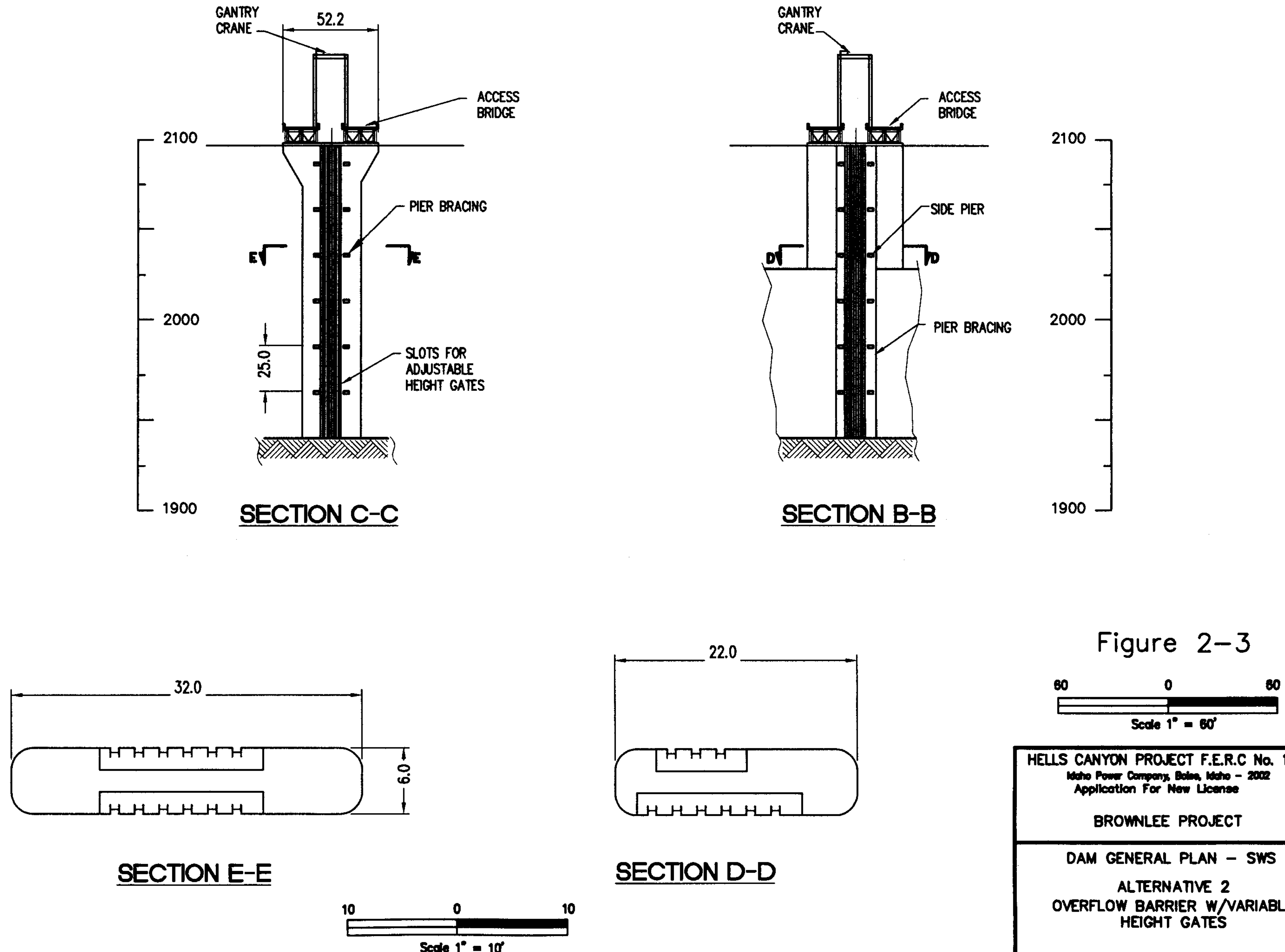


Figure 2-3

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BROWNLEE PROJECT

DAM GENERAL PLAN - SWS

ALTERNATIVE 2
OVERFLOW BARRIER W/VARIABLE HEIGHT GATES

## 4.5 ALTERNATIVE 5 - SELECTIVE WITHDRAWAL BARRIER WITH GATES IN THE EXISTING POWER INTAKE CHANNEL PLUS RE-OPENED DIVERSION TUNNEL CONNECTED BY A VERTICAL SHAFT (WITH PUMP) AND OPEN CUT EXCAVATION TO DISCHARGE DIRECTLY TO THE POWER INTAKE CHANNEL

### 4.5.1 Description

This alternative includes an intake channel barrier with sets of variable height gates to withdraw from Reservoir El. 1930 up to El. 2077, as described in Alternative 2, and a tunnel (re-opened diversion tunnel) with an invert at El. 1776, plus a vertical shaft, with barge mounted upwell pump in a steel pipe, to connect to the existing intake channel. Flow out of the existing intake channel is controlled by the five unit power intakes and flows feeding into the existing power intake channel are hydraulically balanced, but assisted by pumping, through the diversion tunnel/vertical shaft and the upwell pipe. This alternative is designed to operate with a normal head differential of about two to three feet, and a maximum head differential of about 5 feet. When the downstream head differential is greater than 5 feet, spring activated releases occur that would allow water to pass through the gated barrier, thus avoiding overstressing the structure.

The existing horseshoe-shaped, unlined rock diversion tunnel and the existing tunnel entrance would be excavated and re-opened for use. A length of about 760 feet of the existing diversion tunnel would be used, as depicted in Figures 5 and 5-1. At the downstream end of this tunnel section, a 41-foot-diameter vertical drop shaft would be built, excavating from the surface downward to El. 1930. This shaft would lead to a new steel pipe (in a trough) that would lead to a pump located on a barge. The pump would discharge the water from the vertical shaft to the existing power intake channel via the open cut trough. Refer to Figure 5-1. The invert elevation of the trough would be about 1930.

Variable height gates and top access bridge would be located near the beginning of the existing power intake channel at the gated barrier structure. Refer to Figure 5. The variable height gates would be arranged identical to Alternatives 2 and 3.

### 4.5.2 Operation and Hydraulic Performance

By varying the openings in the Barrier, more or less flows are caused to pass through the tunnel/shaft, assisted by pumping. As gated Barrier head losses are increased, more flow is drawn through the diversion tunnel/shaft. When less tunnel flow is desired, the Barrier gate openings are increased, thus reducing Barrier head losses and decreasing head differential that forces flows through the tunnel/shaft.

The total hydraulic head loss between reservoir and the existing power intake channel, for a discharge rate of 10,000 cfs, flowing through the diversion tunnel, drop shaft, pump and new pipes was estimated to be 2.10 feet. The head that the pump needs to pump against was estimated to be 2.10 feet as well.

For the 35,000-cfs discharge rating at the power intake channel barrier/gates facilities, see Alternative 2, Table 4.2-1.

### 4.5.3 Construction Issues

Construction of a gated barrier in the intake channel would require substantial underwater work. Much of the underwater construction is based upon the use of pre-constructed steel or precast concrete shell elements that would be filled with tremie concrete, built-up from the bottom of the channel layer by layer. Use of post tensioning tendons is required to reduce the amount of reinforced concrete and ensure stability of the completed structure for all loading conditions. Piers containing the gate guides would extend from the bottom of the power intake channel to the bridge deck level at El. 2100 to allow gates to be moved up and down to achieve the desired size and level of openings. Construction procedures anticipate the use of a crane mounted on “flexi-float” modules that would be anchored to prevent horizontal movement while supporting the placement of structures. Another large crane would be required at the staging/loading area to load precast concrete segments, structural steel, reinforcing steel and other construction materials for transport to the gated barrier construction area.

Re-opening of the diversion tunnel and excavation of a new vertical shaft and open cut rock excavation to the power intake channel would involve both dry rock drill-and-shoot excavation and underwater drilling and blasting using divers, a crane mounted barge, additional barge support equipment, and submersible construction equipment. The open cut rock excavation of the rock trough into the power intake channel would require a “wet tap” of the connection between the open cut area and the power intake channel. These activities could create significant ground disturbances to the reservoir and existing power intake channel rock slopes. The excavation of the vertical shaft and trough would produce some 219,000 cubic yards of shot rock and tunnel muck that would need to be disposed of somewhere, probably upstream in the Brownlee Reservoir. Re-opening of the diversion tunnel is an aspect of construction for this scheme that could lead to significant time delays and increase in cost, if conditions are undesirable.

### 4.5.4 Construction Cost Estimate

The estimated cost to construct the Barrier with Variable Height Gates plus Re-opened diversion tunnel/vertical shaft/open cut trough with barge mounted pump discharging directly to the existing power intake channel scheme is about **$48 million**, including engineering, project management, permits, and a contingency allowance. This figure does not include sales tax, loss of power generation during construction, allowance for funds used during construction (AFUDC), and the value of lost generation due to head losses occurring during operation of new facilities

### 4.5.5 Construction Schedule

The Barrier with Variable Height Gates in the existing power intake channel facility could be constructed over a period of about 25 to 30 months, depending on the time of year the project is started and plant shutdown allowances for construction activities. The reservoir would need to be drawn down to below El. 2045 continuously for a period of three months to allow tendons to be installed. The construction schedule and its interface with plant operation needs further study to achieve a viable, practical, and cost effective schedule solution.

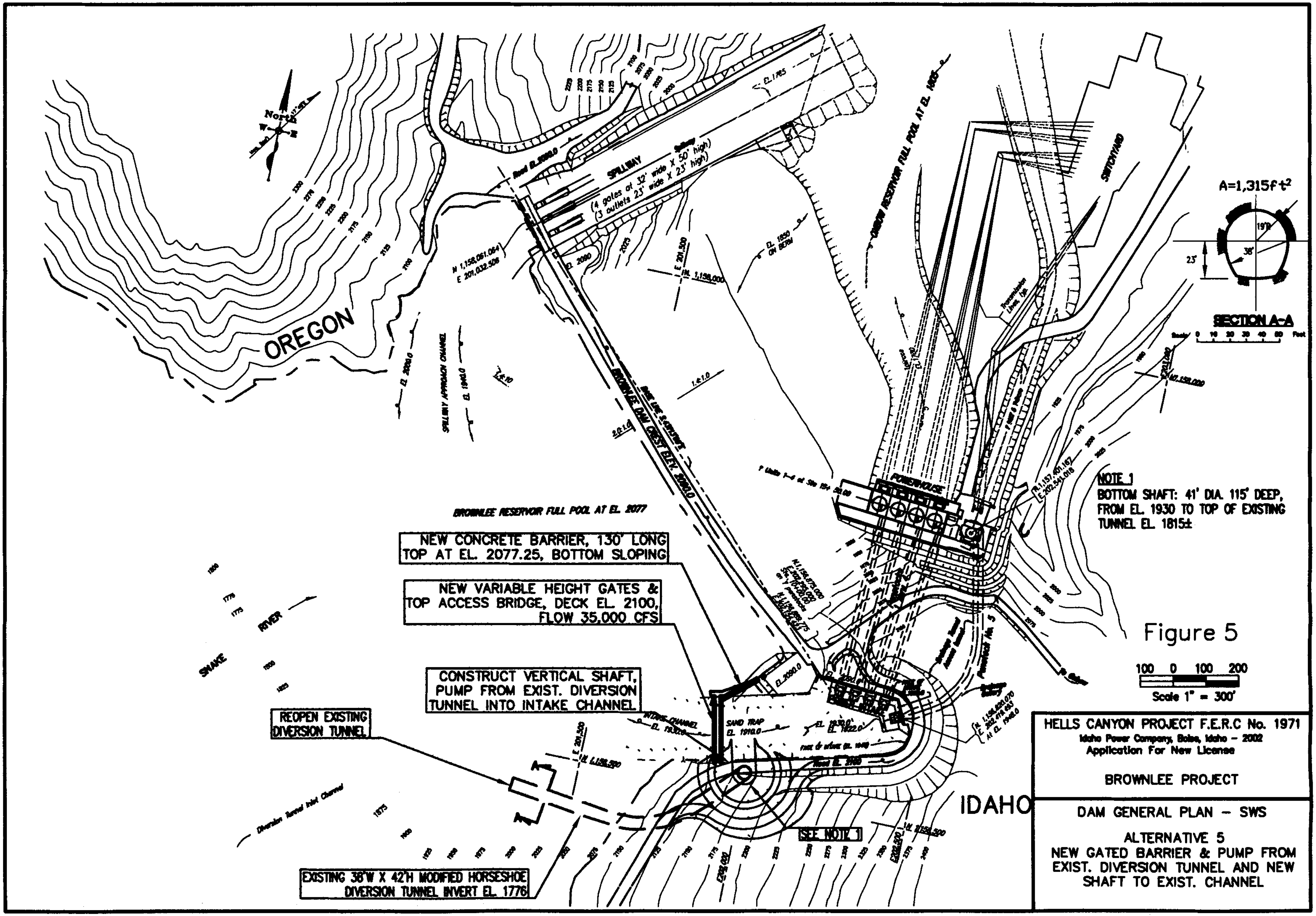
The vertical shaft excavation can be performed "in the dry" until the shaft reaches the appropriate depth above the diversion tunnel for a wet tap. The new open cut trough connection to the tunnel would also be constructed, mostly "in the dry", from the top ground surface to about 100 feet above the diversion tunnel crown. Before the trough is connected to the power intake channel, the vertical shaft would be extended down to the existing diversion tunnel. The connections of the vertical shaft to the existing diversion tunnel and the open cut rock trough to the power intake channel would both require "wet taps" of those structures. This scheme assumes that the existing diversion tunnel is adequate for use as a conduit for 10,000 cfs flows without lining or other treatment. The excavation and underground work may take six to twelve months and needs to be performed before the Barrier structure and barge mounting pump and pipe work can be placed.

The combined length of construction time for the open cut excavation and underground work and the gated barrier structure and pump/pipe arrangement may result in construction lasting up to 50 months. This longer construction schedule is due partly to the close proximity of the new project features.

### 4.5.6 Drawings

The following figures show the plan and profile of Alternative 5:

Figures 5 and 5-1.



OREGON
IDAHO
SPILLWAY
(4 gates at 32' wide X 50' high)
(3 outlets 23' wide X 23' high)
SWITCHYARD
POWERHOUSE
SNAKE RIVER
BROWNLEE RESERVOIR FULL POOL AT EL. 2077
BROWNLEE DAM CREST ELEV. 2080.0
A=1,315ft²
SECTION A-A
NOTE 1
BOTTOM SHAFT: 41' DIA. 115' DEEP, FROM EL. 1930 TO TOP OF EXISTING TUNNEL EL. 1815±
NEW CONCRETE BARRIER, 130' LONG TOP AT EL. 2077.25, BOTTOM SLOPING
NEW VARIABLE HEIGHT GATES & TOP ACCESS BRIDGE, DECK EL. 2100, FLOW 35,000 CFS
CONSTRUCT VERTICAL SHAFT, PUMP FROM EXIST. DIVERSION TUNNEL INTO INTAKE CHANNEL
REOPEN EXISTING DIVERSION TUNNEL
EXISTING 38'W X 42'H MODIFIED HORSESHOE DIVERSION TUNNEL INVERT EL. 1776
SAND TRAP EL. 1910.0
INTAKE CHANNEL EL. 1930.0
SEE NOTE 1
Figure 5
100 0 100 200
Scale 1" = 300'
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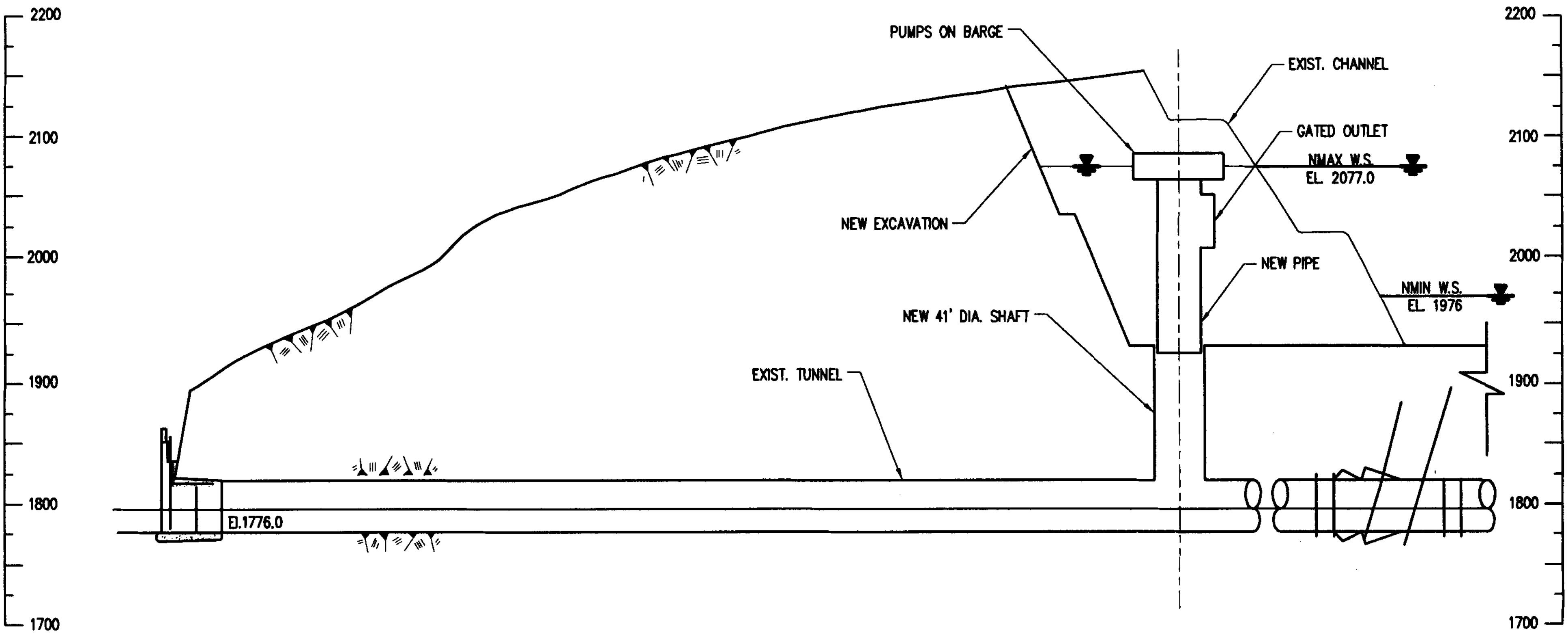
BROWNLEE PROJECT
DAM GENERAL PLAN – SWS
ALTERNATIVE 5
NEW GATED BARRIER & PUMP FROM EXIST. DIVERSION TUNNEL AND NEW SHAFT TO EXIST. CHANNEL




## DEVELOPED PROFILE ON ℄ EXIST. TUNNEL

Figure 5-1

100 0 100

Scale 1" = 100'

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DAM GENERAL PLAN - SWS

ALTERNATIVE 5
NEW GATED BARRIER W/EXISTING DIVERSION TUNNEL, NEW SHAFT & NEW SHAFT W/ADJ. GATES

## 4.9 ALTERNATIVE 8 - A NEW 12,000-CFS CAPACITY TOWER, BUILT AS A FREE STANDING STRUCTURE WITH VARIABLE HEIGHT GATES, OVER THE EXISTING, BUT RE-OPENED, DIVERSION TUNNEL CONNECTED BY A VERTICAL SHAFT AND NEW HORIZONTAL TUNNEL(S) TO UNIT #5 (OR UNITS #3 AND #4) PENSTOCK(S)

### 4.9.1 Description

For this alternative, flows directly into Unit #5 (or Units #3 and #4) would be taken from the reservoir via a new intake structure, pass through the re-opened diversion tunnel, through a new vertical shaft, and through a new connecting tunnel(s). Flows to the remaining units would continue to pass through the existing uncontrolled power intake channel.

A new 310-foot high and 200-foot-diameter precast concrete circular tower equipped with four sets of variable height gates, would be constructed in the reservoir in the wet. The tower's foundation would be located at the entrance to the existing diversion tunnel portal as shown in Figures 8 and 8-1. The free-standing circular tower would be braced by steel struts connected to the rock face on the east side of the reservoir, and would be accessible via a steel bridge connected to the rock slope above the reservoir pool. Each of the 28 gates would be 20 feet wide by 45 feet high. The diversion tunnel entrance and the tunnel would be excavated and re-opened for use with this alternative. A total length of about 1,300 feet of the existing unlined rock diversion tunnel would be used. At 700 feet downstream of the diversion tunnel inlet, a 41-foot-diameter vertical shaft would be built, excavating from the surface downward to intersect the diversion tunnel. This vertical shaft would extend all the way down from the rock (ground) surface at about El. 2100 to intersect the diversion tunnel, as depicted in Figure 8-1.

From the vertical shaft, an additional 600-foot length of the existing diversion tunnel would be used to a location near and under the Unit No. 5 intake structure. Here a second 41-foot-diameter vertical shaft would extend up from the existing diversion tunnel to El. 1944±. Then a short horizontal tunnel and steel lined conduit would join this second shaft to the existing 28-foot-diameter penstock leading to Unit No. 5. A trashrack would be located at the bottom of the first shaft to prevent debris from entering the Unit No. 5 penstock. Also, a full head pressure closure gate would be installed behind the trashrack to allow unwatering of the tunnel and penstock downstream of that point. Refer to Figure 8-1.

### 4.9.2 Operation and Hydraulic Performance

Since Unit No. 5 would be the only one connected to the new reservoir intake tower, mixing of unit discharge flows and respective water temperatures would occur in the powerhouse tailrace discharge, or in the Oxbow reservoir, if Unit #5 were passing flows. This alternative is designed to operate with minimal head differential in the new intake tower. The opening to the new tower would be sized for the full 12,000 cfs with minimal head losses, thus avoiding over stressing the structure.

A peak of 12,000 cfs discharge was considered for this alternative. Total head loss in the tunnels and shafts was estimated to be 4.68 feet at peak discharge. The head loss rating of the variable height gates at the 200-foot-diameter tower plus the underground conduits was estimated as follows:

**Table 4.9-1**
**Head Loss Rating of the Steel Pipe Tower Equipped with Variable Height Gates**

| No. of Gates Open in Each Bay | Flow Area ($ft^2$) | Q (cfs) | Head Loss in Tunnels/Shafts (ft) | Head Loss Across Gates (ft) | Total Head Loss |
|---|---|---|---|---|---|
| 5 | 18,000 | 12,000 | 4.68 | 0.02 | 4.70 |
| 4 | 14,400 | 12,000 | 4.68 | 0.03 | 4.71 |
| 3 | 10,800 | 12,000 | 4.68 | 0.05 | 4.73 |
| 2 | 7,200 | 12,000 | 4.68 | 0.12 | 4.80 |
| 1 | 3,600 | 12,000 | 4.68 | 0.48 | 5.16 |

### 4.9.3 Construction Issues

Construction of the 310-foot high, 200-foot diameter precast concrete intake tower would require substantial pre-assembly preparation and substantial underwater assembly work. Much of the underwater construction would be based upon the use of either fully precast large and heavy components to be fitted together underwater, or pre-constructed steel or precast concrete shell elements that would be filled with tremie concrete after positioning and anchoring underwater. Both approaches would require prefabricated pieces to be built-up from the reservoir bottom layer by layer. Before placement of the precast sections, the tower foundation would need to be anchored to the rock bottom of the reservoir at a depth of some 300 feet. This procedure would require submersible construction equipment and remote operated vehicles (ROV's) to monitor, control, and accomplish the work at such great depths. Post tensioning tendons could be used to reduce the amount of reinforced concrete and ensure stability of the completed structure for all loading conditions, but it is not a common practice to install post tension tendons underwater. These construction procedures anticipate the use of one or more cranes mounted on "flexi-float" modules that would be anchored to prevent horizontal movement while supporting the placement of structures. Another large crane would be required at the staging/loading area to load precast concrete segments, structural steel, reinforcing steel and other construction materials for transport to the tower construction area. For the large tower precast sections, a temporary casting yard/basin would need to be developed to support the casting and floating of 200-foot diameter concrete sections. This facility would include construction of a sheet pile cofferdam and dry-dock structure with full commercial utilities to accommodate the concrete batch plant and precasting work.

Re-opening of the diversion tunnel, connection of the tunnel to the new intake tower, and excavation of two new vertical shafts and a new tunnel would involve extensive curtain grouting and tunnel/shaft grouting to prevent collapse of the underground structures during excavation, unwatering, and lining. These activities could create significant ground disturbances to the existing diversion tunnel and power intake channel rock slopes. The loose rock portal excavation and excavation of the vertical shafts and tunnel would produce some 36,000 cubic yards of shot rock and tunnel muck that would need to be disposed of somewhere, probably upstream in the Brownlee Reservoir. Re-opening of the diversion tunnel is an aspect of construction for this scheme that could lead to significant time delays and increase in cost, if conditions are undesirable.

### 4.9.4 Construction Cost Estimate

The estimated cost to construct the new 12,000-cfs tower, re-opened diversion tunnel, new shaft #1, shotcrete lined diversion tunnel, new shaft #2, and new steel lined tunnel to Unit No. 5 penstock scheme is about **$217 million**, including engineering, project management, permits, and a contingency allowance. This figure does not include sales tax, loss of power generation during construction, allowance for funds used during construction (AFUDC), and the value of lost generation due to head losses occurring during operation of new facilities.

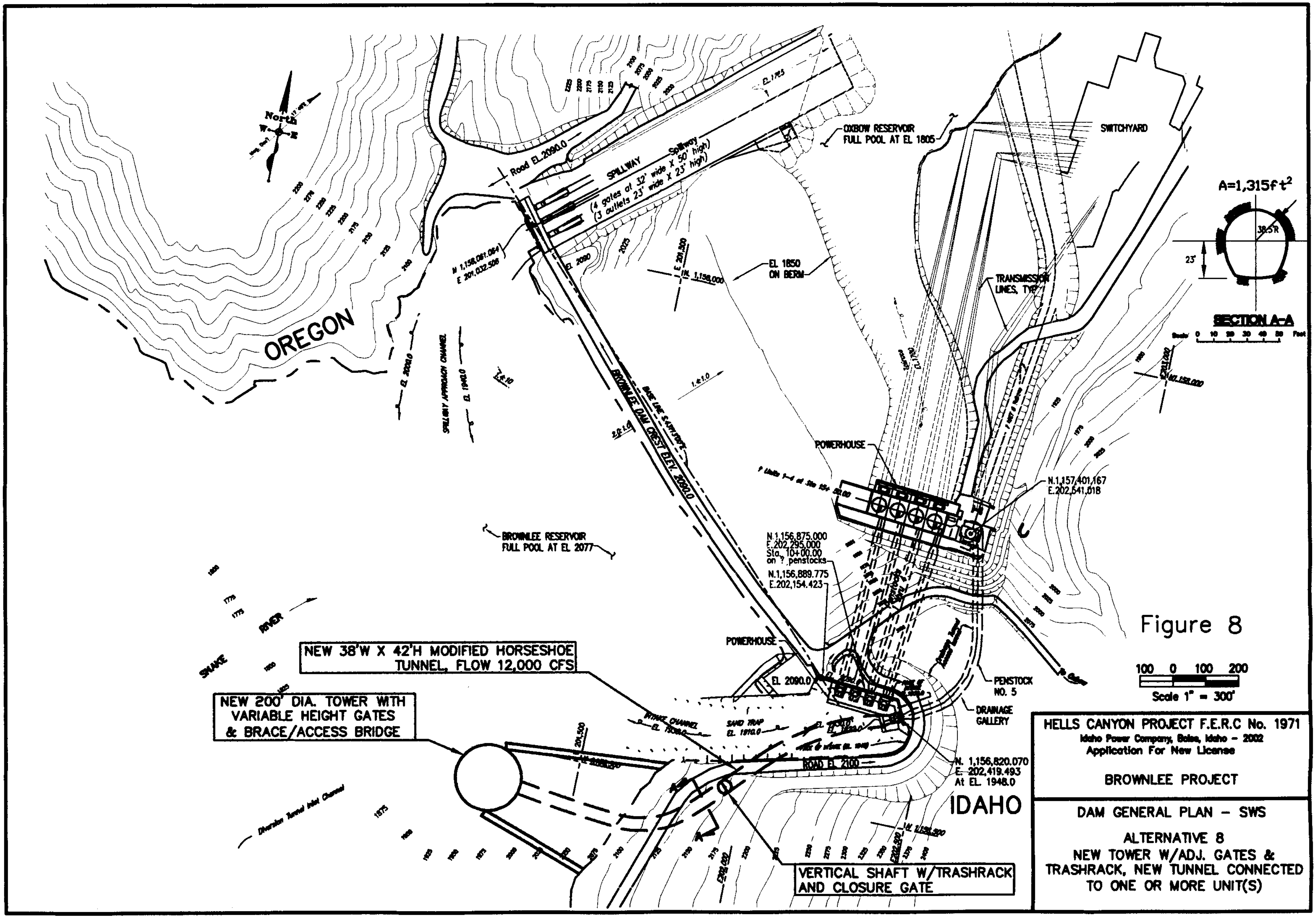
### 4.9.5 Construction Schedule

Establishing the dry dock, casting yard, concrete batch plant, and other commercial facilities needed before construction on the new reservoir intake tower begins would probably require about seven months. Casting of the building blocks for the intake tower and connecting structures would probably take eight to twelve months, but could be done concurrent with other work activities. Excavation of the two vertical shafts, curtain grouting of the existing diversion tunnel, both top down would probably take 12 months. Dewatering and shotcrete lining of the diversion tunnel and construction of the new lined tunnel would probably take about 24 months. The combined length of construction time for these activities is about 48 months. The underground excavation work could proceed without interruption of the power generation at Brownlee, except for the work on the Unit #5 penstock. However, the intake tower construction may have an impact on flows into the existing power intake channel, so that either power generation be reduced or stopped, or the construction period extended.

### 4.9.6 Drawings

The following plan and profile figures depict the layout and general arrangement of Alternative 8:

Figures 8 and 8-1.



OREGON
IDAHO
North
SPILLWAY
Road EL 2090.0
(4 gates at 32' wide X 50' high)
(3 outlets 23' wide X 23' high)
OXBOW RESERVOIR
FULL POOL AT EL 1805
SWITCHYARD
A=1,315ft²
SECTION A-A
EL 1850
ON BERM
TRANSMISSION
LINES, TYP.
BROWNLEE DAM CREST ELEV. 2090.0
SPILLWAY APPROACH CHANNEL
POWERHOUSE
N.1,157,401,167
E.202,541,018
BROWNLEE RESERVOIR
FULL POOL AT EL 2077
N.1,156,875.000
E.202,295,000
Sta. 10+00.00
N.1,156,889.775
E.202,154.423
SNAKE RIVER
POWERHOUSE
NEW 38'W X 42'H MODIFIED HORSESHOE
TUNNEL, FLOW 12,000 CFS
NEW 200' DIA. TOWER WITH
VARIABLE HEIGHT GATES
& BRACE/ACCESS BRIDGE
EL 2090.0
PENSTOCK
NO. 5
DRAINAGE
GALLERY
ROAD EL 2100
N. 1,156,820.070
E. 202,419.493
At EL 1948.0
VERTICAL SHAFT W/TRASHRACK
AND CLOSURE GATE
100 0 100 200
Scale 1" = 300'
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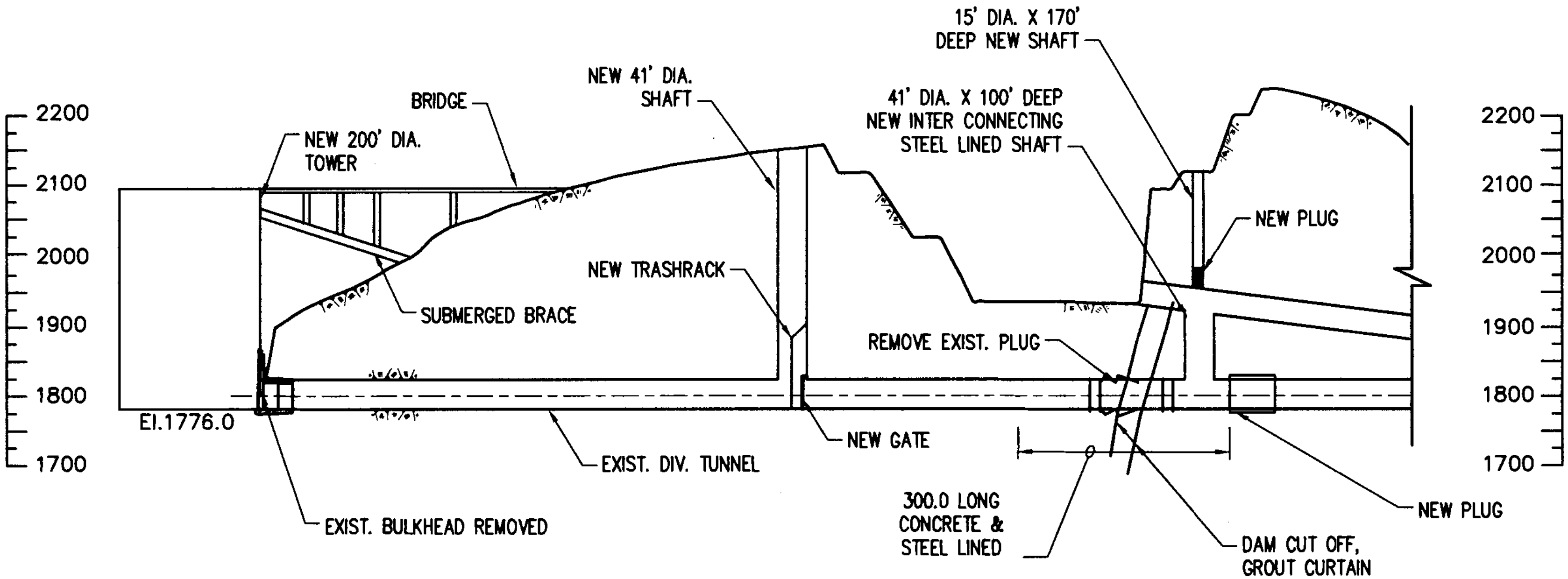
Idaho Power Company, Boise, Idaho - 2002
Application For New License
BROWNLEE PROJECT
DAM GENERAL PLAN - SWS
ALTERNATIVE 8
NEW TOWER W/ADJ. GATES &
TRASHRACK, NEW TUNNEL CONNECTED
TO ONE OR MORE UNIT(S)


Figure 8




DEVELOPED PROFILE ON ℄ EXIST. TUNNEL

Figure 8-1

100 0 100 200

Scale 1" = 200'

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BROWNLEE PROJECT

DAM GENERAL PLAN – SWS

ALTERNATIVE 8
NEW TOWER W/ADJ. GATES,
EXIST. AND NEW TUNNELS &
NEW SHAFT CONNECTED TO
ONE OR MORE UNITS

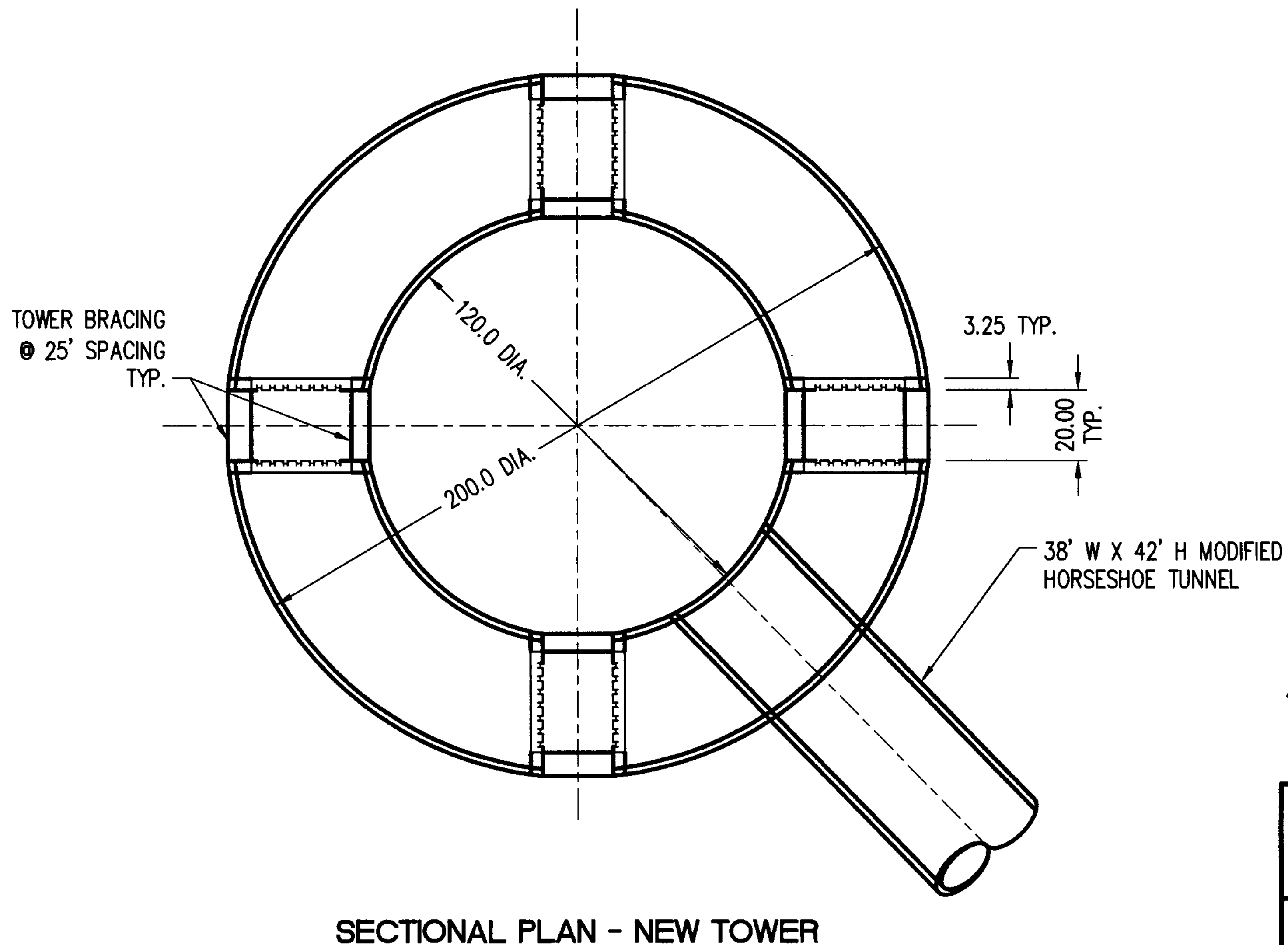


Figure 8-2

40 0 40

Scale 1" = 40'

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BROWNLEE PROJECT

DAM GENERAL PLAN - SWS

ALTERNATIVE 8
NEW TOWER W/ADJ. GATES & TRASHRACK, NEW TUNNEL CONNECTED TO ONE OR MORE UNIT(S)

## 4.18 ALTERNATIVE 12 – A NEW 35,000-CFS CAPACITY INTAKE TOWER, BUILT AS_A FREE STANDING STRUCTURE WITH VARIABLE HEIGHT GATES, OVER THE EXISTING, BUT RE-OPENED AND ENLARGED, DIVERSION TUNNEL, AND CONNECTED BY A LARGE VERTICAL SHAFT AND NEW HORIZONTAL TUNNEL TO THE POWER INTAKE CHANNEL, AND A NEW CONCRETE DAM BLOCKING THE EXISTING POWER INTAKE CHANNEL

### 4.18.1 Description

The tower, enlarged diversion tunnel, drop shaft and upper tunnel arrangement in this alternative are similar to Alternative 10A. Refer to Figures 12and 12-1. The difference between this alternative and Alternative 10A is that the power intake channel barrier (concrete dam) for this alternative does not allow any direct flows from the reservoir to the power intake channel. Refer to Figure 12-2. All flows must pass through the new reservoir intake tower, re-opened and enlarged diversion tunnel, new vertical shaft, and new horizontal tunnel.

### 4.18.2 Operation and Hydraulic Performance

The hydraulic head losses at the variable height gates at the new tower and the head losses in the enlarged tunnel, new drop shaft and new upper tunnel are identical to Alternative 10A, described in Section 4.16.

### 4.18.3 Construction Issues

Construction issues of the new intake tower are similar to those of Alternative 8; and issues of re-opening and enlarging the diversion tunnel, excavating the large vertical shaft, and the new large horizontal tunnel are similar to Alternative 10A.

Construction of a new concrete gravity barrier dam across the intake channel would require under water excavation, abutments and foundation preparation and under water concrete placement. Much of the underwater construction is based upon the use of hollow steel shell or pre-constructed steel or precast concrete shell elements that would be filled with tremie concrete, built-up from the bottom of the channel layer by layer. Construction procedures anticipate the use of a crane mounted on "flexi-float" modules that would be anchored to prevent horizontal movement while supporting the placement of structures. Another large crane would be required at the staging/loading area to load pre-constructed steel or precast concrete shells, structural steel, reinforcing steel and other construction materials for transport to the gated barrier construction area.

Construction of the barrier dam would require periodic and complete Plant Shutdown. Operating the plant in a peaking mode may allow operating the plant for 12 hours or so each day while the construction activities are shut down. Other construction related environmental issues, such as water quality, impact on fishery resources during construction activities also need to be addressed. The existing spillway is located on the north abutment of the Brownlee dam, approximately 1,400 feet north of the new channel barrier construction location. During a flood event flows through the spillway may result in creating high cross-flow currents at the barrier construction location. This issue and the potential impact on construction activities from reservoir level fluctuation during flood events require further consideration.

### 4.18.4 Construction Cost Estimate

The estimated cost to construct the concrete dam Barrier, new 35,000 cfs tower and Re-opened and enlarged diversion tunnel/new shaft/new tunnel to the existing power intake channel scheme is about **$286 million**, including engineering, project management, permits, and a contingency allowance. This figure does not include sales tax, loss of power generation during construction, allowance for funds used during construction (AFUDC), and the value of lost generation due to head losses occurring during operation of new facilities

### 4.18.5 Construction Schedule

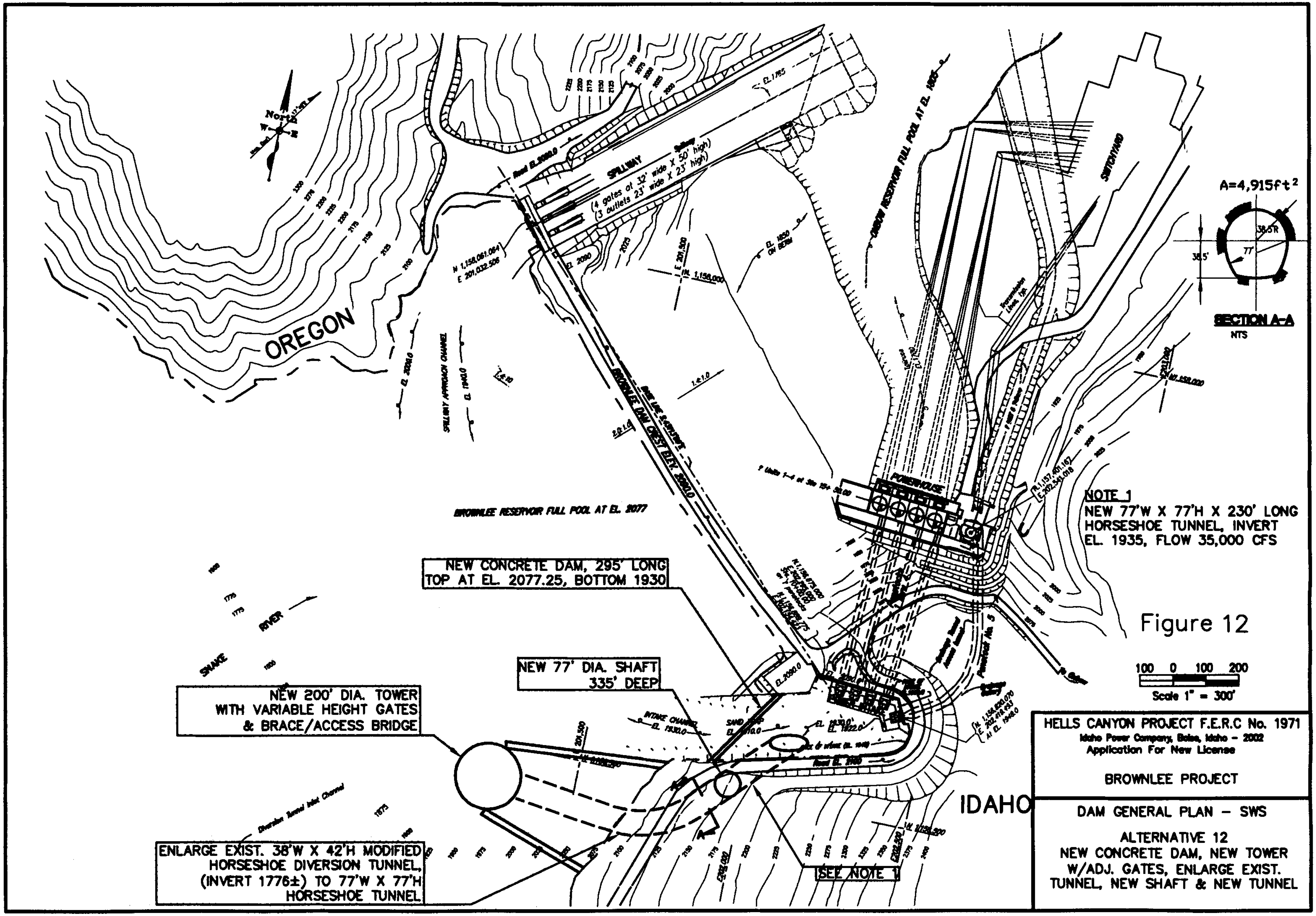
Establishing the dry dock, casting yard, concrete batch plant, and other commercial facilities needed before construction on the new reservoir intake tower begins would probably require about seven months. Casting of the building blocks for the intake tower and connecting structures would probably take eight to twelve months, but could be done concurrent with other work activities. Excavation of the large vertical shaft, curtain grouting of the existing diversion tunnel, both top down would probably take 12 months. Dewatering, enlargement, and shotcrete lining of the diversion tunnel and construction of the new large tunnel would probably take about 24 months. The combined length of construction time for the tower and tunnel work is about 48 months. The underground excavation work may be able to proceed without interruption of the power generation at Brownlee, except for the re-entrance of the new tunnel to the power intake channel. However, the intake tower construction may have an impact on flows into the existing power intake channel, so that either power generation needs to be reduced or stopped, or the construction period extended.

The Concrete Gravity Dam Barrier in the existing power intake channel facility can be constructed over a period of about 18 months, depending on the time of year the project is started and plant shutdown allowances for construction activities. The work could be constructed without drawdown of the reservoir, but drawdown would reduce cost and speed the work.

Since the barrier dam would completely block flows into the power intake channel, it cannot be constructed until after the tower and tunnel conduit is complete and operational. Therefore, the overall construction schedule is probably the sum of the two separate durations, or about 66 months. This construction schedule and its interface with plant operation needs further study to achieve a viable, practical, and cost effective schedule solution.

### 4.18.6 Drawings

Refer to Figures 12, 12-1 and 12-2 for details of this alternative.



OREGON
IDAHO
SNAKE RIVER
SPILLWAY
(4 gates at 32' wide X 50' high)
(3 outlets 23' wide X 23' high)
POWERHOUSE
SWITCHYARD
BROWNLEE RESERVOIR FULL POOL AT EL. 2077
A=4,915ft²
SECTION A-A
NTS
NOTE 1
NEW 77'W X 77'H X 230' LONG
HORSESHOE TUNNEL, INVERT
EL. 1935, FLOW 35,000 CFS
NEW CONCRETE DAM, 295' LONG
TOP AT EL. 2077.25, BOTTOM 1930
NEW 77' DIA. SHAFT
335' DEEP
NEW 200' DIA. TOWER
WITH VARIABLE HEIGHT GATES
& BRACE/ACCESS BRIDGE
ENLARGE EXIST. 38'W X 42'H MODIFIED
HORSESHOE DIVERSION TUNNEL,
(INVERT 1776±) TO 77'W X 77'H
HORSESHOE TUNNEL
SEE NOTE 1
Figure 12
100 0 100 200
Scale 1" = 300'
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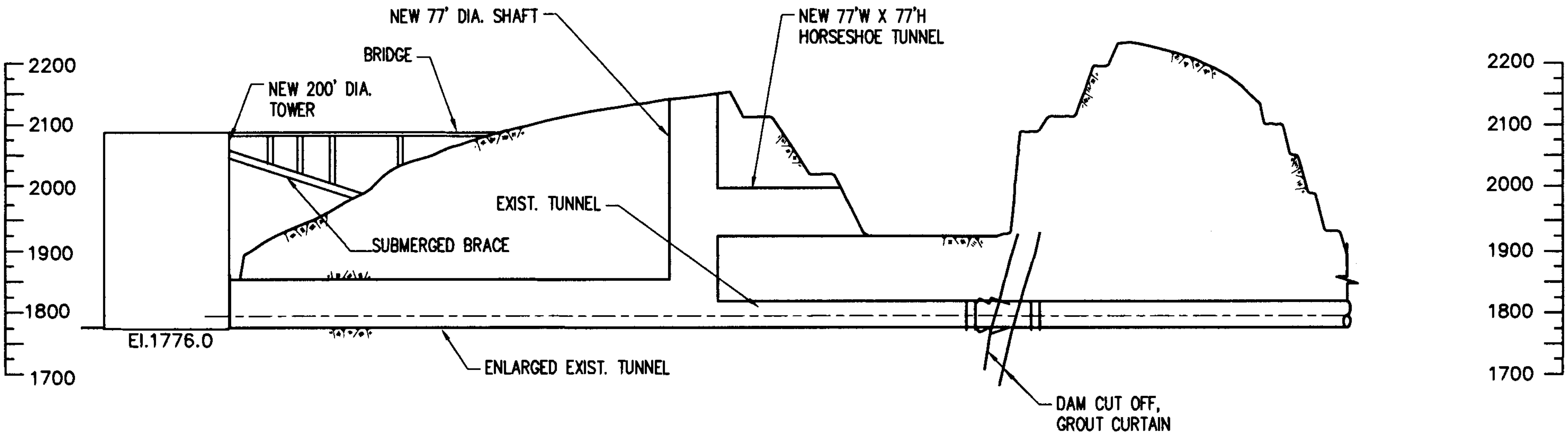
BROWNLEE PROJECT
DAM GENERAL PLAN - SWS
ALTERNATIVE 12
NEW CONCRETE DAM, NEW TOWER
W/ADJ. GATES, ENLARGE EXIST.
TUNNEL, NEW SHAFT & NEW TUNNEL




DEVELOPED PROFILE ON ℄ EXIST. TUNNEL

Figure 12-1

100 0 100 200
Scale 1" = 200'

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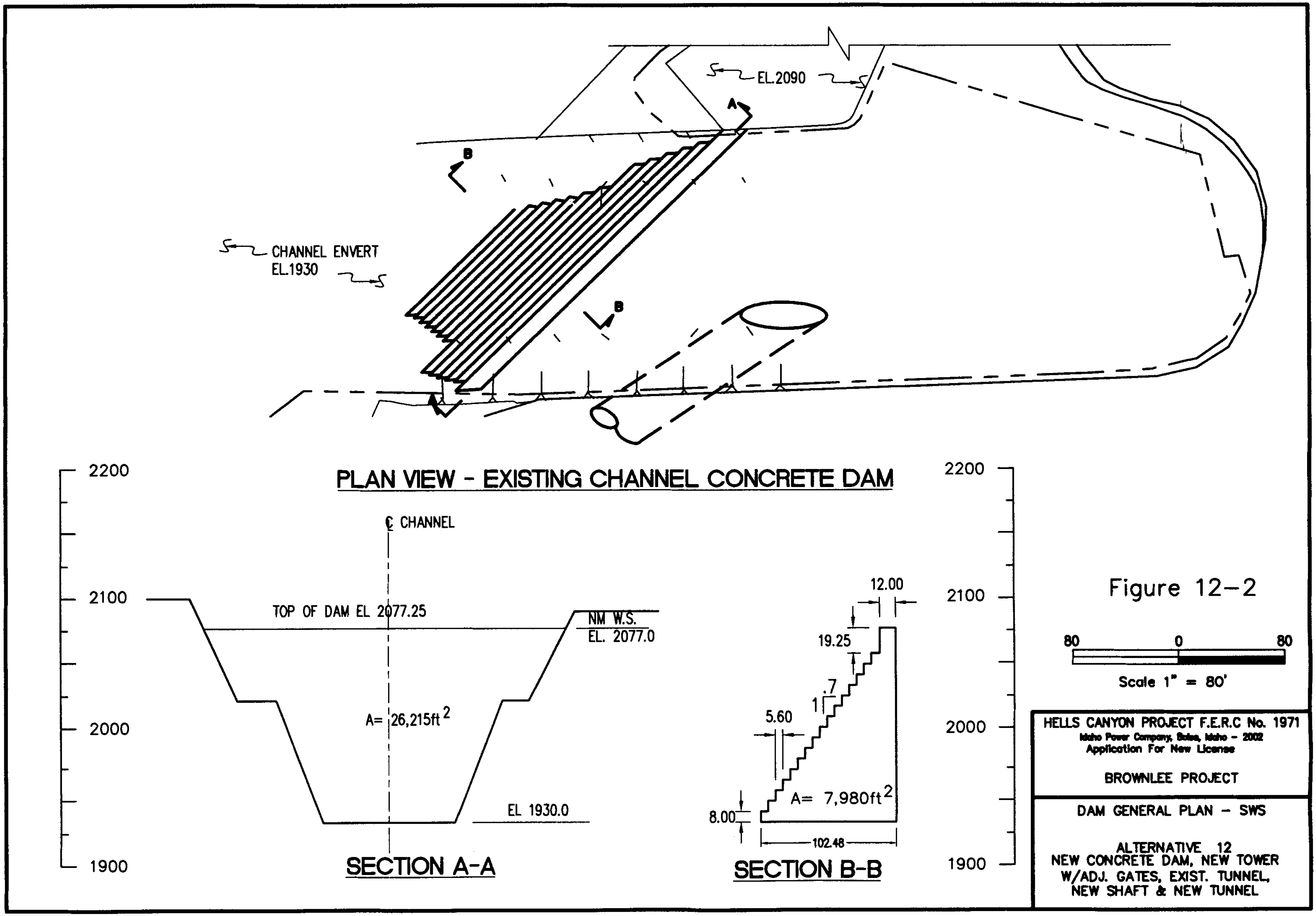
BROWNLEE PROJECT

DAM GENERAL PLAN - SWS

ALTERNATIVE 12
NEW CONCRETE DAM, NEW TOWER
W/ADJ. GATES, ENLARGE EXIST.
TUNNEL, NEW SHAFT & NEW TUNNEL



EL.2090
CHANNEL ENVERT
EL.1930
A
B
PLAN VIEW - EXISTING CHANNEL CONCRETE DAM
2200
2100
2000
1900
℄ CHANNEL
TOP OF DAM EL 2077.25
NM W.S.
EL. 2077.0
A= 26,215ft²
EL 1930.0
SECTION A-A
12.00
19.25
.7
1
5.60
A= 7,980ft²
8.00
102.48
SECTION B-B
80
0
80
Scale 1" = 80'
HELLS CANYON PROJECT F.E.R.C No. 1971
Idaho Power Company, Boise, Idaho - 2002
Application For New License
BROWNLEE PROJECT
DAM GENERAL PLAN - SWS
ALTERNATIVE 12
NEW CONCRETE DAM, NEW TOWER
W/ADJ. GATES, EXIST. TUNNEL,
NEW SHAFT & NEW TUNNEL


Figure 12-2

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Appendix B. Brownlee selective withdrawal alternatives assessed by Washington Group International; cost estimates, October 2004; Alternatives 1, 2, 5, 8, and 12

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**BROWNLEE SWS ALTERNATIVE NO. 1**
**OVERFLOW BARRIER WEIR W/STOPLOGS in INTAKE CHANNEL**
**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

# ALTERNATIVE NO. 1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BROWNLEE SWS ALTERNATIVE NO. 1** | | | | | | | | |
| **OVERFLOW BARRIER WEIR W/STOPLOGS in INTAKE CHANNEL** | | | | | | | | |
| **COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE** | | | | | | | | |
| (2004 Dollars) | | | | | | | | |
| Ref No. | | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
| 1 | Mobilization/Demob | | | | | | Included Below | |
| 2 | Intake Channel Barrier | | | | | | | |
| | 2.1 | Stoplog Weir | | | | | | |
| | 2.1.1 | | Preparatory Work | 1 | LS | 950,605 | 950,605 | Align1 & Align2 Prep |
| | 2.1.2 | | Foundation Preparation | 1 | LS | 160,529 | 160,529 | A1 & A2 Fdn Prep |
| | 2.1.3 | | Concrete Piers w/o Tendons | 6307.2 | CY | 726 | 4,579,027 | See Proport. Worksht |
| | 2.1.4 | | Tendons for Piers | 18 | EA | 35,724 | 643,032 | See Proport. Worksht |
| | 2.1.5 | | Embeds for Piers | 1 | LS | 285,428 | 285,428 | See Proport. Worksht |
| | 2.1.6 | | Access Bridge, El 2100 | 1 | LS | 1,508,988 | 1,508,988 | A1 & A2 Bridges |
| | 2.1.7 | | 2nd Bridge for Crane & Gate Hoists | 1 | LS | 1,508,988 | 1,508,988 | same as 2.1.6 above |
| | 2.1.8 | | Add'l Bridge Piers for Align #2 | 1 | LS | 349,005 | 349,005 | A2 Piers |
| | 2.1.9 | | Concrete Gravity Dam | 358 | CY | 1,928 | 690,264 | Top Elev 2045, A2 |
| | 2.1.10 | | Gantry Crane for Lifting Stoplogs | 1 | LS | 524,120 | 524,120 | A1 Gantry Crane |
| | 2.1.11 | | Stoplogs | 1 | LS | 998,400 | 998,400 | A1 Stop Logs |
| | 2.1.12 | | Pier Bracing Members | 223,880 | LBS | 4 | 895,520 | A1 Steel Pier Bracing |
| | 2.1.13 | | Other | 1 | LS | 1,138,080 | 1,138,080 | Floating Barge, Eros |
| | | | | | | | A1-19,A2-12 | Cntrl, Cleanup A1&A2 |
| | 2.2 | | Subtotal Intake Channel Barrier | | | 14,231,986 | | |
| 3 | Subtotal Direct | | | | | | 14,231,986 | |
| 4 | Contingency @ 30% +/- | | | | | | 4,270,014 | |
| 5 | Construction Total | | | | | | 18,502,000 | |
| 6 | Engineering, PM, Other Owner Costs @ 30% | | | | | | 5,551,000 | |
| 7 | Project Total | | | | | | 24,053,000 | |
| | | | Costs not Included: | Sales Tax | | | | |
| | | | | Loss of Power Generation during Construction | | | | |
| | | | | Loss of Power Generation due to Head Loss in System | | | | |
| | | | | AFUDC | | | | |

PROPORTIONAL ADJUSTMENTS from DETAILED ESTIMATES

Based on Brownlee Temp Control Weir Alignments #1 and #2

Reconn Level Const Cost Estimate (2004 $'s)

| Ref No. | Items | EA | Conc Vol (cy) | Subtotal Cost | Avg Unit Rate | Unit Meas | | |
|---|---|---|---|---|---|---|---|---|
| 3 | Plc Center Peir | | 42 | 41153 | 980 | CY | A1-3 | |
| 4 | Grav Piers | | 739 | 1409634 | 1907 | CY | A1-4 - stl embed | |
| | Steel Embeds | | | 76052 | | | stl embed for A1-4 | |
| 5 | G Piers | | 120 | 81399 | 678 | CY | A1-5 - stl embed | |
| | Steel Embeds | | | 10796 | | | stl embed for A1-5 | |
| 6 | Side Piers | | 120 | 81399 | 678 | CY | A1-6 - stl embed | |
| | Steel Embeds | | | 10796 | | | stl embed for A1-6 | |
| 7 | Abut Conc | | 2418 | 859621 | 356 | CY | | |
| | ~~Steel Forms~~ | | | ~~128000~~ | | | | |
| 8 | Tendons in Abut & Grav | 10 | | 317599 | 31760 | EA | | |
| 9 | Center Piers | | 406.7 | 331729 | 816 | CY | A1-9 - stl embed | |
| | Steel Embeds | | | 94156 | | | stl embed for A1-9 | |
| 10 | Tendons in Cent | 4 | | 212582 | 53146 | EA | | |
| 11 | Tendon in Side & Abut | 4 | | 112842 | 28211 | EA | | |
| 12 | Pier Bracing - Steel | 2E+05 | | 895520 | 4 | LB | | |
| 13 | Grav Piers, 2045 to 2090 | | 907.8 | 581048 | 640 | CY | A1-13 - stl embed | |
| | Steel Embeds | | | 23847 | | | stl embed for A1-13 | |
| 14 | Center Piers | | 453.9 | 285151 | 628 | CY | A1-14 - stl embed | |
| | Steel Embeds | | | 23847 | | | stl embed for A1-14 | |
| 15 | Side Piers, to 2090 | | 907.8 | 589501 | 649 | CY | A1-15 - stl embed | |
| | Steel Embeds | | | 45934 | | | stl embed for A1-15 | |
| | | | | | | | | |
| 3 | Brdg Pier #1 Slab | | 96 | 48522 | 505 | CY | A2-3 | |
| 4 | Brdg Pier #2 Slab | | 96 | 48522 | 505 | CY | A2-4 | |
| 5 | Brdg Pier #1 Colm | | | | | | | |
| 6 | Brdg Pier #2 Colm | | | | | | | |
| | | | | | | | Quant | |
| | Subtotal Steel Embeds | | | 285428 | | | | |
| | Subtotal Steel Bracing | | | 895520 | 4 | LB | 223,880 | |
| | Subtotal Tendons | 18 | | 643023 | 35,724 | EA | | |
| | Subtotal Vol Conc | | 6307.2 | 4578234 | 726 | | | |

**BROWNLEE SWS ALTERNATIVE NO. 2**
**BARRIER W/VARIABLE HEIGHT GATES IN EXISTING INTAKE CHANNEL**
**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

# ALTERNATIVE NO. 2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BROWNLEE SWS ALTERNATIVE NO. 2 | | | | | | | |
| BARRIER W/VARIABLE HEIGHT GATES IN EXISTING INTAKE CHANNEL | | | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | | | |
| (2004 Dollars) | | | | | | | |
| Ref No. | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
| 1 | Mobilization/Demob | | | | | Included Below | |
| 2 | Intake Channel Barrier | | | | | | |
| | 2.1 | Barrier w/Gates | | | | | |
| | 2.1.1 | Preparatory Work | 1 | LS | 950,605 | 950,605 | same as Alt 1 |
| | 2.1.2 | Foundation Preparation | 1 | LS | 160,529 | 160,529 | same as Alt 1 |
| | 2.1.3 | Concrete Piers w/o Tendons | 6307.2 | CY | 726 | 4,579,027 | same as Alt 1 |
| | 2.1.4 | Tendons for Piers | 18 | EA | 35,724 | 643,032 | same as Alt 1 |
| | 2.1.5 | Embeds for Piers | 1 | LS | 285,428 | 285,428 | same as Alt 1 |
| | 2.1.6 | Access Bridge, El 2100 | 1 | LS | 754,494 | 754,494 | Alt 1 x 0.5 |
| | 2.1.7 | 2nd Bridge for Crane & Gate Hoists | 1 | LS | 754,494 | 754,494 | same as 2.1.6 above |
| | 2.1.8 | Add'l Bridge Piers for Align #2 | 1 | LS | 349,005 | 349,005 | same as Alt 1 |
| | 2.1.9 | Side Conc Gravity Dam | 3,500 | CY | 500 | 1,750,000 | Top El 2077.25, Plc Underwater |
| | 2.1.10 | Lifting Mechanisms for Gates | 12 | EA | 300,000 | 3,600,000 | New for Gated Barrier |
| | 2.1.11 | Gates | 240,000 | LBS | 5 | 1,200,000 | New Item 20,000 # per EA Gate,12Gates |
| | 2.1.12 | Additional Embeds | 1 | LS | 400,000 | 400,000 | in Piers |
| | 2.1.13 | Pier Bracing Members | 223,880 | LBS | 4 | 895,520 | A1 Steel Pier Bracing |
| | 2.1.14 | Gantry Service Crane | 1 | LS | 350,000 | 350,000 | |
| | 2.1.15 | Other | 1 | LS | 1,138,080 | 1,138,080 | same as Alt 1 |
| | 2.2 | Subtotal Intake Channel Barrier | | 17,810,214 | | | |
| 3 | Instrumentation & Controls | | 1 | LS | 1,000,000 | 1,000,000 | New for Gated Barrier |
| 4 | Subtotal Direct | | | | | 18,810,214 | |
| 5 | Contingency @ 30% | | | | | 5,642,786 | |
| 6 | Construction Total | | | | | 24,453,000 | |
| 7 | Engineering, PM, Other Owner Costs @ 30% | | | | | 7,336,000 | |
| 8 | Project Total | | | | | 31,789,000 | |
| | | Costs not Included: | Sales Tax | | | | |
| | | | Loss of Power Generation during Construction | | | | |
| | | | Loss of Power Generation due to Head Loss in System | | | | |
| | | | AFUDC | | | | |

**BROWNLEE SWS ALTERNATIVE NO. 5**
**BARRIER w/GATES IN CHANNEL, REOPEN DIVERSION TUNNEL, NEW SHAFT, and PUMP to INTAKE CHANNEL**
**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

# ALTERNATIVE NO. 5

**BROWNLEE SWS ALTERNATIVE NO. 5**

**BARRIER w/GATES IN CHANNEL, REOPEN DIVERSION TUNNEL, NEW SHAFT, and PUMP to INTAKE CHANNEL**

**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

(2004 Dollars)

| Ref No. | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
|---|---|---|---|---|---|---|---|
| 1 | | Mobilization/Demob | 1 | LS | 500,000 | 500,000 | Tunnel Mob/Demob |
| | 1.1 | Subtotal Mob/Demob Tunnel/Shaft | | | 500,000 | | |
| 2 | | Intake Channel Barrier | | | | | |
| | 2.1 | Barrier w/Gates | | | | | |
| | 2.1.1 | Preparatory Work | 1 | LS | 950,605 | 950,605 | same as Alt 1 |
| | 2.1.2 | Foundation Preparation | 1 | LS | 160,529 | 160,529 | same as Alt 1 |
| | 2.1.3 | Concrete Piers w/o Tendons | 6307.2 | CY | 726 | 4,579,027 | same as Alt 1 |
| | 2.1.4 | Tendons for Piers | 18 | EA | 35,724 | 643,032 | same as Alt 1 |
| | 2.1.5 | Embeds for Piers | 1 | LS | 285,428 | 285,428 | same as Alt 1 |
| | 2.1.6 | Access Bridge, El 2100 | 1 | LS | 754,494 | 754,494 | Alt 1 x 0.5 |
| | 2.1.7 | 2nd Bridge for Crane & Gate Hoists | 1 | LS | 754,494 | 754,494 | same as 2.1.6 above |
| | 2.1.8 | Add'l Bridge Piers for Align #2 | 1 | LS | 349,005 | 349,005 | same as Alt 1 |
| | 2.1.9 | Side Conc Gravity Dam | 3,500 | CY | 500 | 1,750,000 | Top El 2077.25, Plc Underwater |
| | 2.1.10 | Lifting Mechanisms for Gates | 12 | EA | 300,000 | 3,600,000 | New for Gated Barrier |
| | 2.1.11 | Gates | 240,000 | LBS | 5 | 1,200,000 | New Item 20,000 # per EA Gate,12Gates |
| | 2.1.12 | Additional Embeds | 1 | LS | 400,000 | 400,000 | in Piers |
| | 2.1.13 | Pier Bracing Members | 223,880 | LBS | 4 | 895,520 | A1 Steel Pier Bracing |
| | 2.1.14 | Gantry Service Crane | 1 | LS | 350,000 | 350,000 | |
| | 2.1.15 | Other | 1 | LS | 1,138,080 | 1,138,080 | same as Alt 1 |
| | 2.2 | Subtotal Intake Channel Barrier | | | 17,810,214 | | |
| 3 | | Reopen Diversion Tunnel Modifications | | | | | |
| | 3.1 | Dewater Existing Diversion Tunnel | 1 | LS | 0 | 0 | Assume not Needed |
| | 3.2 | Rock Debris Excav, Underwater Portal | 14,000 | CY | 50 | 700,000 | Placed at Gate Closure |
| | 3.3 | Remove Tunnel Entrance Plug | | | | | |
| | 3.3.1 | Drill & Shoot Conc Structure, Underwater | 1 | LS | 200,000 | 200,000 | |
| | 3.3.2 | Remove Gate Pieces, Crane & Barge | 100 | HRS | 599 | 59,900 | |
| | 3.3.3 | Diver & Tender Assist | 100 | HRS | 446 | 44,600 | |
| | 3.4 | Grout Div Tun for Leakage | 0 | SF | | 0 | Assume not Needed |
| | 3.5 | Enlarge Tunnel Diameter | 0 | CY | 334 | 0 | |
| | 3.6 | Concrete Lining of Tunnel | 0 | CY | 610 | 0 | Assume not Needed |
| | 3.7 | Subtotal Diversion Tunnel | | | 1,004,500 | 0 | |
| 4 | | Vertical Shaft | | | | 0 | |
| | 4.1 | Open Cut Excav, In Dry | 162,300 | CY | 6.90 | 1,119,870 | Need QTO |
| | 4.2 | Excavate Top Down Shaft | 5,600 | CY | 80 | 448,000 | 41' dia 115' high |
| | 4.3 | Grout for Leakage | | | | | 60' Dia, 230' deep |
| | 4.3.1 | Drill Vertical Holes | 6,900 | LF | | | Incl' in 4.2.2 |
| | 4.3.2 | Grout Vertical Holes | 6,900 | LF | 44 | 303,600 | |
| | 4.3.3 | Redrill Vertical Holes | | LF | | 0 | Incl' in 4.2.2 |
| | 4.3.4 | Set-up for Grouting | | EA | | 0 | Incl' in 4.2.2 |
| | 4.3.5 | Process Mix & Inject Grout | | CF | | 0 | Incl' in 4.2.2 |
| | 4.3.6 | Cement for Grout | | SK | | 0 | Incl' in 4.2.2 |
| | 4.3.7 | Water Test Holes | | EA | | 0 | Incl' in 4.2.2 |
| | 4.4 | Shaft Lining | | | | | |
| | 4.6.1 | Shotcrete Lining | 229 | CY | 485 | 111,065 | All Shaft, 5" Th, 115' |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| BROWNLEE SWS ALTERNATIVE NO. 5 | | | | | | | | |
| BARRIER w/GATES IN CHANNEL, REOPEN DIVERSION TUNNEL, NEW SHAFT, and PUMP to INTAKE CHANNEL | | | | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | | | | |
| (2004 Dollars) | | | | | | | | |
| Ref No. | | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
| | 4.6.2 | | Rock Bolts | 773 | LF | 40 | 30,913 | Assume 30' of shaft |
| | | | | | | | | assume 10' x 10' spacing, 20' Long |
| | 4.6.3 | | Concrete Lining | 0 | CY | 610 | 0 | Assume not Needed |
| | 4.5 | Open Cut Excav, In Wet | | 36,700 | CY | 50 | 1,835,000 | Need QTO |
| | 4.6 | | Subtotal Vertical Shaft | | 3,848,448 | | | |
| 5 | Axial Flow Pump in Vertical Shaft | | | | | | | |
| | 5.1 | Foundation Preparation | | 1 | LS | 50,000 | 50,000 | Allowance |
| | 5.2 | Pumping Unit(s), Complete | | 1 | LS | 500,000 | 500,000 | Allowance |
| | 5.3 | Seal & Guide System | | 1 | LS | 150,000 | 150,000 | Allowance |
| | 5.4 | Floating Barge | | 1 | LS | 250,000 | 250,000 | Allowance |
| | 5.5 | Steel Pipe, Vertical Extension | | 591,699 | LBS | 3.05 | 1,804,683 | 41" dia3/4" Th, 150 LF |
| | 5.6 | Steel Pipe, Horizontal Outlet | | 39,447 | LBS | 3.05 | 120,312 | 41' dia, 3/4" th, 10'L. |
| | | | Subtotal Pump in Shaft | | 2,874,995 | | | |
| 6 | Road Relocation | | | | | | | |
| | 6.1 | Open Cut Rock Excavation | | 8,000 | CY | 10 | 80,000 | Extra Allowance |
| | 6.2 | Rock Bolts | | 6,000 | LF | 40 | 240,000 | 15' Long, 20' x 20' space |
| | 6.3 | Shotcrete | | 200 | CY | 485 | 97,000 | 1,000LF x 50LF @ 3" Th |
| | 6.4 | Rock Fall Fencing | | 4,400 | SY | 30 | 132,000 | 1,000LF x 100LF |
| | 6.5 | Drainage | | 1 | LS | 50,000 | 50,000 | |
| | 6.6 | Paving | | 1,100 | SY | 15 | 16,500 | 24' Wide, 7" Th |
| | 6.7 | Guard Rail | | 400 | LF | 25 | 10,000 | |
| | 6.8 | | Subtotal Road Relocation | | 625,500 | | | |
| 7 | Fill Tunnel, Test Operations | | | 1 | LS | 100,000 | 100,000 | Allowance |
| 8 | Instrumentation & Controls | | | 1 | LS | 1,000,000 | 1,000,000 | New |
| 9 | Subtotal Direct | | | | | | 27,763,658 | |
| 10 | Contingency @ 30% | | | | | | 8,329,342 | |
| 11 | Construction Total | | | | | | 36,093,000 | |
| 12 | Engineering, PM, Other Owner Costs @ 30% | | | | | | 10,828,000 | |
| 13 | Add'l Contingency for Underground @ 20% | | | | | | 971,000 | Applies to Undrgrd only |
| 14 | Project Total | | | | | | 47,892,000 | |
| | | | Costs not Included: | Sales Tax | | | | |
| | | | | Loss of Power Generation during Construction | | | | |
| | | | | Loss of Power Generation due to Head Loss in System | | | | |
| | | | | AFUDC | | | | |

| VERTICAL SHAFT DRILLING & GROUTING WORKSHEET | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ref No. | Item | Shaft Dia (LF) | Unit Meas | Circumference (LF) | Hole Spacing | No Holes | Vert Hole Depth (LF) | Subtotal Length (LF) |
| A | 41' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 41 | LF | 128.8053 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 51 | LF | 160.22123 | 10 | 17 | 115 | 1,955 |
| 3 | Shaft + 20' Dia | 61 | LF | 191.63715 | 10 | 20 | 115 | 2,300 |
| 4 | Shaft + 30' Dia | 71 | LF | 223.05308 | 10 | 23 | 115 | 2,645 |
| | | Cumulative Number of Holes | | | | 60 | | |
| | | | | Cumulative Length of Drill Holes | | | | 6,900 |
| | Total Cost | | | | | Total Cost of Grouting = | | |
| | | | | Equiv Cost of Grouting per LF of Drill Hole = | | | | |
| B | 60' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 60 | LF | 188.49556 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 70 | LF | 219.91149 | 10 | 23 | 230 | 5,290 |
| 3 | Shaft + 20' Dia | 80 | LF | 251.32741 | 10 | 26 | 230 | 5,980 |
| 4 | Shaft + 30' Dia | 90 | LF | 282.74334 | 10 | 29 | 230 | 6,670 |
| | | Cumulative Number of Holes | | | | 78 | | |
| | | | | Cumulative Length of Drill Holes | | | | 17,940 |
| | | | | | | Total Cost of Grouting = | | |
| | Total Cost | | | Equiv Cost of Grouting per LF of Drill Hole = | | | | |
| | | | | | | | | |
| C | 80' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 80 | LF | 251.32741 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 90 | LF | 282.74334 | 10 | 29 | 115 | 3,335 |
| 3 | Shaft + 20' Dia | 100 | LF | 314.15927 | 10 | 32 | 115 | 3,680 |
| 4 | Shaft + 30' Dia | 110 | LF | 345.57519 | 10 | 36 | 115 | 4,140 |
| | | Cumulative Number of Holes | | | | 97 | | |
| | | | | Cumulative Length of Drill Holes | | | | 11,155 |

## BROWNLEE SWS ALTERNATIVE NO. 8
## NEW TOWER INTAKE, REOPEN DIVERSION TUNNEL, NEW SHAFT w/TRASHRACK, and NEW TUNNEL to UNIT PENSTOCK
## COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE

# ALTERNATIVE NO. 8

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BROWNLEE SWS ALTERNATIVE NO. 8 | | | | | | | |
| NEW TOWER INTAKE, REOPEN DIVERSION TUNNEL, NEW SHAFT w/TRASHRACK, and NEW TUNNEL to UNIT PENSTOCK | | | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | | | |
| (2004 Dollars) | | | | | | | |
| Ref No. | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
| 1 | | Mobilization/Demob | | | | | |
| | 1.1 | Tunnel & Shaft Mob/Demob | 1 | LS | 500,000 | 500,000 | Tunnel Mob/Demob |
| | 1.2 | Develop Tower Casting Yard | 1 | LS | 10,000,000 | 10,000,000 | Tower |
| | 1.3 | Set-up Tower Concrete Batch Plant | 1 | LS | 3,000,000 | 3,000,000 | Tower |
| | 1.4 | Subtotal Mob/Demob Tunnel/Shaft | | | 13,500,000 | | |
| 2 | | Intake Channel Barrier | | | | | Not Required |
| 3 | | New 12,000 cfs Tower, 200' Dia | | | | | |
| | 3.1 | Fab & Precast Modules | 4,600 | CY | 800 | 3,680,000 | Ref HDR/LAI Rpt |
| | 3.2 | Fab & Precast Tower Segments | 35,000 | CY | 1,000 | 35,000,000 | New Quant. (avg 2' th) |
| | 3.3 | Prepare Inlet Portal Site | 3,700 | CY | 1,500 | 5,550,000 | Ref HDR/LAI Rpt |
| | 3.4 | Float & Place Inlet Portal | 2 | EA | 2,100,000 | 4,200,000 | Ref HDR/LAI Rpt |
| | 3.5 | Anchor Inlet Portal w/Grout Curtain | 1 | LS | 7,275,500 | 7,275,500 | Ref HDR/LAI Rpt |
| | 3.6 | Mechanical Excav Inlet Portal | 6,210 | CY | 760 | 4,719,600 | Ref HDR/LAI Rpt |
| | 3.7 | Steel Braces & Bridge to Tower | 1 | LS | 4,000,000 | 4,000,000 | New Input |
| | 3.8 | Gates & Guides | 420,000 | LBS | 5 | 2,100,000 | 15,000 # per EA, 28 Gate |
| | 3.9 | Lifting Mech for Gates | 28 | EA | 300,000 | 8,400,000 | New for Gated Tower |
| | 3.10 | Subtotal New 12,000 cfs Tower | | | 74,925,100 | | |
| 4 | | Vertical Shaft #1 | | | | | 41' dia, 335' deep |
| | 4.1 | Excavate Top Down Shaft | 16,400 | CY | 80 | 1,312,000 | |
| | 4.2 | Grout for Leakage | | | | | |
| | 4.2.1 | Drill Vertical Holes | 20,100 | LF | | | Incl' in 4.2.2 |
| | 4.2.2 | Grout Vertical Holes | 20,100 | LF | 44 | 884,400 | |
| | 4.2.3 | Redrill Vertical Holes | | LF | | 0 | Incl' in 4.2.2 |
| | 4.2.4 | Set-up for Grouting | | EA | | 0 | Incl' in 4.2.2 |
| | 4.2.5 | Process Mix & Inject Grout | | CF | | 0 | Incl' in 4.2.2 |
| | 4.2.6 | Cement for Grout | | SK | | 0 | Incl' in 4.2.2 |
| | 4.2.7 | Water Test Holes | | EA | | 0 | Incl' in 4.2.2 |
| | 4.3 | Slash Excav, Enlarge Shaft | 0 | CY | 80 | 0 | |
| | 4.4 | Remove Rock Excav from Shaft | 0 | CY | Included Above | | |
| | 4.5 | Shaft Lining | | | | | |
| | 4.5.1 | Shotcrete Lining | 666 | CY | 485 | 323,010 | All Shaft, 5" Th |
| | 4.5.2 | Rock Bolts | 773 | LF | 40 | 30,913 | Assume 30' of shaft |
| | | | | | | assume 10' x 10' spacing, 20' Long | |
| | 4.5.3 | Concrete Lining | 0 | CY | 610 | 0 | Assume not Needed |
| | 4.6 | Steel Cover for Shaft | 30,000 | LBS | 3 | 90,000 | |
| | 4.7 | Subtotal Vertical Shaft | | | 2,640,323 | | |
| 5 | | Reopen Diversion Tunnel Modifications | | | | | Equiv 41' dia |
| | 5.1 | Grout Div Tun for Leakage | | | | | |
| | 5.1.1 | Drill Vertical Holes | 168,630 | LF | | | Incl'd Below |
| | 5.1.2 | Grout Vertical Holes | 168,630 | LF | 44 | 7,419,720 | |
| | 5.2 | Dewater Existing Diversion Tunnel | 1 | LS | 200,000 | 200,000 | Allowance |
| | 5.3 | Enlarge Tunnel Excavation | 0 | CY | 210 | 0 | |
| | 5.4 | Remove Rock Excav from Shaft | 0 | CY | Included Above | | |
| | 5.5 | Tunnel Lining | | | | | |
| | 5.5.1 | Shotcrete Lining | 2,882 | CY | 485 | 1,397,770 | All Tunnel, 5" Th, 1,450' |
| | 5.5.2 | Rock Bolts | 3,864 | LF | 40 | 154,566 | Assume 150' of Tunnel |
| | | | | | | assume 10' x 10' spacing, 20' Long | |

**BROWNLEE SWS ALTERNATIVE NO. 8**

**NEW TOWER INTAKE, REOPEN DIVERSION TUNNEL, NEW SHAFT w/TRASHRACK, and NEW TUNNEL to UNIT PENSTOCK**

**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

(2004 Dollars)

| Ref No. | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
|---|---|---|---|---|---|---|---|
| | 5.5.3 | Steel Penstock Lining | 1,539,380 | LBS | 4.50 | 6,927,210 | 40' ID, 1.0" Th, 300' |
| | 5.5.4 | Concrete Lining | 2,793 | CY | 610 | 1,703,730 | 300' Length; 24" Th |
| | 5.6 | Rock Debris Excav, Underwater Portal | 14,000 | CY | 50 | 700,000 | Placed at Gate Closure |
| | 5.7 | Remove Tunnel Entrance Plug | | | | | |
| | 5.7.1 | Drill & Shoot Conc Structure, Underwater | 1 | LS | 200,000 | 200,000 | |
| | 5.7.2 | Remove Gate Pieces, Crane & Barge | 100 | HRS | 599 | 59,900 | |
| | 5.7.3 | Diver & Tender Assist | 100 | HRS | 446 | 44,600 | |
| | 5.8 | Remove Tunnel Plug @ Dam Grout Curtain | | | | | |
| | 5.8.1 | Mechanical Rock Excav | 2,327 | CY | 170 | 395,590 | 50' Length, 40' dia |
| | 5.8.2 | Muck & Remove Conc Plug Debris | 2,909 | CY | 10 | 29,088 | |
| | 5.9 | Place Plug in D/S Diversion Tunnel | | | | | |
| | 5.9.1 | Concrete Plug | 3,025 | CY | 610 | 1,845,250 | 65' Long |
| | 5.10 | Subtotal Diversion Tunnel | | 21,077,424 | | | |
| 6 | | Trashracks in Vertical Shaft | | | | | |
| | 6.1 | Steel Trashracks & Guides | 500,000 | LBS | 3.00 | 1,500,000 | |
| | 6.2 | Rockbolts for Trashracks | 2,000 | LF | 40 | 80,000 | 100ea @ 20' |
| | 6.3 | Misc Concrete | 500 | CY | 610 | 305,000 | Allowance |
| | 6.4 | Crane & Lifting Support for Installations | 200 | HRS | 1,446 | 289,200 | |
| | 6.5 | Subtotal Trashrack in Shaft | | 2,174,200 | | | |
| 7 | | Tunnel Isolation Closure Gate in Shaft | | | | | |
| | 7.1 | Steel Gate & Guides | 500,000 | LBS | 5 | 2,500,000 | |
| | 7.2 | Gate Frame | 1 | LS | 40,000 | 40,000 | Allowance |
| | 7.3 | Misc Concrete | 500 | CY | 610 | 305,000 | Allowance |
| | 7.4 | Gate Hoist | 1 | EA | 300,000 | 300,000 | |
| | 7.5 | Crane & Lifting Support for Installations | 200 | HRS | 1,446 | 289,200 | |
| | 7.6 | Subtotal Isolation Gate in Shaft | | 3,434,200 | | | |
| 8 | | New Shaft from Div Tunnel to Existing Penstock | | | | | |
| | 8.1 | Pilot Shaft Excav | 1,100 | CY | 334 | 367,400 | 15' dia; 170'deep |
| | 8.2 | Shaft Excavation | 4,900 | CY | 334 | 1,636,600 | 41' Dia; 100' High |
| | 8.3 | Grouting of Shaft | 1 | LS | 250,000 | 250,000 | Mod. Allowance |
| | 8.4 | Lining of Shaft | | | | | |
| | 8.4.1 | Rock Bolts | 2,576 | LF | 40 | 103,044 | Assume 100' of shaft |
| | | | | | | assume 10' | x 10' spacing, 20' Long |
| | 8.4.2 | Shotcrete Lining | 124 | CY | 485 | 60,140 | 15'dia Shaft, 5" Th |
| | 8.4.3 | Steel Penstock Lining | 593,303 | LBS | 4.50 | 2,669,864 | 37' ID, 1.25" Th, 100' |
| | 8.4.4 | Concrete Lining | 884 | CY | 610 | 539,240 | 100' Length; 24" Th |
| | 8.5 | Conc Plug for 15' Shaft | 200 | CY | | | 15'dia, 30' high |
| | 8.6 | Unwater Existing Unit & Penstock | 1 | LS | 100,000 | 100,000 | |
| | 8.7 | Tap of Steel Penstock | 1 | LS | 100,000 | 100,000 | Cut Liner & Grout Seal |
| | 8.8 | Subtotal New Tunnel | | 5,826,288 | | | |
| 9 | | Fill Tunnel, Test Operations | 1 | LS | 100,000 | 100,000 | Allowance |
| 10 | | Instrumentation & Controls | 1 | LS | 1,000,000 | 1,000,000 | Allowance |
| 11 | | Subtotal Direct | | | | 124,677,535 | |
| 12 | | Contingency @ 30% | | | | 37,403,465 | |
| 13 | | Construction Total | | | | 162,081,000 | |

| BROWNLEE SWS ALTERNATIVE NO. 8 | | | | | |
|---|---|---|---|---|---|
| NEW TOWER INTAKE, REOPEN DIVERSION TUNNEL, NEW SHAFT w/TRASHRACK, and NEW TUNNEL to UNIT PENSTOCK | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | |
| (2004 Dollars) | | | | | |

| Ref No. | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
|---|---|---|---|---|---|---|
| 14 | Engineering, PM, Other Owner Costs @ 30% | | | | 48,624,000 | |
| 15 | Add'l Contingency for Underground @ 20% | | | | 5,909,000 | Applies to Undrgrd only |
| 16 | Project Total | | | | 216,614,000 | |
| | Costs not Included: | Sales Tax | | | | |
| | | Loss of Power Generation during Construction | | | | |
| | | Loss of Power Generation due to Head Loss in System | | | | |
| | | AFUDC | | | | |

## VERTICAL SHAFT DRILLING & GROUTING WORKSHEET

| Ref No. | Item | Shaft Dia (LF) | Unit Meas | Circumference (LF) | Hole Spacing | No Holes | Vert Hole Depth (LF) | Subtotal Length (LF) |
|---|---|---|---|---|---|---|---|---|
| A | 41' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 41 | LF | 128.8053 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 51 | LF | 160.22123 | 10 | 17 | 335 | 5,695 |
| 3 | Shaft + 20' Dia | 61 | LF | 191.63715 | 10 | 20 | 335 | 6,700 |
| 4 | Shaft + 30' Dia | 71 | LF | 223.05308 | 10 | 23 | 335 | 7,705 |
| | | Cumulative Number of Holes | | | | 60 | | |
| | | | | Cumulative Length of Drill Holes | | | | 20,100 |
| B | 45' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 45 | LF | 141.37167 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 55 | LF | 172.7876 | 10 | 18 | 370 | 6,660 |
| 3 | Shaft + 20' Dia | 65 | LF | 204.20352 | 10 | 21 | 370 | 7,770 |
| 4 | Shaft + 30' Dia | 75 | LF | 235.61945 | 10 | 25 | 370 | 9,250 |
| | | Cumulative Number of Holes | | | | 64 | | |
| | | | | Cumulative Length of Drill Holes | | | | 23,680 |

| Ref No. | Item | Horiz Length | Unit Meas | Horiz Width | Hole Spacing | No Holes | Vert Hole Depth (LF) | Subtotal Length (LF) |
|---|---|---|---|---|---|---|---|---|
| C | Grouting for Diversion Tunnel Leakage | | | | | | | |
| 1 | Length of Grout Line, N1 | 625 | LF | | 10 | 62.5 | 335 | 20,938 |
| 2 | Length of Grout Line, N2 | 625 | | | 10 | 62.5 | 335 | 20,938 |
| 3 | Length of Grout Line, N3 | 625 | | | 10 | 62.5 | 335 | 20,938 |
| 4 | Length of Grout Line, S1 | 635 | LF | | 10 | 63.5 | 335 | 21,273 |
| 5 | Length of Grout Line, S2 | 635 | | | 10 | 63.5 | 335 | 21,273 |
| 6 | Length of Grout Line, S3 | 635 | | | 10 | 63.5 | 335 | 21,273 |
| 7 | Plane over Tunnel | 350 | | 80 | 10 | 280 | 150 | 42,000 |
| 7 | | Cumulative Number of Holes | | | | 658 | | |
| | | | | Cumulative Length of Drill Holes | | | | 168,630 |

**BROWNLEE SWS ALTERNATIVE NO. 12**
**NEW TOWER INTAKE, REOPEN & ENLARGE DIVERSION TUNNEL, NEW SHAFT, and NEW TUNNEL to INTAKE CHANNEL**
**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

# ALTERNATIVE NO. 12

**BROWNLEE SWS ALTERNATIVE NO. 12**

**NEW TOWER INTAKE, REOPEN & ENLARGE DIVERSION TUNNEL, NEW SHAFT, and NEW TUNNEL to INTAKE CHANNEL**

**COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE**

(2004 Dollars)

| Ref No. | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Mobilization/Demob | | | | | | |
| | 1.1 | Tunnel & Shaft Mob/Demob | 1 | LS | 500,000 | 500,000 | Tunnel Mob/Demob |
| | 1.2 | Develop Casting Yard | 1 | LS | 10,000,000 | 10,000,000 | Tower |
| | 1.3 | Set-up Concrete Batch Plant | 1 | LS | 3,000,000 | 3,000,000 | Tower |
| | 1.4 | Subtotal Mob/Demob | | | 13,500,000 | | |
| 2 | New Conc Barrier Dam | | | | | | |
| | 2.1 | Conc Gravity Dam | | | | | |
| | 2.1.1 | Preparatory Work | 1 | LS | 950,605 | 950,605 | |
| | 2.1.2 | Foundation Preparation | 1 | LS | 160,529 | 160,529 | |
| | 2.1.9 | Concrete Gravity Dam | 56,500 | CY | 300 | 16,950,000 | Underwater Placement |
| | 2.2 | Subtotal Intake Channel Barrier | | | 18,061,134 | | |
| 3 | New 35,000 cfs Tower, 200' Dia | | | | | | |
| | 3.1 | Fab & Precast Modules | 4,600 | CY | 800 | 3,680,000 | Ref HDR/LAI Rpt |
| | 3.2 | Fab & Precast Tower Segments | 35,000 | CY | 1,000 | 35,000,000 | New Quant. (avg 2' th) |
| | 3.3 | Prepare Inlet Portal Site | 3,700 | CY | 1,500 | 5,550,000 | Ref HDR/LAI Rpt |
| | 3.4 | Float & Place Inlet Portal | 2 | EA | 2,100,000 | 4,200,000 | Ref HDR/LAI Rpt |
| | 3.5 | Anchor Inlet Portal w/Grout Curtain | 1 | LS | 7,275,500 | 7,275,500 | Ref HDR/LAI Rpt |
| | 3.6 | Mechanical Excav Inlet Portal | 6,210 | CY | 760 | 4,719,600 | Ref HDR/LAI Rpt |
| | 3.7 | Steel Braces & Bridge to Tower | 1 | LS | 4,000,000 | 4,000,000 | New Input |
| | 3.8 | Gates & Guides | 840,000 | LBS | 5 | 4,200,000 | 30,000 # per EA, 28 Gate |
| | 3.9 | Lifting Mech for Gates | 28 | EA | 300,000 | 8,400,000 | New for Gated Tower |
| | 3.10 | Subtotal New 35,000 cfs Tower | | | 77,025,100 | | |
| 4 | Reopen Diversion Tunnel Modifications | | | | | | Equiv 41' dia |
| | 4.1 | Grout Div Tun for Leakage | | | | | |
| | 4.1.1 | Drill Vertical Holes | 168,630 | LF | | | Incl'd Below |
| | 4.1.2 | Grout Vertical Holes | 168,630 | LF | 44 | 7,419,720 | |
| | 4.1.3 | Place Plug in D/S Div Tun | 1 | LS | 20,000 | 20,000 | |
| | 4.2 | Dewater Existing Diversion Tunnel | 1 | LS | 200,000 | 200,000 | Allowance |
| | 4.3 | Enlarge Tunnel Excavation | 86,667 | CY | 210 | 18,200,000 | Equiv 77' Dia; 650' Long |
| | 4.4 | Remove Rock Excav from Shaft | 0 | CY | Included Above | | |
| | 4.5 | Tunnel Lining | | | | | |
| | 4.5.1 | Shotcrete Lining | 2,426 | CY | 485 | 1,176,610 | All Tunnel, 5" Th |
| | 4.5.2 | Rock Bolts | 31,447 | LF | 40 | 1,257,894 | Assume 650' of Tunnel |
| | | | | | | assume 10' | x 10' spacing, 20' Long |
| | 4.5.3 | Concrete Lining | 0 | CY | 610 | 0 | Assume not Needed |
| | 4.6 | Rock Debris Excav, Underwater Portal | 14,000 | CY | 50 | 700,000 | Placed at Gate Closure |
| | 4.7 | Remove Tunnel Entrance Plug | | | | | |
| | 4.7.1 | Drill & Shoot Conc Structure, Underwater | 1 | LS | 200,000 | 200,000 | |
| | 4.7.2 | Remove Gate Pieces, Crane & Barge | 100 | HRS | 599 | 59,900 | |
| | 4.7.3 | Diver & Tender Assist | 100 | HRS | 446 | 44,600 | |
| | 4.8 | Subtotal Diversion Tunnel | | | 29,278,724 | 0 | |
| 5 | Vertical Shaft | | | | | | 77' dia, 335' deep |
| | 5.1 | Excavate Top Down Shaft | 57,800 | CY | 80 | 4,624,000 | |
| | 5.2 | Grout for Leakage | | | | | |
| | 5.2.1 | Drill Vertical Holes | 31,490 | LF | | | Incl' in 4.2.2 |
| | 5.2.2 | Grout Vertical Holes | 31,490 | LF | 44 | 1,385,560 | |

| BROWNLEE SWS ALTERNATIVE NO. 12 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NEW TOWER INTAKE, REOPEN & ENLARGE DIVERSION TUNNEL, NEW SHAFT, and NEW TUNNEL to INTAKE CHANNEL | | | | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | | | | |
| (2004 Dollars) | | | | | | | | |
| Ref No. | | | Project Feature | Quant | Unit Meas | Unit Rate | Amount | Comments |
| | | 5.2.3 | Redrill Vertical Holes | | LF | | 0 | Incl' in 4.2.2 |
| | | 5.2.4 | Set-up for Grouting | | EA | | 0 | Incl' in 4.2.2 |
| | | 5.2.5 | Process Mix & Inject Grout | | CF | | 0 | Incl' in 4.2.2 |
| | | 5.2.6 | Cement for Grout | | SK | | 0 | Incl' in 4.2.2 |
| | | 5.2.7 | Water Test Holes | | EA | | 0 | Incl' in 4.2.2 |
| | 5.3 | | Slash Excav, Enlarge Shaft | 0 | CY | 80 | 0 | |
| | 5.4 | | Remove Rock Excav from Shaft | 0 | CY | Included Above | | |
| | 5.5 | | Shaft Lining | | | | | |
| | | 5.5.1 | Shotcrete Lining | 1,251 | CY | 485 | 606,735 | All Shaft, 5" Th |
| | | 5.5.2 | Rock Bolts | 4,838 | LF | 40 | 193,522 | Assume 100' of shaft |
| | | | | | | | assume 10' | x 10' spacing, 20' Long |
| | | 5.5.3 | Concrete Lining | 0 | CY | 610 | 0 | Assume not Needed |
| | 5.6 | | Steel Cover for Shaft | 114,000 | LBS | 3 | 342,000 | 3.8 x 31' dia shaft |
| | 5.7 | | Subtotal Vertical Shaft | | 7,151,817 | | | |
| 6 | Tunnel Isolation Closure Gate in Shaft | | | | | | | Not Required |
| | 6.1 | | Steel Gate & Guides | 0 | LBS | 5 | 0 | Use 3.5 times 10kcfs |
| | 6.2 | | Gate Frame | 0 | LS | 80,000 | 0 | Double 10kcfs |
| | 6.3 | | Misc Concrete | 0 | CY | 610 | 0 | Allowance |
| | 6.4 | | Gate Hoist | 0 | EA | 300,000 | 0 | |
| | 6.5 | | Crane & Lifting Support for Installations | 0 | HRS | 1,446 | 0 | Use 1.5 times 10kcfs |
| | 6.6 | | Subtotal Isolation Gate in Shaft | | 0 | | | |
| 7 | New Tunnel from Shaft to Existing Intake Chan | | | | | | 0 | |
| | 7.1 | | Tunnel Excavation | 39,700 | CY | 334 | 13,259,800 | 77' Dia; 230' Long |
| | 7.2 | | Grouting of Tunnel | 1 | LS | 1,000,000 | 1,000,000 | Mod. Allowance |
| | 7.3 | | Lining of Tunnel | | | | | |
| | | 7.3.1 | Rock Bolts | 11,128 | LF | 40 | 445,101 | Assume 230' of tunnel |
| | | | | | | | assume 10' | x 10' spacing, 20' Long |
| | | 7.3.2 | Shotcrete Lining | 1,030 | CY | 485 | 499,550 | All Tunnel, 6" Th |
| | | 7.3.3 | Concrete Lining | 0 | CY | 610 | 0 | Assume not Needed |
| | 7.4 | | Wet Tap of Intake Channel | | | | | |
| | | 7.4.1 | Over Excav Rock Trap | 600 | CY | 334 | 200,400 | Use 2 times 10kcfs |
| | | 7.4.2 | Fill Shaft/Tunnel w/Water | 1 | LS | 50,000 | 50,000 | |
| | | 7.4.3 | Final Hole Through Shot (30' +/-) | 1 | LS | 500,000 | 500,000 | |
| | | 7.4.4 | Under Water Muck Blasted Rock | 5,500 | CY | 50 | 275,000 | |
| | 7.5 | | Subtotal New Tunnel | | 16,229,851 | | | |
| 8 | Road Relocation | | | | | | | |
| | 8.1 | | Open Cut Rock Excavation | 6,000 | CY | 10 | 60,000 | Extra Allowance |
| | 8.2 | | Rock Bolts | 3,375 | LF | 40 | 135,000 | 15' Long, 20' x 20' space |
| | 8.3 | | Shotcrete | 100 | CY | 485 | 48,500 | 1,000LF x 50LF @ 3" Th |
| | 8.4 | | Rock Fall Fencing | 3,300 | SY | 30 | 99,000 | 1,000LF x 100LF |
| | 8.5 | | Drainage | 1 | LS | 50,000 | 50,000 | |
| | 8.6 | | Paving | 800 | SY | 15 | 12,000 | 24' Wide, 7" Th |
| | 8.7 | | Guard Rail | 300 | LF | 25 | 7,500 | |
| | 8.8 | | Subtotal Road Relocation | | 412,000 | | | |
| 9 | Fill Tunnel, Test Operations | | | 1 | LS | 100,000 | 100,000 | Allowance |
| 10 | Instrumentation & Controls | | | 1 | LS | 1,000,000 | 1,000,000 | New for Gated Barrier |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BROWNLEE SWS ALTERNATIVE NO. 12 | | | | | | | |
| NEW TOWER INTAKE, REOPEN & ENLARGE DIVERSION TUNNEL, NEW SHAFT, and NEW TUNNEL to INTAKE CHANNEL | | | | | | | |
| COMPARATIVE RECONNAISSANCE LEVEL CONSTRUCTION COST ESTIMATE | | | | | | | |
| (2004 Dollars) | | | | | | | |
| Ref No. | Project Feature | | Quant | Unit Meas | Unit Rate | Amount | Comments |
| 11 | Subtotal Direct | | | | | 162,758,626 | |
| 12 | Contingency @ 30% | | | | | 48,827,374 | |
| 13 | Construction Total | | | | | 211,586,000 | |
| 14 | Engineering, PM, Other Owner Costs @ 30% | | | | | 63,476,000 | |
| 15 | Add'l Contingency for Underground @ 20% | | | | | 10,532,000 | Applies to Undrgrd only |
| 16 | Project Total | | | | | 285,594,000 | |
| | | | | | | | |
| | | Costs not Included: | Sales Tax | | | | |
| | | | Loss of Power Generation during Construction | | | | |
| | | | Loss of Power Generation due to Head Loss in System | | | | |
| | | | AFUDC | | | | |

## VERTICAL SHAFT DRILLING & GROUTING WORKSHEET

| Ref No. | Item | Shaft Dia (LF) | Unit Meas | Circumference (LF) | Hole Spacing | No Holes | Vert Hole Depth (LF) | Subtotal Length (LF) |
|---|---|---|---|---|---|---|---|---|
| A | 77' Diameter Shaft | | | | | | | |
| 1 | Vertical Shaft Diameter | 77 | LF | 241.90263 | | No Holes @ Rim of Shaft | | |
| 2 | Shaft + 10' Dia | 87 | LF | 273.31856 | 10 | 28 | 335 | 9,380 |
| 3 | Shaft + 20' Dia | 97 | LF | 304.73449 | 10 | 31 | 335 | 10,385 |
| 4 | Shaft + 30' Dia | 107 | LF | 336.15041 | 10 | 35 | 335 | 11,725 |
| | | Cumulative Number of Holes | | | | 94 | | |
| | | | | Cumulative Length of Drill Holes | | | | 31,490 |

| Ref No. | Item | Horiz Length | Unit Meas | Horiz Width | Hole Spacing | No Holes | Vert Hole Depth (LF) | Subtotal Length (LF) |
|---|---|---|---|---|---|---|---|---|
| B | Grouting for Tunnel Leakage | | | | | | | |
| 1 | Length of Grout Line, N1 | 625 | LF | | 10 | 62.5 | 335 | 20,938 |
| 2 | Length of Grout Line, N2 | 625 | | | 10 | 62.5 | 335 | 20,938 |
| 3 | Length of Grout Line, N3 | 625 | | | 10 | 62.5 | 335 | 20,938 |
| 4 | Length of Grout Line, S1 | 635 | LF | | 10 | 63.5 | 335 | 21,273 |
| 5 | Length of Grout Line, S2 | 635 | | | 10 | 63.5 | 335 | 21,273 |
| 6 | Length of Grout Line, S3 | 635 | | | 10 | 63.5 | 335 | 21,273 |
| 7 | Plane over Tunnel | 350 | | 80 | 10 | 280 | 150 | 42,000 |
| 7 | | Cumulative Number of Holes | | | | 658 | | |
| | | | | Cumulative Length of Drill Holes | | | | 168,630 |

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Appendix C. Mobley Engineering report on oxygenation concepts for temperature control structure alternatives in Brownlee Reservoir; October 2004

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# Hells Canyon Complex Final License Application
# Additional Information Requests
# WQ-2

## Oxgenation Concepts for
## Various Temperature Control Structure Alternatives

*Prepared for:*

***Idaho Power Company***

*Prepared by:*


**Mobley Engineering**

**30 Hickory Trail, PO Box 600**
**Norris, TN 37828-0600**
Ph: (865) 494-0600
Fax: (865) 494-0611
email: mark@mobleyengineering.com


**October 2004**

# Hells Canyon Complex Final License Application
# Additional Information Requests
# WQ-2

# Oxygenation Concepts for
# Various Temperature Control Structure Alternatives

October 2004

## Introduction:

As part of the Hells Canyon Complex License Application to the Federal Energy Regulatory Commission (FERC), Idaho Power Company (IPCo) has received additional information requests (AIRs) to expand and supplement documentation in the license application. AIR WQ2 has requested further information from IPCo on the potential benefits of modifying the Brownlee intake to allow the depth of withdrawal to be adjusted to provide some control over the temperature of the water that is discharged from the project. Since low oxygen levels occur in the deeper parts of the reservoir following summer thermal stratification, any water that is withdrawn from these depths to achieve temperature goals will require oxygenation to avoid adverse effects on downstream dissolved oxygen levels and other water quality issues.

This report presents oxygenation concepts for the various temperature control structures being evaluated by IPCo. Due to the sheer size of the project, the concepts push the limits of what is feasible and many will require extensive design work to ensure constructability. Mobley Engineering and its consultants have extensive experience in the design, installation and operation of oxygenation systems, including some of the largest systems currently in use for hydropower release improvements (U. S. Army Corp's Richard B Russell and TVA's Cherokee). This evaluation is based on that experience and attempts to develop concepts that utilize the best oxygenation opportunities for each temperature control alternative.

## Oxygenation Concepts Design Criteria:

IPCo provided the following design criteria:

Year 1997 Flow Regime:

1) Net DO increase of 4 mg / l
2) Net DO increase of 8 mg / l

Water temperature based on 15° C

Approximate Operating Period: September & October

| | | |
|---|---|---|
| Flow Rates: | Max. Hour: | 32,000cfs |
| | Average Hour: | 15,000 cfs |
| | Min. Hour: | 0 cfs |

Assume only and ALL hypolimnion water will be oxygenated. For all Alternatives except Alternatives 1 & 2, total hypolimnion volume would be: 800,000 acre-feet. For Alternatives 1 & 2, total hypolimnion volume would be: 620,000 acre-feet.

## Design Capacity

In order to meet the specified design criteria, the oxygenation system must provide a net DO increase of 4 or 8 mg/L for up to 32,000 cfs of turbine flow withdrawal from the hypolimnion. If the oxygenation system is applied in an "inline" manner such as in a penstock, tunnel or intake channel with no significant storage volume, the oxygenation must be accomplished as the turbine flow is moving over the effective diffuser location. Thus an inline system would need to have the capacity to supply the required DO increase to the maximum water flow rate (32,000 cfs) unless peaking operations are to be curtailed. Table 1 presents total oxygen capacity requirements for oxygenation to the design criteria:

### Oxygen Requirement Calculations

| DO Increase (mg/L) | Water Flow Rate (cfs) | | Oxygen Required (tons/day) |
|---|---|---|---|
| **4** | 32,000 | max | 344 |
| | 15,000 | avg | 161 |
| **8** | 32,000 | max | 688 |
| | 15,000 | avg | 322 |

Table 1: Oxygenation System Requirement Calculations

These requirements represent the amount of oxygen that is adsorbed into the water flow. Oxygen transfer efficiencies of the various oxygenation system designs will increase the actual oxygen use and supply capacity. These capacities are quite large compared to existing hydropower oxygenation systems, the largest being 200 tons per day at Richard B Russell. Only the use of pure oxygen was considered for the oxygen enhancement requirements of this study due to the total dissolved gas problems that would result from using compressed air.

## Oxygen Supply Facility:

This study concentrates on the conceptual design of diffuser systems for the various temperature control alternatives. Experienced gas supply vendors are separately providing evaluations of the oxygen supply facilities.

## Temperature Control Structure Alternatives:

IPCo provided general conceptual plans for ten temperature control structures to be evaluated. All of the alternatives assume a new thermocline elevation of 2020 is established by operating the various control structures to remove water from above 2020 during the summer so that cold water is stored below 2020 for use in September and October. For this study, the alternatives were reduced into four groups according to oxygen diffuser applicability. Each alternative may require several different diffuser locations to provide the total capacities identified in Table 1.

### Gated Intake Channel (Alternatives 1 and 2)

The first group includes alternatives that utilize some sort of gate at the upstream end of the intake channel to increase the storage of cold water during most of the summer and access that cold water to release it as needed for temperature reductions. The hypolimnetic volume accessed by this group of alternatives is 620,000 acre-feet between elevations 1930 and 2020. For this group of alternatives, four oxygen diffuser designs were identified (Figure 1):

A. Oxygen Diffusers in Intake Channel – Upstream of Gate:

The diffusers would be a modified form of the line diffusers currently in use at fourteen reservoirs across the US. Line diffusers using porous hose or diffuser heads to obtain distribution of high flow rates could be deployed in the intake channel upstream of the gate. The diffusers would be located at the bottom of the channel at elevation 1930 to place oxygen into the water that is drawn through the lowest portions of the gate as when accessing stored cold water.

Conceptual Design

- Four 200 foot long diffuser lines at elevation 1930
- Maximum flow 2 scfm/foot
- Maximum oxygen distribution 100 tons per day
- Estimated oxygen transfer efficiency 68%
- Capacity (oxygen into the water) 68 tons per day

Limitations

- 200' by 100' area in front of gate

Disadvantages

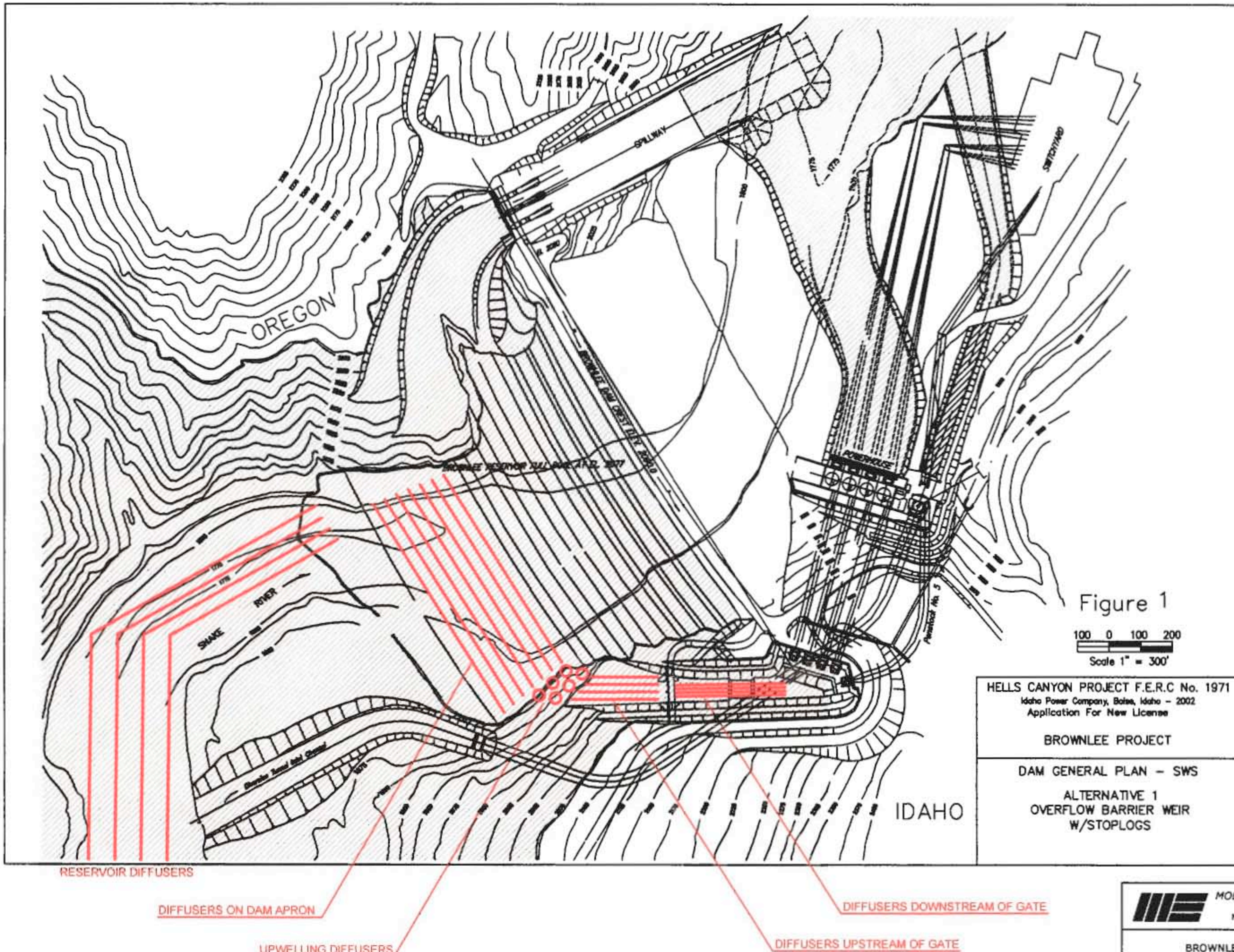
- Potential high water velocities
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate

- $800,000

B. Oxygen Diffusers in Intake Channel – Downstream of Gate:

Line diffusers using porous hose or diffuser heads could be deployed in the intake channel downstream of the gate. The diffusers would be located at the bottom of the channel at elevation 1930 to place oxygen into any water that is drawn through intake channel.




MOBLEY ENGINEEING, INC.
P.O. Box 600
Norris, TN 37828-0600

BROWNLEE PROJECT

| | | | |
|---|---|---|---|
| Customer: Idaho Power Company | | | |
| Designed by: MHM | Date: 10/18/04 | Drawn by: SRM | Plot Date: 10/29/04 |
| Scale: NTS | File Name: Diffuser Layout 1.dwg | | |

Conceptual Design

- Four 350 foot long diffuser lines at elevation 1930
- Maximum flow 2 scfm/foot
- Maximum oxygen distribution 170 tons per day
- Estimated oxygen transfer efficiency 68%
- Capacity (oxygen into the water) 100 tons per day

Limitations

- 350' by 70' area in intake channel

Advantages

- Oxygenate all flow through intake channel

Disadvantages

- Potential high water velocities
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate

- $1,100,000

C. Oxygen Diffusers on Dam Apron:

Line diffusers using porous hose could be located on the apron at elevation 1870 just upstream of the dam. The diffusers would place oxygen in the hypolimnion some distance from the intake channel; therefore there could be some delay before oxygenated water reaches the intake. The system could be operated 24 hours/day to build a volume of oxygenated water in front of the intake, but the volume would be small enough to be removed quickly with turbine flows.

Conceptual Design:

- Seven 800 foot long diffuser lines at elevation 1970
- Maximum flow 2 scfm/foot
- Maximum oxygen distribution 670 tons per day
- Estimated oxygen transfer efficiency 85%
- Capacity (oxygen into the water) 570 tons per day

Limitations and Considerations

- Oxygenated water may not be withdrawn into the intake
- System may work well in combination with upwelling diffusers

Advantages

- Deep, large area provides better oxygen transfer efficiency
- High capacity

Disadvantages

- 24-hour per day oxygen flow required to maintain oxygenated volume in front of the intake.
- Oxygenated water may not be withdrawn into the intake
- High flow diffusers may stir up sediment and incur additional oxygen demands

- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $3,600,000 (could be reduced as a function of capacity)

D. Upwelling Oxygen Diffusers Near the Intake Channel:
Upwelling diffusers could be located on the apron at elevation 1870 just upstream of the intake channel. The diffusers would place large amounts of oxygen in a small area to create a strong upwelling plume. The plume would entrain cold water from the hypolimnion, oxygenate it, and release the water in the thermocline. Since the coldest water was warmed by the entrainment of warmer water at the thermocline, the oxygenated plume water would tend to fall back to a layer of like density some height above the diffuser. The upwelling diffuser can be designed so that the fall back elevation is above the elevation of intake channel bottom so that some percentage of the upwelled water is removed with turbine operation. Conceptually, the depths available at Brownlee provide for efficient water entrainment as well as efficient oxygen transfer into the plume water. The intake gate would lower the turbine withdrawal zone during cold-water releases, increasing the likelihood that the upwelled water would get withdrawn.

Conceptual Design
- Five to six 30 foot diameter diffusers at elevation 1870 to 1900
- Maximum flow 1,300 scfm/ea
- Maximum oxygen distribution 460 tons per day
- Estimated oxygen transfer efficiency 76%
- Capacity (oxygen into the water) 350 tons per day

Limitations and Considerations
- Oxygenated water may not be withdrawn at intake
- Access to cold water above 1870

Advantages
- Deep area in front of intake provides efficient oxygen transfer efficiency and upwelling
- High capacity
- Least capital costs per capacity (small diffusers)

Disadvantages
- Oxygenated water may not be withdrawn at intake
- High flow diffusers may stir up sediment and incur additional oxygen demands
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $1,300,000 (could be reduced as a function of capacity)

## Diversion Tunnel (Alternatives 3 and 5)

The second group includes alternatives that utilize the existing diversion tunnel with new connections to the existing intake channel. The diversion tunnel would provide access to cold water at the very deepest portion of the reservoir. A gate on the existing intake channel or a pump would be utilized to direct turbine flow to the cold water available at the tunnel. For this group of alternatives, two oxygen diffuser designs were identified (Figure 2 and 3):

A. Oxygen Diffusers in Low Level Intake Channel Upstream of Diversion Tunnel:
Line diffusers using porous hose or diffuser heads to obtain distribution of high flow rates could be deployed in the intake channel upstream of the diversion tunnel. The diffusers would be placed at the bottom of the channel at elevation 1780 to place oxygen into the water that is drawn into the tunnel when accessing stored cold water.

Conceptual Design
- Three 1000-foot long diffuser lines at elevation 1780
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 110 tons per day
- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 100 tons per day

Limitations
- Intake channel area
- Oxygen distribution must be in low level withdrawal zone

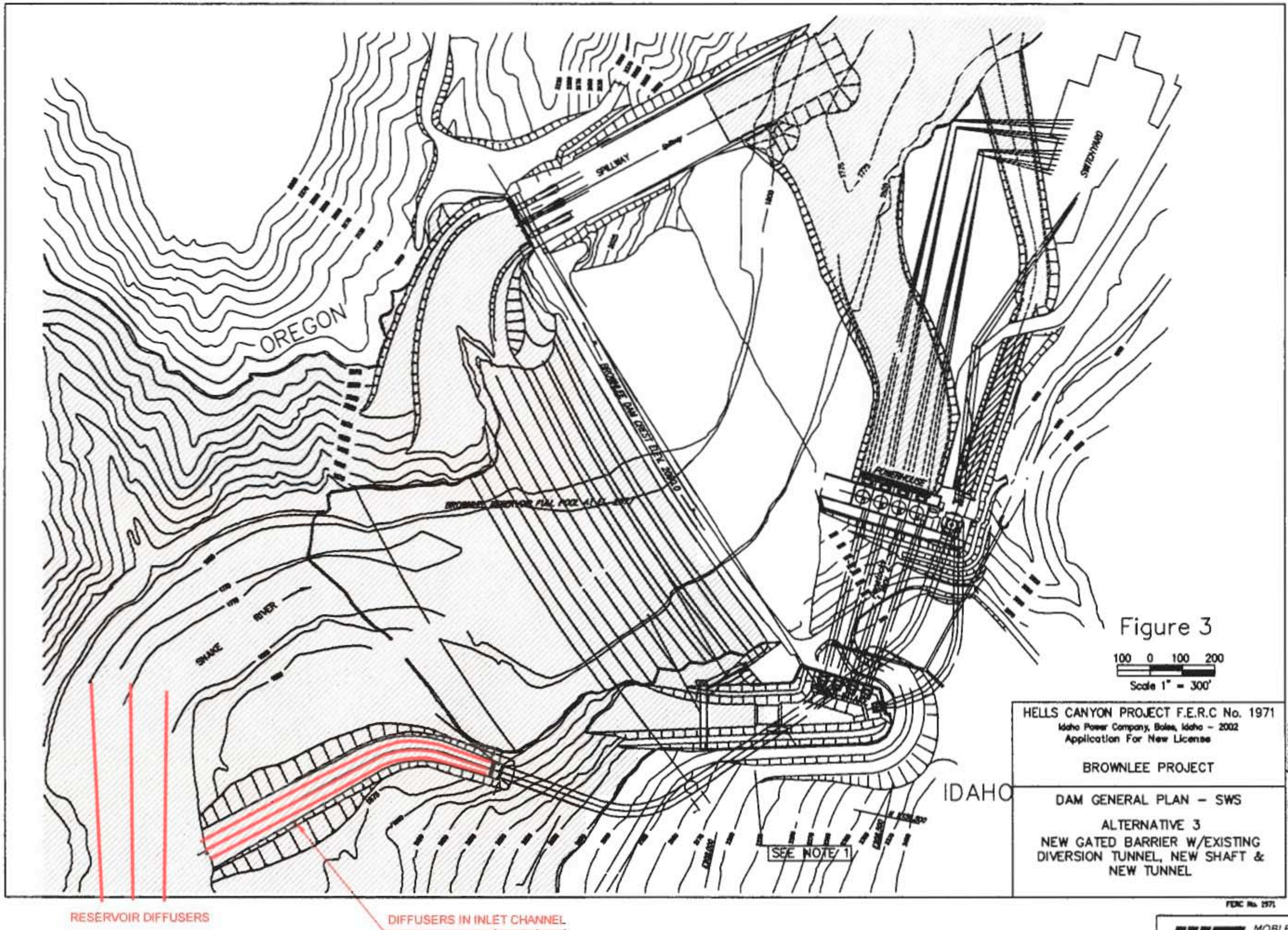
Advantages
- Good oxygen transfer efficiency

Disadvantages
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $800,000

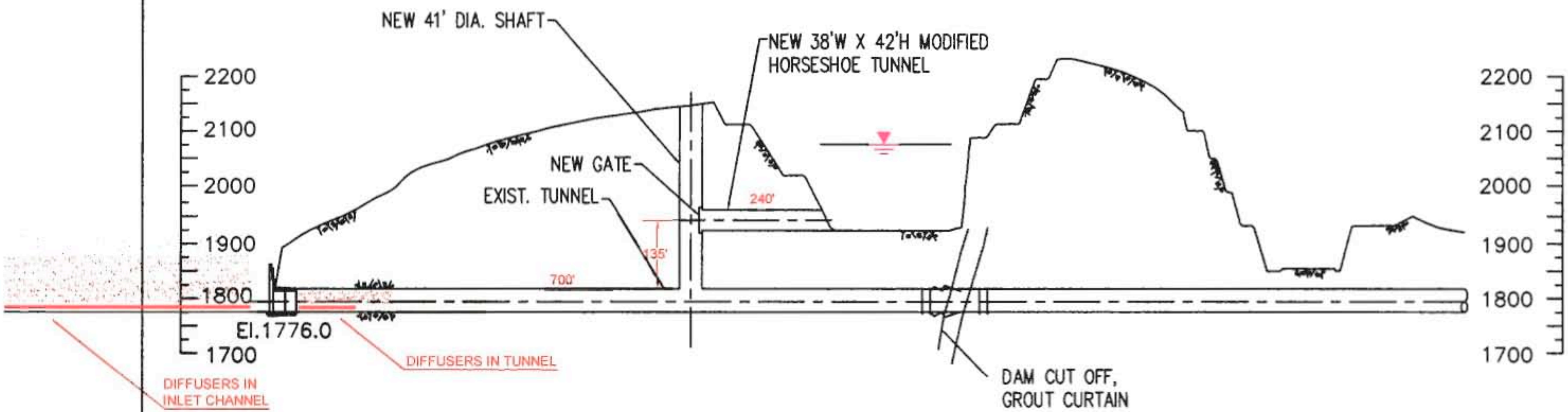
B. Oxygen Diffusers in the Diversion Tunnel:
Diffusers could be located at the upstream end of the tunnel. Oxygen bubbles from the diffusers will be subjected to high pressures, turbulence and long travel times in the long tunnel resulting in high oxygen transfer efficiencies. A vertical tunnel section and discharge into the existing intake channel would vent any excess gas bubbles before they are entrained into the turbine flow – eliminating potential disruption of raw water supplies and flow measurement instrumentation that might otherwise result with bubbly flow.

Conceptual Design:
- One hundred 100-foot long diffuser lines near tunnel entrance at elevation 1776
- Maximum flow 0.062 scfm/foot
- Maximum oxygen distribution 360 tons per day
- Estimated oxygen transfer efficiency 90%




FERC No. 1971

| | | | |
|---|---|---|---|
| MOBLEY ENGINEEING, INC.<br>P.O. Box 600<br>Norris, TN 37828-0600 | | | |
| BROWNLEE PROJECT | | | |
| Customer: Idaho Power Company | | | |
| Designed by: MHM | Date: 10/18/04 | Drawn by: BRM | Plot Date: 10/28/04 |
| Scale: NTS | File Name: Diffuser Layout 5.dwg | | |




DEVELOPED PROFILE ON ℄ EXIST. TUNNEL

Figure 3-1

100 0 100 200 300
Scale 1" = 200'

HELLS CANYON PROJECT F.E.R.C No. 1971
Idaho Power Company, Boise, Idaho - 2002
Application For New License

BROWNLEE PROJECT

DAM GENERAL PLAN - SWS

ALTERNATIVE 3
NEW GATED BARRIER W/EXISTING DIVERSION TUNNEL, NEW SHAFT & NEW SHAFT W/ADJ. GATES

MOBLEY ENGINEEING, INC.
P.O. Box 600
Norris, TN 37828-0600

BROWNLEE PROJECT

| | | | |
|---|---|---|---|
| Customer: Idaho Power Company | | | |
| Designed by: MHM | Date: 10/18/04 | Drawn by: SRM | Plot Date: 10/21/04 |
| Scale: NTS | File Name: Diffuser Layout 3.dwg | | |

- Capacity (oxygen into the water) 325 tons per day

Limitations
- Tunnel area near entrance

Advantages
- Oxygen bubbles placed in confined flow conduit
- Long, deep tunnel should provide for high oxygen transfer efficiency
- An additional diffuser could be placed directly under vertical section of tunnel to upwell cold water

Disadvantages
- Potential high water velocities
- Difficult installation
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $2,800,000

## New Deep Intake Channel (Alternative 6a)

This alternative is a new deep intake channel with gate to access water at desired levels. For this alternative, two oxygen diffuser designs were identified (Figure 4):

A. Oxygen Diffusers in Intake Channel – Upstream of Gate:

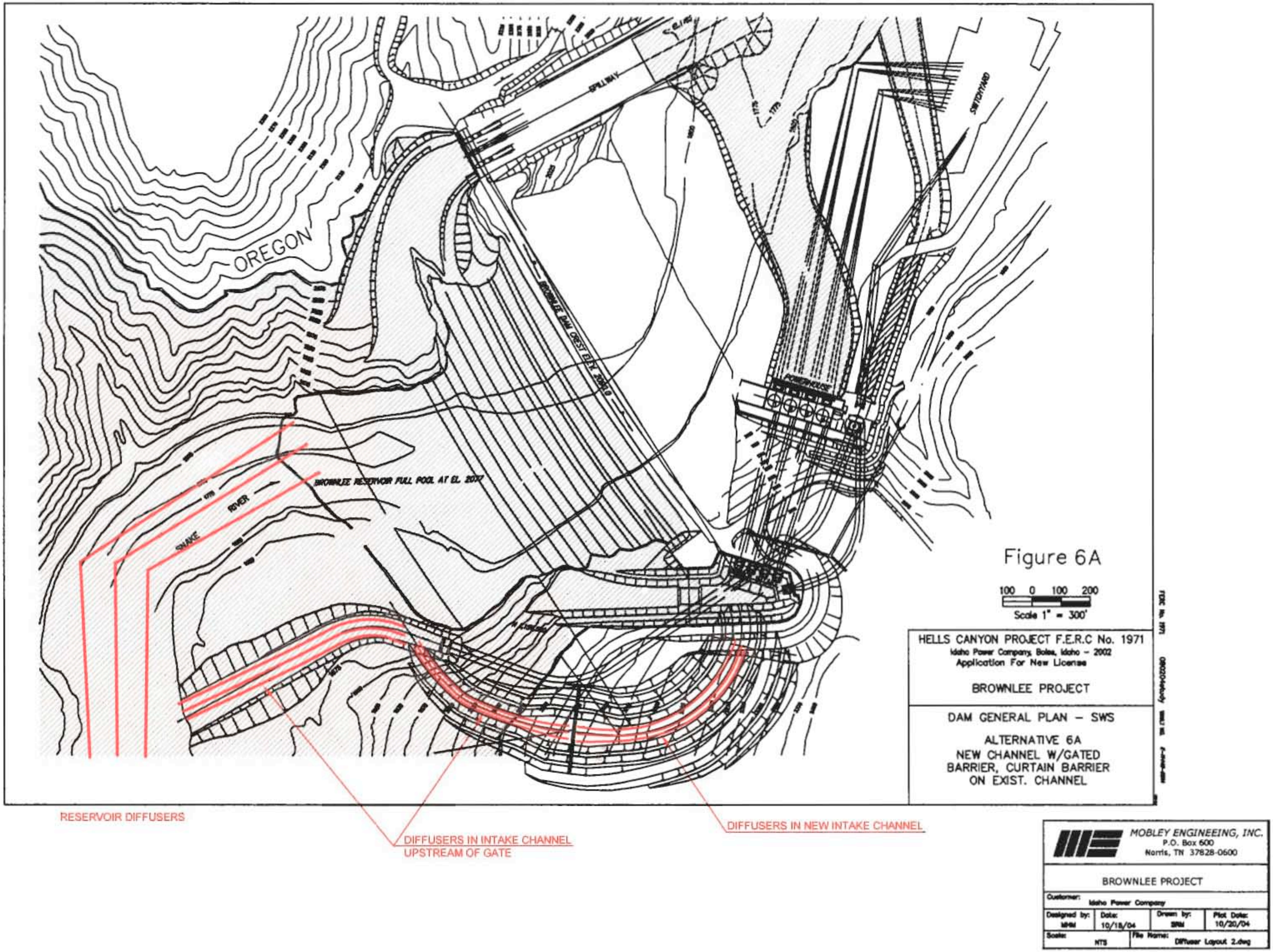
Line diffusers using porous hose or diffuser heads to obtain distribution of high flow rates could be deployed in the intake channel upstream of the gate. The diffusers would be placed at the bottom of the new channel and the existing channel in front of the diversion tunnel, both at elevation 1780 to place oxygen into the water that is drawn through the lowest portions of the gate as when accessing stored cold water.

Conceptual Design
- Three 1,500-foot long diffuser lines at elevation 1780
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 160 tons per day
- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 145 tons per day

Limitations
- Intake channel area in front of gate

Advantages
- Deep area provides high oxygen transfer

Disadvantages
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors



OREGON
SPILLWAY
SWITCHYARD
BROWNLEE RESERVOIR FULL POOL AT EL. 2077
SNAKE
RIVER
Figure 6A
100 0 100 200
Scale 1" = 300'
HELLS CANYON PROJECT F.E.R.C No. 1971
Idaho Power Company, Boise, Idaho – 2002
Application For New License
BROWNLEE PROJECT
DAM GENERAL PLAN – SWS
ALTERNATIVE 6A
NEW CHANNEL W/GATED
BARRIER, CURTAIN BARRIER
ON EXIST. CHANNEL
RESERVOIR DIFFUSERS
DIFFUSERS IN INTAKE CHANNEL
UPSTREAM OF GATE
DIFFUSERS IN NEW INTAKE CHANNEL
MOBLEY ENGINEEING, INC.
P.O. Box 600
Norris, TN 37828-0600
BROWNLEE PROJECT
Customer: Idaho Power Company
Designed by: MHM
Date: 10/15/04
Drawn by: SRM
Plot Date: 10/20/04
Scale: NTS
File Name: Diffuser Layout 2.dwg

Budget Estimate
- $1,100,000

B. Oxygen Diffusers in New Intake Channel – Downstream of Gate:
Line diffusers using porous hose or diffuser heads could be located in the new intake channel downstream of the gate. The diffusers would be placed at the bottom of the channel that slopes from elevation 1780 to 1930 to place oxygen into any water that is drawn through the intake channel.

Conceptual Design
- Three 800-foot long diffuser lines at elevation 1780 to 1930
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 90 tons per day
- Estimated oxygen transfer efficiency 85%
- Capacity (oxygen into the water) 75 tons per day

Limitations
- 800' by 40' area in intake channel

Advantages
- Oxygenate all flow through intake channel

Disadvantages
- Potential high water velocities
- Diffuser distribution on slope
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

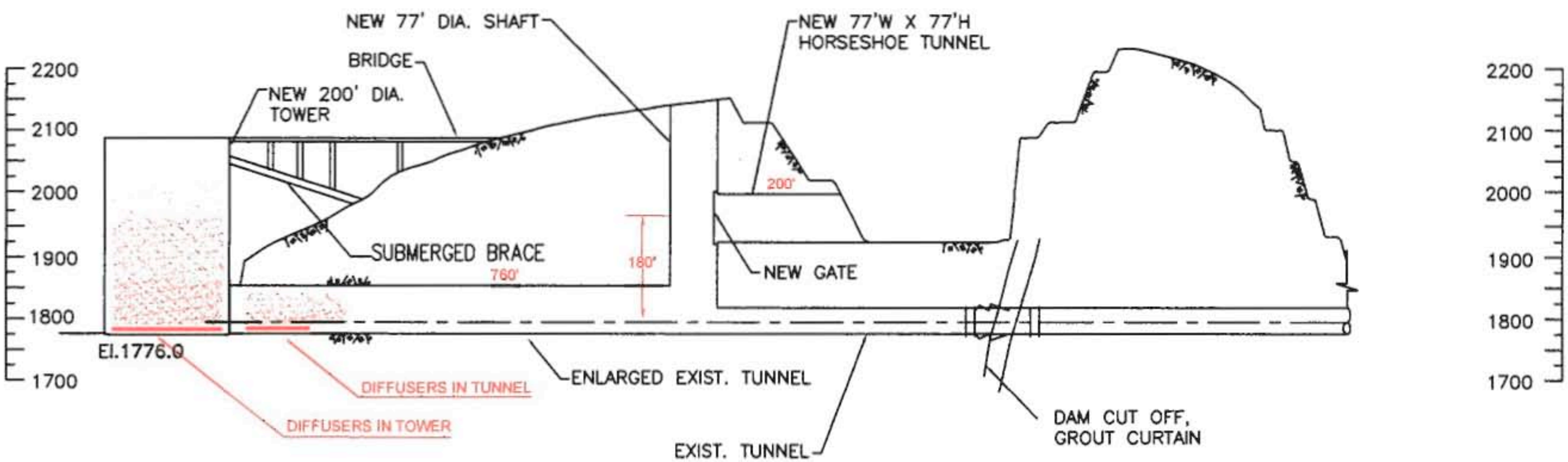
Budget Estimate
- $700,000

## Gated Intake Tower (Alternatives 8a, 10, 10a and 12)

The last group includes alternatives that include a new intake tower upstream of the diversion tunnel with new connections to the existing intake channel, or turbine penstocks. The intake tower would provide access to cold water at the very deepest portion of the reservoir. For this group of alternatives, two oxygen diffuser designs were identified (Figure 5):

A. Oxygen Diffusers in Low Level Intake Channel Upstream of Intake Tower:
Line diffusers using porous hose or diffuser heads to obtain distribution of high flow rates could be deployed in the intake channel upstream of the intake tower. The diffusers would be located at the bottom of the channel at elevation 1780 to place oxygen into the water that is drawn into the tower when accessing stored cold water.

Conceptual Design
- Three 800-foot long diffuser lines at elevation 1780
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 90 tons per day




DEVELOPED PROFILE ON ℄ EXIST. TUNNEL

Figure 10–1

100 0 100 200

Scale 1" = 200'

HELLS CANYON PROJECT F.E.R.C No. 1971
Idaho Power Company, Boise, Idaho – 2002
Application For New License

BROWNLEE PROJECT

DAM GENERAL PLAN – SWS

ALTERNATIVE 10
NEW GATED BARRIER, NEW TOWER W/BOTTOM INLET, ENLARGE EXIST. TUNNEL, NEW SHAFT & NEW TUNNEL

080204study FERC No. 1971

MOBLEY ENGINEEING, INC.
P.O. Box 600
Norris, TN 37828-0600

BROWNLEE PROJECT

| Customer: Idaho Power Company | | | |
|---|---|---|---|
| Designed by: MHM | Date: 10/18/04 | Drawn by: SRM | Plot Date: 10/21/04 |
| Scale: NTS | File Name: Diffuser Layout 4.dwg | | |

- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 80 tons per day

Limitations
- Intake channel area
- Oxygen distribution must be in intake tower withdrawal zone

Advantages
- Good oxygen transfer efficiency

Disadvantages
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $700,000

B. Oxygen Diffusers in the Intake Tower:

Diffusers could be located at the 120-foot diameter bottom area of the tunnel. Some percentage of the diffused bubbles would be entrained into the water flow into the tunnel entrance as a function of flow in the tower (downward from upper gates), oxygen flow rate, and turbine flow rate. The bubbles entrained into the tunnel would likely get high oxygen transfer efficiency, those that pass through the water flow and vent to the atmosphere at the top of the intake tower would contribute only while passing through turbine flow. Thus this location would be most effective for withdrawal from high intake gate elevations.

Conceptual Design
- Five thousand diffuser heads at bottom of tower
- Maximum flow 2 scfm/each
- Maximum oxygen distribution 600 tons per day
- Estimated oxygen transfer efficiency 60 to 90%
- Capacity (oxygen into the water) 360 to 540 tons per day

Limitations
- Tower floor area
- Placing oxygen in low level water withdrawal

Advantages
- Oxygen bubbles placed in confined flow conduit

Disadvantages
- Potential high water velocities
- Difficult installation (unless constructed in dry)
- Potential for oxygen enriched environment in intake tower
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $3,300,000

C. Oxygen Diffusers in the Diversion Tunnel:

Diffusers could be located at the upstream end of the tunnel. Oxygen bubbles from the diffusers will be subjected to high pressures, turbulence and long travel times in the long tunnel resulting in high oxygen transfer efficiencies. A vertical tunnel section and discharge into the existing intake channel would vent any excess gas bubbles before they are entrained into the turbine flow – eliminating potential disruption of raw water supplies and flow measurement instrumentation that might otherwise result with bubbly flow.

Conceptual Design
- One hundred 100-foot long diffuser lines near tunnel entrance at elevation 1776
- Maximum flow 0.062 scfm/foot
- Maximum oxygen distribution 360 tons per day
- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 325 tons per day

Limitations
- Tunnel area near entrance

Advantages
- Oxygen bubbles placed in confined flow conduit
- Long, deep tunnel should provide for high oxygen transfer efficiency
- An additional diffuser could be placed directly under vertical section of tunnel to upwell cold water

Disadvantages
- Potential high water velocities
- Difficult installation
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- $2,100,000

## Operating Costs

The operating costs for these oxygenation systems will be primarily the cost of the liquid oxygen used each year. Oxygen usage will depend on the oxygen transfer efficiency of the diffuser system chosen and how it is operated. Table 2 presents annual oxygen costs based on average oxygen transfer efficiencies of the enhancement options available and supplier prices. Hypolimnetic oxygen demands have not been accounted for in these estimates.

| Hypolimnetic Volume (acre-ft) | Delta DO (mg/L) | O2 Required (tons) | OTE | SF | Annual O2 Usage (tons) | LOx Cost ($/ton) | Annual Cost |
|---|---|---|---|---|---|---|---|
| 800,000 | 4 | 4,335 | 90% | 1.15 | 5,539 | $ 300 | $1,700,000 |
| | 8 | 8,670 | 80% | 1.15 | 12,463 | $ 300 | $3,800,000 |
| 620,000 | 4 | 3,360 | 85% | 1.15 | 4,545 | $ 300 | $1,400,000 |
| | 8 | 6,719 | 75% | 1.15 | 10,303 | $ 300 | $3,100,000 |

Table 2: Estimated Annual Oxygen Costs

## Reservoir Diffusers:

Diffusers in the reservoir could be used to place oxygen in the hypolimnion for any of the temperature control alternatives.

### Oxygenation of the Hypolimnion for Daily Operations

Oxygen can be placed in large areas of hypolimnion over 24 hours that would be a sufficient volume to provide for a full day's generation and peaking flow rates. The capacity requirement for the system would be smaller since maximum oxygen input would be based on average turbine flows (15,000 cfs) and usage would be constant over 24 hours. This could be important to get oxygen supply facility capacity down to a reasonable size. Line diffusers operating can provide nearly 100% oxygen transfer in the depths available at Brownlee.

### Capacity Calculations

| DO Increase (mg/L) | Water Flow Rate (cfs) | | Oxygen Required (tons/day) |
|---|---|---|---|
| 4 | 32,000 | max | 344 |
| | 15,000 | avg | 161 |
| 8 | 32,000 | max | 688 |
| | 15,000 | avg | 322 |

Table 3: Oxygenation System Capacity Calculations

To provide a volume of at least one day's average generation the oxygenation should extend at least 2 miles upstream of the dam (for 800,000 acre feet hypolimnion). An oxygen supply facility location may be available at some point upstream of the dam that would be convenient.

Conceptual Design – (4 mg/L increase)

- Two 2,500-foot long lines at elevation 1800
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 180 tons per day
- Estimated oxygen transfer efficiency 95%
- Capacity (oxygen into the water) 161 tons per day

Conceptual Design – (8 mg/L increase)

- Two 5,500-foot long lines at elevation 1800
- Maximum flow 0.6 scfm/foot
- Maximum oxygen distribution 360 tons per day
- Estimated oxygen transfer efficiency 95%
- Capacity (oxygen into the water) 322 tons per day

Limitations

- Oxygenation must be distributed over hypolimnetic volume being accessed

Advantages

- Allows for smaller oxygen supply facility capacity
- High oxygen transfer efficiency
- Some anoxic products oxidized in the reservoir

Disadvantages
- Additional oxygen costs to satisfy some hypolimnetic oxygen demands
- The discharge could contain anoxic products that would not be oxidized before they reach the tailwater, releasing green house gases and odors

Budget Estimate
- 4 mg/L uptake – $1,200,000
- 8 mg/L uptake – $2,000,000

### Oxygenation of the Hypolimnion for Entire Low DO Period

Reservoir diffusers could also be used to maintain most of the hypolimnetic volume at oxygenated levels by providing enough oxygen to meet demands in the hypolimnion and oxidize anoxic products. This approach would entail a constant oxygen input in the reservoir from April or May through October. The constant oxygen input rate can be referred to as the hypolimnion maintenance input. Depending on oxygen supply availability, it may be desirable to place a smaller amount of oxygen in the reservoir over time to avoid the peak oxygen requirements of the inline systems. This is the only approach that would reduce or eliminate the anoxic products in the hypolimnion that could detrimentally affect cold-water releases.

An estimate of the oxygen demands was obtained by evaluating the DO decline in the hypolimnion. Using monthly profiles from 2000 (Figure 6), it was determined that the rate that the hypolimnion was declining was 3 mg/L per month at when the hypolimnion DO content was about 4 mg/L and 2 mg/L per month at 2 mg/L. Depletion rates for other years may be different. A sensitivity check using limited 1997 data when the hypolimnetic temperature levels were warmer (e.g., 12-14 $^{o}$C) at river mile 285 indicated that the DO depletion rate could be twice the rate determined for 2000. It is likely that the DO depletion rate would vary from year to year and probably from week to week within each year.

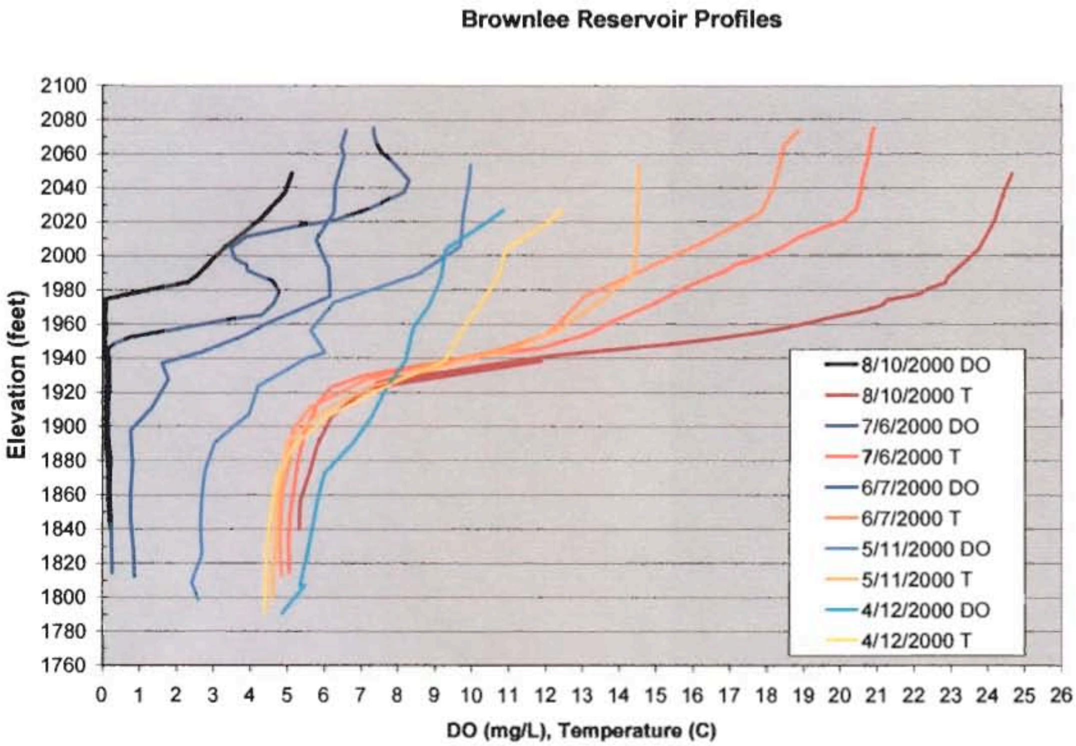



Figure 6: Brownlee Profiles at RM 290 for 2000

The volume of the existing hypolimnion (below elevation 1930) is about 200,000 acre-feet. These rates can then be used to estimate the amount of oxygen input that would be required to maintain a specific level and extrapolated to the 800,000 acre-feet volume of the design criteria as shown in Table 4.

| Hypolimnetic Volume (acre-feet) | Average DO Content of the Hypolimnion (mg/L) | Depletion Rate (mg/L per mo) 2000, RM 290 | Oxygen Input Required to Maintain DO (Tons/day) | Oxygen Required (tons/year) |
|---|---|---|---|---|
| 200,000 | 4 | 3 | 26 | 5,650 |
| 200,000 | 2 | 2 | 17 | 3,150 |
| 800,000 | 4 | 3 | 105 | 22,800 |
| 800,000 | 2 | 2 | 70 | 13,000 |

Table 4: Estimated Maintenance Rates to Maintain the Hypolimnion at Various DO Levels (based on 2000 profiles at river mile 290)

These maintenance rates are rough estimates based on a very limited evaluation. Mixing near the sediment interface due to aeration could increase these numbers by 150%. Limited profile data from 1997 indicate much higher depletion rates. Also, depletion rates elsewhere in the hypolimnion (such as near the upstream end) may be much larger. And, DO demands in the water column could be higher during the summer after DO is already zero and the DO depletion rates cannot be used to determine demands. However, extrapolating the same depletion rate to the larger hypolimnion volume (800,000 acre feet) could be conservative because the large additional volume will have a much smaller sediment area to water volume ratio and therefore less oxygen demand per volume. On the other hand, DO depletion in the water column in the larger hypolimnion could be greater than currently indicated because more detritus (dead algae) could be trapped in the larger hypolimnion creating higher DO demands. Further evaluation using hydrodynamic water quality modeling will be required to determine the capacity and annual oxygen requirements for this approach.

Conceptual Design – (maintain 2 mg/L in 800,000 acre-foot hypolimnion)
- Three 6,000-foot long lines at elevation 1820
- Maximum flow 0.1 scfm/foot
- Maximum oxygen distribution 80 tons per day
- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 72 tons per day

Conceptual Design – (maintain 4 mg/L in 800,000 acre-foot hypolimnion)
- Four 6,000-foot long lines at elevation 1820
- Maximum flow 0.1 scfm/foot
- Maximum oxygen distribution 120 tons per day
- Estimated oxygen transfer efficiency 90%
- Capacity (oxygen into the water) 108 tons per day

Limitations
- Oxygenation must be distributed over a large portion of the hypolimnetic volume

Advantages
- Allows for smaller oxygen supply facility capacity
- High oxygen transfer efficiency
- Reduce or eliminate anoxic products in the reservoir
- Steady, relatively low level oxygen supply requirement suitable for on site generation

Disadvantages
- Additional oxygen costs to satisfy hypolimnetic oxygen demands
- Several oxygen supply facility locations would be required to spread oxygen over 20 – 25 mile long hypolimnetic volume

Budget Estimate
- Maintain 2 mg/L – $ 900,000
- Maintain 4 mg/L – $1,200,000

## Operating Costs

The operating costs for maintaining the hypolimnion in an oxygenated state would be primarily the cost of the liquid oxygen used each year. The reservoir diffuser system is nearly 100% efficient. Oxygen usage will depend on the actual oxygen demands in the hypolimnion each year. Based on the total oxygen usage of Table 4, and a multiplier to cover a range for higher oxygen demands in other years or due to mixing; the costs for oxygen are presented in Table 5 below. Costs are based on $180/ton because of the lower peak usage.

| Hypolimnetic Volume (acre-feet) | Average DO Content of the Hypolimnion (mg/L) | Oxygen Required (tons/year) | Annual Oxygen Cost |
|---|---|---|---|
| 200,000 | 4 | 5,650 – 14,000 | $1.0M - $2.5M |
| 200,000 | 2 | 3,150 – 9,500 | $0.5M - $1.7M |
| 800,000 | 4 | 22,800 – 57,000 | $4.0M – $10.2M |
| 800,000 | 2 | 13,000 – 40,000 | $2.3M - $7.2M |

Table 5: Estimated Oxygen Costs to Maintain the Hypolimnion at Various DO Levels

Based on these costs, maintaining the entire hypolimnion at an oxygenated state may not be economically feasible. However, placing oxygen in the lowest volume (200,000 acre-feet) could dramatically reduce the anoxic products and their detrimental affect in the tailwater. Modeling of the dynamics of the DO demands would be needed to assess this potential.

## Other Water Quality Considerations in Accessing the Hypolimnion:

The inflow to Brownlee Reservoir is high in nutrients and organic matter. These loads significantly affect water quality in the reservoir resulting in fish kills, algal mats, and among the highest DO depletion rates observed in hydropower reservoirs in the United States.

Low DO is not the only water quality issue that occurs. As the DO in the water in the hypolimnion decreases, other water quality issues develop. Methane, carbon dioxide, ammonia, and sulfides occur as natural processes under anoxic conditions. Considering the high DO depletion rates at Brownlee, it is expected that these water quality constituents occur at some of the highest concentrations that occur in the USA. In addition, methylmercury may also be an issue depending on the inputs of mercury to this system—if mercury enters this system in sufficient quantity, the water quality conditions for the above constituents suggest that mercury could be a significant consideration as to potential water quality impacts that need to be considered in the overall water quality management strategies.

Only limited data are available on water quality in the hypolimnion, so estimates for these constituents were developed based on experience at other eutrophic reservoirs (i.e., Lake McConaughy on the North Platte River and Cherokee and Douglas Reservoirs in East Tennessee).

Using the DO depletion rates from some of the lake profile data, the following estimates of water quality conditions associated with the hypolimnion were developed, assuming it was not oxygenated for a period of several months:

- Ammonia concentration would be about 2 mg/L
- Methane concentration would be about 10 mg/L
- Methane alone (i.e., not including carbon dioxide) would contribute 11,200 tons to greenhouse gases (i.e., 225,000 tons equivalent to carbon dioxide for global warming potential) if the water from the hypolimnion was discharged to the tailwater without sufficient time to be oxidized (at least several weeks)
- Sulfide concentration would be about 2-4 mg/L
- The maximum overall DO demand for the period March through September could be about 46 mg/L based on data collected in 1997

These water quality estimates would apply to the hypolimnion that would occur in the water below elevation 2020' near the end of the summer. An estimate of carbon dioxide that would be produced in the hypolimnion was not developed, but it would be significant from a greenhouse gas perspective and it would remain an issue even if the hypolimnion were oxygenated. Considering the high DO demand that develops over the course of the months considered, it is assumed that an oxygenation system would be operated over the entire period of low DO in the hypolimnion.

Many of these anoxic products require 15 – 20 days to oxidize. Therefore, oxygen diffuser systems that operate "inline" at the dam or even 1 to 2 days of volume upstream would be ineffective at removing them before they are released into the tailwater. Oxygenation of part or all of the hypolimnion would be the most effective means to reduce or eliminate this potential problem.

## Conclusion:

**Oxygen Diffuser Concepts**
Conceptual diffuser designs were developed to place suitable amounts of oxygen in the water flow at each temperature control structure alternative to increase dissolved oxygen content by 4 to 8 mg/L

- Diffuser designs to meet design criteria are available for each temperature control structure alternative
- Installation costs for the diffuser systems are small compared to oxygen costs, oxygen supply facility costs or cost of other modifications.
- Deep reservoir allows placement of large volumes of oxygen with high oxygen transfer efficiency
- Optimization of diffuser designs will be necessary to reduce operating costs once a temperature control alternative is chosen.

**Hypolimnion Water Quality**
Accessing the cold-water storage of the hypolimnion may involve more water quality concerns than just dissolved oxygen levels in the release.

- The discharge would contain methane, ammonia, and probably sulfide at levels that would not be oxidized before they are released to the tailwater, causing green house gases, odors, and possibly toxic levels of sulfide (depending on pH and concentration of sulfide). Methylmercury could also occur in the anoxic water and would not be oxidized before being released to the tailwater.
- Oxygenation of at least part of the hypolimnion may be required to control anoxic products
- More data and water quality modeling would be needed to better assess these water quality concerns and to develop water quality management strategies

**Oxygen Supply**
The availability and economics of oxygen supply and generation will affect the selection of oxygen diffuser systems and operation strategies.

- Operational and economical feasibility is more likely to be associated with oxygen supply than diffuser systems.
- The supply of trucked in liquid oxygen is limited in the Boise area.
- Onsite generation facilities are best applied to long-term steady oxygen supply requirements.

**Oxygenation System Operation**
A combination of oxygenation systems and operational strategies is likely to be necessary to access the cold water of the hypolimnion and maintain downstream water quality.

- Oxygenation using a reservoir diffuser system may be required as a base oxygen input to control anoxic products.
- Final desired oxygen level could be obtained at the dam with the oxygen concept options listed for the various temperature control structures

| Temperature Control Structure and DO Enhancement Option | Maximum Oxygen Capacity (tons/day) | Limitations | Design Details | Advantages | Disadvantages | Budget Estimate |
|---|---|---|---|---|---|---|
| **Gated Intake Channel (1and 2)** | | | | | | |
| A. Oxygen diffusers in intake channel<br>Upstream of gate | 100<br>(68) | Area = 200 x 100 | 68% OTE<br>4 - 200' lines<br>2 scfm/ft | Enhance all flows | Limited area<br>Velocity concerns | $ 800,000 |
| B. Oxygen diffusers in intake channel<br>Downstream of gate | 170<br>(100) | Area = 200 x 70 | 68% OTE<br>4 - 350' lines<br>2 scfm/ft | Enhance all flows | | $1,100,000 |
| C. Diffusers on dam apron elev. 1870 | 670<br>(570) | Cold water only | 85 % OTE<br>7 - 800' lines<br>2 scfm/ft | Deep, large area<br>High capacity | May not get withdrawn<br>Upwelling required | $3,600,000 |
| D. Upwelling diffusers upstream of channel | 460<br>(350) | Effective location | 76% OTE<br>5 - 6 plumes | Cold water upwelling | | $2,600,000 |
| **Diversion Tunnel (3 and 5)** | | | | | | |
| A. Diffusers upstream of diversion tunnel<br>Diffusers in inlet channel, elev.1800 | 110<br>(100) | Cold water only<br>Area<br>O2 in withdrawal zone | 90% OTE<br>3 - 1000' lines<br>0.6 scfm/ft | | | $ 800,000 |
| B. Diffuser in tunnel | 360<br>(325) | Cold water only | 90% OTE<br>100 - 100' lines<br>0.6 scfm/ft | | Difficult installation<br>High velocities<br>Turbulence | $2,100,000 |

Note: Number in parenthesis indicates oxygen adsorbed into water (tons/day)

Table 6: Summary Table: Temperature Control Structures and Dissolved Oxygen Enhancement Options

| Temperature Control Structure and DO Enhancement Option | Maximum Oxygen Capacity (tons/day) | Limitations | Design Details | Advantages | Disadvantages | Budget Estimate |
|---|---|---|---|---|---|---|
| **New Deep Intake Channel (6a)** | | | | | | |
| A. Diffuser in new intake channel<br>Upstream of gate | 160<br>(145) | Cold water only<br>Area<br>O2 in withdrawal zone | 90% OTE<br>3 - 1500' lines<br>0.6 scfm/ft | | | $1,100,000 |
| B. Diffuser in new intake channel<br>Behind gate | 90<br>(75) | Cold water only<br>Area | 85% OTE<br>3 - 800' lines<br>0.6 scfm/ft | | Distribution on slope | $ 700,000 |
| **New Gated Intake Tower (8a, 10, 10a, 12)** | | | | | | |
| A. Diffuser upstream of tower<br>Diffusers in inlet channel, elev. 1800 | 90<br>(80) | Cold water only<br>Area<br>O2 in withdrawal zone | 90% OTE<br>3 - 800' lines<br>0.6 scfm/ft | | | $ 700,000 |
| B. Diffuser in tower | 600<br>(360-540) | Area<br>O2 in withdrawal zone | 60-90% OTE<br>5,000 diffusers<br>2 scfm ea | Enhance all flows<br>Construct in dry? | Low OTE at high flows<br>Overshoot withdrawal | $3,300,000 |
| C. Diffuser in tunnel | 360<br>(325) | Cold water only | 90% OTE<br>100 - 100' lines<br>0.6 scfm/ft | Enhance all flows | | $2,100,000 |

Note: Number in parenthesis indicates oxygen adsorbed into water (tons/day)

Table 6: Summary Table: Temperature Control Structures and Dissolved Oxygen Enhancement Options (Continued)

| Reservoir Diffuser DO Enhancement Options | Maximum Oxygen Capacity (tons/day) | Limitations | Design Details | Advantages | Disadvantages | Budget Estimate |
|---|---|---|---|---|---|---|
| **To Provide 4 mg/L Uptake** | | | | | | |
| Diffuser in deepest reservoir channel 2 miles Upstream of dam | 180 (161) | 15,000 cfs daily flow | 95% OTE<br>2 – 2,500' lines<br>0.6 scfm/ft | Smaller supply capacity<br>Reduce anoxic products<br>Simpler controls | Oxygen demands | $800,000 |
| **To Provide 8 mg/L Uptake** | | | | | | |
| Diffuser in deepest reservoir channel 2 miles Upstream of dam | 360 (322) | 15,000 cfs daily flow | 95% OTE<br>2 – 5,500' lines<br>0.6 scfm/ft | Smaller supply capacity<br>Reduce anoxic products<br>Simpler controls | Oxygen demands | $1,200,000 |
| **To Maintain 2 mg/L Hypolimnion** | | | | | | |
| Diffusers spread over 20 miles | 80 (72) | Distribute oxygen over entire hypolimnion | 90% OTE<br>3 – 6,000 lines | Smaller supply capacity<br>Eliminate anoxic products | Oxygen demands in hypolimnion | $900,000 |
| **To Maintain 4 mg/L Hypolimnion** | | | | | | |
| Diffusers spread over 20 miles | 120 (108) | Distribute oxygen over entire hypolimnion | 90% OTE<br>4 – 6,000 lines | Smaller supply capacity<br>Eliminate anoxic products | Oxygen demands in hypolimnion | $1,200,000 |

Table 7: Summary Table: Reservoir Diffuser

Appendix D. Idaho Power Company Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River, August, 2004

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IDAHO POWER
An IDACORP Company

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

CHRIS RANDOLPH
Manager
Environmental Affairs

208-388-2922
208-388-6902 FAX
crandolph@idahopower.com

To: Larry Koenig, DEQ- Water Quality & Remediation Division

Re: Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River

Dear Mr. Koenig,

Enclosed is a Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River. By the submission of this petition, the Idaho Power Company seeks to initiate the necessary processes to establish site-specific criteria (SSC) for temperature and dissolved oxygen for the Snake River at and below the Company's Hells Canyon Complex (HCC). The HCC consists of the Brownlee, Oxbow and Hells Canyon hydroelectric projects, located between river mile (RM) 343.0 to RM 247.0 on the Snake River. The Company operates three hydroelectric projects in the HCC pursuant to Federal Energy Regulatory Commission (FERC) license, Project # 1971, that expires in 2005 and filed an application with the FERC to re-license the HCC in July 2003. In conjunction with the licensing process, the Company will apply for Section 401 water-quality certification from Idaho and Oregon. In preparation for Section 401 certification, the Company has undertaken the development of the technical documentation necessary for the Idaho Department of Environmental Quality (IDEQ) to consider the initiation of rulemaking to establish the two SSC described in the attached petition. Because the Snake River is boundary water between Idaho and Oregon, the Company anticipates that the Oregon Department of Environmental Quality (ODEQ) will necessarily have to participate with IDEQ in a coordinated process to address the issues raised by the petition. If necessary, the Company will initiate complimentary rulemaking procedures with ODEQ to facilitate this coordination.

After you have the opportunity to review the enclosed petition, we would appreciate having the opportunity to meet and discuss the basis for the petition and what the necessary next steps may be in the process.

cc: D. Nichols/ODEQ

Sincerely,

Chris Randolph

Chris Randolph

# Petition to Initiate a Process for Site Specific Criteria for Hells Canyon Snake River

## I. INTRODUCTION

Idaho Power Company (IPC) submits this petition to initiate the process to establish site-specific criteria (SSC) for temperature and dissolved oxygen for the Snake River at and below the Hells Canyon Complex (HCC). The HCC consists of the Brownlee, Oxbow and Hells Canyon hydroelectric projects, located between river mile (RM) 343.0 to RM 247.0 on the Snake River. The Snake River is boundary water between Oregon and Idaho. [1] IPC operates the three hydroelectric projects in the HCC pursuant to Federal Energy Regulatory Commission (FERC) license, Project # 1971, that expires in 2005. IPC filed an application with the FERC to re-license the HCC in July 2003. In conjunction with the licensing process, IPC will apply for Section 401 water-quality certification from Idaho and Oregon. In preparation for Section 401 certification, IPC has undertaken the development of the technical documentation necessary for the Idaho Department of Environmental Quality (IDEQ) to initiate rulemaking to establish the two SSC described in this document. Because the Snake River is a boundary water, IPC anticipates that the Oregon Department of Environmental Quality (ODEQ) will participate with IDEQ in a coordinated process to address the issues raised by this petition. As necessary, IPC will initiate complimentary rulemaking procedures with ODEQ to facilitate this coordination.

In July 2003, Oregon and Idaho issued the Snake River-Hells Canyon TMDLs (SR-HC-TMDLs) that cover the mainstem Snake River from RM 409 near the town of Adrian, Oregon to the inflow of the Salmon River at RM 188.2, this river reach includes the HCC. IPC received load allocations through the SR-HC-TMDLs for temperature, DO and TDG. The U.S. Environmental Protection Agency (EPA) approved the bacteria, pH, pesticides, and TDG TMDLs in March 2004. EPA has not approved the remaining TMDLs. [2] Issuance of a SSC for temperature may affect IPC's temperature load allocation in the pending TMDLs.

### A. SSC Process

IDEQ may develop new or modified criteria through site-specific analysis, which will effectively protect designated and existing beneficial uses. IDAPA 58.01.02-276. Likewise, Oregon regulations provide that ODEQ may establish by separate rulemaking, alternative SSC for all or a portion of a water body that fully protects the designated use. OAR 340-041-0028 (13). EPA must approve any final SSC implemented by the states. 40 CFR 131.20(c). While Idaho, Oregon, and EPA regulations provide the authority to promulgate SSC, they do not fully prescribe the procedure. As such, IPC proposes the following process to establish SSC and modify IPC's temperature load allocation.

- IPC presents its current understanding of data supporting the SSC.
- IDEQ, in coordination with ODEQ and IPC, develops a schedule for the process.

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[1] This Petition, at times, refers to the Hells Canyon Reach. This is intended to reference the Snake River from Hells Canyon Dam to the OR/WA border.

[2] Although EPA has not yet approved the TMDLs, IPC has filed a petition for judicial review of those portions of the TMDLs that impose a temperature load allocation on the HCC. That petition is pending in Baker County, Oregon.

- A Technical Advisory Group (TAG) of agencies is established to assess available data and identify additional data needs. IPC proposes that the TAG include representatives from the IDEQ, ODEQ, National Oceanic and Atmospheric Association (NOAA), U.S. Fish and Wildlife Service (USFWS) and IPC.

- IPC submits a draft final petition for SSC rulemaking to the TAG for comments.

- IPC submits a final petition for SSC rulemaking to IDEQ.

- IDEQ initiates formal rulemaking.

- Within 30 days of completion of final rules, IDEQ submits rules to EPA for approval.

- Upon EPA approval, IDEQ revises IPC's temperature load allocation in the SR-HC-TMDLs.

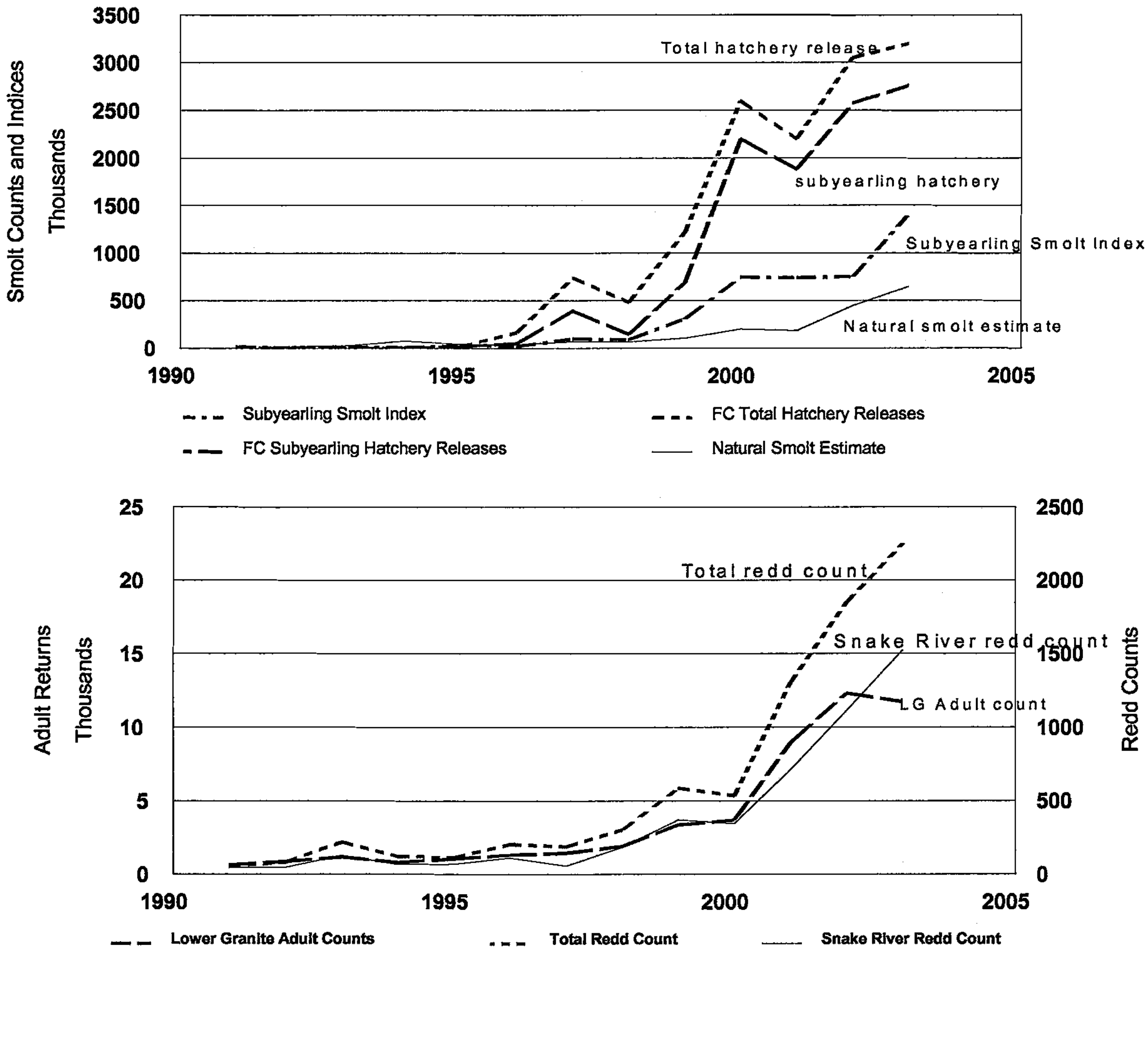
This initial petition begins the process and while it includes all relevant data available to IPC with regard to the proposed SSC, IPC recognizes that IDEQ (or ODEQ) may require further data and material to support the requested SSC. IPC proposes in this document initial SSC, which may be modified based on further studies or assessment by IPC in coordination with the TAG. As described above, IPC proposes to initiate the SSC process by filing this petition initially with IDEQ, anticipating that ODEQ may join in the Idaho SSC process or that IDEQ and ODEQ will otherwise establish coordinated processes in an effort to develop consistent standards for the Hells Canyon Reach of the Snake River. As necessary, IPC is prepared to file a complimentary petition with ODEQ to initiate a SSC in that state. IPC will submit initial technical supporting data for the proposed SSC to the TAG for review. As described in Section IV, IPC has commissioned a study by Battelle Northwest to supplement existing data that investigates effects on chinook salmon of different thermal and dissolved oxygen regimes including the proposed SSC. IPC is also prepared to commit such resources as are necessary to collect, analyze and submit such additional technical data as is required to facilitate a final decision by the agencies on this Petition.

### B. Snake River Fall Chinook Status

IPC proposes site-specific modifications to the Snake River fall chinook spawning criteria for temperature and dissolved oxygen. Since Snake River fall chinook salmon were listed as a threatened species in 1992 under the Endangered Species Act, their population has been steadily increasing. (Figure 1). Many factors led to their protected status, including the development of the lower Snake and Columbia rivers and the corresponding necessity for the species to migrate through eight federal hydroelectric projects below the HCC. However, as NOAA has observed, Snake River fall chinook returns have been significantly higher since 2000 than had been observed in the two decades leading up to 2000. (Declaration of D. Robert Lohn, Case No. CV01-00640-RE, June 12, 2003, attached as Exhibit A). While IPC has not changed project operations in a manner that would alter its effects on temperature or dissolved oxygen since the mid-1990's, Snake River fall chinook salmon returns and the number of redds constructed below Hells Canyon Dam have been increasing (Figure 1). The estimated adult returns of natural origin Snake River fall chinook salmon have increased more than 3.5-times greater than levels from outmigration in the early to mid-1990's (Williams et al. 2004). As explained in the data summary below, HCC's effects on temperature or dissolved oxygen below the Hells Canyon are not indicated as factors that contributed to the previous population decline.[3]

This increase in relative abundance of Snake River fall chinook, together with the data referenced herein, demonstrate that the proposed SSC for dissolved oxygen and temperature are fully supportive of fall chinook salmon spawning below the Hells Canyon Dam.

**Figure 1. (Top) Total & subyearling hatchery releases of fall chinook salmon above Lower Granite Dam, subyearling index count at Lower Granite Dam, and estimates of natural smolt production for the years 1991 to 2003. Wild estimates assumed a fecundity of 3500 eggs/female and a 10% egg-to-smolt survival multiplied by the number of redds constructed the previous fall. (Bottom). Total redd counts, Snake River redd counts and adult counts at Lower Granite Dam for the years 1991-2003.**




[3] While neither ODEQ or IDEQ have determined whether the designated uses downstream of Hells Canyon Dam, including fall chinook salmon spawning and rearing, are fully supported, IDEQ in its comments to the IPC's draft license application indicated that it has not identified any evidence that the fall chinook salmon population below Hells Canyon Dam is impaired by the temporal shift in water temperatures influenced by the HCC. (See the FLA, Consultation Appendix [T. Dombrowski, 2002, "Idaho Department of Environmental Quality Comments on Idaho Power Hells Canyon Complex Draft Application," FERC]).

## II. PROPOSED SALMONID SPAWNING TEMPERATURE CRITERIA

### A. Existing Idaho and Oregon Water Quality Standards[4]

Idaho's water quality standards are found in Idaho statute (IDAPA) 58.01.02. Oregon's water quality standards are found in Oregon Administrative Rules (OAR) 340-041.

#### 1. Snake River Fall Chinook Salmon Spawning Period

Oregon has a basin-specific period for salmon and steelhead spawning through fry emergence for the Snake River of October 23 through April 15 [OAR 340-041-0121 Table 121B, see Table 1 below]. Idaho's water quality standards do not identify a subbasin-specific salmonid spawning period for the Hells Canyon Reach. Instead, Idaho's criteria are generally applicable during the spawning and incubation period for a particular species inhabiting the waters. The SR-HC-TMDLs, authored by both IDEQ and ODEQ, establish that the salmonid spawning criteria in the Snake River apply from October 23 through April 15.

**Table 1. Idaho and Oregon salmonid spawning period criteria applicable to the Snake River below Hells Canyon Dam.**

| | Criteria |
|---|---|
| Idaho | During the spawning and incubation period for species inhabiting the waters |
| Oregon | October 23-April 15 |

#### 2. Snake River Fall Chinook Salmon Spawning Location

Oregon has identified a specific geographic location in which salmon and steelhead spawning through fry emergence must be protected for the Snake River (OAR 340-041-0121 Table 121B, see: Table 2). However, Oregon's standard is partially incorrect. Oregon identifies the Oregon/Washington border to be river mile 169. This is near the confluence of the Grande Ronde River. The correct river mile for the Oregon/Washington border is river mile 176.1. Idaho similarly has identified in IDAPA 58.01.02.130.01 waters of the Snake River that must support salmonid spawning. The SR-HC-TMDLs establish that salmonid spawning must be protected in the Snake River from Hells Canyon Dam to the confluence with the Salmon River.

**Table 2. Idaho and Oregon Snake River waters protected for salmonid spawning.**

| | Criteria |
|---|---|
| Idaho | Hells Canyon Dam to Salmon River (RM 247.6-188.2) |
| Oregon | Hells Canyon Dam to Oregon/Washington border (RM 247.6-176.1) |

[4] Because the Snake River is boundary water and IPC seeks the development of consistent standards by each state, IPC references the applicable water quality standards of both Idaho and Oregon in this petition.

### 3. Snake River Fall Chinook Salmon Spawning Temperature

Idaho and Oregon have salmonid spawning temperature criteria applicable to the Snake River (OAR 340-041-0028(4a); IDAPA 58.01.02.250.02.f. II, see: Table 3). In addition, Oregon has species specific and life stage specific criteria. Bull trout criteria do not apply to the Snake River in either Idaho or Oregon.

**Table 3. Idaho and Oregon salmonid spawning temperature criteria applicable to the Snake River below Hells Canyon Dam.**

| | Criteria |
|---|---|
| Idaho | Daily Maximum 13°C/Daily Average 9°C |
| Oregon | 7-D Average Maximum 13°C |

Each State also has natural conditions and air temperature exclusions, which generally provide that should IDEQ or ODEQ determine that the natural thermal potential temperatures exceed any biologically, based numeric criteria, that the natural thermal potential temperatures supersede the biologically based criteria. Exceedences of biologically based numeric temperature criteria that are attributable to maximum air temperatures that exceed the 90$^{th}$ percentile of the seven-day average maximum temperatures over specified periods of data are not violations of the standard. Oregon's OAR 340-041-0028(4)(d) further provides, "the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern." Similarly, Idaho's IDAPA 58.01.02.401.03.a.ii provides that wastewater discharges must maintain the "daily and seasonal temperature cycles characteristic of the water body."

Each state also allows anthropogenic temperature increases. Oregon allows a cumulative increase of no more than 0.3°C while Idaho allows no cumulative thermal discharges greater than 0.5°C. The SR-HC-TMDLs establish salmonid spawning temperature targets of less than or equal to 13°C daily maximum and 9°C daily average, or if the natural thermal potential is greater, an allowable cumulative increase of no more than 0.14°C.

## B. Proposed Snake River Fall Chinook Salmon Site-Specific Temperature Criteria

IPC proposes a Snake River fall chinook salmon spawning daily maximum temperature criterion not greater than 16.5°C on October 23 with a natural rate of declining water temperatures to a daily maximum temperature criterion not greater than 13.0°C through April 15. These site-specific criteria should be applied to the Hells Canyon Reach, the Snake River from Hells Canyon Dam (RM 247.6) to the Oregon/Washington border (RM 176.1).

## C. Existing Conditions

Hydrology, inflowing warm water from sources upstream of the HCC, reservoir operations and air temperatures all affect the magnitude and timing of seasonal warming and cooling in the Hells Canyon Reach. The SR-HC-TMDLs concluded that the hot, arid climate and non-quantifiable influences, such as upstream impoundments, upstream tributaries, water withdrawals, channel straightening, dikes, and removal of streamside vegetation, were the dominant causes of increased water temperatures in the Snake River.

The HCC impoundments are uniquely located within a relatively narrow and steep walled canyon. The HCC impoundments are not a heat source, but they do affect the flow of water, which correspondingly affects the timing of seasonal water temperatures exiting the Hells Canyon Dam. In the spring and summer, the HCC has an overall cooling effect because as upstream water temperatures increase, outflow from Hells Canyon Dam remains cooler than the inflow to Brownlee Reservoir. This trend reverses in the fall as upstream water temperatures decline and outflow from the HCC is warmer than inflow. Warm summer water flowing into and through the HCC results in an average of 14 days per year, as calculated in the SR-HC-TMDLs, when the 13°C maximum temperature is exceeded below Hells Canyon Dam. Because water temperatures are declining during the fall, the exceedence is greatest at the beginning of the designated spawning period on October 23 and then tapers to 0°C approximately two weeks later. A mean temperature change of 1.3°C is required to meet the 13°C target over the two-week period. It is this two-week period that is addressed by the proposed SSC.

## D. Rationale for Snake River Fall Chinook Salmon Temperature Site Specific Criteria

A single salmonid spawning temperature criterion is not equally appropriate in all waters, at all latitudes, in all years, or even for the entire spawning season in a single year. IPC seeks to establish a temperature decline that more closely approximates the temperature requirements of the Snake River fall chinook salmon. The current temperature criteria are overly simplistic and were developed based on studies of constant temperature regimes. Evaluations of the declining temperature regime in the Columbia River demonstrate that healthy fall chinook salmon populations initiate spawning at temperatures above 13°C. In an in-river environment, fall chinook salmon spawning typically begins at temperatures near 16°C under a declining thermal regime. A temperature decline of approximately 0.2°C per day during this fall spawning period is typical in (1) historical (pre-project measured at Oxbow), (2) present day inflowing waters to the HCC, and (3) present day waters below Hells Canyon Dam. IPC is currently conducting studies that examine the Snake River fall chinook salmon survival at various declining temperature regimes. Preliminary results suggest no significant differences in egg-to-fry survival between the existing standard and a declining thermal regime with initial temperatures at 15°C. Other studies suggest no significant difference in survival at initial temperatures of 16.1°C and less under a declining thermal regime.

With the increased fall chinook salmon returns over the last decade, there has been a corresponding increase in the number of redds constructed in the Hells Canyon Reach as well as a corresponding increase in abundance of naturally produced fall chinook salmon - all of which indicates that fall chinook salmon are spawning successfully (Figure 1) A site specific salmon-spawning criteria is warranted below the HCC because the data demonstrate that fall chinook salmon spawning below the HCC is fully supported under the current temperature regime even though those temperatures are initially higher than the current criteria.

### 1. Snake River Fall Seasonal Thermal Pattern

Existing temperature criteria do not accurately reflect the fall seasonal thermal pattern in the Snake River. Existing criteria literally interpreted, allow an instantaneous reduction in water temperature on a specific date when designated beneficial uses change from aquatic life to salmonid spawning. The applicable aquatic life criteria on October 22nd is a 20°C seven day average maximum for Oregon and a daily maximum of 22°C and a daily average of 19°C for Idaho. The next day, October 23rd, the criterion is a 13°C seven-day average maximum for Oregon and a daily maximum of 13°C and a daily average of 9°C for Idaho. Such an abrupt drop in temperature is not reflective of natural in-river thermal patterns and, even if achievable, would be potentially stressful to biological communities. IPC advocates site-specific temperature criteria that incorporate a realistic temperature decline.

The seasonal thermal pattern for the Snake River is marked by declining temperatures at the initiation of spawning. IPC has recorded Snake River fall chinook salmon spawning as early as October 9 (Groves 2001). Prior to construction of Brownlee Reservoir, the Snake River cooled in the fall after October 9 an average of 0.2°C per day (Figure 2). Consistent with Oregon's "natural seasonal thermal pattern" standard, current outflows from the HCC also cool an average of 0.2°C per day (Figure 3).

**Figure 2. Historical (pre-Brownlee) Snake River daily average temperature near present day Oxbow Dam site.**

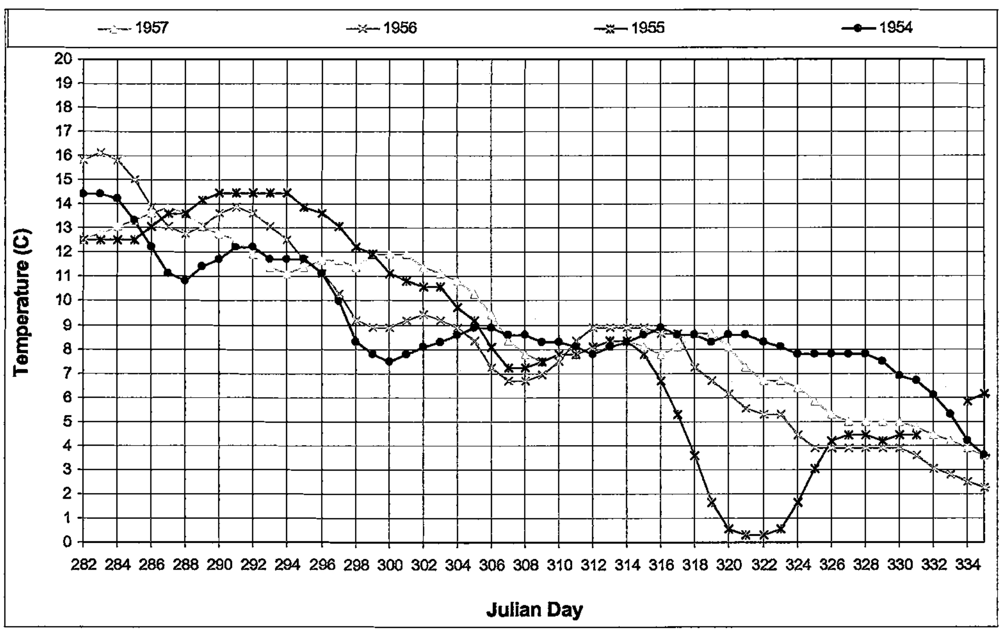
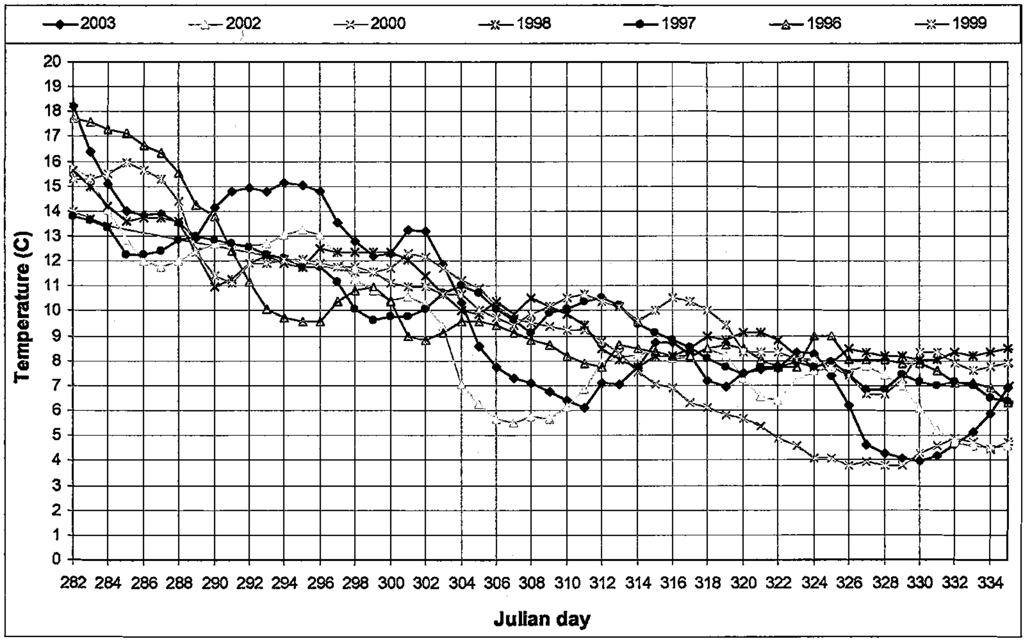


**Figure 3. Recent daily maximum Snake River temperature at the inflow to Brownlee Reservoir (RM 345.6).**




Water temperatures below Hells Canyon Dam have been recorded in the fall since 1991 at or near RM 229.8 (Figure 4). The highest maximum daily temperature measured on October 9 was 19.3°C. This is less than the most conservative aquatic life temperature standard of 20.0°C. Applying a natural rate of decline in water temperatures of 0.2°C to the highest maximum daily temperature measured, water temperatures would be 16.5°C on October 23[5]. Both published and site-specific data as presented in Sections 2 and 3 above demonstrate that a standard that applies the 0.2°C rate of decline would be protective of fall Chinook spawning. A maximum daily temperature of 16.4°C was measured in 1991, 1992, and 2001 (Figure 4). All other recorded temperatures were less than 16.0°C.

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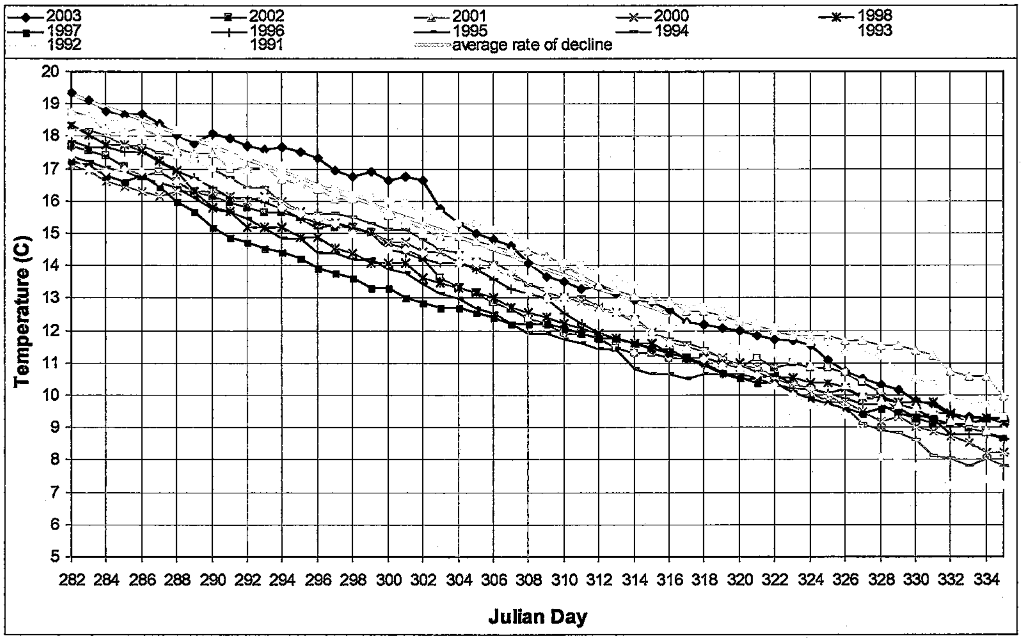
[5] A maximum daily temperature of 17.3°C was measured on October 23, 2003. This date, as well as other dates in 2003, are not considered relative to compliance with the standards as air temperature exclusion statutes OAR 340-041-0028(12)(c) and IDAPA 58.01.02.080.04 exclude water temperatures when air temperatures of a given day exceed the ninetieth percentile of a yearly series of maximum weekly maximum air temperatures (Appendix Table 1).

**Figure 4. Snake River daily maximum temperature below Hells Canyon Dam (RM 229.8) and temperature resulting from the calculated average 0.2°C/day rate of decline.**




Fall chinook salmon begin spawning in October when ambient air and water temperatures are naturally declining. Temperature at the initiation of fall chinook salmon spawning in the natural environment is typically near 16°C (Healey 1991). In a natural environment, exposure to higher temperatures is typically for short periods at the beginning of the spawning season as the thermal regime begins to decline as atmospheric and river waters cool. For example, Chandler et al. (2001) estimated that 2% or less of redds are constructed below Hells Canyon Dam early enough to experience temperatures greater than 16°C. Similar observation of fall chinook salmon spawning above 16°C have been reported for the Hanford Reach of the Columbia River (Groves and Chandler 2003; Dauble and Watson 1990) and for the lower Columbia River (van der Naald et al. 2000). Boles et al. (1985) determined that initial spawning temperatures under a declining natural regime could be as high as 15.5 °C. Several authors have estimated favorable ranges for Chinook salmon incubation. Bell (1986) as cited in Bjornn and Reiser (1991) estimated favorable incubation conditions to occur between 5 and 14.5 °C. Raleigh et al. (1986) recommends a range of between 6°C and 14 °C. McCullough et al. (2001) suggested daily maximums during the incubation period not exceed 13.5 to 14.5 °C. Seymour (1956) estimated the upper thermal limit (50% mortality at hatch) for fall chinook salmon to be 16 °C based on constant exposure through hatch.

Many of the studies evaluating thermal tolerances and survival of incubating eggs have been designed around constant temperature regimes during the incubation period (see Appendix Table 2). Although studies using constant thermal regimes are useful for hatchery environments where thermal conditions are generally constant, the application of these studies to natural environments has limited value other than to provide generalized ranges. Yet, these studies appear to provide the primary basis for existing standards. Laboratory studies that simulate thermal regimes experienced by chinook salmon during a natural incubation period result in higher survival and alevin size than a constant regime (Murray and Beacham 1986).

Studies that have examined the survival of chinook salmon under a declining thermal regime suggest that survival of eggs spawned at 16.1°C is comparable to those spawned at lower temperatures. Olson and Foster (1955) and Olson and Nakatani (1968) mimicked a declining thermal regime under several initial spawning temperatures, and followed survival through the fry stage and early fingerling stage. The initial temperatures of the thermal regimes of Olson and Foster (1955) were 11.7°C, 13.9°C, 15°C, 16.1°C, and 18.3°C. The egg lot that experienced initial temperatures of 18.3°C experienced high mortality. Olson and Nakatani (1968) spawned four females between October and December, at initial temperatures ranging from 2°C to 12°C above the base river temperature at the time of spawning. Only the egg lots that were spawned at initial temperatures greater than approximately 16°C experienced excessive mortality. Seymour (1956) reported similar findings; however survival was only monitored through the egg stage.

### 3. Site-specific research

Battelle Northwest (Battelle) and IPC are conducting temperature survival studies for Snake River fall chinook salmon following a declining thermal regime pattern. In fall 2003, Battelle and IPC initiated laboratory experiments to compare the survival and development through emergence of Snake River fall chinook salmon embryos exposed to temperatures ranging from 11°C to 19°C during the initial part of their incubation.

Based on the water temperature at the time when redds were first observed in the Hells Canyon Reach during a recent warm year (19.7°C on October 9, 2001), it was determined that 37 days post-fertilization (37 d PF) would be representative of the maximum number of days that fall chinook salmon eggs would potentially be exposed to temperatures greater than 13.0°C in the Hells Canyon Reach. During this 37-day period, eggs in each temperature group were stepped down in temperature increments that paralleled the natural rate of declining temperatures. The eggs that survived this early incubation period were all transferred, following suitable acclimation, to an incubation system that represented the average thermal regime of the Hells Canyon Reach. The embryos stayed in this system until emergence was complete.

The study was initiated by collecting individual adult Snake River fall chinook salmon from Lower Granite Dam in September, 2003. Four females were successfully held at Battelle's facilities until mature, and then spawned and fertilized. In addition, eggs from three Columbia River fall chinook salmon that returned to Priest Rapids salmon hatchery were combined into one lot, fertilized with milt from two males, and then re-allocated into three aliquots. Throughout the duration of the experiment, the eggs from the Snake River females and the three Columbia River aliquots were kept as seven separate families.

Immediately following fertilization, the eggs from each family were divided into six groups. One group was placed in a standard salmon hatchery incubator and incubated at a constant temperature of 12°C. The remainder of each family's eggs was divided into five groups (~200 eggs each), placed in an egg tube, and assigned to an initial incubation temperature of 11°C, 13°C, 15°C, 17°C, or 19°C[6]. After each egg tube was acclimated to its initial incubation temperature, it was held at this temperature for six days and then moved to a temperature that

[6] This initial study assessed survival at initial spawning temperature above and below 16°C. A study to be initiated in fall 2004 will include 16°C, 16.5°C, and 17°C, to better define the relationship of initial temperature and survival in this transition temperature range. This study is described in Section IV.

was 2°C cooler. Each egg tube was then systematically stepped down 2°C over 12 day intervals until they completed the 37-d early incubation period. The different incubation temperatures were achieved in a continuous water table with cold-water inputs systematically placed along the water table such that temperatures declined from 19 °C to 9°C along the length of the table. For those eggs that started in the two coldest incubation temperatures (11°C and 13°C), they reached the 9°C compartment of the water table before the completion of the 37-d incubation period. Therefore, these eggs were moved into supplemental cold-water (7°C and 5°C) incubation systems to complete the 37-d incubation period. After 37 days of incubation in the water table (and supplemental water baths), eggs were transferred to a Living Stream system mimicking the Hells Canyon Reach temperature regime.

The study is still in progress. However, preliminary survival comparisons through the eyed stage, hatch and emergence suggest no significant differences in survival for initial incubation temperatures of 15°C and less. Comparisons of growth (maximum alevin wet weights, maximum tissue weight, maximum fork length, and a development index) will be completed approximately 80 days after emergence, following published protocol for growth comparisons using preserved tissue. This is the only temperature study specific to Snake River fall chinook salmon and temperature during the incubation period, and should provide relevant information for this site-specific criteria evaluation.

### 4. Support of the Beneficial Use

Fall chinook salmon returns have continued to increase since the early 1990's. There are several potential reasons for the increased abundance. Increased hatchery supplementation is a primary factor, however, increasing returns of non-hatchery salmon and steelhead including Snake River spring chinook and Snake River steelhead over the last several years suggest improvements in migration survival and/or ocean conditions. With the increased fall chinook returns, there has been a corresponding increase in the number of redds constructed in the Hells Canyon Reach as well as a corresponding increase in abundance of naturally produced fall chinook salmon indicating that fall chinook salmon are spawning successfully (Figure 1). Recent studies demonstrate sufficient habitat in the Upper and Lower Hells Canyon Reach of the Snake River to support increasing numbers and that the use should continue to be supported. (Groves and Chandler 2001; Connor et. al. 2001).

Many factors influence the success of Snake River fall chinook salmon. Fall chinook salmon have variable rearing and migration patterns, natural variation in spawn timing and emergence, and delayed migrations through reservoir habitats. In addition, many unmarked hatchery fish planted in the system complicate estimates of natural origin smolt-to-adult returns (SARs). To separate out effects specific to temperature during the spawning period and assess the ability of a temperature standard for fall chinook salmon to be fully supported, we compared the existing standard and the above proposed standard relative to survival during incubation, production of smolts arriving at Lower Granite Dam, and the SARs that would be required for replacement to sustain the population.

We assumed reasonable values for fecundity (3500 eggs/female-Lyons Ferry Hatchery – Milks et al. 2003), egg-to-smolt survival (15%; Chandler and Chapman 2001), and survival of migrating smolts to Lower Granite Dam (65%; Chandler and Chapman 2001). We then estimated the SAR that would be required to return enough adults sufficient to sustain a stable number of redds. We used an adult-to-redd ratio observed for fall chinook salmon upstream of

Lower Granite Dam (3.5 adults/redd; IPC, unpublished information), which would account for any pre-spawn mortality.

We assumed that the salmonid spawning temperature standard would influence only incubation (egg-to-fry) survival (this assumption will be discussed in more detail later). We examined the preliminary results of the Battelle study discussed above and also the results of the Olson and Foster (1955) and Olson and Nakatani (1968) studies as a basis for choosing an egg-to fry survival in our comparison. Olson and Foster found no difference in egg-to-fry survival for fall Chinook salmon spawned at initial temperatures between 13°C and 16.1°C. Egg-to-fry survival was 89.6% for egg lots at initial temperatures of 16.1°C, and 48.3% at initial temperatures of 18.3°C. Egg-to-fry survival in the Olson and Nakatani study for initial temperatures of approximately 16°C ranged from 72% to 90%, with an average of 83.3%. The preliminary egg-to-fry survival results of the Battelle study for Snake River fall chinook salmon at initial spawning temperature of 15°C and less averaged 64% (ranged from 54% to 73%), and did not statistically differ from each other. At initial temperatures of 17°C, survival of egg-to-fry was significantly less at 13%. In the same study, egg lots from a pooled group of fall Chinook salmon from Priest Rapids hatchery near the Hanford Reach exposed to initial temperatures of 15°C and less experienced an average survival of 74%, and did not statistically differ. Survival at initial temperature of 17°C for these eggs was 19%.

For purposes of our comparison, we used 65% to represent survival from egg to fry for all redds constructed at 16.1°C and less. To be further conservative in this analysis, we also assumed the 13% survival rate measured in the Battelle study for Snake River fall chinook salmon applies to all fish initially spawned above 16.1°C. This allowed us to estimate fry-to-smolt survival, using our assumption of 15% egg-to-smolt survival (Egg-to-Fry Survival x Fry-to-Smolt Survival = Egg-to-Smolt Survival). While there is natural variation among some of these assumptions, this method allowed a relative comparison to the influence of temperature and egg-to-fry survival, while holding other variables at a constant.

We focused our analysis on the area between Hells Canyon Dam and RM 176.1, the section of the Snake River included in existing and proposed criteria. Redds constructed below the Salmon River and in other production areas have always been below 16.1°C (IPC unpublished data) and are therefore unaffected by survival during incubation relative to temperature based on the above premise. The proposed and existing criteria for salmonid spawning have a start date of October 23. Although spawning has been observed earlier (as discussed above), the basis for this comparison assumes spawning is initiated on October 23 at 16.5°C. Actual observations of fall chinook salmon spawning between 1991 and 2003 (excluding 1999 because of lack of temperature data) show that only 2 of those 12 years had fall chinook salmon redds constructed above 16.1 °C. An average of the number of redds constructed above 16.1°C over the 12 years period is 2%. Thus on average, 2% of the redds above RM 176.1 may potentially experience a lesser survival because of temperature.

Based on the period of record, approximately 36% of all redds constructed above Lower Granite Dam have been constructed above the Salmon River. NOAA Fisheries has made a preliminary proposed recovery goal of 2,500 adults upstream of Lower Granite Dam which equates to a redd capacity of 1,250 assuming an equal sex ratio for spawners (NMFS 1995 cited in Connor et al. 2001). With the observed percentage of redds upstream of the Salmon River, this would equate to 450 redds upstream of the Salmon River. The 800 remaining redds would be constructed at temperatures below 16.1°C and presumably would have egg-to-fry survival unaffected by temperature for purposes of this comparison.

If we were to assume that 2% of the 450 redds (9 redds) may be affected by temperatures greater than 16.1°C, using the above assumptions, smolt production to Lower Granite Dam would be reduced by 1.6% relative to the existing standard (Table 4). This equates to a required SARs of 1.05% to sustain that redd production, a 0.02% increase relative to that required by the existing standard (1.03%) (Table 4). If all potential 1,250 redds above Lower Granite Dam were included in the analysis, there would be a 0.01% difference between SARs required to sustain production (Table 4).

**Table 4. Comparison of smolt production and required smolt-to-adult returns (SARs) between existing temperature criteria and proposed temperature criteria to sustain 450 redds upstream of the Salmon River and 1,250 redds above Lower Granite Dam. Assumptions on fecundity, egg-to-fry survival, fry-to-smolt survival, and migration survival to Lower Granite Dam are listed. Required SARs assume an adult to redd ratio of 3.5:1.**

| | Above Salmon River | | | Total production area | | |
|---|---|---|---|---|---|---|
| | No loss | 2% loss | 5% loss | No loss | 2% loss | 5% loss |
| Total Redds | 450 | 450 | 450 | 1,250 | 1,250 | 1,250 |
| **Temperature < 16.1 C** | | | | | | |
| Redds affected | 450 | 441 | 427 | 1,250 | 1,241 | 1,227 |
| Fecundity | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 |
| Egg-to-Fry Survival | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| Fry-to-Smolt Survival | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 |
| Smolt Production | 235,462 | 230,753 | 223,689 | 654,062 | 649,353 | 642,289 |
| Survival to L. Granite | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| Smolt Production to L. Granite | 153,051 | 149,990 | 145,398 | 425,141 | 422,080 | 417,488 |
| **Temperature > 16.1 C** | | | | | | |
| Redds affected | | 9 | 23 | | 9 | 23 |
| Fecundity | | 3,500 | 3,500 | | 3,500 | 3,500 |
| Egg-to-Fry Survival | | 0.13 | 0.13 | | 0.13 | 0.13 |
| Fry-to-Smolt Survival | | 0.23 | 0.23 | | 0.23 | 0.23 |
| Smolt Production | | 942 | 2,355 | | 942 | 2,355 |
| Survival to L. Granite | | 0.65 | 0.65 | | 0.65 | 0.65 |
| Smolt Production to L. Granite | | 612 | 1,531 | | 612 | 1,531 |
| **Total** | | | | | | |
| Total Smolt Production at L. Granite | 153,051 | 150,602 | 146,929 | 425,141 | 422,692 | 419,019 |
| Required SARs to sustain total redds | 1.03% | 1.05% | 1.07% | 1.03% | 1.04% | 1.04% |

If the proposed temperature criterion of 16.5°C on October 23, under a natural declining temperature rate of 0.2 °C per day, would always be met exactly, there would be two days of temperatures greater than 16.1°C (October 23 and 24). Based on the average (1991-2003) number of redds constructed during that 2-d period (regardless of temperature), an average of 5% of redds upstream of RM 176.1 would be constructed during this time frame. Assuming 5% of 450 redds (23 redds) would be affected by temperatures greater than 16.1°C, using the above assumptions, we estimated that smolt production to Lower Granite Dam would be reduced by 4% relative to the existing standard (Table 4). This equates to a required SARs of 1.07% to sustain that redd production, a 0.04% increase relative to that required by the existing standard (1.03%; Table 4). If all potential 1,250 redds above Lower Granite Dam were included in the analysis there would be a 0.01% increase in SARs required to sustain production (47).

These differences in SARs are negligible relative to variation of other factors that influence SAR. Thus, the influence of the existing thermal regime below Hells Canyon Dam relative to the ability of the beneficial use to be supported is negligible. Based on observations of hatchery fall chinook salmon, SARs can fluctuate widely among years ranging from less than 0.5% to levels above 2% (Chandler and Chapman 2001; Williams et al. 2004). Factors that can significantly influence SARs include in-river migration conditions, ocean conditions and levels of adult harvest.

One assumption in our analysis was that temperature during spawning only influenced egg-to-fry survival. However, temperature directly influences emergence timing, which can have indirect effects on fry-to-smolt survival as well as SARs. There is evidence that earlier emerging fry in the Snake River have higher survival migrating to Lower Granite Dam than those that emerge later (Connor et al. 2003). Earlier emerging fish have a growth advantage because of a prolonging of the time period of suitable rearing conditions (Connor and Burge 2003). In some instances, later migrating smolts will holdover in the slack water environments of the lower Snake River and outmigrate late or as yearlings the following spring. As a group, overall survival is suspected to be low, even though the survivors may have higher SARs than their earlier migrating counterparts (Williams et al. 2004). Based on the above premise relative to survival, early spawning individuals will be the earliest emergers. In addition, those spawned in warmer temperatures will emerge earlier than they would under the existing standard. As such, the small differences estimated in SARs in this comparison may be offset by a survival advantage in early outmigration and a greater period to obtain sufficient size before temperatures in the lower Snake River become too warm.

## III. PROPOSED DISSOLVED OXYGEN SITE SPECIFIC CRITERION

### A. Existing Idaho and Oregon Water Quality Standards

Similar to temperature, Idaho and Oregon have salmonid spawning dissolved oxygen criteria applicable to the Snake River (Table 5). The SR-HC-TMDLs concluded that the salmonid rearing/cold water dissolved oxygen criteria apply below the HCC between October 23rd and April 15th.

**Table 5. Idaho and Oregon salmonid spawning dissolved oxygen criteria applicable to the Snake River below Hells Canyon Dam.**

| | Criteria |
|---|---|
| Idaho | Daily minimum intergravel 5 mg/L<br>7-D average mean intergravel 6 mg/L<br>Daily minimum water column 6 mg/L or 90% saturation |
| Oregon | Daily minimum intergravel 8 mg/L<br>Daily minimum water column 11 mg/L, 9 mg/L if intergravel is 8 mg/L, or 95% saturation |

The SR-HC-TMDLs established a salmonid spawning water column dissolved oxygen target of 11 mg/L minimum or 95% saturation where barometric pressure, altitude, and temperature preclude attainment of 11 mg/L and an intergravel dissolved oxygen target of 8 mg/L. If sufficient data exists such as continuous monitoring data, then intergravel targets of 6.0 mg/L (daily minimum), 6.5 mg/L (7-day mean minimum) and 8.0 mg/L (30-day mean minimum) can be used. The SR-HC-TMDLs established a dissolved oxygen load allocation for IPC only for Brownlee Reservoir.

### B. Proposed Snake River Fall Chinook Salmon Dissolved Oxygen Site-Specific Criteria

IPC proposes Snake River fall chinook salmon spawning criteria of a daily minimum water column dissolved oxygen concentration not less than 6.0 mg/L and an intergravel dissolved oxygen concentration not less than 4.0 mg/L from October 23 through November 7; a daily minimum water column concentration not less than 8.0 mg/L and an intergravel concentration not less than 6.0 mg/L from November 8 through November 30: and a daily minimum water column concentration not less than 10.0 mg/L and an intergravel concentration not less than 8.0 mg/L from December 1 through April 15.

### C. Existing Conditions

Upstream water quality conditions influence water quality within and below the HCC including oxygen demand and dissolved oxygen concentrations. (Harrison et al. 1999, IDEQ and ODEQ 2001). Dissolved oxygen concentrations are lowered by several processes including high nutrient, organic or algal loading. Although water temperatures can somewhat control dissolved oxygen concentrations, reduced dissolved oxygen levels within the HCC are in part attributable to in-reservoir processing of inflows that carry municipal, industrial and agricultural wastes.

Intergravel dissolved oxygen concentrations are critical to support salmonid spawning. While water column dissolved oxygen is often relied upon as an indicator of suitable salmonid spawning habitat, it is concentrations of intergravel dissolved oxygen that directly affect egg survival in salmonid redds. (Alderice et al. 1958; Coble 1961; Maret et al. 1993). Generally dissolved oxygen concentrations in the HCC decrease throughout the summer and early fall and are higher throughout the rest of the year. Intergravel dissolved oxygen concentrations below the HCC are currently below criteria at the initiation of the spawning season and increase as the embryos develop.

### D. Rationale for Snake River Fall Chinook Salmon Dissolved Oxygen Site Specific Criteria

The dissolved oxygen salmonid spawning criteria apply a uniform concentration throughout the spawning period. As discussed below, salmon embryos have a lower oxygen requirement in the early stages of development than in the later stages. A uniform criterion is not appropriate throughout the entire spawning season. IPC seeks to establish site-specific criteria that correspond to the developmental needs of fall chinook salmon embryos.

#### 1. Supporting Published Data

Developing embryos have a variable requirement for dissolved oxygen (Alderdice et al. 1958, Silver et al. 1963, Shumway et al. 1964, Garside 1966, Davis 1975). Dissolved oxygen requirements relate to intergravel water velocity and the embryo's development stage. In summary, these authors report that oxygen requirements are lowest in early stages of development (survival is not significantly affected at levels as low as 2.0 mg/L). However, as development progresses, eggs and larvae demand more oxygen. For example, for chum salmon (*O. keta*), developing eggs at early stages required 1.0 mg/L of oxygen, while those about to hatch required 7.0 mg/L (Alderdice et al. 1958). The most critical period (requiring higher dissolved oxygen levels) occurs after hatching. Reduced oxygen levels in the mature egg and post hatch larvae can retard growth, reduce yolk-sac absorption, and cause developmental deformities and mortality (Davis 1975). For fall chinook salmon, hatching occurs generally around an accumulation of 500-Centigrade thermal units (based on average daily temperature).

Based on review of literature, Davis (1975) distinguished among three levels of salmonid incubation development: early eggs, mature eggs and pre-hatch larvae, and hatching eggs and larvae salmonids. Each of the stages of development has a progressively greater requirement for oxygen as development advances. Further, Davis defined three levels of protection (A-C; Table 6). Level A defines the maximum protection. For early eggs, a minimum intergravel dissolved oxygen concentration of 1.61 mg/L is required for maximum protection. For mature eggs and prehatch salmonids, a minimum dissolved oxygen concentration of 6.94 mg/L is required. Lastly, for hatching eggs and larval salmonids a minimum dissolved oxygen concentration of 9.74 mg/L is required.

**Table 6. Dissolved oxygen levels presented by Davis (1975) for protection of incubating salmonids. Level A represents more or less ideal conditions, it assures a high degree of safety; Level B represents a level where the average member of a species in a community starts to exhibit symptoms of oxygen distress; and Level C represents a level where a large portion of the fish population may be affected by low oxygen.**

| Salmonid incubation stage | Protection Level | DO level (mg/L) |
|---|---|---|
| Early eggs | A | 1.61 |
| | B | 1.14 |
| | C | 0.67 |
| Mature eggs/ prehatch | A | 6.94 |
| | B | 5.93 |
| | C | 4.92 |
| Hatching eggs and larval | A | 9.74 |
| | B | 8.09 |
| | C | 6.44 |

Davis's (1975) Level A intergravel dissolved oxygen concentrations are more protective than existing standards. Existing numeric criteria are reflective of Level B protection as defined by Davis (1975). IPC's proposed criteria are based on the varying needs of dissolved oxygen by critical developmental life stages and Level B protection. Therefore, proposed criteria provide the same level of protection as the most conservative existing standard. The proposed dissolved oxygen criterion of 4 mg/L in the intergravel environment through November 7 is overly protective of the early egg stage as stated by Davis (1975). Davis did not distinguish the stage of development between early and mature eggs.[7] IPC has identified November 7 in the proposed criteria based on the approximate date that under the proposed temperature criteria 250 centigrade thermal units would be achieved (using daily maximum temperatures), which is a half-way point to hatching at 500 centigrade thermal units. The eyed-stage of the egg is also reached at 250 centigrade thermal units, which is a critical development phase in a developing embryo. The November 30 transition to 8 mg/L in the gravel corresponds to late maturing eggs and hatching, a developmental period that requires high availability of oxygen, and a time frame that would protect hatching of the earliest spawned eggs. This level of protection is the same as the most conservative existing criterion of not less than 8 mg/L as a spatial median intergravel dissolved oxygen concentration.

[7] Davis is neither specific to fall chinook salmon nor the Hells Canyon Reach of the Snake River. IPC's review did not find any studies of variable or increasing DO levels under a naturally declining thermal regime such as that experienced in the Hells Canyon Reach.

### 2. Site Specific Research

During the 2003-2004 fall chinook spawning and incubation period, IPC constructed artificial redds[8] in known fall chinook spawning areas below Hells Canyon Dam. A PVC intergravel sampler was buried at egg pocket depth (~ 20 cm) with vinyl tubing protruding out of the redds similar to a hyporheic monitoring system proposed by Maret et al. (1993). A peristaltic pump was used to pump pore water from the artificial redd environment and pore water was passed through a closed hydrolab system to measure DO, conductivity and pH. Water samples were collected at two week intervals from October 24th through the period of what would be emergence based on thermal unit accumulation estimated from thermographs in the artificial redd. Water column dissolved oxygen was measured concurrently with the dissolved oxygen in the artificial redds to compare with the redd environment.

The average dissolved oxygen concentration difference between the water column and the artificial redd environment during the period October 24 through December 16, a period roughly corresponding to the observed spawning period, was 1.37 mg/L (range 0.99 to 1.72 mg/L). This illustrates that the proposed water column dissolved oxygen criteria of 6 mg/L during the early egg developmental stage, 8 mg/L for mature eggs and pre-hatch larvae, and 10 mg/L for hatching eggs and larval salmonids is reflective of the most conservative differential of 2 mg/L between the redd environment and the water column.

## IV. ADDITIONAL SITE SPECIFIC RESEARCH

As described above, IPC contracted with Battelle Pacific Northwest National Labs in the fall of 2003 to study whether initial warm spawning temperatures affect survival of Snake River origin fall chinook salmon embryos through emergence. The results of that study (when synthesized with results of earlier studies) indicated that decreased survival likely occurred when initial incubation temperatures are at some level between 16.1 and 17.0°C. Battelle labs has been contracted to complete a new study during the fall 2004 through fall 2005 period that will further narrow and identify the upper initial incubation temperatures that are fully protective. The study proposal is attached as Exhibit B. This new study will also include variable levels of dissolved oxygen above and below the criteria being proposed by IPC. This study will help verify that the site-specific temperature and dissolved oxygen criteria proposed are protective of the beneficial uses.

IPC used fall Chinook salmon that originated in the Snake River in the 2003 study, and intended to use Snake River origin fall chinook salmon for the new study. However, IPC was not permitted to procure that stock by several management agencies. Based on projected returns to regional hatchery facilities, the capacity to handle fish at the Lower Granite Dam trapping facility, and an agreement between several management agencies (Idaho Fish and Game, Washington Department of Fish and Wildlife, Nez Perce Tribe, NOAA Fisheries, and several others), certain of the agencies refused to allow Snake River origin fall chinook salmon adults to

[8] While the exact morphology of natural redds is difficult to mimic, Burton et al. (1990) and King and Thurow (1991) found that intergravel Dissolved Oxygen (DO), temperatures, and fine sediments in artificially constructed redds did not significantly differ from conditions in nearby natural redds. Other work by Maret et al. (1993) concluded that it was possible to relate environmental factors to survival in artificial redds and recommended using artificial redds as monitoring tools. Soulsby et al. (2001) and Groves and Chandler (Accepted 2004) also used simulated redds to describe the hyporheic environment of a redd.

be trapped and used for any purpose other than hatchery propagation during the fall of 2004. While IPC would prefer to use Snake River origin fall chinook salmon for the study, the management agencies have advised that Umatilla origin fall chinook strays could be used as a surrogate, representative stock, and that data resulting from the Umatilla fall chinook stock would be representative of the Snake River origin fall Chinook salmon. The results from this study should be complete and ready for peer-review by early fall 2005.

## V. SIGNATURE

For the reasons stated above, IPC respectfully submits this petition to initiate the process to establish SSC for temperature as described in Section II.B. and dissolved oxygen as described in Section III.B.

**Idaho Power Company**

Date:

By: ______________________________

Name: ______________________________

Title:

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# Appendix Tables

## Appendix Table 1. Dates in 2003 where maximum daily air temperature exclusion applies.

Note: 7-day average maximum air temperatures are from Parma, Idaho. 90th percentile of historical 7-day average maximum air temperature are calculated using Parma air temperatures (1986 – 2003).

| Date | Julian Day | 7-day average maximum air temperature (°C) | 90th percentile of historical 7-day average maximum air temperature (°C) |
|---|---|---|---|
| 10/23/2003 | 296 | 25.0 | 21.1 |
| 10/24/2003 | 297 | 23.9 | 21.3 |
| 10/25/2003 | 298 | 22.9 | 21.7 |
| 10/26/2003 | 299 | 22.2 | 21.5 |
| 10/27/2003 | 300 | 21.9 | 20.8 |
| 10/28/2003 | 301 | 21.8 | 19.7 |
| 10/29/2003 | 302 | 20.8 | 19.1 |

**Appendix Table 2. Summary of temperature studies reviewed and the temperatures evaluated relative to chinook salmon embryo development. Studies that evaluated a constant thermal regime throughout the incubation subjected developing embryos to a constant uniform temperature, studies that evaluated a variable thermal regime subjected developing embryos to changing temperatures sometime during or throughout the incubation period depending on the objective of the individual study. Results summarized by study with individual footnotes below.**

| Author (Year) | (C)CONSTANT / (V)VARIABLE | Temperature studied (°C) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Murray and Beacham (1986) | C[1] | X | | | | X | | | | X | | | | | | | | |
| Velsen (1987) – cited in McCullough et al. 2001 | C[2] | | | | 7.2 | | 9.6 | | | | | | | | | | | |
| Heming (1982) | C[3] | | | X | | X | | X | | X | | | | | | | | |
| Heming et al. (1982) | C[4] | | | X | | X | | X | | X | | | | | | | | |
| Seymour (1956) | C[5] | 4.4 | | | 7.2 | | | X | | 12.8 | | 14.2 | 15.6 | 16.9 | | 18.3 | | |
| Jensen and Groot (1991) | C[6] | | | | | | | 10.2 | 11.7 | | | 14 | | 16.4 | | 18.3 | | |
| Healy (1979) – cited in Boles et al. 1998 and McCullough et al. 2001 | C[7] | | | | | | | | | | | | 15.6 | | | | | |
| | | | | | | | | | | | | | | | | | | |
| Rice 1960 – cited in McCullough et al. 2001 – through egg stage only | V[8] | | | | | | | | | | | | 15.6 | | | | | |
| Johnson and Brice (1953) | V[9] | | | | | | | | | | | | 15.6 | 18.3 | | | | |
| Healy (1979) – cited in Boles et al. 1988 and McCullough et al. 2001 | V[10] | | | | | | | | | 12.8 | | 14.2 | | | | | | |
| Seymour (1956) – through egg stage only | V[11] | | | | 7.2 | | | X | | 12.8 | | | 15.5 | | | 18.3 | | |
| Donaldson (1955) | V[12] | | | | | | | | | | | | | | 17.2 | 18.3 | 19.4 | |
| Olson and Nakatani (1968) | V[13] | | | | | | | | | | | 14.7 | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Olson and Foster (1955) | V[14] | | | | | | | | 11.6 | | 13.8 | | X | X | | 18.3 | | |
| | | | | | | | | | | | | | | | | | | |

Appendix Table 2 footnotes

[1] incubation at 10 °C and 12 °C result in higher incubation survival than 4 °C; temperature regimes that simulate those experienced by a species during a natural incubation tend to enhance survival and alevin size.
[2] best survival for constant thermal regimes between 7.2 °C and 9.6 °C
[3] constant temperatures of 6 °C, 8 °C, 10 °C had similar survival, slight reduction at 12 °C
[4] constant temperatures of 6 °C, 8 °C, 10 °C had similar survival, slight reduction at 12 °C
[5] Egg lots reared at constant 1.1 °C and 18.3 °C had 100% mortality; egg lots at 15.5 °C and 16.9 °C low survival to hatch, 100% mortality at yolk-sac; egg lots 13.8 °C and 12.7 °C, high hatch survival, low yolk-sac survival; egg lots at 10, 7.2, and 4.4 optimum constant incubation temperatures.
[6] tests with lots at 100% water exposure and lots at varying degrees of air exposure and differing constant temperatures regimes. 100% water exposures – similar mortality (~25%) through alevin development for 10.2 °C, 11.7 °C and 14 °C, 16.3 °C had some survival through hatch 100% mortality for yolk-sac, 18 °C and 20.2 °C had 100% egg mortality
[7] eggs held at constant 15.5 °C and 17.2°C suffered high mortality (80 and 88%); eggs exposed to declining thermal regime of the river had much lower mortality with initial temperatures beginning at 15.5 °C and final temps 7.2 °C
[8] temps declining from 15.6 °C to 8.3 °C resulted in satisfactory egg development (no survival rates); experiment only included egg stage
[9] test lots with temps starting at 15.5 °C and increasing to 18.8 C before dropping again suffered excessive mortality
[10] eggs held at constant 15.5 °C and 17.2°C suffered high mortality (80 and 88%); eggs exposed to declining thermal regime of the river had much lower mortality with initial temperatures beginning at 15.5 °C and final temps 7.2 °C
[11] 6 different egg lots with different initial temperatures– 4 different rivers –egg lots with initial temps of 15.5, 12.8, 10, 7.2 had comparable survival, egg lots with initial temps at 18.3 had markedly lower survival; experiment did not continue into the alevin stage
[12] exposed egg lots to brief periods of high initial temperatures of 17.2 °C, 18.3 °C, and 19.4 °C before transferring to lower temps - high mortality associated with these high initial temps.
[13] egg lots that were initiated at generally below 15.5 °C to 16 °C had similar survival rates. Egg lots above this temperature had markedly higher mortality rates. These authors tested 7 different thermal regimes following a declining temperature progression
[14] tested egg lots 5 different thermal regimes – initial starting temperatures were 11.6 °C, 13.8 °C, 15 °C, 16 °C, 18.3 °C. Eggs only in the 18.3 °C lot suffered significant mortality. Survival among the other groups did not differ.

# Exhibit A

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF OREGON

| | |
|---|---|
| NATIONAL WILDLIFE FEDERATION, *et al.*,<br>Plaintiffs,<br>v.<br>NATIONAL MARINE FISHERIES SERVICE,<br>Defendants. | Civ.No. CV01-00640-RE<br><br>**DECLARATION OF D. ROBERT LOHN** |

MAIL-61881

I, D. Robert Lohn, aver as follows:

1. I am the Regional Administrator of the Northwest Region of the National Marine Fisheries Service (NMFS or NOAA Fisheries), an agency within the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, a position I have held since October 2001. Prior to coming to NOAA I have, over the past decade, held various positions relevant to Columbia Basin salmon issues including, most recently, the position of Director of the Fish and Wildlife Division for the Northwest Power Planning Council. The NOAA Fisheries' Northwest Region is responsible for the administration of the Endangered Species Act (ESA) for anadromous Pacific salmonids (species of salmon and steelhead) originating within the states of Oregon, Washington and Idaho and for other marine species. These responsibilities include: recommending ESA listings and designating critical habitat for listed species to the NOAA Assistant Administrator for Fisheries; preparing recovery plans for listed species; conducting Section 7 consultations and issuing Section 10 permits for activities that may adversely affect or take listed species or modify critical habitat.

2. NOAA Fisheries issued the December 2000 Biological Opinion (BiOp) concerning the Federal Columbia River Power System (FCRPS) that is the subject of this lawsuit. The BiOp evaluated the effects of a proposal from the federal Action Agencies that operate and manage the dams and power generated in the Columbia River system (Bonneville Power Administration, Army Corps of Engineers and Bureau of Reclamation) on twelve listed anadromous fish stocks referred to for ESA listing as Evolutionary Significant Units (ESUs). Although all of these stocks were affected

to some extent, NMFS found that proposal was likely to jeopardize the continued existence of eight ESUs: Snake River Spring/Summer Chinook, Snake River Fall Chinook, Snake River Steelhead, Snake River Sockeye Salmon, Upper Columbia River Spring Chinook, Upper Columbia River Steelhead, Middle Columbia River Steelhead and Columbia River Chum Salmon. NMFS found that the remaining four ESUs[1], which occupy portions of the Columbia River and its tributaries entirely below the lower-most FCRPS project, Bonneville Dam, were not likely to be jeopardized by the FCRPS because the level of FCRPS effect on those stocks was minimal and overshadowed by other factors. NOAA subsequently designed its Reasonable and Prudent Alternative (RPA) for operation of the FCRPS to avoid jeopardy to the eight stocks jeopardized by the original proposal. Under the 2000 BiOp NOAA Fisheries has worked continuously with the Action Agencies to monitor the implementation of the RPA and its effects on the listed ESUs.

3. In the past NOAA Fisheries has generally listed only the naturally spawning fish within an ESU. NOAA Fisheries would list the hatchery fish within the ESU if and when a specific hatchery population was determined to be essential to the conservation of the species. In *Alsea Valley Alliance v. Evans*, 161 F.Supp.2d 1154 (D. Or. 2001) the court ruled that NOAA Fisheries must list all fish it determines to be within an ESU including both naturally spawned fish and hatchery fish. NOAA Fisheries has acceded to this ruling and is currently in the process of reviewing the status of the listed ESUs for consistency with this ruling. Similarly, NOAA Fisheries has also in the past omitted from listed steelhead ESUs resident rainbow or redband trout that are part of the same ESU, a practice that is also called into question by the *Alsea* ruling. NOAA Fisheries is currently reviewing its steelhead listing decisions to determine if changes are required on account of resident fish. For these and other purposes, NOAA Fisheries is currently engaged in a status review of all 12 of the ESUs affected by the FCRPS, along with others.

4. This declaration presents the best available scientific information on the following subjects concerning the eight ESUs of principal concern in the 2000 BiOp:

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[1] Upper Willamette River Chinook, Lower Columbia River Chinook, Upper Willamette Steelhead, and Lower Columbia River Steelhead.

- NMFS' evaluation of the current abundance of these stocks of Columbia Basin salmon and steelhead considered in the FCRPS 2000 BiOp;

- Extinction risks for these ESUs in the short term as evaluated in the FCRPS BiOp; and

- Identification of ongoing actions by NOAA Fisheries that are dependant upon the continuing effect of the 2000 FCRPS BiOp.

**Overview of the Current Abundance of Eight ESUs Addressed by the FCRPS 2000 Biological Opinion**

5. In seven of the eight ESUs addressed by the RPA, Middle Columbia River steelhead, Upper Columbia River spring-run chinook, Upper Columbia River steelhead, Snake River fall chinook, Snake River spring/summer chinook, Snake River steelhead and Columbia River chum ESUs, adult returns have been significantly higher since 2000 than had been observed in the two decades leading up to 2000. This new information increases our confidence about the adequacy of the measures in the 2000 BiOp to protect ESA listed salmon and steelhead. Graphic depictions of the run size information are attached as Exhibit A to this Declaration and are further discussed below.

6. The ESU information presented in this declaration was derived from a February, 2003, draft report NOAA issued entitled "Preliminary Conclusions Regarding the Updated Status of Listed ESUs of West Coast Salmon and Steelhead"[2], prepared by the West Coast Salmon Biological Review Team (BRT), a panel of scientists, for the purpose of reviewing the status of these and other ESUs in response to the *Alsea* ruling. We have provided this draft report to regional federal, state and tribal authorities with jurisdiction over salmon, for their technical review. The data utilized in generating the figures presented in Exhibit A incorporate corrections and updates provided by co-managers during this technical review, and represent the most recent compilation of salmon abundance

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[2] February 2003. The Introduction and Methods section of that report are attached to this Declaration as Exhibit __.

information available. The BRT's draft report is undergoing final editorial changes and has not yet been finalized.

7. Additionally, the abundance figures presented in Exhibit A were developed for this Declaration to provide an indication of relative ESU-level abundance at this time. There are several caveats associated with ESU-level abundance descriptions derived from the available population-level data. The ability to distinguish fish resulting from natural reproduction and hatchery production varies among the constituent populations within an ESU. Accordingly, the abundance information presented represents the total (hatchery plus natural fish) for an ESU. The sources of the abundance data vary among and within ESUs, spanning the full spectrum of estimation methods (e.g., direct counts of returning salmon at dams, spawner estimates from redd surveys, etc.). Abundance data is often not available for all populations in an ESU, and all sites are not regularly or consistently monitored. The totals presented, therefore, represent only a rough estimate of salmonid abundance at the ESU level. The full February 2003 draft Biological Review Team report, partially attached as Exhibit B, is a more complete and rigorous evaluation of ESU status by subpopulation. The complete draft report is available on the Internet at http://www.nwfsc.noaa.gov/cbd/trt/brt/brtrpt.html.

8. The ESU abundance information presented in this Declaration is not based on consideration of any future impacts, either harmful or beneficial. These conclusions are based entirely upon currently available empirical data relevant to the status of these ESUs.

9. *Columbia River Chum ESU*: In 2000, the total number of chum in the Columbia was around 1,400 fish, divided near equally into two populations. One of these populations is in the tailrace of Bonneville dam and is influenced by hydrosystem operation. The preliminary abundance estimate for 2002 is approximately 20,000 fish (Exhibit A, Figure 1). The encouraging increase in 2002 was evident at many locations.

10. *Middle Columbia River Steelhead ESU*: The abundance in this ESU has shown large increases since 1999 when it was listed. From 1989-99 the returns had never exceeded 20,000 fish, while the 2000-2002 returns all approached or exceeded 20,000, rising to a 22 year high of over 30,000 returns in 2002 (Exhibit A, Figure 2). The abundance in three major basins (Deschutes, John Day, Umatilla) is near or in excess of NMFS' interim recovery expectations.

11. *Upper Columbia River Spring-run Chinook ESU*: Many of the populations in this ESU have rebounded recently from critically low levels of just a few hundred fish in the mid 1990's, to over 1,500 fish in 2000, to nearly 15,000 fish in 2001 (Exhibit A, Figure 3). The abundance in one of the basins (Methow) is near NMFS' interim recovery expectations. The majority of the hatchery programs in this ESU are used for supplementation. These programs provide a safety-net in critically low years, and may ultimately play a role in helping to restore self-sustaining natural populations in this ESU. These safety net hatchery programs have undergone ESA Section 7 consultation and have received ESA Sec. 10 permits for production though 2007.

12. *Upper Columbia River Steelhead ESU*: The last 2-3 years have seen an encouraging increase in the number of naturally and hatchery produced fish in this ESU (Exhibit A, Figure 4). In 2000 the ESU abundance exceeded 7,500 fish, while in 2001 the abundance had increased to over 20,000 fish. Interpretation of the abundance trends for this ESU is confounded for many of its constituent populations where data distinguishing between spawners of natural and hatchery origin are unavailable. All the hatchery programs in this ESU are used for supplementation. These programs provide a safety-net in critically low years, and may ultimately play a role in helping to restore self-sustaining natural populations in this ESU. These safety net hatchery programs are completing ESA Section 7 consultation and issuance of 10-year ESA Sec. 10 permits for production is imminent.

13. *Snake River Fall Chinook ESU*: The abundance of spawners passing Lower Granite Dam in 2001 (> 8,500 fish) is the highest since counts began in 1975 (Exhibit A, Figure 5), and represents a 3 ½ fold increase over the abundance in 2000 (< 2,500 fish). This is particularly encouraging after the population hit a low of 335 fish in 1990 after which it has been increasing steadily.

14. *Snake River Spring/Summer Chinook ESU*: 2001 escapement for this ESU exceeded 9,800 fish (Exhibit A, Figure 6), representing a large increase over recent escapement levels (e.g., 2,700 spawners in 2000). This increase is particularly encouraging in the context of the record low returns observed in many of the ESU populations in the mid -1990s.

15. *Snake River Basin Steelhead ESU*: Sharp upturns in 2000 and 2001 in adult returns in this ESU (particularly in A-run populations) are encouraging (Exhibit A, Figure 7). Total returns in 2000 exceeded 115,000 fish, with more than a 2-fold increase in the 2001 returns. Although the naturally

produced A-Run fish exhibited increases in these years, the recent large increases in total ESU abundance were composed of approximately 85% hatchery-origin fish.

16. *Snake River Sockeye ESU*: The Snake River sockeye ESU (Exhibit A, Figure 8) remains at very low levels. Between 1991 and 1998, 16 naturally-produced adult sockeye returned to the weir at Redfish Lake, and all were incorporated into the captive broodstock program. Since 1999 all returning fish have originated in the captive broodstock program. This program utilizes three different rearing sites to minimize chances of catastrophic failure, and has produced several hundred thousand eggs and juveniles, as well has several hundred adults for release into the wild. A milestone was reached in 2000, when more than 250 adults from the program returned to Redfish Lake, Idaho, with subsequent captive program returns in 2001 and 2002 exceeding 20 fish/year. The Snake River sockeye captive broodstock program represents a short-term safety net, buffering the ESU against imminent extinction risk as recovery efforts are implemented.

**Extinction Risks for ESUs Jeopardized by FCRPS are Low for the Short-term**

17. The RPA in the 2000 BiOp was designed to avoid any likelihood of jeopardizing the continued existence of listed ESUs or destroying or adversely modifying their critical habitat. Avoiding jeopardy means avoiding any appreciable reduction in the likelihood of both the survival and recovery of the listed species, and necessarily focuses on long term improvements while avoiding short term catastrophes. After ten years of ESA consultations, the FCRPS operators have steadily improved the survival rate for salmon migrating through the projects as juveniles and adults, e.g. see Table 9.7-5 at page 9-197 of the 2000 BiOp, and has reduced the short term risks to a negligible level. While it is important to maintain the existing survival improvements, it is unlikely that additional changes in the short term operation of the FCRPS beyond those called for in the 2000 Biop would make a meaningful contribution to avoiding jeopardy. The objective of NOAA Fisheries' RPA in 2000 has been to define a long-term program that would allow the listed ESUs to recover. It is the long-term program for the FCRPS, to be reconsidered during the remand, that will be most meaningful for avoiding jeopardy and achieving recovery of the listed species.

18. As demonstrated above, the abundance of most of the ESUs addressed by the RPA has improved since the BiOp was issued in December, 2000. Even with the information available in 2000, NMFS concluded that no additional improvement was necessary for most of the relevant ESUs to have no greater than 5% risk of extinction in 24 years (Table A-2 of BiOp). The methodology for this analysis is explained in Appendix A to the BiOp. The analysis of extinction risk in the 2000 BiOp was made without considering any future actions and thus is not affected by this Court's ruling clarifying the future actions that can be considered during consultation. The extinction risk analysis simply calculates the percent change in the historic growth rate that would be needed for the ESU, or component population, to have an extinction risk of less than 5% in 24 years. The analysis does not consider what measures would likely provide any additional change that may be required to achieve the desired extinction risk. It is merely used to determine if any improvement is needed.

19. For six of the eight ESUs the risk of extinction was less than 5% in 24 years. The 24 year survival metric does not fully equate with avoiding jeopardy but it is relevant to the decision to leave the BiOp in effect during the remand because it indicates that in the short term, if conditions present in the past persist into the future, the risk of extinction for most listed ESUs is relatively low.

20. The two stocks that required additional change in growth rate to meet the survival criterion, Upper Columbia Spring-run Chinook and Upper Columbia Steelhead, are supported by well established conservation hatcheries to supplement natural runs. The 24-year survival analysis did not assume any future conservation actions to reach its conclusions, and thus did not assume that there would be continuing safety net hatchery support for these stocks. In fact, consideration of these hatcheries is consistent with this Court's recent ruling. The hatcheries that support the chinook ESU are authorized through 2007 because they have undergone Sec. 7 consultation and have received Sec. 10 permits. For the steelhead ESU, the hatchery safety net support was authorized through May 31, 2003, and proceedings for their reauthorization are in the final stages approaching approval. With nothing more than continuation of existing hatchery practices, the survival of these ESUs is not a concern in the short-term.

21. We believe the best available scientific information demonstrates that the RPA provides a cautious and conservative guide for managing the FCRPS during the remand ordered by the court.

Our confidence in this conclusion is further supported by the tributary and estuarine habitat measures that the FCRPS action agencies are already funding which are designed to provide short-term survival improvements in addition to those achieved in the hydropower corridor. These measures are detailed in the declarations of the FCRPS Action Agencies, submitted herein.

**NOAA Actions Dependent Upon 2000 FCRPS BiOp**

22. An integral part of the FCRPS operation that assures the highest survival rate for the Snake River listed stocks is the Juvenile Fish Transportation Program, a system of barges, supplemented on a limited basis by trucks, that collect and transport migrating juvenile salmonids from the Lower Granite Dam, Little Goose Dam and Lower Monumental Dam on the Lower Snake River and McNary Dam on the Columbia River for delivery to the river below Bonneville Dam, the lower-most FCRPS project. This program provides demonstrated survival benefits to juvenile salmon, although its role in recovery are the subject of ongoing research and scientific debate. In particular, the Transportation Program is the undisputed preferred method of moving listed juvenile salmon through the FCRPS projects when river conditions are detrimental due to low river flows and higher temperatures experienced in July and August each year and during drought years. The Transportation Program is an important measure to provide immediate survival enhancement especially during the pendency of a remand.

23. The collection of fish for the Transportation Program takes listed salmon that would be prohibited by Section 9 of the ESA. However, NMFS issued an ESA Section 10(a)(1)(A) permit to the Corps of Engineers, which authorizes take from programs that are designed to enhance the survival of listed species. NMFS' action in issuing that permit also required consultation pursuant to ESA Section 7(a)(2) to insure that issuance of the permit is not likely to jeopardize the listed salmon species. In the case of the permit issued to the Corps, the 2000 FCRPS BiOp also provides this required Section 7 analysis. Setting aside the BiOp would cloud the legal basis for NMFS' Section 10 permit and its authorization of take associated with that Transportation Program. Operators of that critical mitigation program would run the risk of liability under Section 9 of the ESA.

24. The 2000 FCRPS BiOp also provides Section 7(a)(2) analysis and take authorization for twenty five major salmon research projects that are currently underway to aid in the recovery of the listed ESUs. The projects are described in Appendix H of the 2000 BiOp. See Exhibit C. If the 2000 BiOp is set aside for one year, these research projects would be halted while alternative take authorization is sought. Much of this research depends upon continuity of sampling and detecting fish. A research project's ability to answer important questions for salmon conservation, described for each project in Exhibit C, would be seriously compromised if it is stopped prematurely. Work already undertaken for that research, including the salmon that have already been taken, would most likely be wasted.

I declare under penalty of perjury that the foregoing is true and correct. Executed on June 12, 2003, in Portland, Oregon.

D. Robert Lohn

***Exhibit A: Overview of the Current Abundance of Eight Evolutionarily Significant Units of Pacific Salmon and Steelhead Covered Under the FCRPS 2000 Biological Opinion***

## Columbia River Chum ESU

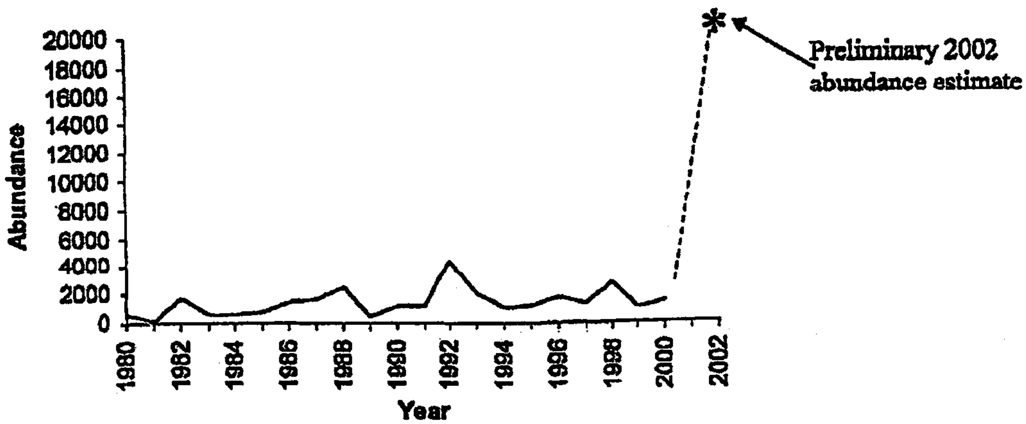


Figure 1. Estimated abundance of the Columbia River chum ESU. Abundance reflects naturally produced spawners only for 1980-2001. The Grays River chum hatchery program was initiated in 1998, with the first artificially produced returns in 2001 (note there is no estimate of 2001 abundance). ESU-level abundance estimated as the sum of the two populations for which spawner escapement data is available. This estimate may represent an underestimate as the quantity of spawning that occurs in the mainstem Columbia is not well estimated. The Columbia River chum ESU was listed as a threatened species under the ESA in 1999.

## Middle Columbia River Steelhead ESU

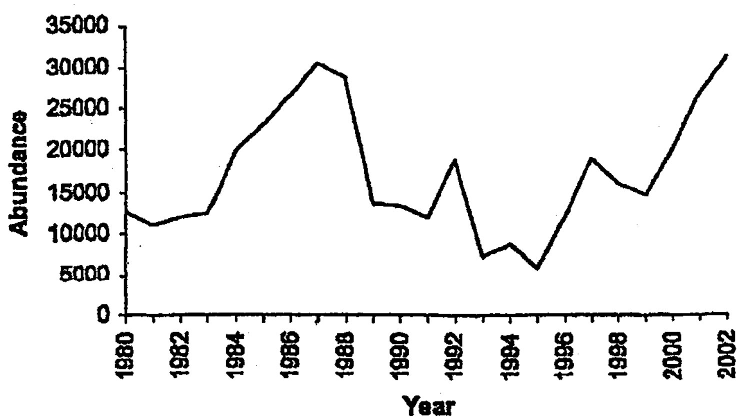


Figure 2. Estimated abundance of the Middle Columbia River steelhead ESU. Abundance shown includes both natural and hatchery produced spawners in a given year. ESU-level abundance estimated as the sum of populations for which spawner escapement data is available, and may represent an underestimate of total ESU abundance. The Middle Columbia River steelhead ESU was listed as a threatened species under the ESA in 1999.

Upper Columbia River spring-run Chinook ESU

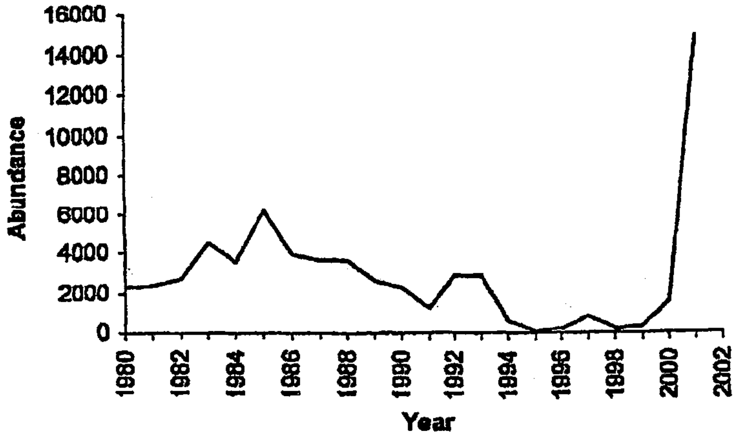


Figure 3. Estimated abundance of the Upper Columbia River spring-run chinook ESU. Abundance shown includes both natural and hatchery produced spawning adults in a given year. ESU-level abundance estimated as the sum of populations for which spawner escapement data is available (Methow, Entiat, and Wenatchee Rivers), and may represent an underestimate of total ESU abundance. The Upper Columbia River spring-run chinook ESU was listed as an endangered species under the ESA in 1999.

Upper Columbia River Steelhead ESU

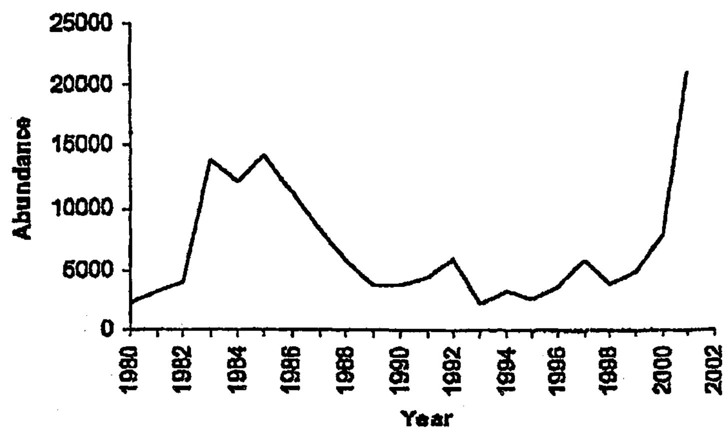


Figure 4. Estimated abundance of the Upper Columbia River steelhead ESU. Abundance shown includes both natural and hatchery produced spawning adults in a given year. ESU-level abundance estimated as the sum of populations for which spawner escapement data is available, and may represent an underestimate of total ESU abundance. The Upper Columbia River steelhead ESU was listed as an endangered species under the ESA in 1997.

**Snake River Fall-run Chinook ESU**

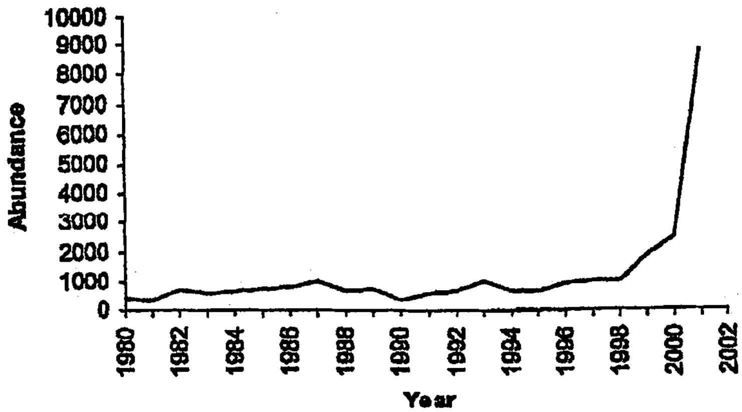


Figure 5. Estimated abundance of the Snake River steelhead ESU. Abundance shown includes both natural and hatchery produced potential spawners returning over Lower Granite Dam in a given year. The Snake River fall-run chinook ESU was listed as a threatened species under the ESA in 1992.

**Snake River Spring/Summer-run Chinook ESU**

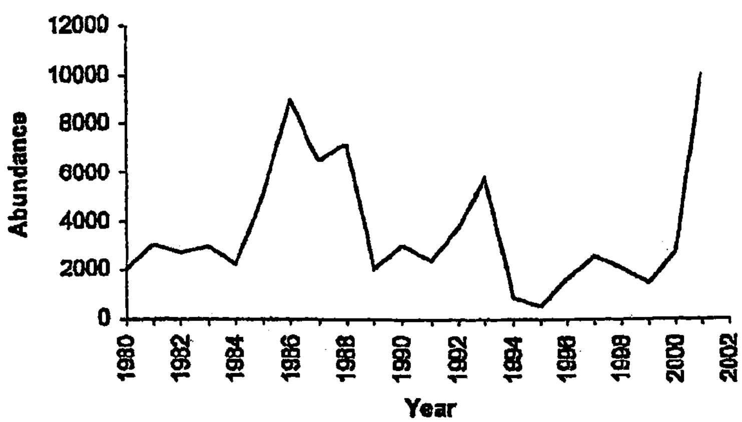


Figure 6. Estimated abundance of the Snake River spring/summer-run chinook ESU. Abundance shown includes both natural and hatchery produced spawning adults in a given year. ESU-level abundance estimated as the sum of populations for which spawner escapement data is available, and may represent an underestimate of total ESU abundance. The Snake River spring/summer-run chinook ESU was listed as a threatened species under the ESA in 1992.

**Snake River Basin Steelhead ESU**

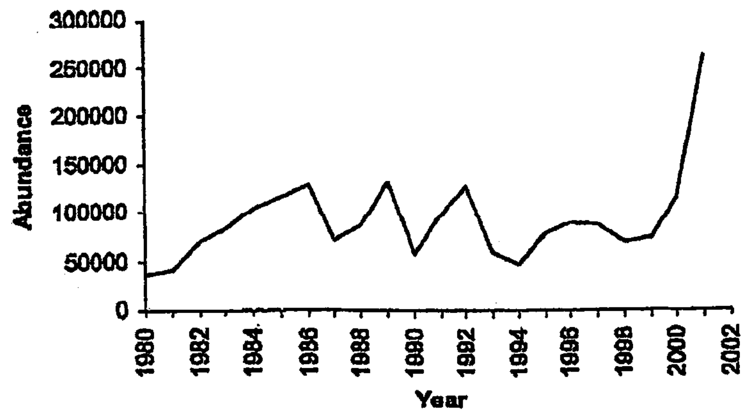


Figure 7. Estimated abundance of the Snake River steelhead ESU. Abundance shown includes both natural and hatchery produced potential spawners returning over Lower Granite Dam in a given year. The Snake River steelhead ESU was listed as a threatened species under the ESA in 1997.

**Snake River Sockeye ESU**

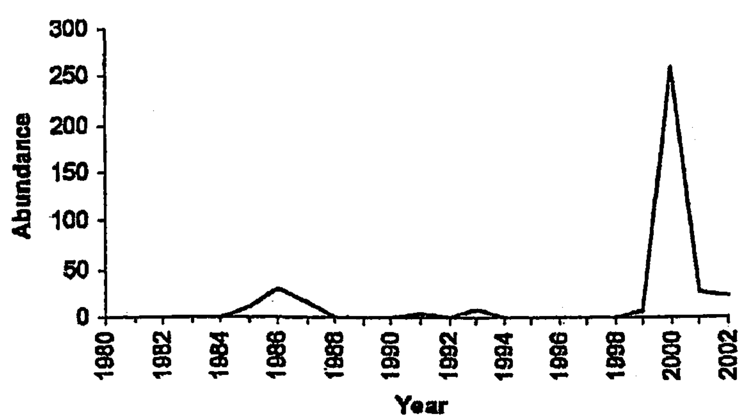


Figure 8. Abundance of the Snake River sockeye ESU 1980-present. Abundance includes natural and artificially produced adults returning to Redfish Lake. The Redfish Lake captive propagation program was initiated 1991, with the first artificially produced adults returning in 1999, and a peak of 257 returns in 2000. The Snake River sockeye ESU was listed as an endangered species under the ESA in 1991.

# Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

**West Coast Salmon Biological Review Team**

**Northwest Fisheries Science Center**
**2725 Montlake Boulevard East**
**Seattle, WA 98112**

**Southwest Fisheries Science Center**
**Santa Cruz Laboratory**
**110 Shaffer Road**
**Santa Cruz, CA 95060**

**February 2003**

## Co-manager review draft

**[This is a draft document being provided to state, tribal, and federal comanagers for technical review.]**

# EXECUTIVE SUMMARY

This draft report summarizes preliminary scientific conclusions of the NMFS Biological Review Team (BRT) regarding the updated status of 26 ESA-listed Evolutionarily Significant Units (ESUs) of salmon and steelhead (and one candidate species ESU) from Washington, Oregon, Idaho, and California. These ESUs were listed following a series of status reviews conducted during the decade of the 1990s. The status review updates were undertaken to allow consideration of new data that have accumulated over the various time periods since the last updates and to address issues raised in recent court cases regarding the ESA status of hatchery fish and resident (nonanadromous) populations. The draft BRT conclusions in this report should be considered preliminary for two reasons. First, the BRT will not finalize its conclusions until state, tribal, and other federal comanagers have had an opportunity to review and comment on the draft report. Second, some policy issues regarding the treatment of hatchery fish and resident fish in ESU determinations and risk analyses are not resolved at this time.

When finalized, this draft report would represent the first major step in the agency's efforts to review and update the listing determinations for all listed ESUs of salmon and steelhead. By statute, ESA listing determinations must take into consideration not only the best scientific information available, but also those efforts being made to protect the species. After receiving the final BRT report and after considering the conservation benefits of such efforts, NMFS will determine what changes, if any, to propose to the listing status of the affected ESUs.

As in the past, the BRT used a risk-matrix method to quantify risks in different categories within each ESU. In the current report, the method was modified to reflect the four major criteria identified in the NMFS Viable Salmonid Populations (VSP) document: abundance, growth rate/productivity, spatial structure, and diversity. These criteria are being used as a framework for approaching formal ESA recovery planning for salmon and steelhead. Tabulating mean risk scores for each element allowed the BRT to identify the most important concerns for each ESU as well as make comparisons of relative risk across ESUs and species. These data and other information were considered by the BRT in making their overall risk assessments. Based on provisions in the draft revised NMFS policy on consideration of artificial propagation in salmon listing determinations, the risk analyses presented to the BRT focused on the viability of populations sustained by natural production.

For the following ESUs, the majority BRT conclusion was "in danger of extinction:" Upper Columbia spring-run chinook, Sacramento River winter-run chinook, Upper Columbia steelhead, Southern California steelhead, California Central Valley steelhead, Central California Coast coho, Lower Columbia River coho, Snake River sockeye. For the following ESUs, the majority BRT conclusion was "likely to become endangered in the foreseeable future:" Snake River fall-run chinook, Snake River spring/summer-run chinook, Puget Sound chinook, Lower Columbia River chinook, Upper Willamette River chinook, California Coastal chinook, Central Valley spring-run chinook, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Northern California steelhead, Central California Coast steelhead, South-Central California Coast steelhead, Oregon Coast coho, S. Oregon/N. California Coast coho, Lake Ozette sockeye, Hood Canal summer-run chum, and Lower Columbia River chum. In a number of ESUs, adult returns over the last 1-3 years

have been significantly higher than have been observed in the recent past, at least in some populations. The BRT found these results, which affected the overall BRT conclusions for some ESUs, to be encouraging. For example, the majority BRT conclusion for Snake River fall chinook salmon was "likely to become endangered," whereas the BRT concluded at the time of the original status review that this ESU was "in danger of extinction." This change reflects the larger adult returns over the past several years, which nevertheless remain well below preliminary targets for ESA recovery. In the Upper Columbia River, the majority BRT conclusions for spring chinook salmon and steelhead were still "in danger of extinction," but a substantial minority of the votes fell in the "likely to become endangered" category. The votes favoring the less severe risk category reflect the fact that recent increases in escapement have at least temporarily somewhat alleviated the immediate concerns for persistence of individual populations, many of which fell to critically low levels in the mid 1990s. Overall, although recent increases in escapement were considered a favorable sign by the BRT, the response was uneven across ESUs and, in some cases, across populations within ESUs. Furthermore, in most instances in which recent increases have occurred, they have not yet been sustained for even a full salmon/steelhead generation. The causes for the increases are not well understood, and in many (perhaps most) cases may be due primarily to unusually favorable conditions in the marine environment rather than more permanent alleviations in the factors that led to widespread declines in abundance over the past century. In general, the BRT felt that ESUs and populations would have to maintain themselves for a longer period of time at levels considered viable before it could be concluded that they are not at significant continuing risk.

## INTRODUCTION/METHODS

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INTRODUCTION/METHODS

# INTRODUCTION

During the 1990s, the National Marine Fisheries Service (NMFS) conducted a series of reviews of the status of West Coast populations of Pacific salmon and steelhead (*Oncorhynchus* spp.) with respect to the United States Endangered Species Act (ESA). Initially these reviews were in response to petitions for populations of a particular species within a particular geographic area, but in 1994, the agency began a series of proactive, comprehensive ESA status reviews of all populations of anadromous Pacific salmonids from Washington, Idaho, Oregon, and California (Federal Register, Vol. 59, No. 175, September 12, 1994, p. 46808).

The first step in these reviews is to determine the units that can be considered "species" under the ESA and, hence, listed as threatened or endangered if warranted based on their status. The ESA allows listing not only of full species, but also named subspecies and "distinct population segments (DPSs) of vertebrates (including fish). The ESA petitions and status reviews for Pacific salmonids have focused primarily on the DPS level. To guide DPS evaluations of Pacific salmon, NMFS has used the policy developed in 1991 (NMFS 1991; Waples 1991, 1995), which is described in the next section. As a result of these status reviews, NMFS has identified over 50 ESUs of salmon and steelhead from California and the Pacific Northwest, of which 26 are listed as threatened or endangered species under the ESA. A complete list of these evaluations can be found at (http://www.nwr.noaa.gov/1salmon/salmesa/fractlist.htm), and the technical documents representing results of the status reviews can be accessed online at Northwest Fisheries Science Center (http://www.nwfsc.noaa.gov/pubs/), Southwest Regional Office (http://swr.nmfs.noaa.gov/salmon.htm), Santa Cruz Laboratory (http://www.pfeg.noaa.gov/tib/esa/salmonids/esa_docs/index.html), and Northwest Regional Office (http://www.nwr.noaa.gov/1habcon/habweb/listnwr.htm) websites.

In 2000, NMFS initiated formal ESA recovery planning for listed salmon and steelhead ESUs. Recovery efforts are organized into a series of geographic areas or domains. Within each domain, a Technical Recovery Team (TRT) has been (or is in the process of being) formed to develop a sound scientific basis for recovery planning, and regional planners will use this information to help craft comprehensive recovery plans for all listed ESUs within each domain. For more information about the ESA recovery planning process for salmon and steelhead and the TRTs, see the NMFS Northwest Salmon Recovery Planning web site (http://www.nwfsc.noaa.gov/cbd/trt/).

Recently, several factors led NMFS to conclude that the ESA status of listed salmon and steelhead ESUs should be reviewed at this time. First, a September 2001 ruling in a lawsuit called into question the NMFS decision to not list several hatchery populations considered to be part of the Oregon Coast coho salmon ESU (Alsea Valley Alliance v. Evans (161 F. Supp. 2d 1154, D. Oreg. 2001; Alsea decision). That ruling held that the ESA does not allow listing of any unit smaller than a DPS (or ESU), and that NMFS had violated that provision of the act by listing only part of an ESU. Although this legal case applied directly only to the Oregon Coast coho salmon ESU, the same factual situation (hatchery populations considered part of listed ESUs but not listed) also applied to most of the other listed ESUs of salmon and steelhead. Second, another lawsuit currently pending that involves the Southern California ESU of steelhead (EDC v. Evans, SACV-00-1212-AHS (EEA), United States District Court, C.D. California) raised a similar issue—NMFS concluded that resident fish were part of the ESU but only the anadromous steelhead were listed. Again, this same factual situation is found in most, if not all, listed steelhead ESUs. Finally, at least several years of new data are available even for the most recently listed ESUs, and up to a decade has passed since the first populations were listed in the Sacramento and Snake Rivers. Furthermore, in some areas, adult returns in the last few years have been considerably higher than have been seen for several decades.

As a result of these factors, NMFS committed to a systematic updating of the ESA status of all listed ESUs of Pacific salmon and steelhead (Federal Register Vol. 67, No. 28, February 11, 2002). This report summarizes updated biological information for the 26 listed salmon and steelhead ESUs and one candidate ESU (Lower Columbia coho salmon), and presents preliminary conclusions of the Biological Review Team (BRT) regarding their current risk status. The BRT consisted of a core group of scientists from the NMFS Northwest and Southwest Fisheries Science Centers, supplemented by experts on particular species from NMFS and other federal agencies. The BRT membership is indicated in the sections for each species.

## ESU determinations

As amended in 1978, the ESA allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. However, the ESA provided no specific guidance for determining what constitutes a distinct population, and the resulting ambiguity led to the use of a variety of criteria in listing decisions over the past decade. To clarify the issue for Pacific salmon, NMFS published a policy describing how the agency will apply the definition of "species" in the ESA to anadromous salmonid species, including sea-run cutthroat trout and steelhead (NMFS 1991). A more detailed description of this topic appeared in the NMFS "Definition of Species" paper (Waples 1991). The NMFS policy stipulates that a salmon population (or group of populations) will be considered "distinct" for purposes of the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. An ESU is defined as a population that: 1) is substantially reproductively isolated from conspecific population, and 2) represents an important component in the evolutionary legacy of the species. Information that can be useful in determining the degree of reproductive isolation includes incidence of straying, rates of recolonization, degree of genetic differentiation, and the existence of barriers to migration. Insight into evolutionary significance can be provided by data on genetic and life-history characteristics, habitat differences, and the effects of stock transfers or supplementation efforts. The NMFS Biological Review Teams have used a comprehensive approach to defining ESUs that utilized all available scientific information. A discussion of how the NMFS policy was applied in a number of ESA status reviews can be found in Waples (1995).

## Geographic boundaries

The status review updates focused primarily on risk assessments, and the BRT did not consider issues associated with the geographic boundaries of ESUs. If significant new information arises to indicate that specific ESU boundaries should be reconsidered, that would be done at a later time.

## Artificial propagation

Most salmon and steelhead ESUs have hatchery populations associated with them, and it is important for administrative, management, and conservation reasons to determine the biological relationship between these hatchery fish and natural populations within the ESU. The ESA status reviews conducted since 1993 have been guided by the NMFS ESA policy for artificial propagation of Pacific salmon and steelhead (NMFS 1993). That policy recognizes that "genetic resources important to the species' evolutionary legacy may reside in hatchery fish as well as in natural fish, in which case the hatchery fish can be considered part of the biological ESU in question." As part of the coastwide status reviews, the NMFS BRTs applied this principle in evaluating the ESU status of hatchery populations associated with all listed salmon and steelhead ESUs, with the result that many hatchery populations are currently considered to be part of the ESUs. However, only a small fraction of these hatchery populations have been listed—generally, those associated with natural populations or ESUs considered at high risk of extinction. NMFS felt that listing other hatchery populations in the ESUs would provide little or no additional conservation benefit beyond that conferred by the listing of natural fish, but would greatly increase the regulatory burden on stakeholders, researchers, and the general public.

As discussed above, a recent court decision has determined that this approach is inconsistent with the act—an ESU must be listed or not listed in its entirety. At the same time that NMFS announced the status review updates, the agency committed to revising the ESA artificial propagation policy for Pacific salmon and using the revised policy to guide the hatchery ESU determinations and consideration of artificial propagation in the risk analyses (Federal Register Vol. 67, No. 28, February 11, 2002). Although a revised policy has not yet been proposed through formal rulemaking, a draft has been publicly available on the agency's web site since August 2002 (http://www.nwr.noaa.gov/HatcheryListingPolicy/DraftPolicy.pdf). That draft indicates that hatchery populations that have "diverged substantially from the evolutionary lineage represented by the ESU" will not be considered part of the ESU. The draft policy is currently under revision, and one issue that remains to be resolved is how "substantial" the divergence must be before a hatchery population should no longer be considered part of a salmon or steelhead ESU, even if it was originally derived from populations within the ESU. Due to the pending resolution of this issue, the BRT has not attempted to revisit the ESU determinations for hatchery populations in this draft report. However, a working group has updated the stock histories and biological information for every hatchery population associated with each listed ESU, and comanagers and others are currently reviewing that information for accuracy and completeness (SSHAG 2003). This draft report has also provisionally assigned each hatchery population to one of four categories: (listed below). It remains to be determined how these categories relate to ESU membership.

**Category 1**—The hatchery population was derived from a native, local population; is released within the range of the natural population from which it was derived; and has experienced only relatively minor genetic changes from causes such as founder effects, domestication or non-local introgression. Examples of populations that fall into this category include:

a) A hatchery population that has been recently founded (e.g., within one or two generations) from a representative sample of a native, natural population.

b) A hatchery population that was founded some time in the past (e.g., more than two generations ago) as a representative sample from a native, natural population, and has received regular, substantial, and representative infusions of natural fish from the original founding population into the broodstock since that time.

**Category 2**—The hatchery population was derived from a local natural population, and is released within the range of the natural population from which it was derived, but is known or suspected to have experienced a moderate level of genetic change from causes such as founder effects, domestication or non-native introgression. Examples of populations that fall into this category include:

a) A hatchery population for which there is direct evidence (e.g., from molecular genetic data or breeding studies) of moderate genetic divergence between the hatchery population and the natural population from which it was derived. In this context, "moderate divergence" would be a level of divergence typical of that observed among natural populations within the same ESU.

b) A hatchery population that was founded from a native, natural population, but 1) the sample was not representative; or 2) the broodstock has received few or no reintroductions of native, natural fish since the time of founding; or 3) the hatchery population is believed to have experienced moderate genetic change (e.g., from domestication or non-local introgression) since the time of founding.

c) A hatchery population that was founded predominantly from a local natural population but has also had a greater level of introgression from non-local stocks than would be expected from natural straying rates.

**Category 3**—The hatchery population was derived predominantly from other populations that are in the same ESU, but is substantially diverged from the local, natural population(s) in the watershed in which it is released. Examples include:

a) A hatchery population that has been deliberately artificially selected, has experienced substantial unintentional domestication, or both.

b) A hatchery population that was founded in a substantially non-representative way or was founded long ago (many salmon generations) and has received few or no infusions of wild fish into the broodstock since the time of founding.

c) A hatchery population that was founded from a mixture of several natural or hatchery populations from within the ESU, or has experienced substantial introgression from non-local populations (much higher than would be expected from natural straying).

d) A hatchery population that was founded from within the ESU, but is released outside of the historical range of the natural population from which it was founded (but still within the historical range of the ESU).

**Category 4**—The hatchery population was predominantly derived from populations that are not part of the ESU in question; or there is substantial uncertainty about the origin and history of the hatchery population.

## Resident fish

In addition to the anadromous life history, sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*) have nonanadromous or resident forms, generally referred to as kokanee and rainbow trout, respectively. As is the case with hatchery fish, it is important to determine the relationship of these resident fish to anadromous populations in listed ESUs. This issue is complicated by the complexity of jurisdictional responsibilities—NMFS has ESA responsibility for anadromous Pacific salmonids, but the U.S. Fish and Wildlife Service (USFWS) has jurisdiction for resident fish. At the time this report was prepared, the two agencies had not reached agreement on how to determine the ESU/DPS status of resident fish or how to make the listing determinations for the overall ESU/DPSs.

For the purposes of this status-review update, the BRT adopted a provisional working framework for determining the ESU/DPS status of resident *O. mykiss* geographically associated with listed steelhead ESUs. These evaluations were guided by the same biological principles used to define ESUs of natural fish and determine ESU membership of hatchery fish: the extent of reproductive isolation from, and evidence of biological divergence from, other populations within the ESU. Ideally, each resident population would be evaluated individually on a case-by-case basis, using all available biological information. In practice, little or no information is available for most resident salmonid populations. To facilitate provisional conclusions about the ESU/DPS status of resident fish, NMFS and USFWS have identified three different cases, reflecting the range of geographic relationships between resident and anadromous forms within different watersheds:

Case 1: no obvious physical barriers to interbreeding between resident and anadromous forms;

Case 2: long-standing natural barriers (e.g., a waterfall) separate resident and anadromous forms;

Case 3: relatively recent (e.g., within last 100 years) human actions (e.g., construction of a dam without provision for upstream fish passage) separate resident and anadromous forms.

As a provisional framework, NMFS has adopted the following working assumptions about ESU membership of resident fish falling in each of these categories:

Case 1: Resident fish assumed provisionally to be part of the ESU. Rationale: Empirical studies show that resident and anadromous *O. mykiss* are typically very similar genetically when they co-occur in sympatry with no physical barriers to migration or interbreeding (Chilcote 1976, Currens et al. 1987, Leider et al. 1995, Pearsons et al. 1998). Note: this assumption is not necessarily applicable to *O. nerka*, because sockeye and kokanee can show substantial divergence even in sympatry.

Case 2: resident fish assumed provisionally not to be part of the ESU. Rationale: Many populations in this category have been isolated from contact with anadromous populations for thousands of years. Empirical studies (Chilcote 1976, Currens et al. 1990) show that in these cases the resident fish typically show substantial genetic and life history divergence from the nearest downstream anadromous populations.

Case 3: resident fish assumed provisionally to be part of the ESU. Rationale: Case 3 populations were, most likely, Case 1 populations (and hence part of the ESU) prior to construction of the artificial barrier.

These default assumptions about ESU membership can be overridden by specific information for individual populations. For example, as noted above, anadromous and resident *O. nerka* can diverge substantially in sympatry, and it is possible the same may be true for some *O. mykiss* populations. In addition, some Case 3 populations that historically were part of the ESU may no longer be, as a result of rapid divergence in a novel environment, or displacement by or introgression from non-native hatchery rainbow trout. The BRT reviewed available information about individual resident populations of *O. mykiss* and *O. nerka* to determine which Case each population fits into and whether any information exists to override the default assumption about ESU membership.

## Risk Assessments

### ESA definitions

After the composition of an ESA species is determined, the next question to address is, "Is the 'species' threatened or endangered?" The ESA (section 3) defines the term "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." The term "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Neither NMFS nor the FWS have developed any formal policy guidance about how to interpret the definitions of threatened or endangered species in the act.

A variety of information is considered in evaluating the level of risk faced by an ESU. According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific information available regarding its current status, after taking into consideration conservation measures that are proposed or are in place. In its biological status reviews, the BRT does not evaluate likely or possible effects of conservation measures except to the extent they are reflected in metrics of population or ESU viability; these measures are taken into account in a separate process by the NMFS regional offices prior to making listing determinations. Therefore, the BRT does not make recommendations as to whether identified ESUs should be listed as threatened or endangered species, because that determination requires evaluation of factors not considered by the team. Rather, the BRT draws scientific conclusions about the risk of extinction faced by identified ESUs under the assumption that present conditions will continue into the future (recognizing, of course, that existing trends in factors affecting populations and natural demographic and environmental variability are inherent features of "present conditions").

## Artificial propagation

The 1993 NMFS ESA policy for artificial propagation of Pacific salmon and steelhead recognizes that artificial propagation can be one of the conservation tools used to help achieve recovery of ESA listed species, but it does not consider hatcheries to be a substitute for conservation of the species in its natural habitat. Therefore, ESA risk analyses for salmon and steelhead ESUs have focused on "natural" fish (which are defined as the progeny of naturally spawning fish),and whether the natural populations can be considered self sustaining without regular infusion of hatchery fish. This is the same provision articulated in the joint USFWS-NMFS policy on artificial propagation of all species under the ESA (Federal Register, Volume 65, Number 114, June 13, 2000, p. 37102) and is consistent with the approach USFWS has used in evaluating captive propagation programs for other species, such as the condor (USFWS. 1996) and the Bonytail chub (USFWS 2002).

The draft revised salmon hatchery policy outlines a three-step approach for considering artificial propagation in listing determinations:

1. Identify which hatchery populations are part of the ESU (see previous section)
2. Review the status of the ESU
3. Evaluate existing protective efforts and make a listing determination

This document is concerned with Step 2—the risk analysis for listed salmon and steelhead ESUs.

The draft revised hatchery policy reaffirms the interpretation that the purpose of the ESA is to conserve threatened and endangered species in their natural habitats. In its risk evaluations, the BRT therefore used the approach it has in the past—focusing on whether populations and ESUs are self-sustaining in their natural habitat. The draft policy also indicates that the potential conservation benefits of artificial propagation should be considered before a listing determination is made. The potential conservation benefits of artificial propagation, together with other conservation measures, will be considered by NMFS Regional Office and Headquarters staff in developing a listing proposal.

Artificial propagation is also important to consider in ESA evaluations of anadromous Pacific salmonids for several other reasons. First, although natural fish are the focus of ESU determinations, possible positive or negative effects of artificial propagation on natural populations must also be evaluated. For example, artificial propagation can alter life history characteristics such as smolt age and migration and spawn timing. Second, in addition to the potential to increase short-term abundance of fish in an ESU, artificial propagation poses a number of risks to natural populations that may affect their risk of extinction or endangerment. In contrast to most other types of risk for salmon populations, those arising from artificial propagation are often not reflected in traditional indices of population abundance. For example, to the extent that habitat degradation, overharvest, or hydropower development have contributed to a population's decline, these factors will already be reflected in population abundance data and accounted for in the risk analysis. The same is not necessarily true of artificial propagation. Hatchery production may mask declines in natural populations that will be missed if only raw population abundance data are considered. Therefore, a true assessment of the viability of natural populations cannot be attained without information about the genetic and demographic


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contribution of naturally spawning hatchery fish. Furthermore, even if such data are available, they will not in themselves provide direct information about possibly deleterious effects of fish culture. Such an evaluation requires consideration of the genetic and demographic risks of artificial propagation for natural populations.

### Resident fish

As indicated above, the BRT concluded in previous status reviews that at least some resident *O. mykiss* populations belonged to steelhead ESUs, and these resident fish were considered in the overall risk analyses for those ESUs. However, in most cases little or no information was available about the numbers and distribution of resident fish, as well as about the extent and nature of their interactions with anadromous populations. Given this situation, the previous risk analyses for steelhead ESUs focused primarily on the status of anadromous populations.

In these updated status reviews, increased efforts have been made to gather biological information for resident *O. mykiss* populations to assist in the risk analyses. (Although the two listed sockeye salmon ESUs considered in this report [Redfish Lake and Lake Ozette] have associated kokanee populations, in neither case are the kokanee considered to be part of the sockeye salmon ESU, and so the kokanee were not formally considered in the risk analyses.) Information on resident fish is summarized below in the report for steelhead (Section B), where ESU-specific information is discussed in more detail. The steelhead report also contains a more general discussion of how resident fish were considered in the risk analyses for steelhead ESUs.

### Factors Considered in Status Assessments

Salmonid ESUs are typically metapopulations; that is, they are usually composed of multiple populations with some degree of interconnection, at least over evolutionary time periods. This makes the assessment of extinction risk difficult. An approach to this problem has been adopted by NMFS for recovery planning, and is outlined in the "Viable Salmonid Populations" (VSP) report by McElhany et al. (2000). In this approach, risk assessment is addressed at two levels: first, the simpler population level, then at the overall ESU level. We have modified previous BRT approaches to ESU risk assessments to incorporate VSP considerations.

Individual populations are assessed according to the four VSP criteria: abundance, growth rate/productivity, spatial structure, and diversity. The condition of individual populations is then summarized on the ESU level, and larger-scale issues are considered in evaluating status of the ESU as a whole. These larger-scale issues include total number of viable populations, geographic distribution of these populations (to insure inclusion of major life-history types and to buffer the effects of regional catastrophes), and connectivity among these populations (to ensure appropriate levels of gene flow and recolonization potential in case of local extirpations). These considerations are detailed in McElhany et al. (2000).

## The Risk Matrix

In previous status reviews, the BRTs have used a simple "risk matrix" for quantifying ESU-scale risks according to major risk factors. The revised matrix (see Appendix 1) integrates the four major VSP criteria (abundance, productivity, spatial structure, diversity) directly into the risk assessment process. After reviewing all relevant biological information for a particular ESU, each BRT member assigns a risk score (see below) to each of the four VSP criteria. Use of the risk matrix makes it easier to compare risk factors within and across ESUs. The scores are tallied and reviewed by the BRT before making its overall risk assessment (see FEMAT method, below). Although this process helps to integrate and quantify a large amount of diverse information, there is not a simple way to translate the risk matrix scores directly into an assessment of overall risk. For example, simply averaging the values of the various risk factors would not be appropriate; an ESU at high risk for low abundance would be at high risk even if there were no concerns for any other risk factor.

**Scoring VSP criteria.** Risks for each of the four VSP factors are ranked on a scale of 1 (very low risk) to 5 (high risk):

1) *Very Low Risk.* Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.

2) *Low Risk.* Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may, in combination with other factors.

3) *Moderate Risk.* This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

4) *Increasing Risk.* Present risk is Low or Moderate, but is likely to increase to high risk in the foreseeable future if present conditions continue.

5) *High Risk.* This factor by itself indicates danger of extinction in the near future.

**Recent Events.** The "Recent Events" category considers events that have predictable consequences for ESU status in the future but have occurred too recently to be reflected in the population data. Examples include a flood that decimated most eggs or juveniles in a recent broodyear, or large jack returns that generally anticipate strong adult returns in subsequent year(s). This category is scored as follows: "++" - expect a strong improvement in status of the ESU; "+" - expect some improvement in status; "0" - neutral effect on status; "-" - expect some decline in status; "--" - expect strong decline in status.

## Overall risk assessment

The BRT analysis of overall risk to the ESU uses categories that correspond to definitions in the ESA: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (As discussed above, these evaluations do not consider conservation measures and therefore are not recommendations regarding listing status). The overall risk assessment reflects


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professional judgment by each BRT member. This assessment is guided by the results of the risk matrix analysis as well as expectations about likely interactions among factors. For example, a single factor with a "High Risk" score might be sufficient to result in an overall score of "in danger of extinction," but a combination of several factors with more moderate risk scores could also lead to the same conclusion.

To allow for uncertainty in judging the actual risk facing an ESU, the BRTs have adopted a "likelihood point" method. This method, also referred to as the FEMAT method because it was used by scientific teams evaluating options under President Clinton's Forest Plan (Forest Ecosystem Management: An Ecological, Economic, and Social Assessment Report of the Forest Ecosystem Management Assessment Team (FEMAT; http://www.or.blm.gov/ForestPlan/NWFPTitl.htm), allows each reviewer to distribute 10 likelihood points among the three ESU risk categories, reflecting their opinion of the likelihood that that category correctly reflects the true ESU status. Thus, if a reviewer were certain that the ESU was in the "not at risk" category; then s/he could assign all 10 points to that category. A reviewer with less certainty about ESU status could split the points among two or even three categories. The FEMAT method has been used in all status review updates for anadromous Pacific salmonids since 1999.

# METHODS

Data on adult returns were obtained from a variety of sources, including time series of freshwater spawner surveys, redd counts, and counts of adults migrating past dams/weirs. Time series were assembled at the scale of population where these have been identified by TRTs or quasi-population where population identification is ongoing.

## Calculating recruits

Recruits from a give brood year are calculated as

$$C_t = \sum_{i=1}^{MaxAge} N_{t+i} A(i)_{t+i} \,, \qquad \text{(Eq. 1)}$$

where $R_t$ is the number of recruits from brood year $t$, $N_t$ is the number of natural-origin spawners in year $t$, and $A(i)_t$ is the fraction of age $i$ spawners in year $t$. The estimate of preharvest recruits is similarly

$$C(preHarvest)_t = \sum_{i=1}^{MaxAge} P_{t+i} A(i)_{t+i} \,, \qquad \text{(Eq. 2)}$$

where $C(preHarvest)_t$ is the number of preharvest recruits in year $t$, $P_t$ is the number of natural origin spawners that would have returned in year $t$ if there had not been a harvest, and $A(i)_t$ is the fraction of age $i$ spawners in year $t$ had there not been a harvest. [Because $P_t$ is in terms of the number of fish that would have appeared on the spawning grounds had there not been a harvest, it can be quite difficult to estimate and simplifying assumptions are often made].

## Mean abundance

Recent average abundance of natural-origin spawners is reported as the geometric mean of the most recent data. Five-year geometric means were calculated to represent the recent abundance of natural-origin spawners for each population or quasi-population within an ESU. Five-year geometric means for the most recent 5 years of available data were calculated, as well as the minimum and maximum 5-year geometric means for the entire time series. The equation for a 5-year geometric mean is

$$GM_{N_t} = \sqrt[5]{N_t N_{t-1} N_{t-2} N_{t-3} N_{t-4}}, \qquad \text{(Eq. 3)}$$

where $t$ is year and $N_t$ is the abundance of natural origin spawners in year $t$.

Zero values in the data set were replaced with a value of one, and missing data values within a 5-year range were excluded from geometric mean calculations. For example, if data were available from 1997–2001, with no data for 1998, the geometric mean was calculated as

$$GM_{N_{1997}} = \sqrt[4]{N_{1997} N_{1999} N_{2000} N_{2001}}. \qquad \text{(Eq. 4)}$$

## Trends in abundance

Short-term and long-term trends were calculated from time series of adult spawners. Short-term was defined as that resulting from data from 1990 to the most recent year of data, with a minimum of 10 data points in the 13-year span. Long-term trend was defined as that resulting from all data in a time series.

Trend was calculated as the slope of the regression of natural-origin spawners (log-transformed); one was added to natural-origin spawners before transforming the data to mediate for zero values. Trend was reported in the original units as exponentiated slope such that a value > 1 indicates a population trending upward, and a value < 1 indicates a population trending downward. The regression was calculated as

$$\ln(N+1) = \beta_0 + \beta_1 X + \varepsilon, \qquad \text{(Eq. 5)}$$

where $N$ is the natural-origin spawner abundance, $\beta_0$ is the intercept, $\beta_1$ is the slope of the equation, and $\varepsilon$ is the random error term.

Confidence intervals (95%) for the slope, in their original units of abundance, were calculated as

$$\exp(\ln(b_1) - t_{0.05(2),df} s_{b_1}) \le \beta_1 \le \exp(\ln(b_1) + t_{0.05(2),df} s_{b_1}), \qquad \text{(Eq. 6)}$$

where $b_1$ is the estimate of the true slope $\beta_1$, $t_{0.05(2),\,df}$ is the two-sided $t$-value for a confidence level of 0.95, $df$ is equal to $n$-2, $n$ is the number of data points in the time series, and $s_{b1}$ is the standard error of the estimate of the slope, $b_1$. In addition, the probability that the trend value was declining [P(trend < 1)] was calculated.

**Lambda calculations**

The median growth rate (λ) of natural-origin spawners was calculated in two ways for each population over both short-term and long-term time frames as above (short-term = 1990-most recent year and long-term = all data). The first (λ) assumed that hatchery-origin spawners had zero reproductive success, while the second ($\lambda_H$) assumed that hatchery-origin spawners had reproductive success equivalent to that of natural-origin spawners. These extreme assumptions bracket the range likely to occur in nature. Empirical studies indicate that hatchery-origin spawning fish generally have lower (and perhaps much lower) reproductive success than natural-origin spawners. However, this parameter can vary considerably across species and populations, and it is very rare that data are available for a particular population of interest.

A multi-step process based on methods developed by Holmes (2001), Holmes and Fagan (2002) and described in McClure et al. (in press) was used to calculate estimates for λ, its 95% confidence intervals, and its probability of decline [P(λ < 1)]. The first step was calculating 4-year running sums for natural-origin spawners as

$$R_t = \sum_{j=1}^{4} N_{t-j+1} \; . \qquad \text{(Eq. 7)}$$

where $N_t$ is the number of natural-origin spawners in year $t$.

Next, an estimate of μ, the rate at which the median of $R$ increases through time (Holmes 2001), was calculated as

$$\hat{\mu} = mean\left(\ln\left(\frac{R_{t+1}}{R_t}\right)\right) \qquad \text{(Eq. 8)}$$

—the mean of the natural log-transformed running sums of natural-origin spawners. The point estimate for λ was then calculated as the median annual population growth rate,

$$\hat{\lambda} = e^{\hat{\mu}} \; . \qquad \text{(Eq. 9)}$$

Confidence intervals (95%) were calculated for $\hat{\lambda}$ to provide a measure of the uncertainty associated with the growth rate point estimate. First, an estimate of variability was determined by calculating an estimate for $\sigma^2$ using the slope method (Holmes 2001). An estimate for $\sigma^2$, $\hat{\sigma}^2_{slp}$ was calculated for each population in an ESU, after which an arithmetic average of populations was calculated. This average was used as the measurement of variability for calculating confidence intervals for both short-term and long-term time series for all populations in an ESU.

We determined the degrees of freedom for the appropriate *t*-value for use in confidence interval calculations based on the method for adjusting degrees of freedom when variance is calculated using the slope method (Holmes and Fagan 2002). The adjusted degrees of freedom were then summed over all populations in an ESU to obtain the *df* to determine *t*. The degrees of freedom for each population was calculated as

$$df = 0.333 + 0.212n - L, \qquad \text{(Eq. 10)}$$

where $n$ is the length of the time series and $L$ is the number of counts summed to calculate $R_t$ ($L = 4$ in these analyses). Confidence intervals were calculated as

$$\exp\left(\hat{\mu} \pm t_{.05(2),df} \sqrt{\hat{\sigma}_{sp}^{\,2} / \gamma(n-4)}\right), \qquad \text{(Eq. 11)}$$

where $\gamma \cong 1$. In addition, the probability that trend was less than one was calculated utilizing the fact that $\ln(\lambda)$ follows a *t*-distribution. The probability that $\lambda$ is less than one is calculated by finding the probability that the natural log of the calculated lambda divided by its standard error is less than one, given the degrees of freedom, which is the number of data points used to calculate lambda minus two.

The preceding treatment ignores contributions of hatchery-origin spawners to the next generation, in effect assuming that they had zero reproductive success. This assumption produces the most optimistic view of viability of the natural population. The other extreme assumption produces the most pessimistic view of viability of the natural population. To calculate the median growth rate under this assumption, that hatchery-origin spawners have reproductive success equivalent to that of natural-origin spawners ($\lambda_h$), a modified approach to the method developed by Holmes (2001) was used to calculate estimates for $\lambda_h$, 95% confidence intervals for $\lambda_h$, and to determine $P(\lambda_h < 1)$. The first step was calculating 4-year running sums ($RN$) for natural-origin spawners as

$$(RN)_t = \sum_{i=1}^{4} N_{t-i+1}\,. \qquad \text{(Eq. 12)}$$

Next, the 4-year running sum of hatchery-origin spawners was calculated as

$$(RH)_t = \sum_{i=1}^{4} H_{t-i+1}\,, \qquad \text{(Eq. 13)}$$

where $H_t$ is the number of hatchery spawners in year $t$.

The ratio of total spawners to natural origin spawners was calculated as

$$\psi_t = \frac{(RN)_t + (RH)_t}{(RN)_t}. \qquad \text{(Eq. 14)}$$

The average age at reproduction, *T*, was calculated in three steps:

1. Determine the total number of spawners for each age (*A*) by calculating

$$A_j = \sum_{j=1}^{\max age}\sum_{all\ t} a_j (N+H)_t. \qquad \text{(Eq. 15)}$$

2. Calculate the total number of spawners (*G*)

$$G = \sum_{j=1}^{\max age} A_j. \qquad \text{(Eq. 16)}$$

3. Determine the average age at reproduction (*T*) by calculating

$$T = \sum_{j=1}^{\max age} \frac{j \times A_j}{G}. \qquad \text{(Eq. 17)}$$

Next, an estimate of $\mu$, the rate at which the median increases through time (Holmes 2001), was calculated as

$$\hat{\mu} = mean\left(\ln\left(\frac{(RN)_{t+1}}{(RN)_t}\right) - \frac{1}{T}\ln(\psi_t)\right) \qquad \text{(Eq. 18)}$$

The point estimate for $\lambda_h$ was then calculated as the median annual population growth rate.

$$\hat{\lambda}_h = e^{\hat{\mu}}. \qquad \text{(Eq. 19)}$$

Confidence intervals (95%) for $\lambda_h$ and its probability of decline [$P(\lambda_h < 1)$] were calculated as for $\lambda$, with modification to the slope method for calculating the variance:

$$\hat{\sigma}^2 = \text{slope of var}\left(\ln\left(\frac{(RN)_{t+\tau}}{(RN)_t}\right) - \frac{1}{T}\ln\left(\prod_{i=0}^{\tau-1} \psi_{t+i}\right)\right) \text{vs. } \tau. \qquad \text{(Eq. 20)}$$

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Appendix 1. A template for the risk matrix used in BRT deliberations. The matrix is divided into five sections: corresponding to the four VSP "parameters" (McElhany et al. 2000) plus a "recent events" category.

[ESU Template]

| Risk Category | Score* |
|---|---|
| *Abundance*<br>Comments: | |
| *Growth Rate/Productivity*<br>Comments: | |
| *Spatial Structure and Connectivity*<br>Comments: | |
| *Diversity*<br>Comments: | |
| *Recent Events* | |

*Rate overall risk of ESU on 5-point scale (1–very low risk; 2–low risk; 3–moderate risk; 4–increasing risk; 5–high risk), except recent events double plus (++, strong benefit) to double minus (--, strong detriment)

As described in Section 9.6.5.5, some of the research and monitoring activities associated with the RPA can be anticipated in sufficient detail now, based on elements of the RPA described in Section 9.6.1. The RPA therefore instructs the Action Agencies to implement the activities listed below.

## H.1 RESEARCH AND MONITORING ACTIVITIES

Research Action 900: Research to determine the relative survival of migrating juvenile salmonids passing through the spillway of The Dalles Dam. Run-of-the-river fish, including ESA-listed fish, will be collected at John Day Dam and/or obtained from the smolt monitoring program. Study fish will be handled (anesthetized and sorted) and released or PIT-tagged, transported to The Dalles Dam, held for up to 24 hours, and released at selected locations. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.

Research Action 946: Research to assess the migration timing and relative survival of transported and inriver juvenile chinook salmon migrating volitionally from Bonneville Dam to the mouth of the Columbia River. Run-of-river fish, including ESA-listed juvenile fish, will be observed/harassed while they pass through a PIT-tag interrogation net or captured, anesthetized, examined for PIT-tags and the degree of descaling, allowed to recover from the anesthetic, and released. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.5.3.5.1.

Research Action 994: Research to assess the passage success of migrating adult salmonids at the eight dams and reservoirs on the lower Columbia and the lower Snake rivers, to evaluate specific flow and spill conditions, and to evaluate measures to improve adult anadromous fish passage. Adult salmonids will be captured at Bonneville, Ice Harbor, and/or Lower Granite dams, anesthetized, fitted with radio transmitters and identifier tags, allowed to recover from the anesthetic, transported, and released. Once the fish are returned to the river, the movement and migration timing of each fish will be recorded at fixed-site and mobile receiver stations as the fish migrate upstream. The primary benefits of the research will be identifying problematic areas in the migration corridor for adult passage and determining the proportion of salmonids that ultimately pass the upstream dams and enter tributaries to spawn, that enter hatcheries, that are taken in fisheries, or that are losses. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.6, 9.6.1.6.2, and 9.6.1.7.2.

Research Action 996: Research to monitor the effects of the juvenile fish bypass system at Ice Harbor Dam on the Snake River in Washington. Run-of-the-river juvenile fish, a proportion of which will be ESA-listed fish, will be collected from the bypass system at the dam, anesthetized, handled, allowed to recover from the anesthetic, and released. The primary purpose of the sampling is to ascertain fish condition and, thereby, to certify that the bypass system functions



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correctly. Some adult fish, including ESA-listed adult salmon, are expected to fall back through the juvenile bypass system and be captured and handled in the effort to return them to the river. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 1036: Research to document the growth, migration timing, survival, and SARs for wild juvenile fall chinook salmon migrating from the Snake River to the mouth of the Columbia River. Wild fall chinook salmon will be collected along the Hells Canyon Reach of the Snake River and PIT-tagged. The results will be used to monitor the effects of supplementation, to forecast passage at Lower Granite Dam to help plan summer flow augmentation, and to assess the relative impacts due to predation. Observed migration timing and survival will be used to evaluate the effectiveness of summer flow augmentation. If feasible, one group of PIT-tagged fish will be transported from Lower Granite Dam, and another group will be allowed to continue inriver migration. The research consists of six assessment tasks for which ESA-listed fish will be taken: 1) life cycle, 2) food and growth, 3) predation, 4) temperature response, 5) migratory behavior, and 6) race and residualism. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.1, 9.6.1.2.6, 9.6.1.3.3, 9.6.1.5.2, 9.6.1.7.2, 9.6.2.1, and 9.6.5.3.5.

Research Action 1058: Research designed to monitor and evaluate adult returns of hatchery-origin fall chinook salmon released as juveniles above Lower Granite Dam on the Snake River. Information on ESA-listed, natural-origin fish is needed to assess the impacts of fish management (e.g., hatchery supplementation) and other human activities (e.g., regulated river flows) on wild fish populations. The research has two components: 1) radio-tagging returning adult salmon at Lower Granite Dam to document the movements and spawning distribution of known natural-origin fall chinook salmon above the dam and 2) collecting data and scale or tissue samples from spawned-out adult fish in the Snake River and tributaries above Lower Granite Dam to augment information on spawning distribution collected from the radio-tagged fish. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.6.2.

Research Action 1130: Research to determine the movement, distribution, and passage behavior of radio-tagged juvenile salmonids at Bonneville, The Dalles, and John Day dams on the lower Columbia River. The results will be used to assess fish passage efficiency at John Day and The Dalles dams and to increase bypass efficiency for juvenile salmonids at the dams by designing and positioning prototype surface bypass/collection structures. ESA-listed fish will be acquired from smolt-monitoring program personnel at Bonneville, John Day, and/or McNary dams, implanted with radio transmitters, transported, held for as long as 24 hours, released, and tracked electronically. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.



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Research Action 1136: Research to compare the biological and physiological indices of wild and hatchery juvenile fish exposed to stress from bypass, collection, and transportation at the dams on the lower Snake and Columbia rivers. The goal is to provide information that can be used to improve outmigrating juvenile salmonid survival by determining the effects of manmade structures and management activities on the fish. ESA-listed juvenile fish will be captured at Lower Granite and Little Goose dams on the lower Snake River and at Bonneville, John Day, and McNary dams on the lower Columbia River, or acquired from smolt-monitoring-program personnel. The captured juvenile fish will be examined and released or tagged with radio transmitters, released, and tracked electronically. A lethal take of ESA-listed juvenile fish will also occur. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3, 9.6.1.3.4, and 9.6.1.4.6.

Research Action 1193: Research to produce information on migrational characteristics of Columbia and Snake river basin salmon and steelhead. The smolt monitoring program produces information on the migrational characteristics of the various salmon and steelhead stocks in the Columbia and Snake River basins and provides management information for implementing flow and spill measures designed to improve fish passage conditions in the mainstem lower Snake and Columbia rivers. The smolt-monitoring sites include tributary monitoring at the Whitebird trap on the Salmon River, the lower Grande Ronde River trap, and the Lewiston (Snake River) trap. The program also includes monitoring at Lower Granite, Little Goose, Lower Monumental, McNary, and John Day dams and at Bonneville Dam First and Second Powerhouses. Monitoring, including tagging actively migrating smolts with PITs at the tributary traps, yields information on migration timing to FCRPS dams, travel time, and relative survival data from release to Lower Granite Dam, the first dam encountered by outmigrating Snake River salmonids. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1 and 9.6.5.3.5.1.

Research Action 1194: Research to develop and evaluate adult PIT-tag interrogation systems for future installation at mainstem FCRPS facilities on the lower Columbia and Snake rivers. Studies will evaluate the ability of new PIT-tag detection technology to detect and read tag codes in orifices of fish ladders and to evaluate the effects of the detection system on the behavior of adults as they approach the system and pass through. Initial efforts will provide information about adult salmonid behavior during passage through Bonneville Dam and will help evaluate fish passage at other hydropower dams in the future. The new technology will allow tag readings from a greater distance than is currently feasible to allow data collection in a more natural fishway environment. The study is directed at nonlisted adult hatchery fish, but authorization is provided for ESA-listed adult hatchery fish because they often cannot be distinguished while collecting run-of-the-river fish. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3, 9.6.1.3.4, and 9.6.5.3.5.2.

Research Action 1212: Research consisting of four studies at the hydropower dams on the lower Snake and Columbia rivers. Study 1 will provide up-to-date survival estimates of juvenile salmonids as they migrate past McNary Dam. Study 2 will identify specific trouble areas in the juvenile fish bypass system at Lower Monumental Dam. Study 3 will compare the performance of juvenile salmonids tagged with sham radio-transmitters with the performance of juvenile salmonids PIT-tagged at Lower Granite Dam. The use of radio tags reduces research fish requirements, but the larger tag size could affect fish behavior. If survival studies can be conducted with radio-tagged juveniles, handling of ESA-listed species for important research would be significantly reduced. Study 4 will determine the tailrace residence times and behavior of radio-tagged hatchery chinook salmon under various operational conditions at Lower Monumental Dam and will identify spill conditions that maximize fish passage efficiency at Ice Harbor Dam. The research will be used to develop corrective measures to improve juvenile fish passage at the dams. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5, 9.6.1.4.6, and 9.6.5.3.5.1.

Research Action 1224: Research to evaluate the conversion rates (i.e., survival through the FCRPS), travel times, and passage routes of adult steelhead that have spawned (kelts) and are emigrating past hydroelectric facilities on their migration back to the ocean. Fish will be obtained from smolt-monitoring-program personnel at John Day and McNary dams on the lower Columbia River, anesthetized, handled (examined for spawning condition, length, fin condition, and descaling), and released, or they will be obtained from smolt-monitoring-program personnel, tagged/marked (tagged with PIT, radio-telemetry, or visual implant tags), and released. Fish migrating past downstream dams and reservoirs will be monitored by aerial and underwater telemetry arrays. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.6.2 and 9.6.5.3.5.2.

Research Action 1240: Research to provide fishery managers with detailed information on the response of outmigrating juvenile anadromous salmon to operation of a prototype surface bypass structure (removable spillway weir) at Lower Granite Dam. Juvenile fish for the study will be collected at preselected trap sites operated by smolt monitoring program personnel. ESA-listed juvenile fish may also be collected by purse seine in Lower Granite reservoir or from smolt monitoring program personnel at Lower Granite Dam. The fish will then be transported as necessary, anesthetized, implanted with radio transmitters, allowed to recover, transported to an upstream release site, released, and tracked electronically. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.

Research Action 1241: Studies to provide fishery managers with data on the timing, passage, and survival of outmigrating juvenile salmonids in relation to the operations of John Day, The Dalles, and Bonneville dams. Fish for the study will be collected from the juvenile fish bypass facilities at Bonneville, John Day, and/or McNary dams on the lower Columbia River by smolt monitoring program personnel. The fish will then be transported as necessary, anesthetized, implanted with radio transmitters, allowed to recover, transported to an upstream release site, released, and tracked electronically. Some research tasks will result in lethal takes of ESA-listed juvenile fish. Those tasks are designed to 1) statistically evaluate the survival rates of juvenile salmonids through John Day, The Dalles, and Bonneville dams and 2) evaluate the stress of juvenile salmonids that pass through the new bypass outfall pipe at Bonneville Dam Second Powerhouse DSM by measuring physiological indices (blood cortisol and lactate concentrations). For item 1), above, fish will be acquired from smolt monitoring program personnel at the dams, exposed to a lethal dose of anesthetic, and released in paired groups with the live radio-tagged fish to test the potential for dead research fish to be mistaken for live research fish. For item 2), run-of-the-river fish will be netted from the sampling flume at Bonneville Dam to acquire the target fish; ESA-listed juvenile fish will be captured, handled, and released, or captured and sacrificed. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.5.3.5.1.

Research Action 1242: Research to evaluate inriver migration survival versus transportation survival from Lower Granite Dam to below Bonneville Dam. Whether the transportation of depressed anadromous fish species should be maximized to enhance recovery is one of the most controversial and critical questions before fisheries managers today. Among other work, this research is designed to provide definitive information on this important question. ESA-listed juvenile fish will be captured at Lower Granite Dam, handled (checked for condition), and released, or they will be captured at Lower Granite Dam, PIT-tagged, and returned to the river below the dam. Study fish will be tracked downriver as juveniles, and when they return to the Snake River basin as adults, by using automated PIT-tag detectors at the mainstem FCRPS dams. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.1.3.4.

Research Action 1243: Research to evaluate juvenile fish survival through the Ice Harbor Dam spillway on the Snake River. Survival estimates for juvenile chinook salmon that migrate through the reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia rivers are essential for developing effective strategies to recover depressed stocks. Recent survival studies have evaluated passage through various routes at all of the dams on the lower Snake River except Ice Harbor Dam. ESA-listed juvenile fish will be collected at Lower Monumental Dam on the Snake River by smolt-monitoring-program personnel. The fish will then be tagged with radio transmitters and/or PITs, transported to Ice Harbor Dam, held for recovery, and released into the spillway or transferred to a small barge, transported, and released into the tailrace. Tagged fish will be tracked downriver as juveniles, and later when they return to the Snake River as adults, using automated PIT-tag detectors at FCRPS dams. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 1244: Six research studies to evaluate juvenile fish collection/bypass facilities at selected Snake and Columbia river FCRPS dams. Problems associated with juvenile fish passage through mainstem FCRPS facilities are major factors in the decline of ESA-listed anadromous fish species. Based on the results of bypass studies, guidance devices and bypass system components can be redesigned, modified, or deployed using specific configurations to improve juvenile fish passage. ESA-listed juvenile fish will be collected at Ice Harbor Dam on the Snake River (study 1) and at McNary (studies 2 and 3) and Bonneville dams (studies 4, 5, and 6) on the Columbia River. Once collected, the fish will be routed to holding tanks, handled (checked for fish condition and fork length), and released or routed to holding tanks, tagged/marked (with PITs, radio transmitters, and/or fin clips), and released. For study 4, artificially propagated chinook salmon juveniles will be PIT-tagged at the Idaho Department of Fish and Game's McCall Hatchery in Idaho. Tagged fish will be tracked downriver as juveniles, and later when they return to the Columbia and Snake river basins as adults, using automated PIT-tag detectors at FCRPS dams. Lethal takes of ESA-listed juvenile fish will occur for studies 2, 4, and 5. For study 4, previously PIT-tagged hatchery yearling chinook salmon will be collected at Bonneville Dam, held in artificial seawater for extended periods, and ultimately sacrificed for physiological characteristics and disease profiles. For study 5, ESA-listed juvenile fish that are not guided by intake screens will be collected in fyke nets as a way to estimate the number of unguided fish during the FGE research on submersible traveling screens at that dam. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.5.3.5.1.

Research Action 2000: Research at several mainstem FCRPS dams (Lower Granite, Little Goose, Lower Monumental, and McNary dams) to identify and enumerate adult steelhead kelts that pass through associated juvenile fish bypass facilities by using mark-recapture methods. Corps project personnel will remove ESA-listed adult steelhead from the juvenile fish separators during their downstream emigration, examine them using ultrasound, treat them for parasites, mark them (with Floy anchor tags, radio transmitters, or PITs), and release them into the tailrace through the flume used to remove adults from the wet separator. Alternatively, the fish will be held for up to 3 days, transported, and released below Bonneville Dam. A small (0.5 $cm^2$) piece of fin tissue will be excised. Up to 5 ml of milt will be collected from a maximum of 60 wild male steelhead that 1) are positively identified by ultrasound as kelts, 2) are in good condition, and 3) are readily able to express milt. The samples will be useful in future population restoration efforts, in conjunction with the population of origin identification provided by DNA analysis. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.6.2 and 9.6.5.3.5.2.

Research Action 2001: Research to collect relevant information for lower Columbia River fall chinook and chum salmon so that recommendations can be made for configuration and operation of the FCRPS to protect and/or enhance mainstem spawning populations. Additional studies are planned to characterize stranding of juvenile fish associated with fluctuating stream flows (due to FCRPS operations). The project will provide baseline data to properly manage natural spawning fall chinook and chum salmon in the mainstem Columbia River downstream of McNary Dam. Research will also evaluate the effects of fluctuating flows and power system load on fall chinook and chum salmon and their habitat as outlined in NWPPC (1994). The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.1, 9.6.1.2.3, and 9.6.5.3.3.

Research Action 2002: Research to evaluate modifications to the juvenile fish PIT-tag diversion systems at Lower Granite and Little Goose dams on the Snake River. The evaluation will include fish condition (descaling, injury, and mortality rates), travel time, detection efficiency, and relative survival for PIT-tagged fish. In addition, primary bypass survival will be compared with PIT-tag bypass survival, and a new three-way, diversion sampling system will be evaluated at Little Goose Dam. If injuries, descaling, or mortalities for PIT-tagged fish passing through the modified PIT-tag diversion systems are observed, additional PIT-tagged fish will be released at various locations along the passage route to determine where injuries or descaling occur. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 2003: Research to compare SARs of marked yearling and subyearling chinook salmon and steelhead juveniles transported from McNary Dam to below Bonneville Dam with the SARs of marked inriver migrating juveniles of these species released into the tailrace of McNary Dam. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.1.3.4.

Research Action 2004: Research to identify empirically the benefit to juvenile salmon of tidal freshwater and oligohaline transition zones in the Columbia River estuary. The long history of wetland loss in the Columbia River estuary, coupled with changed flow patterns, suggests that restoring these habitats may benefit the recovery of depressed salmon stocks. Habitat-salmon linkages in the Cathlamet Bay region (upstream of Tongue Point) will be evaluated using a combined monitoring and modeling approach to identify and validate the salmon-habitat associations in the lower Columbia River and estuary. That information will be coupled with a historical reconstruction of flow and sediment input in the system and a historical reconstruction of critical salmon habitat change using the geographic information system (GIS) to compare the historical data with present conditions. The approach will be to determine the relationship among shallow water habitats and the presence, use, and benefit to juvenile salmon (emphasizing subyearling chinook salmon) in the Columbia River estuary; understand change in flow and sediment input to the Columbia River estuary in the past and change in habitat availability throughout the lower river and estuary; and develop a numerical model of the lower Columbia River and estuary that can be used to evaluate associations between salmon use and habitat affected by both natural processes and human actions. The research is necessary to satisfy elements of the RPA described in Section 9.6.5.3.6.

Research Action 2005: Research to quantify the abundance of potential predators before and after a trash boom is installed in the forebay of Little Goose Dam. Potential predator fishes (smallmouth bass-*Micropterus dolomieu*, northern pikeminnow-*Ptychocheilus oregonensis*, and channel catfish-*Ictalurus punctatus*) will be collected using nighttime boat electrofishing along the shoreline (effective depth 2 to 4 m) and baited set-lines in deeper water. Sampling will be conducted for 3 to 4 nights over each 2-week period during the study until an acceptable population estimate (±95% confidence interval) can be determined. Adult and juvenile salmonids that encounter the electrical field are expected to move rapidly out of it. As proposed, sampling will cover the area along both the south and north shorelines and open water from Little Goose Dam (approximately RM 70) upstream to approximately RM 71.4. Most predator fishes will be marked with a Floy tag, except for about 50 individuals of all species that will be used for radiotelemetry distribution studies. The recapture of marked fish will make it possible to calculate predator populations by using closed and open population estimators before and after installation of the trash boom. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.5.2.

Research Action 2006: Research designed to evaluate the large-scale predation patterns of northern pikeminnow on juvenile salmonids and American shad (BPA project 9007800). The goal is to investigate large, systemwide (upriver versus downriver) patterns in predation processes, which may have consequences for salmonid survival and management. The large-scale patterns may include higher rates of predation on salmonids and higher growth and reproductive rates for predators in the Columbia River below Bonneville Dam than in the Columbia or lower Snake river reservoirs. The primary task will be to collect data on the size, age structure, and growth of northern pikeminnow populations at upriver versus downriver locations. Temporal variation in northern pikeminnow predation rates and diet will be emphasized. Two particular hypotheses will be examined: 1) temperature differences in the mainstem rivers can explain predation patterns, and 2) the abundance of alternative prey, especially juvenile American shad, can explain predation patterns. Boat electroshocking will be used to collect northern pikeminnow annually during May through October in the tailrace areas of Bonneville, The Dalles, and McNary dams on the Columbia River and at Lower Monumental Dam on the lower Snake River. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.5.1, 9.6.1.5.2, 9.6.1.5.3, and 9.7.1.5.

Research Action 2007: Research on the energy expenditure of upstream migrating adult salmon and steelhead in the Columbia and Snake rivers, for assessing the potential influence of delay, fallback, water temperature, and dam operations (e.g., spill) on migration energetics and, ultimately, on the reproductive performance of these fish. Adult spring chinook salmon en route to upstream locations will be collected from the Bonneville Dam collection facility. The fish will be surgically tagged with electromyogram/temperature radio transmitters and released either downstream or upstream of the Bradford Island fishway. The fish will be tracked using both mobile and fixed receivers and antennas. Telemetered electromyograms and fish temperature data will be collected as the fish move upstream through the tailrace, fishway, and forebay of Bonneville Dam (or other projects recommended by fish managers). Some of the fish will be tracked through Bonneville pool to the tailrace of The Dalles Dam. The research, funded by the Corps, will begin in 2001 and continue for an undetermined number of years. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.6, 9.6.1.6.2, and 9.6.1.7.2.

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Exhibit B

Survival and growth of fall Chinook salmon embryos exposed to elevated temperature and reduced dissolved oxygen during the first 40 days of incubation

Proposal to

Jim Chandler, Idaho Power Company, Boise, Idaho

By

David Geist, Battelle Northwest, Richland, Washington

July 22, 2004

## Introduction

Idaho Power Company (IPCo) is interested in assessing whether there are impacts to fall Chinook salmon embryos associated with either temperatures above the state water quality standards, and/or dissolved oxygen levels below the water quality standards. State water quality standards require that at the initiation of the fall Chinook salmon spawning period (October 23), water temperatures shall be no higher than 13 °C and dissolved oxygen (DO) levels should be no lower than 8 mg/L (Oregon).[1] In some years in the Hells Canyon Reach, these conditions are not met. IPCo is proposing that that the temperature at the initiation of fall Chinook salmon spawning be 16.5 °C and decrease according to the average temperature decline of the river during this time of year (~0.2 °C/d). IPCo is also proposing that the DO standard be revised to ≥ 4.0 mg/L October 23-November 7 (16 days); ≥ 6 mg/L November 8-November 30 (23 days); and ≥ 8 mg/L December 1-April 15.

Research by Battelle in 2003 showed there appeared to be a reduction in survival to emergence for fall Chinook salmon eggs incubated at an initial temperature ≥ 17 °C, but no significance difference in eggs incubated at temperatures ≤ 15 °C. Dissolved oxygen levels used in these studies were at 100% air-saturation. Research by Olsen and Foster (1958) and Olsen and Nakatani (1968) showed no apparent reduction in survival at temperatures ≤ 16 °C, but reductions in survival at temperatures ≥ 18 °C. Based on the results of the investigations mentioned above, there appears to be a reduction in survival at temperatures between 16 and 17 °C.

Dissolved oxygen requirements are variable during the early incubation period of salmonids with eggs requiring less dissolved oxygen than hatching embryos. Early eggs may only require < 2 mg/L, while hatching embryos may require up to 10 mg/L (see literature review section in IPCo document dated 7/13/2004).

In any event, very few studies have been conducted using a variable temperature or dissolved oxygen regime that mimics the temperature or dissolved oxygen regime of a

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[1] Note that Idaho's standard is 5.0 mg/L (daily minimum) and 6.0 mg/L (7-d average). For purposes of designing this experiment, we are using the more restrictive Oregon value of 8.0 mg/L.

natural river. A variable temperature/DO test of the impacts to embryo survival would offer an evaluation of alternative standards that may provide protection to the resource that is equal to the current standards.

## Objectives

The objectives of the work in 2004-2005 are to determine if elevated temperature and/or reduced dissolved oxygen during the first 40 days of incubation affects survival and growth of fall Chinook salmon embryos. Variable exposures will be done to mimic the rates in the natural river environment.

## Methods

### Equipment and Facilities

This study will be conducted at the U.S. Department of Energy's (DOE) Pacific Northwest National Laboratory (PNNL), Richland, Washington. PNNL is operated by Battelle for US DOE. Battelle will be responsible to obtain all the necessary permits and approvals required to conduct this work, including, but not limited to, a collection and transport permit from the Washington Department of Fish and Wildlife and Animal Care approval from the Animal Care Committee at PNNL.

Incubation during the first 40 days post-fertilization (PF) will be done in three separate troughs containing four experimental groups each (Groups 1 – 4 and 6 – 13 from Table 1). The remaining two groups (Group 5 and Group 14 from Table 1) will be incubated in separate water baths (130 L capacity). Each group will be assigned to a chamber in the in the troughs or to a water bath and will not be moved during the first 40 days PF.

Each trough (i.e., 4 groups) will be temperature controlled to one of three initial temperatures: 13 °C (Groups 1-4), 16 °C (Groups 6-9), and 16.5 °C (Groups 10-13). Each group will be exposed to an initial dissolved oxygen level of either 4 mg/L, 6 mg/L, 8 mg/L, or 100% air-saturation. The remaining two groups in the water baths (Group 5 and Group 14) will have initial starting temperatures of 15 °C and 17 °C, respectively with both at 100% air-saturation.

The temperature regime will mimic the natural river temperature regime, i.e., a decline of ~0.2 °C/d starting on Day 1 PF of the experiment. Temperatures in the three troughs will be achieved in 3 separate head tanks (one per trough). Cold and hot water will be mixed in the head tanks with water delivery controlled by temperature-controlled solenoid valves (precision 0.1 °C). A supplemental chiller may be used to achieve temperatures in the troughs that are cooler than ~9 °C; this primarily occurs in the groups 1 through 3 (13 °C head tank). The two water baths will be equipped with mechanical chillers that will be used to achieve the desired temperatures. The precision of the mechanical chillers is only ± 0.4°C which does not meet the precision requirements of the experiment. Therefore, we will use temperature-controlled solenoid values to operate the chillers so that precision (0.1 °C ) is the same as in the troughs.

Dissolved oxygen levels within the troughs will be achieved by establishing a "mixing" chamber between each treatment chamber. Nitrogen gas will be used to strip water of oxygen either in the head tanks or in the mixing chambers. Because this will not be done under pressure, nitrogen super-saturation is not expected to be a problem. Nitrogen gas will be delivered into the water supply via an oxygen sensor connected to a solenoid valve controlling nitrogen delivery. The troughs will be covered to eliminate mixing with air. Where necessary, air will be used to re-oxygenate experimental chambers.

After 40 days of incubation in the three troughs and water baths, eggs will be transferred to a Living Stream system (0.6 m x 2.74 m x 0.55 m deep, 700 L capacity) to continue incubation through emergence. The temperature within the Living Stream will be maintained using a mechanical chiller (±0.4°C temperature control) at temperatures based on recent historical temperature records for the upper Hell's Canyon Reach (unpublished data, Idaho Power Company). Once again, a temperature-controller may be used to increase precision. Dissolved oxygen levels in the Living Stream will be at 100% air-saturation. Egg tubes will be placed on a submerged platform that will hold the egg tubes at the water surface. Water will be circulated under and around the egg tubes by the recycling water within the tank.

Eggs will be placed in the same egg incubation tubes as were used in 2003. Egg tubes are constructed of 15-cm sections of 10-cm PVC pipe. Fiberglass fly screen (1.5 mm mesh) is glued to the bottom end of each tube with aquarium grade silicon sealant. Grooves have been cut in the sides of each tube (4 banks of eleven horizontal grooves, each 2.5 mm x 5-cm). Sections of PVC pipe will be placed in the water bath to act as spacers to allow water flow under as well as around and through each egg tube.

The same emergence systems used successfully in 2003 will be used in 2004. Emergence will be done in the Living Stream system. The emergence systems were designed to provide a dark, gravel-filled area where embryos could develop as well as a light "emergence" area which fish would seek upon emergence. The dark area is constructed of 5 cm white PVC pipe, ~ 17 cm long, and capped at the bottom while the clear collection area is constructed of 6.5 cm clear PVC pipe, screened on the bottom with fiberglass fly screen (1.5 mm mesh). The two chambers are connected at the water surface by a 1 cm clear PVC tube. Approximately 750 mls/minute of water will be introduced into the bottom of the dark side from a pressurized header system using water from the Living Stream. The flow from the dark tube will overflow into the top of the clear tube. Approximately 50 cc of pea gravel will be added to the bottom of the dark tube. Several gravel cobble (~ 2.5 cm diameter) and water will then be added to the dark side of the tube to create habitat with interstitial gravel spaces for the developing alevins. As alevins are added to the tube, more cobble will be added. When finished, the gravel will extend to ~ 2.5 cm below the water line and tube leading to the clear collection area.

Proposed Experimental Protocol

In 2003, adult Chinook salmon were obtained from Lower Granite Dam and were held at the PNNL facility until they were ready for spawning. Because of the variability in time-to-maturity for Chinook salmon, the spawn date of the females was spread out over 6 weeks. This type of variability is problematic for the experiments proposed in 2004. Therefore, we are proposing to collect 15 adult fall Chinook salmon (9 females and 6 males) from Lyons Ferry Fish Hatchery within one to two days of them being ready for spawning. For the experiment, we propose to spawn five females with several males; extra fish are needed to ensure we have sufficient eggs. We will coordinate delivery of adult fish with Lyons Ferry personnel. We expect to be present on the days that fish are examined by Lyons Ferry staff for readiness to spawn, and take only those fish that are ready to spawn based on the presence of mature gonads.

Fish will be transported from Lyons Ferry Fish Hatchery to PNNL in a 750 L plastic container filled with well water at 12-13°C and supplied with oxygen. Up to seven fish are normally transported per trip. More than one trip may be needed, and each trip is anticipated to last about 3 hours. During transport, fish will be sedated with MS-222 (15 mg/L) to minimize stress. Polyaqua (150 mg/L) will also be added to the water to treat and protect any external scrapes and lesions on the fish. Temperature and dissolved oxygen will be monitored continuously during the trip.

Upon arrival at the laboratory, fish will be individually netted from the transport tank and placed in one of three circular tanks. There will be no more than six fish per tank. The insulated fiberglass circular tanks are 1.8 m in diameter by 0.8 m deep with a 2.0 $m^3$ volume. Each tank will be covered with a hinged and padded fiberglass lid that will be propped open ~10 cm on one side to allow natural light to enter the tank while preventing the salmon from jumping out of the tank. Water flow through each tank will be approximately 95 L/min (three exchanges/h). Air stones will provide additional aeration and a bubble curtain for cover. Inlet flow will be introduced through a restricted orifice to produce a jet that will be adjusted to provide a velocity of ~0.3 m/sec along the outer wall of the tank. Each tank will have a screened center standpipe for effluent discharge. All holding tanks will be supplied with a continuous flow-through supply of aerated water from PNNL's groundwater well. The temperature of the circular tanks will be set to 12°C and this temperature will be maintained until fish are ready to be spawned.

To initiate spawning, a ripe female will be euthanized in a water bath (250 mg/L solution of MS-222). After euthanization, each female will be weighed (±0.1 kg) and measured (±0.5 cm). Excess moisture will be wiped from the external surfaces of the fish with a cloth towel. The fish will be held by the isthmus of the gills in a head-up position with the oviduct positioned over an empty plastic pail. Using a Wyoming knife, an incision will be made along the midline of the belly from the oviduct to the pectoral girdle, taking care not to allow blood to drip into the pail. The pail of ova will be covered and set aside while milt is collected from the males. Males will be placed in the anesthetic bath until they lose equilibrium and can be easily handled. Gentle pressure will be applied near the vent to check for the presence of free-flowing milt. If the extruded fluid is clear, the male will not be used. Milt will be collected in a plastic beaker and observed under a microscope for the presence and mobility of sperm. Sperm will be added to the ova and mixed. After sitting for about five minutes, four liters of 10°C well water will be added to the ova/sperm mixture. After one minute, about 90% of the water will be decanted off and replaced with clean water. The pail will then be placed in a water bath at 11°C and allowed to water-harden for 45 minutes. A sample of 50 eggs from each family will be weighed (nearest mg) and measured for diameter (nearest mm).

The eggs will be transferred to the labeled egg tubes (used to identify female and initial temperature and initial dissolved oxygen level) to begin incubation. Eggs from each family will be divided equally among the 14 experimental groups; one group will also be placed in an incubator at a constant 12 °C and 100% air-saturated dissolved oxygen. Families will be kept separate during the study. Fertilized eggs will be acclimated to their initial incubation temperature by moving egg tubes from one temperature compartment to the next at ~45-minute intervals until the egg tubes are distributed to the appropriate temperature/dissolved oxygen level.

After 40 days of incubation in the three troughs and water baths, all eggs will be transferred to the Living Stream system to continue incubation through emergence. Water temperatures and dissolved oxygen levels in the Living Stream will be representative of the Hells Canyon temperature and dissolved oxygen regime, and because of the different incubation temperatures, the temperatures of the incubation troughs, water baths and Living Stream will not be the same. This is not expected to harm the embryos because nearly all embryos will still be at the egg stage, which is very tolerant of temperature shock. Acclimation to the Living Stream system will be done by slowly raising or lowering the temperature of the egg tubes (2°C every 30 minutes) until the temperatures of all the egg tubes are at the temperature of the Hells Canyon regime. For example, assuming that the average temperature of the Snake River in the upper Hells Canyon Reach is around 15 °C on Day 1 PF of the experiment (assumed to be around October 23), then the temperature of the river at Day 40 PF would be ~7 °C (0.2°C/d*40 ds = 8°C drop). Thus, at the time the eggs are transferred, the Living Stream would range from 2°C warmer to 2°C cooler than the water table or water baths. Because it is not certain on what date the fish will be spawned, the temperature of the Living Stream at Day 40 PF will likely vary somewhat from 7 °C. Dissolved oxygen levels will be the same at Day 40 PF in all systems.

During incubation, temperatures, dissolved oxygen levels, and egg tubes will be checked daily. Temperatures will be recorded using a mercury thermometer and adjustments will be made to the water mixture and/or temperature-controlled solenoids to correct temperature aberrations. In addition, submersible temperature data loggers (e.g., Onset Hobo Water Temp Pro, certified accuracy ± 0.2°C) will be placed in each compartment of the troughs, the incubator, and water baths to record temperatures at 30-min intervals. Dissolved oxygen levels will also logged at 30-min intervals using .... (Jim – we are in the final stages of selecting a DO sensor/data logger).

Dead embryos will be counted and removed daily. Abnormal and/or retarded embryos will be noted and may include spinal deformities, eye defects, blue-sac disease (hydrocoele embryonalis), and full or partial twinning. Signs of fungus infection in some egg tubes, especially those in the warmer compartments, will make it necessary to remove dead (opaque) eggs daily with either forceps or a squeeze bulb and glass tube. Since eggs are very sensitive during the first two to three weeks of incubation, we will take care to minimize disturbance of developing eggs while removing dead eggs. Fungus (*Saprolegnia* sp.) will be treated daily until cured using 1,667 mg/L formalin solution for fifteen minutes. Eggs that are clumped together by fungus will be counted and removed.

When eggs reach 225 accumulated temperature units (ATUs), the eggs will be counted and scored as either eyed or dead/retarded. The embryos will be gently poured from their egg tube into a clear glass tray containing water at the same temperature and dissolved oxygen level as where the egg tube is positioned. The glass tray will be placed on a lighted table to examine the embryos. Pouring the embryos will cause most of the dead embryos to begin turning opaque; however, normal embryos will not be affected. An embryo will be considered normal if 1) eyes are obviously pigmented, 2) the embryo encircles ≥ half the circumference of the egg, and 3) the yolk is strongly vascularized.

Dead and retarded embryos will be counted and removed. "Normal" embryos will be counted and returned to their egg tubes for continued incubation.

The date of first hatch, 50% hatch, and 100% hatch will be determined by counting the number of un-hatched eggs and comparing that count to the total number of eggs/alevins in the egg tube. Hatched alevins will remain in egg tubes until they reach ~750 ATU's development. At that time they will be transferred to a shallow water-filled tray where the number of normal and abnormal alevins will be recorded. Abnormal alevins will be removed and euthanized and 100 normal alevins (when available) will be transferred to a labeled emergence tube. The transfer of alevins from the tray to the emergence tube will be made by gently scooping up alevins with a small piece of soft plastic mesh material and pouring them into the emergence tube. The alevins that are placed in the emergence tubes will be checked daily. Any alevins that emerges during the first 24 h will be discarded and their number subtracted from the original number placed in the tube. After 24 h, all emerging alevins will be counted and transferred back to an egg tube. We will record the date of first emergence, 50% emergence, and 100% emergence. Monitoring of emergence will continue until all alevins emerge or until 1200 ATU's is reached.

Within +/- 1 day of 50% hatch and again at 50% emergence, a sample of 15 alevins will be euthanized and preserved in 10% neutral buffered formalin (NBF). Alevins from the egg tubes will also be sampled for growth analysis at periodic intervals from hatching until post-emergence. The sample frequency will be adjusted to account for the speed at which development progresses (our goal is 10 to 11 samples per experimental group). At each sampling, 3 to 11 embryos (depending on survival rate) will be randomly removed from each egg tube, euthanized (if necessary), and preserved in 10% NBF. After 80 days in 10% NBF, all samples (i.e., 50% hatch, 50% emergence, and growth intervals) will be removed from the formalin, blotted dry, and individually measured for length (nearest 1 mm) and mass (wet; nearest 1 mg). Body tissue and yolk will be separated for each alevin, dried in an oven at 60 °C for 2 d, and then weighed as a group to the nearest 1 mg, i.e., one tissue and one yolk weight will be obtained for all samples sampled on the same date from each egg tube.

Data Analysis

Egg diameter and egg weight will be compared using a one-way ANOVA.

Survival will be calculated as the percentage of fertilized eggs or alevins that survived from one development period to the next, i.e., egg to eyed, eyed to hatch, and hatch to emergence. Survival to each development period within each experimental group will be evaluated among embryos. In each case, pairwise comparisons will be made to one of two reference groups – the incubator group that represents a constant temperature environment and the 13°C/100% air-saturation experimental group. The incubator group is used to represent ideal hatchery conditions while the 13°C/100% air-saturation group represents the state current water quality standard.

Differences in alevin and fry fork length (FL) or wet weight (WWT) at 50% hatching and 50% emergence among females and temperatures/dissolved oxygen will be analyzed using regression methods. Development index (kd) will be calculated as described in Bams (1970). Relationships between growth metrics and time (days post-fertilization) will be estimated by fitting the data to either a linear or polynomial regression.

Maximum alevin wet weights (MAWW), maximum tissue weight (MTW), maximum fork length (MFL), and minimum kd values will be estimated by taking the first derivative of the various polynomial equations and solving for the maximums/minimums.

The effect of temperature and initial egg size on the variation in time to 50% hatch and 50% emergence will be analyzed with a one-way ANOVA model.

## Schedule and Reporting

Preparation of laboratory equipment and incubation systems will commence upon award of contract, although some equipment will need to be ordered as soon as possible. In addition, preliminary testing will need to commence immediately. Adult fall Chinook salmon will be delivered to the PNNL facility in mid to late October, depending on approval from WDFW, fish availability and handling restrictions. Experimental studies will commence once fish are spawned, and will be terminated upon completion of emergence (expected early May, 2005). Embryos preserved in formalin will be measured June through July, 2005. Data analysis will be conducted from April, 2005 through August, 2005. A draft project completion report will be presented to Idaho Power Company by September 1, 2005. The report will incorporate results from year 1 of the study (2003-2004) and year 2 (2004-2005 as described here). A final report (4 copies) will be presented no later than October 1, 2005. The final report will incorporate comments made on the draft report.

Periodic reports to IPC will be made as requested, usually via email or telephone.

This work is of scientific interest and publication in a peer-reviewed journal is anticipated.

## Budget

This is provided under separate cover.

## Project Management

Dr. David Geist will be the project manager for this study. He will be responsible for ensuring all tasks are completed on time and within budget. He will also be responsible for the care and well being of experimental animals. An animal care certification will be obtained for this study.

## References

Bams, R.A. 1970. Evaluation of a revised hatchery method tested on pink and chum salmon fry. Journal of the Fisheries Research Board of Canada 27:1429-1452.

Olson , P.A., and R.F. Foster. 1955. Temperature tolerance of eggs and young of Columbia River chinook salmon. Trans. Am. Fish. Soc. 85:203-207.

Olson, P.A. and R.E. Nakatani. 1968. Effect of elevated temperatures on mortality and growth of young Chinook salmon. Annual Report of the Pacific Northwest National Laboratory to the USAEC Division of Biology and Medicine.

Table 1. Proposed experimental groups and treatment regimes for evaluating dissolved oxygen and temperature effects on the early incubation of fall Chinook salmon eggs and embryos. T = temperature (°C); DO = dissolved oxygen (mg/L); S = 100% air-saturation.

| | Group 1 | | Group 2 | | Group 3 | | Group 4 | | Group 5 | | Group 6 | | Group 7 | | Group 8 | | Group 9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO |
| 1 | 13 | 4 | 13 | 6 | 13 | 8 | 13 | S | 15 | S | 16 | 4 | 16 | 6 | 16 | 8 | 16 | S |
| 16 | 9.8 | 4 | 9.8 | 6 | 9.8 | 8 | 9.8 | S | 11.8 | S | 12.8 | 4 | 12.8 | 6 | 12.8 | 8 | 12.8 | S |
| 17 | 9.6 | 6 | 9.6 | 8 | 9.6 | 8 | 9.6 | S | 11.6 | S | 12.6 | 6 | 12.6 | 8 | 12.6 | 8 | 12.6 | S |
| 39 | 5.2 | 6 | 5.2 | 8 | 5.2 | 8 | 5.2 | S | 7.2 | S | 8.2 | 6 | 8.2 | 8 | 8.2 | 8 | 8.2 | S |
| 40 | 5.0 | 8 | 5.0 | 8 | 5.0 | 8 | 5.0 | S | 7.0 | S | 8.0 | 8 | 8.0 | 8 | 8.0 | 8 | 8.0 | S |

| | Group 10 | | Group 11 | | Group 12 | | Group 13 | | Group 14 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Day | T | DO | T | DO | T | DO | T | DO | T | DO |
| 1 | 16.5 | 4 | 16.5 | 6 | 16.5 | 8 | 16.5 | S | 17 | S |
| 16 | 13.3 | 4 | 13.3 | 6 | 13.3 | 8 | 13.3 | S | 13.8 | S |
| 17 | 13.1 | 6 | 13.1 | 8 | 13.1 | 8 | 13.1 | S | 13.6 | S |
| 39 | 8.7 | 6 | 8.7 | 8 | 8.7 | 8 | 8.7 | S | 9.2 | S |
| 40 | 8.5 | 8 | 8.5 | 8 | 8.5 | 8 | 8.5 | S | 9.0 | S |

Appendix E. Letters from the US Department of Commerce, NOAA, National Marine Fisheries Service, dated January 10, 2005, and from the Oregon Department of Environmental Quality, Eastern Region, Bend Office, dated January 10, 2005

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Oregon
Theodore R. Kulongoski, Governor

**Department of Environmental Quality**
2146 NE 4th Street, Suite 104
Bend, OR 97701
(541) 388-6146
Eastern Region
Bend Office

January 10, 2005

Ralph Myers
Water Quality Program Supervisor
Idaho Power Company
P.O. Box 70
Boise, ID 83707

Pete Newton
Idaho Power Company
P.O. Box 70
Boise, ID 83707

Re: Hells Canyon Complex Hydroelectric Project; FERC Project No. 1971;
ODEQ Comments on Draft Response to Additional Information Requests for WQ-1 (Dissolved Oxygen Augmentation), WQ-2(a) (Temperature Control, Conceptual Design Report), and OP-1(e) (Operational Scenarios – Water Quality).

Dear Mr. Myers and Mr. Newton:

The Oregon Department of Environmental Quality (ODEQ) has received a number of compact disks (CDs) containing Idaho Power Company's (IPC) draft response to additional information requests (AIRs) issued by the Federal Energy Regulatory Commission (FERC). As requested, ODEQ has reviewed and prepared the enclosed comments on IPC's draft response to the three draft AIRs responses identified above. ODEQ understands that per FERC's request, our comments will be considered and included in IPC's final response to AIRs.

Considering the tight timeline for requested comments, these comments are being provided by electronic facsimile as well as by overland mail to meet the January 10, 2005 deadline.

Please contact me if you have any questions or need clarification regarding these comments.

Sincerely,
Paul C. DeVito

Paul A. DeVito
Hydroelectric Specialist

PAD/rm
Enclosures:
Attachment 1: Comments on AIR WQ-1 (Dissolved Oxygen Augmentation)
Attachment 2: Comments on AIR WQ-2(a) (Temperature Control, Conceptual Design)
Attachment 3: Comments on AIR OP-1(e) (Operational Scenarios – Water Quality)

# Attachment 2

## ODEQ Comments on AIR WQ-2(a)
## (Temperature Control, Conceptual Design Report)

| Section | Comment |
|---|---|
| 1. | In the Introduction, the draft report states that "*The HCC, under its current configuration and operations, adequately protects and supports fall chinook spawning and rearing. This protection and support includes adequate water temperature and dissolved oxygen conditions below the project.*" ODEQ considers these statements as positions of IPC, rather than proven statements of fact, considering that both Oregon and Idaho state water quality standards for temperature and dissolved oxygen (DO) are seasonally violated below the project. For the waters downstream of Hells Canyon Dam, the temperature and DO standard criteria that apply were developed to protect the most sensitive beneficial uses of chinook spawning and rearing. Since the standard criteria are not being met at times of the year, ODEQ would argue that adequate temperature and DO conditions do not exist year-round below the project and that the current configuration and operation of the HCC do not adequately protect fall chinook spawning and rearing. ODEQ recognizes that IPC has submitted a petition to Idaho Department of Environmental Quality (IDEQ) to initiate a process for Site Specific Criteria (SSC) for the waters downstream of the HCC relative to temperature and DO. We also recognize that IPC may soon petition ODEQ for temperature and DO SSC. Further, we recognize that IPC believes that it can satisfactorily demonstrate that less stringent temperature and DO criteria are adequately protective. However, until the merits of SSC have been fully evaluated and ruled upon by the two states and the U.S. Environmental Protection Agency, ODEQ cannot and does not consider meeting proposed SSC standard criteria as being adequately protective. It should be stressed, too, that it is unknown whether or not SSC will be fully approved, and, if approved, what the SSC will be. Thus, IPC should rewrite this portion of the Introduction to more properly reflect this status. |
| 2.1.1. | IPC, in its development and evaluation of Protection, Mitigation and Enhancement (PME) measures, should be targeting the existing water quality standards as opposed to any criteria that are less stringent. ODEQ in its evaluation of water quality standards compliance for purposes of Clean Water Act Section 401 certification (401 certification) will evaluate the proposed project in the context of compliance with standards that exist on the books, or, in the case of an approved Total Maximum Daily Load (TMDL) load allocation, in terms of compliance with said load allocation. The Snake River-Hells Canyon (SR-HC) TMDL has established a temperature load allocation for the HCC for the river downstream of the HCC. Thus, for the lower river, ODEQ's 401 certification evaluation will consider the project's compliance relative to compliance with the SR-HC TMDL temperature load allocation and the DO criteria existing on the books for the protection of fall chinook and spawning. Thus, until such time as |

| | |
|---|---|
| | SSC are fully evaluated and approved, IPC alternatives should be developed and evaluated relative to temperature and DO objectives reflective of the SR-HC TMDL load allocation and the applicable state water quality standard DO criteria that exist on the books today. IPC's draft report evaluation does not reflect this and should be re-evaluated in terms of the appropriate temperature and DO objectives. |
| 2.1.2. | The conceptual designs and various costs (direct and indirect construction, oxygenation, lost power revenue, O&M, and total) should be revisited and revised in the context of compliance with appropriate temperature and DO objectives. These objectives should be consistent with the SR-HC TMDL load allocation for temperature and compliance with the existing DO standard criteria for the protection of chinook salmon spawning (including incubation up to fry emergence) and rearing. |
| Consultation | The consultation record should clearly indicate that while a 30-day commenting period was provided, a collaborative forum for stakeholder discussion and input regarding the draft AIR response was not provided. ODEQ understands that IPC proposes to provide presentation and discussion of the final AIR response reports to stakeholders during settlement negotiations to clarify IPC's AIR final responses, provide for related discussion, and to aid the determination of any additional information needs or revised presentation. ODEQ believes this should be clearly articulated in the final report. The draft report for this AIR response lacks a section for reporting on the requisite consultation. |
| Conclusion | Should be revised pending re-evaluation of alternatives developed for compliance with appropriate temperature and DO objectives and in consideration of consultation. |

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
NATIONAL MARINE FISHERIES SERVICE
525 NE Oregon Street
PORTLAND, OREGON 97232-2737

F/NWR5

January 10, 2005

Craig Jones, Project Manager
Idaho Power Company
PO Box 70
Boise, ID 83707

Dear Mr. Jones:

The National Marine Fisheries Service (NOAA Fisheries) is pleased to provide you with comments regarding Additional Information Request WQ-1 - (Dissolved Oxygen Augmentation), and WQ-2(a) - (Temperature Control, Conceptual Design Report). We look forward to working with Idaho Power Company in the coming months to further refine these concepts.

Sincerely,

Keith Kirkendall

Keith Kirkendall, Chief
FERC & Water Diversions Branch
Hydropower Division

cc: Ralph Myers (IPC)
Pete Newton (IPC)

**NOAA Fisheries' Comments on Idaho Power Company's Response to FERC Additional Information Request WQ-2(a): Temperature Control Conceptual Design Draft Report.**

**January 10, 2005**

NOAA Fisheries appreciates Idaho Power Company's (IPC) effort to comply with FERC Additional Information Request WQ-2(a) by providing additional information relating to the design and cost of structures allowing some control over the temperature of Hells Canyon Complex (HCC) outflows. To assist IPC in this effort, NOAA Fisheries offers the following comments.

## Introduction

1. NOAA Fisheries appreciates IPC's efforts to identify cost-effective methods of achieving the desired temperatures beyond those specified by FERC. We are open to further discussions relating to the three additional alternatives that IPC has identified (report at page 4).

2. We agree with IPC's identification of critical considerations, especially the first which notes the relationship between inflow, flood control operations, and water temperatures. This characterization is supported by NOAA Fisheries' discussion in our previous FERC filings relating this matter.

## Response to WQ-2(a)

3. On page 7, IPC indicates that as a target, the "daily temperature of water being discharged from Hells Canyon dam equals the temperature of water flowing into Brownlee Reservoir… through the time that inflow temperatures rise above 21 degrees $^{O}$C." On page 8, IPC notes that water quality standards for the summer migration period are 20 $^{O}$C, but goes on to indicate that McCullough (1999) indicates that temperatures of 21 $^{O}$C or lower should be protective of migrating fall chinook. NOAA Fisheries advises IPC to proceed with the assumption that 20 $^{O}$C is the maximum water temperature that is protective of migrating fish. Further, although this temperature criteria may comply with state water quality criteria for temperature, NOAA Fisheries believes that even lower temperatures are likely to be even more protective of specific life-stages of anadromous fish (see Table 1 – Summary of Temperature Considerations For Salmon and Trout Life Stages excerpted from *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards – March 11, 2003 Draft* included at the end of these comments). We urge you to consider the ability of the proposed structures to release 18 $^{O}$C water throughout the summer and early fall – even though this may be cooler than that minimally required to meet state temperature criteria.

4. We are concerned with IPC's proposed DO target of 6.0 mg/L or the DO concentration of inflows to Brownlee Reservoir, whichever is less, from October 23 – November 2 to protect incubating fall chinook salmon eggs and fry (report at page 10). We feel, for endangered fish, that it is important to have DO's closer to optimal ranges, rather than merely on the fringes of their tolerance. Assuming that IPC's statement that DO concentrations in newly constructed redds experience a drop in DO of about 2.0 mg/L is true, and based on information previously reviewed by NOAA Fisheries, we believe that 8.0 mg/L is more appropriately protective of incubating eggs and fry.

5. NOAA Fisheries notes on page 15 that IPC has discovered that redesigning the weir and/or gate structures would reduced the loss of energy due to head losses associated with these structures, and hence the estimated costs of alternatives 1 and 2 displayed in this report are therefore higher than would be the case if either of these structures was actually constructed. We suggest that in the final report, IPC continue to further refine their estimate of the lost power costs associated with these proposed structures, consistent with the purposes and underlying uncertainties of this reconnaissance level study.

6. We do not see much utility in pursuing the additional design and cost analysis of Alternative 1. This alternative does not include a mechanism for accessing cooler water in deeper strata of the reservoir. This has been identified by NOAA Fisheries as a capability necessary for reducing downstream summer and fall water temperatures to enhance migration conditions for juvenile and adult salmon and steelhead.

United States
Environmental Protection Agency | Region 10 Office of Water | EPA March 2003

EPA

# EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards

**March 11, 2003 Draft**

**Table of Contents**

**Table 1 - Summary of Temperature Considerations For Salmon and Trout Life Stages**

| Life Stage | Temperature Consideration | Temperature & Unit | Reference |
|---|---|---|---|
| Spawning and Egg Incubation | *Temp. Range at which Spawning is Most Frequently Observed in the Field | 4 - 14°C (daily avg ) | Issue Paper 1; pp 17-18<br>Issue Paper 5; p 81 |
| | * Egg Incubation Studies<br>- Results in Good Survival<br>-Optimal Range | <br>4 - 12°C (constant)<br>6 - 10°C (constant) | <br>Issue Paper 5; p 16 |
| | *Reduced Viability of Gametes in Holding Adults | > 13°C (constant) | Issue Paper 5; pp 16 and 75 |
| Juvenile Rearing | *Lethal Temp. (1 Week Exposure) | 23 - 26°C (constant) | Issue Paper 5; pp 12, 14 (Table 4), 17, and 83-84 |
| | *Optimal Growth<br>- unlimited food<br>- limited food | <br>13 - 20°C (constant)<br>10 - 16°C (constant) | <br>Issue Paper 5; pp 3-6 (Table 1), and 38-56 |
| | *Rearing Preference Temp. in Lab and Field Studies | 10 - 17°C (constant)<br>< 18°C (7DADM) | Issue Paper 1; p 4 (Table 2).<br>Welsh et al. 2001. |
| | *Impairment to Smoltification | 12 - 15°C (constant) | Issue Paper 5; pp 7 and 57-65 |
| | *Impairment to Steelhead Smoltification | > 12°C (constant) | Issue Paper 5; pp 7 and 57-65 |
| | *Disease Risk (lab studies)<br>-High<br>- Elevated<br>- Minimized | <br>> 18 - 20°C (constant)<br>14 - 17°C (constant)<br>12 - 13°C (constant) | Issue Paper 4, pp 12 - 23 |
| Adult Migration | *Lethal Temp. (1 Week Exposure) | 21- 22°C (constant) | Issue Paper 5; pp 17, 83 - 87 |
| | *Migration Blockage and Migration Delay | 21 - 22°C (average) | Issue Paper 5; pp 9, 10, 72-74.<br>Issue Paper 1; pp 15 - 16 |
| | *Disease Risk (lab studies)<br>- High<br>- Elevated<br>- Minimized | <br>> 18 - 20°C (constant)<br>14 - 17°C (constant)<br>12- 13°C (constant) | <br>Issue Paper 4; pp 12 - 23 |
| | *Adult Swimming Performance<br>- Reduced<br>- Optimal | <br>> 20°C (constant)<br>15 - 19°C (constant) | <br>Issue Paper 5; pp 8, 9, 13, 65 - 71 |
| | * Overall Reduction in Migration Fitness due to Cumulative Stresses | > 17-18°C (prolonged exposures) | Issue Paper 5; p 74 |

**Table 2 - Summary of Temperature Considerations For Bull Trout Life Stages**

| Life Stage | Temperature Consideration | Temperature & Unit | Reference |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Spawning and Egg Incubation | *Spawning Initiation | < 9°C (constant) | Issue Paper 5; pp 88 - 91 |
| | *Temp. at which Peak Spawning Occurs | < 7°C (constant) | Issue Paper 5; pp 88 - 91 |
| | *Optimal Temp. for Egg Incubation | 2 - 6°C (constant) | Issue Paper 5; pp 18, 88 - 91 |
| | *Substantially Reduced Egg Survival and Size | 6 - 8°C (constant) | Issue Paper 5; pp 18, 88 - 91 |
| Juvenile Rearing | *Lethal Temp. (1 week exposure) | 22 - 23°C (constant) | Issue Paper 5; p 18 |
| | *Optimal Growth<br>- unlimited food<br>- limited food | 12 - 16 °C (constant)<br>8 - 12°C (constant) | Issue Paper 5; p 90. Selong et al 2001. Bull trout peer review, 2002. |
| | *Highest Probability to occur in the field | 12 - 13 °C (daily maximum) | Issue Paper 5; p 90. Issue Paper 1; p 4 (Table 2). Dunham et al., 2001. Bull trout peer review, 2002. |
| | *Competition Disadvantage | >12°C (constant) | Issue Paper 1; pp 21- 23 |

*Cold Water Salmonid Uses*

Cold water salmonids are considered a sensitive aquatic life species with regard to water temperatures and a general indicator species of good aquatic health. EPA, therefore, believes it is appropriate for States and Tribes in the Pacific Northwest to focus on cold water salmonids when establishing temperature criteria to support aquatic life.

Under EPA's WQS regulations, States and Tribes may adopt sub-categories of uses and set appropriate criteria to protect those uses. See 40 C.F.R § 131.10(c). Because Pacific Northwest salmonids have multiple freshwater life stages with differing temperature tolerances, it is appropriate to establish sub-categories of use based on life stages. In addition, EPA's WQS regulations allow States and Tribes to adopt seasonal uses where a particular use applies for only a portion of the year. EPA's recommended approach is for States and Tribes to utilize both of these use designation options in order to more precisely describe where and when the different cold water salmonid uses occur.

In this guidance, EPA recommends seven sub-categories of cold water salmonid uses (see Tables 3 and 4). Four uses apply to the summer maximum temperature condition and three apply to specific locations and times for other times of the year (except for rare instances when these uses may apply during the period of summer maximum temperatures).

*Focus on Summer Maximum Conditions*

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Albert Teeman
Burns-Paiute Tribe
100 Pasigo Street
HC 71
Burns, OR 97720

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Teeman:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

In AIR WQ-2, the FERC directs IPC to consult with various entities (see attached list) on IPC's responses to items (a) – (c) of the AIR. Enclosed is a CD with an electronic copy of IPC's draft response to WQ-2(a) in .pdf format.

In its cover letter issuing the AIRs, the FERC directs IPC to allow for a 30-day review and comment period. Because of the tight time constraints established by the FERC for this AIR, your comments must be delivered to me by no later than January 10, 2004 for inclusion in the final report submitted to FERC. Comments received after the 30-day review period may not be included in the final response to AIR WQ-2.

Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Don Sampson
Columbia River Inter-Tribal Fish Commission
729 NE Oregon Street, Suite 200
Portland, OR 97232

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Sampson:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Robert Lothrop
Columbia River Inter-Tribal Fish Commission
729 NE Oregon Street, Suite 200
Portland, OR 97232

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Lothrop:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Peter C. Newton

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Gary Burke
Confederated Tribes of the Umatilla Indian Reservation
PO Box 638
Pendleton, OR 97801

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Burke:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Olney Patt, Jr.
Confederated Tribes of the Warm Springs
PO Box C
Warm Springs, OR 97761-0078

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Patt, Jr.:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
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IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Alan Mitchnick
Federal Energy Regulatory Commission
888 First Street, NE Mail Stop HL 11.4
Washington, DC 20426

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Mitchnick:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Sincerely,

Pete Newton

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IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Kate Kelly
Idaho Department of Environmental Quality
1445 North Orchard
Boise, ID 83706-2239

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Ms. Kelly:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

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BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Tracey Trent
Idaho Department of Fish and Game
600 South Walnut
PO Box 25
Boise, ID 83702

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Trent:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Peter G. Newton

Pete Newton

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Enclosure
Cc: Jim Tucker, IPC
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IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Rick Eichstaedt
Nez Perce Tribe
PO Box 305
Lapwai, ID 83540

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Eichstaedt:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Pete Newton

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P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Ritchie Graves
NOAA Fisheries
525 NE Oregon Street, Suite 500
Portland, OR 97232

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Graves:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
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Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Bob Lohn
NOAA Fisheries
525 NE Oregon Street, Suite 500
Portland, OR 97232-2737

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Lohn:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Peter G. Newton

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Paul DeVito
Oregon Department of Environmental Quality
2146 NE Fourth Street, Suite 104
Bend, OR 97701

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr DeVito:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

In AIR WQ-2, the FERC directs IPC to consult with various entities (see attached list) on IPC's responses to items (a) – (c) of the AIR. Enclosed is a CD with an electronic copy of IPC's draft response to WQ-2(a) in .pdf format.

In its cover letter issuing the AIRs, the FERC directs IPC to allow for a 30-day review and comment period. Because of the tight time constraints established by the FERC for this AIR, your comments must be delivered to me by no later than January 10, 2004 for inclusion in the final report submitted to FERC. Comments received after the 30-day review period may not be included in the final response to AIR WQ-2.

Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Colleen Fagan
Oregon Department of Fish and Wildlife
107 20th Street
La Grande, OR 97850

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Ms. Fagan:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Peter C. Newton

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

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BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Frederick Auck
Shoshone-Bannock Tribe
PO Box 306
Fort Hall, ID 83203

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Auck:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
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Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Donald Clary
Shoshone-Paiute Tribe
633 West Fifth Street Twenty-First Floor
Los Angeles, CA 90071-2040

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Clary:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Please contact me if you have questions or need clarification.

Sincerely,

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Pete Newton
Engineering Project Leader
Power Production Department

Phone 208-388-2845
Fax: 208-388-6902
E-mail PNewton@idahopower.com

December 8, 2004

Jeffery Foss
U.S. Fish and Wildlife Service
1387 South Vinnell Way, Suite 368
Boise, ID 83709

Re: Hells Canyon Additional Information Request WQ-2(a) – Temperature Control, Conceptual Design Report

Dear Mr. Foss:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application. As part of the AIR, FERC directed IPC to provide information on a temperature control structure (AIR WQ-2).

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Sincerely,

Peter G. Newton

Pete Newton

PN/cgs
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, Davis Wright Tremaine

**Idaho Power Company**
**Hells Canyon Complex (FERC Project No. 1971)**
**WQ-2 (a) Additional Information Request - Consulting Entities List**

| | |
|---|---|
| Albert Teeman | Burns-Paiute Tribe |
| Robert Lothrop | Columbia River Inter-Tribal Fish Commission |
| Don Sampson | Columbia River Inter-Tribal Fish Commission |
| Gary Burke | Confederated Tribes of the Umatilla Indian Reservation |
| Olney Patt, Jr. | Confederated Tribes of the Warm Springs |
| Alan Mitchnick | Federal Energy Regulatory Commission |
| Kate Kelly | Idaho Department of Environmental Quality |
| Tracey Trent | Idaho Department of Fish and Game |
| Rick Eichstaedt | Nez Perce Tribe |
| Ritchie Graves | NOAA Fisheries |
| Bob Lohn | NOAA Fisheries |
| Paul DeVito | Oregon Department of Environmental Quality |
| Colleen Fagan | Oregon Department of Fish and Wildlife |
| Frederick Auck | Shoshone-Bannock Tribe |
| Donald Clary | Shoshone-Paiute Tribe |
| Jeffery Foss | U.S. Fish and Wildlife Service |