US Army Corps of Engineers ®
Portland District

**DESIGN DOCUMENTATION REPORT**

**BONNEVILLE DAM**
**COLUMBIA RIVER BASIN**
**COLUMBIA RIVER, WASHINGTON**

# BONNEVILLE SECOND POWERHOUSE AUXILIARY WATER SUPPLY TRASH RAKING SYSTEM

**90 Percent DDR**
**February 28, 2014**

**BONNEVILLE DAM**
**SECOND POWERHOUSE AUXILIARY WATER SUPPLY TRASH RAKING SYSTEM**
**DESIGN DOCUMENTATION REPORT**

## SYNOPSIS

## 1. INTRODUCTION

This Design Documentation Report (DDR), in support of the Bonneville B2 fish turbine trash rake, describes the design, construction, operation and maintenance of the preferred alternative to improve fishway operations at the Bonneville Second Powerhouse.

## 2. PURPOSE

This document augments the document *Bonneville Second Powerhouse Auxiliary Water Supply Backup System* (Design Documentation Report) dated November 2001 under Project No. DACW57-97-D-0004, Task Order No. 0023. In that report a number of modifications were suggested to improve fishway operation at Bonneville Second Powerhouse in an emergency when a fish unit fails or is taken out of service:

a. Stockpile crucial spare parts for the Fish Units (turbines).
b. Block off the lower trash rack panels at the Fish Unit intakes to better control sediment transport into the Auxiliary Water Supply (AWS) system.
c. Replace the existing trash racks and trash rake with new continuous bar trash racks and an automatic traveling gripper rake system.
d. Place a log barrier in front of the Fish Unit intakes.
e. Install two sets of level transducers across the diffuser grating at the A and B diffuser gates in order to monitor clogging.

The 2014 DDR recommends the following to supplement the 2001 DDR recommendations to improve fishway operation at Bonneville Second Powerhouse:

*Construction:*

f. Existing rake should be modified to improve its ability to strip and retain matted grasses from the surface of the intake racks.

*Operations and Maintenance:*

g. Rake as needed to maintain acceptable rack differentials.
h. Maintain design bathymetry in front of the Fish Units by maintenance dredging the forebay. Develop criteria to initiate action to dredge based on results of annual monitoring of sediment accumulation.
i. Rake as needed based on rate of debris accumulation and known high debris periods.
j. Conduct annual sediment buildup monitoring upstream of the fish units following peak spring river flows based on bathymetry and soundings so that a dredging contract can be executed for the next in water work period.
k. Monitor water height differential at each trash rack before and after cleanings and floating of debris. These events should be logged with date, time, duration, and any other information deemed necessary by the operator.

l. Annually remove intake racks and manually remove wedged in woody debris.
m. Biennial rack inspection of the structure, coating system, and damage repair.
n. Periodically exercise Auxiliary Water Supply (AWS) system diffuser gates that are not used regularly.
o. Continue to operate with the existing trash racks and maintain intake rack bar to bar spacing of 0.875 inch until new evidence requires a change.
p. Float debris only in emergency situations.

3. BONNEVILLE DAM LOCATION

Bonneville Lock and Dam is a large hydroelectric facility on the Columbia River. The Dam consists of several run-of-the-river dam structures that together complete a span of the Columbia River between the states of Oregon and Washington at River Mile 145.2. The dam is located 40 miles east of Portland, Oregon, in the Columbia River Gorge. The primary functions of Bonneville Lock and Dam are electrical power generation, flood control, and river navigation. There are two powerhouses and a spillway at Bonneville Lock and Dam. The first powerhouse and spillway were completed in 1938 and the second powerhouse was completed in 1981. The Corner Collector channel is an extension of the original ice and trash sluiceway that was constructed at the southern end of powerhouse two.

4. CONSTRUCTION

A formal plans and specifications package will not be used to complete the work. Sketches of the required rake modifications will be provided to the Bonneville Dam project staff that will perform the proposed modifications. Future dredging and hydro surveys should be coordinated with agencies and will likely occur during normally scheduled fish unit outages.

5. COST

The cost of this project is estimated to be $69,144 dollars. This cost includes labor, materials, and off the shelf parts.

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## PERTINENT PROJECT DATA

| Item | Data |
|---|---|
| Dam | |
| Dam Location | Columbia River, Oregon and Washington, River Mile 145.2 |
| Forebay Deck EL | 90 fmsl |
| Tailrace Deck EL | 55 fmsl |
| Maximum Operating Reservoir Level Elevation | 77 fmsl |
| Maximum Pool Elevation | 87.5 fmsl |
| Maximum Tailwater Elevation | 35 fmsl |
| Minimum Tailwater Elevation | 7 ft fmsl |
| | |
| Fishway | |
| Fish Turbines | 2- Escher Wyss Turbines |
| Maximum Flow | 3000 cfs per unit |
| Intake Invert | -22.52 fmsl |
| Trash Rack Area | 2530 sf per unit |
| Fishway Main Entrances | 4 – South Downstream Entrance (SDE), South Upstream Entrance (SUE), North Downstream Entrance (NDE), North Upstream Entrance (NUE) |
| Gate Type | Three leaf telescoping weir. |
| Main Entrance Invert EL | - 3 fmsl |
| Main Entrance Width | 12 ft |
| Flow @ Main Entrances | Varies with tailwater. Approximately 1200 cfs per gate. |
| Floating Orifice Gates | 12 total (20 slots) |
| Location | Access from El 55 fmsl tailrace deck |
| Width | 8 ft |
| Length | 42 ft |
| Weight | Approximately 12,000 lbs |
| Orifice Width | 8 gates – 2 ft wide, 4 gates – 4 ft wide |
| Orifice Height | 6 ft |
| Flow Through Orifices | Varies with head difference across the orifice. Approximately 90 cfs per orifice. |

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing Materials |
| ASME | American Society of Mechanical Engineers |
| AWS | Auxiliary Water Supply |
| B1 | Bonneville First Powerhouse |
| B2 | Bonneville Second Powerhouse |
| CENWP | Corps of Engineers Northwest Division Portland District |
| CFD | Computational Fluid Dynamics |
| CMAA | Crane Manufactures Association of America |
| cf | Cubic feet |
| cfs | Cubic feet per second |
| cy | Cubic yard |
| DDR | Design Documentation Report |
| EL | Elevation |
| EMT | Electrical Metallic Tubing |
| fmsl | Feet mean sea level |
| fpm | Feet per minute |
| fps | Feet per second |
| FPP | Fish Passage Plan |
| FU | Fish Unit |
| H | High |
| HDC | Hydroelectric Design Center, US Corps of Engineers -Portland |
| HP | Horse power |
| ID | Identifier |
| in | Inch |
| IEEE | Institute of Electrical and Electronic Engineers |
| IMC | Intermediate Metal Conduit |
| kW | Kilowatt |
| NEC | National Electrical Code |
| NEMA | National Electrical Manufactures Association |
| NFPA | National Fire Protection Code |
| NDE | North Downstream Entrance |
| NUB | North Upstream Entrance |
| PVC | Poly vinyl chloride |
| PE | Polyethylene |
| lb | Pound |
| lbs | Pounds |
| pcf | Pounds per cubic feet |
| psf | Pounds per square feet |
| psi | Pounds per square inch |
| PRM | Progress Review Meeting |
| RGS | Rigid Galvanized Steel |
| SDE | South Downstream Entrance |
| SUE | South Upstream Entrance |

| | |
|---|---|
| sf | Square feet |
| scfm | Standard cubic feet per minute |
| Stn Stl | Stainless Steel |
| kcfs | Thousand cubic feet per second |
| UHMW | Ultra High Molecular Weight |
| UMT | Cascade Island Upstream Migration Tunnel |
| USACE | United States Army Corps of Engineers |
| v | Volt |
| w | Wide |

5 March 2014

**Attachment C-1**
**COMPLETION OF DISTRICT TECHNICAL REVIEW**

The District Technical Review (DTR) has been completed for the DDR for the Bonneville Second Powerhouse Auxiliary Water Supply Trashrake. During the DTR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The DTR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the DTR have been resolved and the comments have been closed in DrChecks[sm].

Marie J. Phillips
DTR Team Leader
CENWP-EC-HD

3/5/14
Date

Eric Stricklin
Project Manager
CENWP-PM-F

3/5/14
Date

**CERTIFICATION OF DISTRICT TECHNICAL REVIEW**

Significant concerns and the explanation of the resolution are as follows: Additional details to clarify objectives and design were requested from several reviewers and were provided in the evaluation and backcheck copy provided to the DTR team.

As noted above, all concerns resulting from the DTR of the project have been fully resolved.

*SIGNATURE*
Lance Helwig, P.E.
Chief, Engineering Division
CENWP-EC

4/1/14
Date

# SECTION 1
# PURPOSE AND INTRODUCTION

## 1.1 SCOPE AND PURPOSE

a. General. The U.S. Army Corps of Engineers (Corps), Regional fisheries agencies, and tribes have been concerned with deficiencies in the Auxiliary Water Supply (AWS) system for the adult fishway at the Bonneville Second Powerhouse (B2). The basis for concern has largely been due to improved fish passage data as well as events since 2001 when debris accumulation occurred in and upstream of the AWS that significantly impaired the operation and performance of the AWS system.

Current operations during periods of elevated debris in the Columbia River have required that the Fish Units that supply water to the AWS system be shut down for short durations. This procedure enables project personnel to float the debris away from the Fish Units in order to maintain a safe range of headloss across the trash racks. There is evidence that shutting the units down is detrimental to salmonid as well as lamprey passage due to the inability to maintain fish ladder operating criteria. The Corps has assembled a Product Development Team (PDT) to design, construct, and install a debris removal system that allows effective and efficient debris removal without shutting the units down.

The scope of modification for this project focuses on improvements to the intake racks and raking system without adversely affecting the AWS system functionality. The system improvement goals are listed below.

b. System Improvement Goals

(1) Develop a strategy to improve adult salmon and lamprey passage conditions related to debris accumulation on the fish turbine intake trash racks.
(2) Provide a system or improve upon the current method that can keep the fish unit intake racks clean during operation of the AWS system for the adult salmon ladder.
(3) Ensure sediment build up does not increase due to implementation of an improved system or method.
(4) Explore possible changes to operational procedures to minimize debris accumulation in the AWS system.

## 1.2 AUTHORIZATION

Authorization for this study comes from the following: Flood Control Act of 1950, in accordance with the Report of the Chief of Engineers in House Document 531, 81$^{st}$ Congress, 2$^{nd}$ Session, and modified for development of waterfowl management areas by the Flood Control act of 1965 in accordance with the Report of the Chief of Engineers in Senate Document 28, 89$^{th}$ Congress, 1$^{st}$ Session.

## 1.3 PROJECT DESCRIPTION

This project was started under the 1995 FCRPS BiOP, Reasonable and Prudent measure #7, Incidental Take Statement #16. RPA #7 required the Corps to stay within Fish Passage Plan

Criteria. The 2014 Supplemental and 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) RPA #32 states –

*"The Corps will annually prepare a Fish Passage Plan (FPP) in coordination with NOAA Fisheries and the Regional Forum through Fish Passage Operations and Maintenance (FPOM). The Corps will operate its projects year round in accordance with criteria in the FPP."*

A list of measures was developed through coordination with the Fish Passage Operations and Maintenance (FPOM) regional group and the System Configuration Team. These measures were addressed in a letter report entitled Adult Fish Passage Improvements for Bonneville, The Dalles and John Day Dams, dated September 1997. For Bonneville Dam, a trash rake for the B2 fish units was designed, constructed and delivered to the site. This rake has never functioned properly and has not been used by the Project maintenance staff, despite numerous attempts to address its deficiencies over the years. The current method of removing debris from the B2 fish unit trash racks includes shutting down the fish units at night to float the debris off. This method of trash removal puts the B2 adult ladders out of fish passage criteria and it delays adult lamprey which pass predominantly at night. In addition, starting and stopping the units creates undue wear and tear on the turbines.

a. Main Features. The main features studied in this DDR, beginning at the forebay and ending at the tailrace, are as follows: the north forebay approach flow and bathymetry, the two fish units, the two fish unit trash racks, the trash rake and trash handling, and the auxiliary water supply (AWS) system and how it interacts with the adult fish ladder (see plates 5-13, also found in the 2001 DDR as plates 1-9).

## 1.4 AGENCY COORDINATION

Agency coordination is conducted through the Fish Facility Design Review Work Group (FFDRWG) regional forum. Members include representatives from the Action Agencies, Federal and State fisheries managers, and Columbia River Inter-Tribal Fish Commission (CRITFC). Agency review occurred at 90 percent DDR.

## 1.5 PROJECT SPECIFIC REFERENCES


a. Bonneville Second Powerhouse Auxiliary Water Supply backup System DDR, November 2001.
b. Bonneville 2nd Powerhouse Fish Unit Debris Study Reconnaissance Report, Final, July 20, 2000.
c. Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems (HELCRABS) Bonneville Second Powerhouse Fishway Evaluation Report, September 2005.
d. 99% Lamprey Grating Report, May 2008.
e. Washington Shore Fishway Structural and Mechanical Work Performed Report, March 2011.
f. Fish Passage Plan, Corps of Engineers Projects, 2013.
g. Anadromous Salmonid Passage Facility Design, NMFS, July 2011.
h. Johnson, E. L., C. C. Caudill, M. L. Keefer, T. S. Clabough, C. A. Peery, M. A. Jepson, and M. L. Moser. 2012. Movement of Radio-Tagged Adult Pacific Lampreys during a Large-Scale Fishway Velocity Experiment. Transactions of the American Fisheries Society. 141:3, 571–579.

i. Bonneville Powerhouse 2 Fish Unit Sedimentation Studies: CFD Model of the Forebay with Structural Alternatives, PNNL, August 2013.
j. $2^{nd}$ Powerhouse Trash Structure Design Memorandum No. 25

# SECTION 2
# BACKGROUND

## 2.1 GENERAL

Several studies regarding the Bonneville Second Powerhouse Auxiliary Water System were completed between 1998 and 2000 and were discussed in the November 2001 report entitled "Bonneville Second Powerhouse Auxiliary Water Supply Backup System Design Documentation Report." For a reference, there are 20 individual trash racks. Each unit has two slots that contain five trash racks per slot. The bottom trash rack in each slot has been plated over to capture debris in front of the units. The upper 16 trash racks are currently still operational.

a. AWS system improvements recommended in the 2001 DDR included:

(1) Stockpile crucial spare parts for the fish units (turbines).
(2) Block off the lower trash rack panels at the Fish Unit intakes to better control sediment transport into the AWS system.
(3) Replace the existing trash racks and trash rake with new continuous bar trash racks and an automatic traveling gripper rake system.
(4) Place a log barrier in front of the fish unit intakes.
(5) Install two sets of level transducers across the diffuser grating at the A and B Diffuser Gates in order to monitor clogging.

b. Recommended operations improvements from the 2001 DDR included the following:

(1) Perform annual soundings immediately upstream of the fish unit intakes and dredge during the in-stream work window (December through February if required).
(2) Outfit the floating orifice gates with aluminum sliding closure plates that can be installed into guides mounted around the orifices. Plates would be installed by raising the floating orifice gates up to the EL 55 deck level.
(3) Test and verify the recommended operations plan after modifications to the floating orifices have been made.
(4) Implement the proposed operations plan, in the event of a Fish Unit turbine failure, to modify gate settings, close floating orifices, close selected gates, and regulate flow at the remaining Fish Unit Turbine.

c. Improvements related to the trash raking system performed to date:

(1) The lower trash racks have been blocked off. This creates a bedload sediment and debris trap for the fish unit turbines. In operation this appears to have the benefit of allowing a longer period of time that the turbines can operate before sediment inundates the diffuser channels within the ladder. The debris trap also seems to help with debris management at the intake racks. The modification does not appear to have affected turbine operation. In 2012, a sounding was conducted in the area upstream of the fish units as a prerequisite to a planned dredging effort. Dredging occurred during the 2013 in-water work period removing approximately 8000 cubic yards of sediment from the forebay area in front of the fish turbines. The effort yielded a final elevation in front of the fish units of -22 msl.

(2) A new manual rake designed to improve debris removal was fabricated in 2005. This new rake is currently not being used by the rigging crew as it proved to be less effective than the existing manual rake. The rigging crew noted the following problems:

- Rake does not capture and retain debris (Logs or Grasses)
- Rake trips upper crane limit switch
- Rake intermittently trips the maximum load cell switch during rake retrieval
- Rake teeth, fabricated using composite bearing material are damaged beyond repair after three rake events

## 2.2 EXISTING CONDITIONS

a. General. B2 auxiliary fishway water supply turbines are protected by trash racks with a very high vertical bar to width ratio. The vertical bars have a clear spacing between the bars of 0.875 in. There are two rakes on site designed to clean the racks; one is referred to as the existing rake, shown in Figure 2-1, and the other is referred to as the new rake, shown in Figure 2-2. The auxiliary hoist on gantry crane 7 is used to perform any needed raking. The new rake was built in an effort to make raking more efficient. However, after use it was determined to be less effective than the previous model.

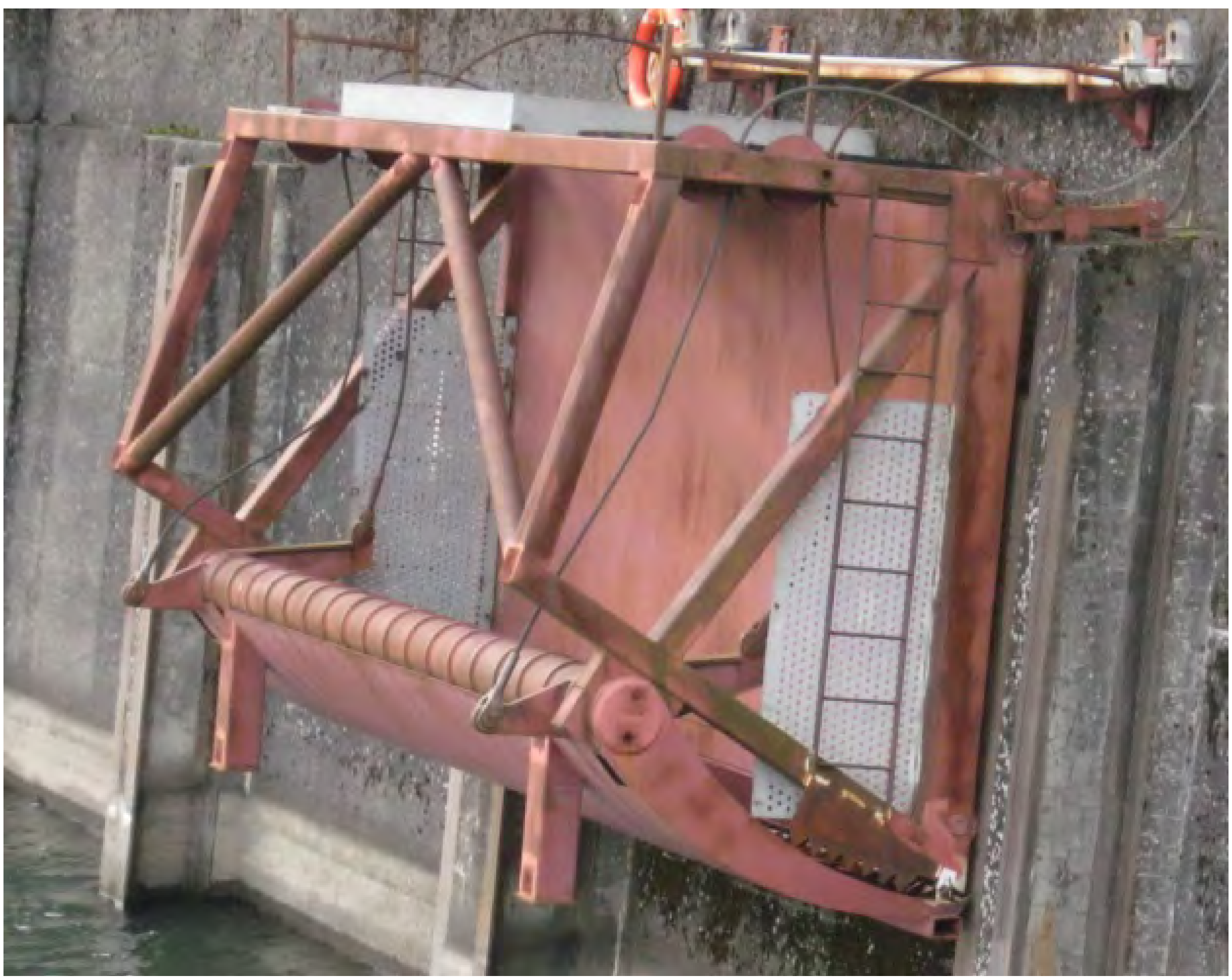


**Figure 2-1:** Existing or "Old Trash Rake"

**Figure 2-2:** New Trash Rake

b. Current Methods to Clean Fish Unit Trash Racks During Fish Passage Season.

(1) The primary method includes using the original trash rake operated from the auxiliary hoists of the upstream gantry crane 7 at B2 located on the elevation +90 intake deck. The existing rake was designed to capture debris against the trash rack on the down-stroke with back-teeth that were meant to engage the rack. Once at the bottom, an opened jaw that pivots would close and capture debris. The closed rake would then be pulled up and the debris released into a container on the intake deck. The container would then be hauled off to a land site for debris disposal. The actual rake operation captures and removes some of the larger debris in front of the trash rack but also pushes some close-in debris down to the bottom of the trash rack. The spring loaded back-teeth do not engage the rack as intended and the rake tends to ride over the top of low profile debris that has accumulated on the surface of the trash rack as well as any impacted debris between the trash rack bars.

(2) The secondary method of cleaning the trash racks is to shut down the fish units allowing trash to "float" off the trash racks. Floating debris is done at night for approximately three hours, or during the day when needed. Some of the debris appears to be drawn into main unit 18 as the rate of debris build up on the unit's Vertical Barrier Screens (VBS) tend to accumulate at an accelerated rate when

compared to the other B2 main units. To keep the unit 18 VBS differential head within criteria between cleanings, there may be a need to alter unit operations by reducing load (within the 1 percent best efficiency curve). Reducing load on this priority unit may have an impact to power production.

(3) A third method to clean the trash racks include periodically pulling each trash rack out of its slot and manually removing the woody debris wedged in the clear space between the flat bars.

c. Debris Management. The existing trash rake does not engage the clear spacing between rack bars to completely remove small wood or other material that can get lodged in the clear spaces between bars. Stopping fish unit operation to float trash is likely ineffective for removing debris stuck in the clear spacing between bars. Trash rack extraction to the +90 msl deck level during the winter maintenance period and manual removal of embedded debris with hand tools is required to clear the racks.

High drawdown on the fish unit trash racks increases pressure on the racks and increases the risk of forcing embedded woody debris between the trash rack bars, through the fish units, and into the AWS system. In past years, small woody debris has accumulated within the AWS system forcing complicated extraction and the potential for blockage of the AWS diffuser gratings. It is likely that many of the variable sized pieces of woody debris that make it through the trash racks align in such a way as to become trapped under the AWS diffuser gratings .

Small woody debris, Asian clam shells (genus *Corbicula*), and significant accumulation of fine sediment occluded flow through the diffusion gratings and diffuser chambers resulting in numerous sections of grating becoming dislodged in 1996 and 2011. This allowed access of any fish species that may have been present in the ladder to enter the AWS system including salmonids, lamprey, bull trout, and sturgeon. It is very difficult to remove fish that access areas under grating. It consists of dewatering the entire AWS system to get access throughout the system if diffuser gratings north of the junction pool become dislodged. Ladder dewatering below tailwater is required for fish salvage and grating repair.

## 2.3 Fish Unit Down Time

Operations flow data and gantry crane 7 logs were used to analyze the fish units. Gantry crane 7 logs are used by crane operators to log their tasks when they perform work on the dam. The crane logs were reviewed to determine how many times the fish unit trash racks were raked and operations data was used to determine how often the fish units had down time.

Operations data is automatically recorded for Bonneville Dam in five minute intervals. The records are comprised of the turbines, spillway gates and fish units of the dam. The objective of analyzing operations data for this project was to identify durations of time when the two fish units were shut down simultaneously to better assess the magnitude of the biological and maintenance impact. Typically, operators only turn off both fish units to float trash or perform maintenance. Floating trash can range from durations of ten minutes to several hours. This analysis assumed that when both fish units were not operating at the same time within the aforementioned range of durations, the operators were floating trash to clear the fish unit trash racks of debris.

The turbines, spillway gates and fish units are denoted as T, S, and F, respectively, in the raw operations data sets. Relevant measured variables in the data include Kilo Cubic Feet per Second (KCFS), megawatt (MW) output, time of day (TIME), and the date of data recorded (DATE). Measurements included that were not of concern are forebay (FB), tailwater (TW) and head on the unit (HD). These were eliminated when parsing the data for this analysis. Each flow data report comes out as one or two month increments and can be inserted into spreadsheets. The purpose of this analysis was to isolate fish unit records. Therefore, turbine and spillway gate information were not needed and were removed from the spreadsheets.

The data was condensed to periods where both fish units had a KCFS value of zero. Each of these periods was recorded in a table that shows the date of collected data, the start of the time period, the end of the time period, and the time duration. There is a table for each year from 2004 to 2013. These tables were then combined to show how many periods were within certain ranges of time. These ranges consist of 0 to 0.25 hours, over 0.25 hours to 1 hour, over 1 hour to 5 hours, and over 5 hours. Data is collected during the fish passage season, which is March 1$^{st}$ to November 30$^{th}$. Results from this data can be found in Appendix I.

Gantry crane 7 logs were reviewed to determine how many times the fish unit trash racks were raked to help deduce how often the fish rake was used as well as link the relationship between manual raking and floating trash during maintenance of the system. The results from this review were inconclusive due to crane log availability from past years and inconsistency in the gantry crane 7 event log specifying fish unit raking events.

### 2.4 Trash Rack, AWS System, and Diffuser Grating Debris Accumulation

*The B2 Fish Unit Debris Study Reconnaissance Report*, Final, July 20, 2000 and *B2 Auxiliary Water Supply Backup System*, November 2001, DDR contain information regarding trash rack debris accumulation as well as sediment debris accumulation in the fishway and forebay. Plate 11 (plate 7 in 2001 report) indicates a March 2000 rise in invert elevation in front of fish unit 2 of up to 20 feet above the original 1986 design. Significant events that have occurred in the system since those reported in the sources above are described below:

a. A contracted dredging event in 2004 with SDS Lumber occurred upstream of the Fish Units and 2000 cy of material was removed.

b. During 2011, a routine B2 collection channel ROV inspection in early August revealed three diffuser gratings in the B2 north monolith junction pool where fasteners failed and the gratings became dislodged, many of which exposed openings that allowed fish to access the diffusion chamber and AWS system. A comprehensive inspection followed with a crane and manbasket where personnel used underwater camera equipment in the weirs upstream to determine the extent of the diffuser grating damage. An emergency ladder dewatering and dive was coordinated to secure eight gratings that were found misplaced. The WA shore ladder was dewatered from the junction of the Cascade Island Upstream Migration Tunnel (UMT), near weir 67, to tailwater and out of service from August 16-17. Divers re-secured diffuser gratings that came loose below tailwater and the project structural crew worked on securing diffusers in the dry areas of the ladder downstream of weir 35. The diffuser gratings that were dislodged are identified in **Figure 2-3** by shaded area from weir 35 downstream to the junction pool area below weir 8.

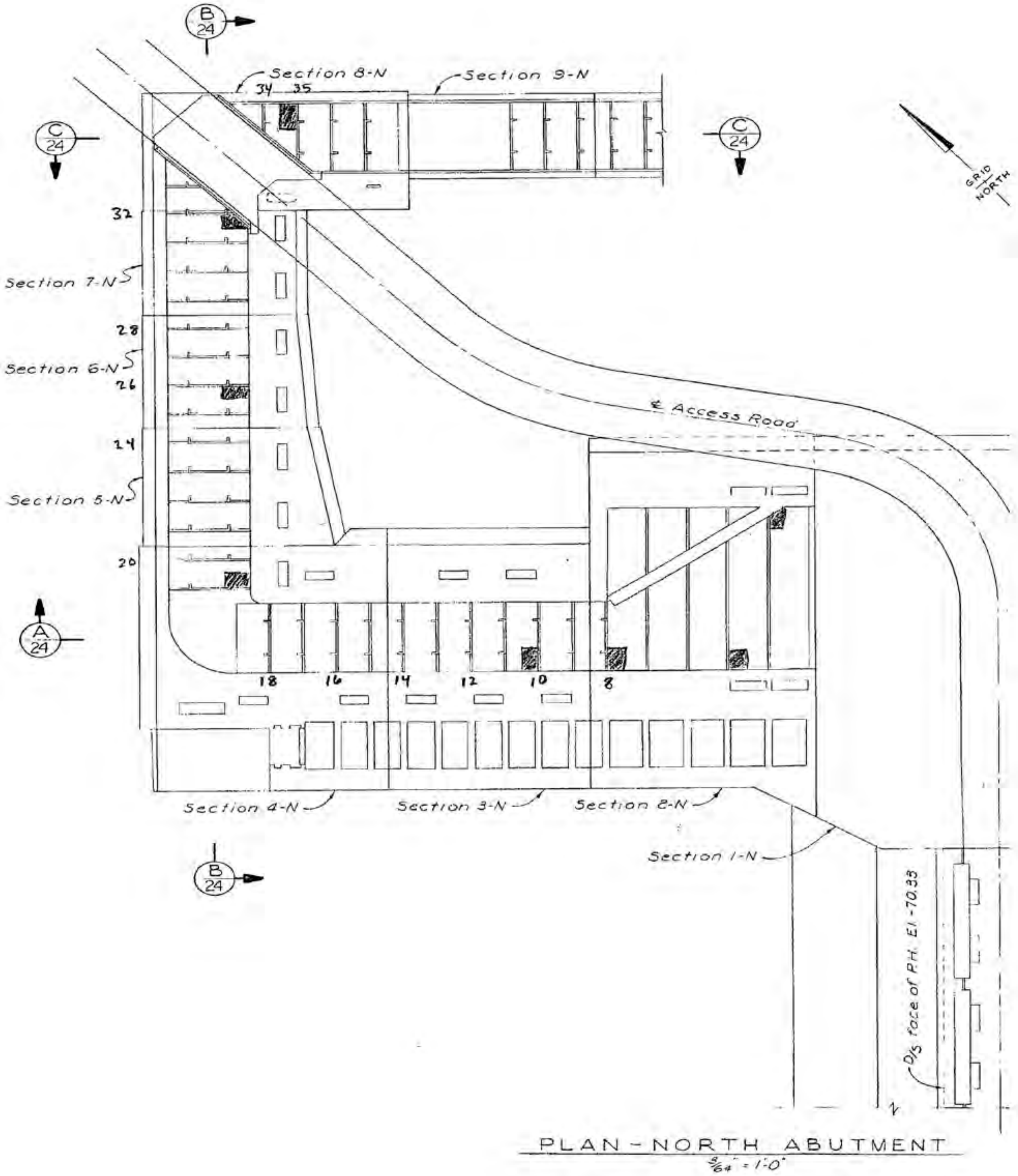



**Figure 2-3:** North Shore Fishway Plan

c. An ROV inspection of the south monolith B-diffuser shafts occurred in October 2011 following reports that they would not operate from the closed to the open position. The ROV was lowered into the access shaft. Project staff observed that sediment had filled a significant portion of the inoperable B7 and B8 chimney style B-diffusers. 20 feet of sediment filled the B7 chimney and 17 feet filled B8, impacting the movement of the diffuser gate from the closed position. Figure 2-4 shows a typical B 6-8 and ladder diffusion chamber layout (HELCRABS, 2005).

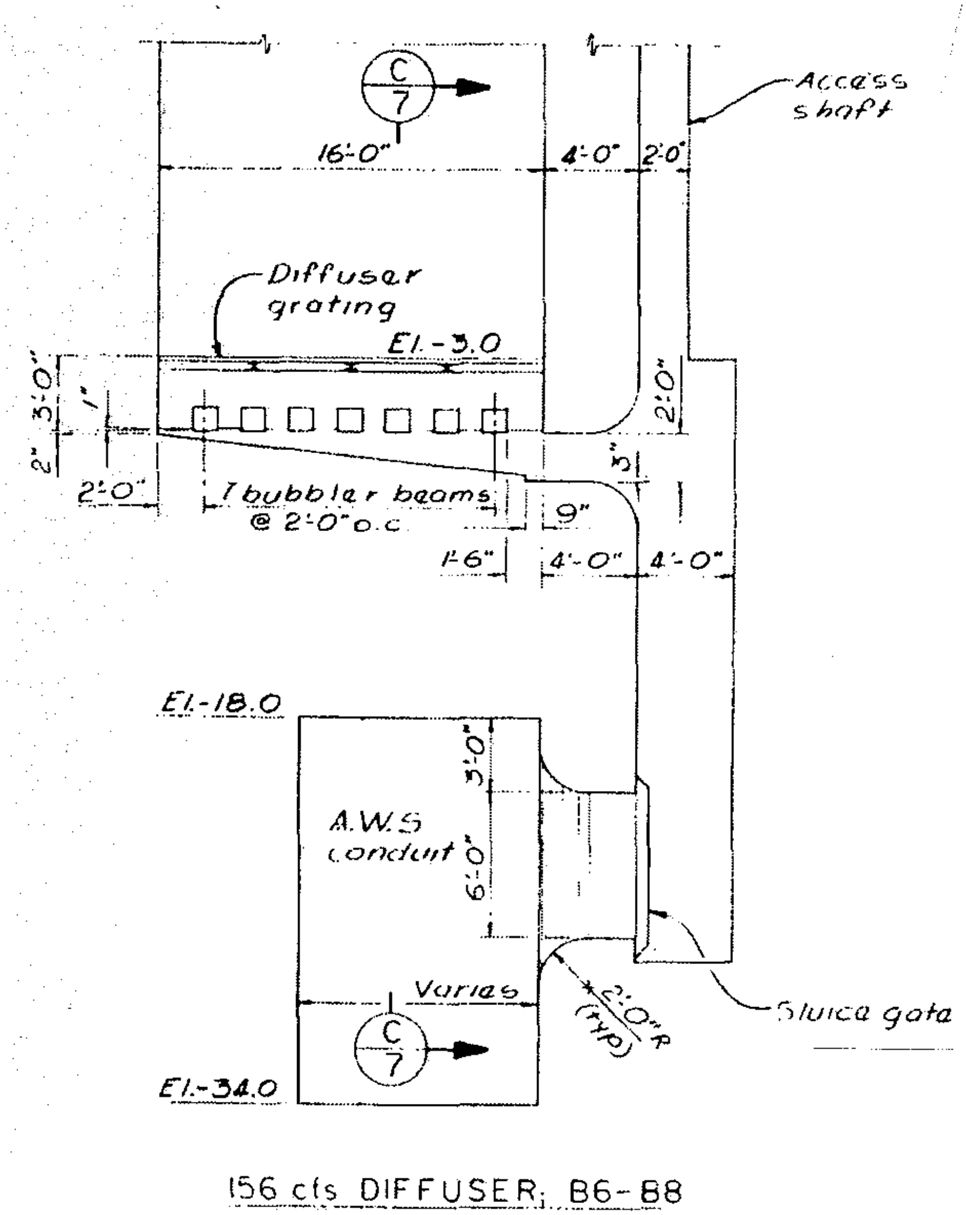



**Figure 2-4:** B Diffusers 6-8

d. The ladder was again dewatered from the UMT junction below tailwater from Oct. 14 – Dec. 8, 2011. Additionally, a complete dewater of the AWS system occurred to remove debris. This occurred prior to the regularly scheduled Bradford Island ladder dewatering from Dec. 1 - Feb 28 to minimize impacting the work schedule on the Oregon side of the project. The WA shore B2 work had not been scheduled or funded and considered emergency maintenance to repair diffuser gratings and clear the AWS system and diffusion chambers of sediment type debris. Contractors equipped to vacuum the B-diffuser chimneys removed the debris. Project personnel dealt with sediment cleanup that included sand piles as high as approximately 10 feet that accumulated in the AWS system. An estimated 600 cy of debris were removed from the AWS system.

e. See Appendix D for supplemental information regarding diffuser repair and sediment cleanup.

## 2.5 FOREBAY SEDIMENT ACCUMULATION

The 2001 DDR contains information on sediment debris accumulation in the B2 forebay. Plate 11 (plate 7 in 2001 report) shows several forebay inverts in front of fish unit 2 intake with 1998 and 2000 inverts much higher than the design invert. The March 2000 survey indicates an invert elevation in front of fish unit 2 of up to 20 feet above original 1986 design. Figure 2-5 provides a view of the fish units during construction and Figure 2-6 portrays the bathymetry of the 1986 design.

Fish Units


**Figure 2-5:** Bonneville Dam Fish Units (Adjacent to Wall) During Construction

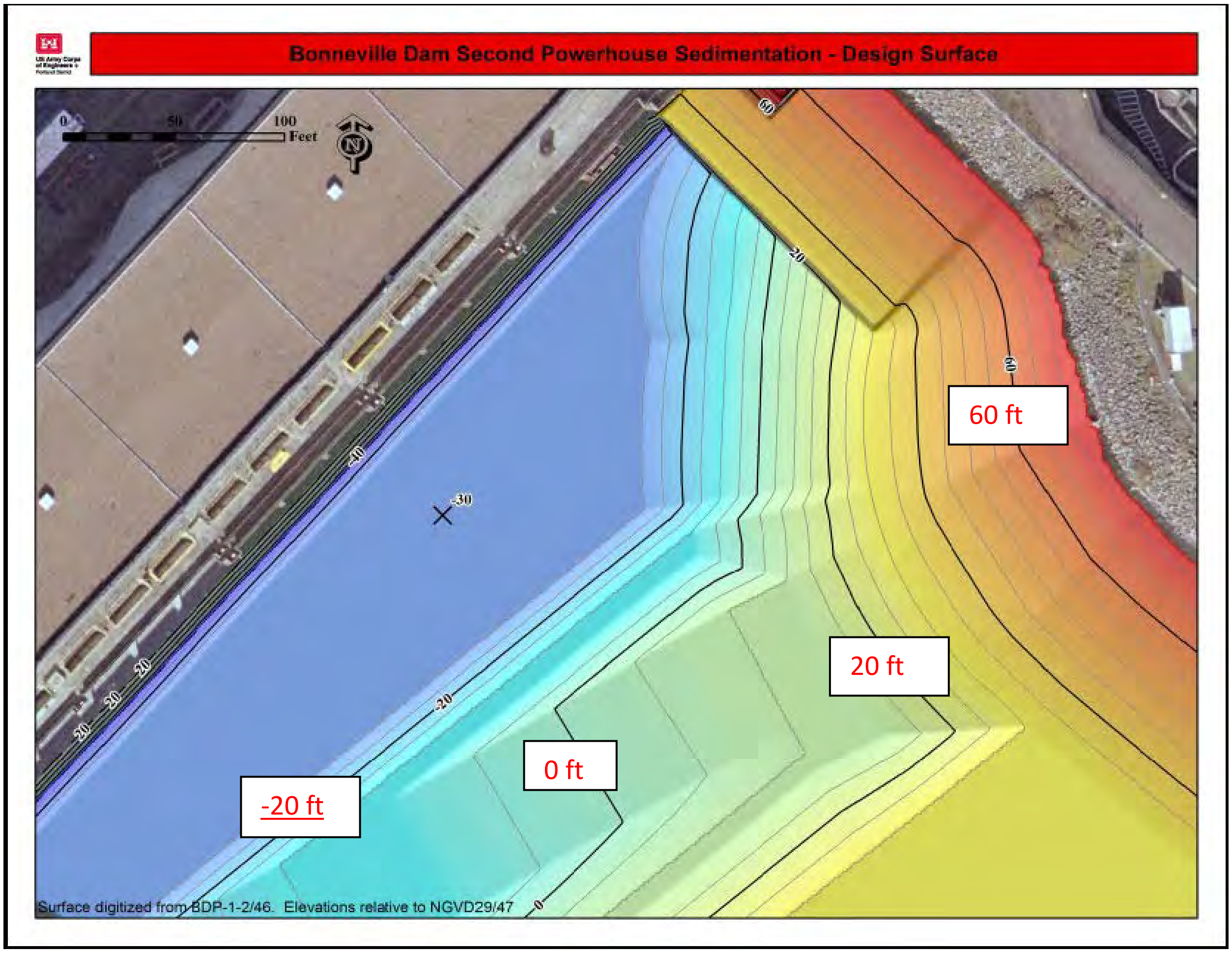



**Figure 2-6:** B2 Design Forebay Bathymetry (1986)

As sediment continues to deposit in the powerhouse forebay, an increasing amount will pass through the fish units and settle in the AWS system channels and restrict flow to the adult fishway entrances. Sediment buildup in front of the intake also contributes to headloss across the intake trash racks. The buildup tends to clog the lower trash rack section. This reduces the water passage area and prevents the trash rake from reaching and cleaning to the bottom of the intake. Below are known forebay dredging events:

a. 1990 - unknown quantity removed.
b. February 1997 - 2850 cy in front of fish units.
c. Fall 1997 - 4550 cy in front of fish units and 11032 cy in front of the main units for a total of 15,582 cy.
d. 2004 - 2000 cy in front of fish units
e. 2013 - 8000 cy in front of fish units

Forebay bathymetry from September 2010, as seen in Figure 2-7, shows some sediment accumulation in front of the fish units. Additional accumulation is seen in October 2011 (see Figure 2-8) with more visible accumulation in front of unit 18 in August 2012 (see Figure 2-9). Figure 2-10 shows depth in feet from October 2011 surface to September 2010 surface and associated cubic yards of infill. Figure 2-11 shows depth in feet from October 2011 surface to the design surface and associated cubic yards of infill. Figure 2-12 through Figure 2-14 compare bathymetry from 1986, 2010 and 2011. The most recent surveys are depicted in Figure 2-15 for pre and post dredging images for 2012/2013 winter debris removal from the Bonneville Forebay, approximately 8000 cy.

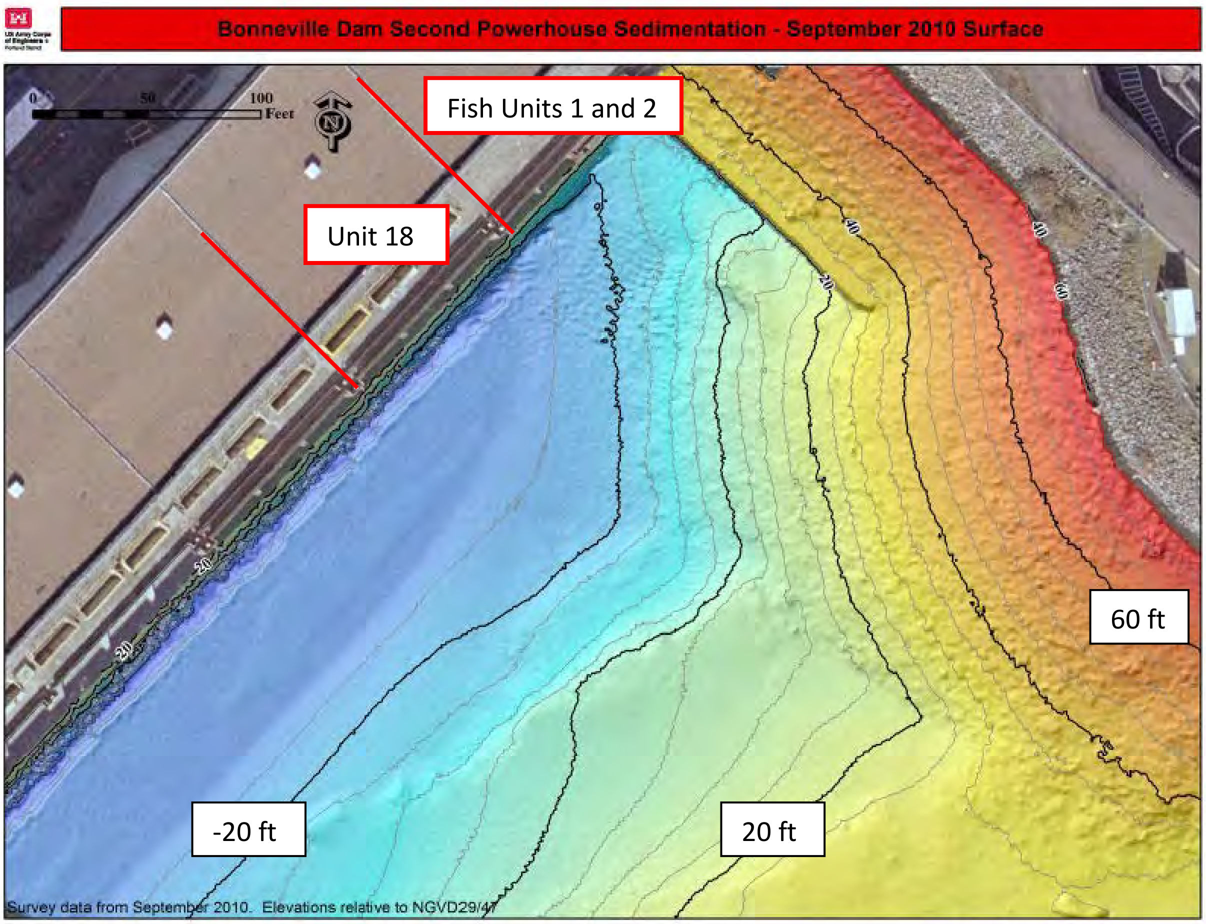



**Figure 2-7:** September 2010 Forebay Bathymetry

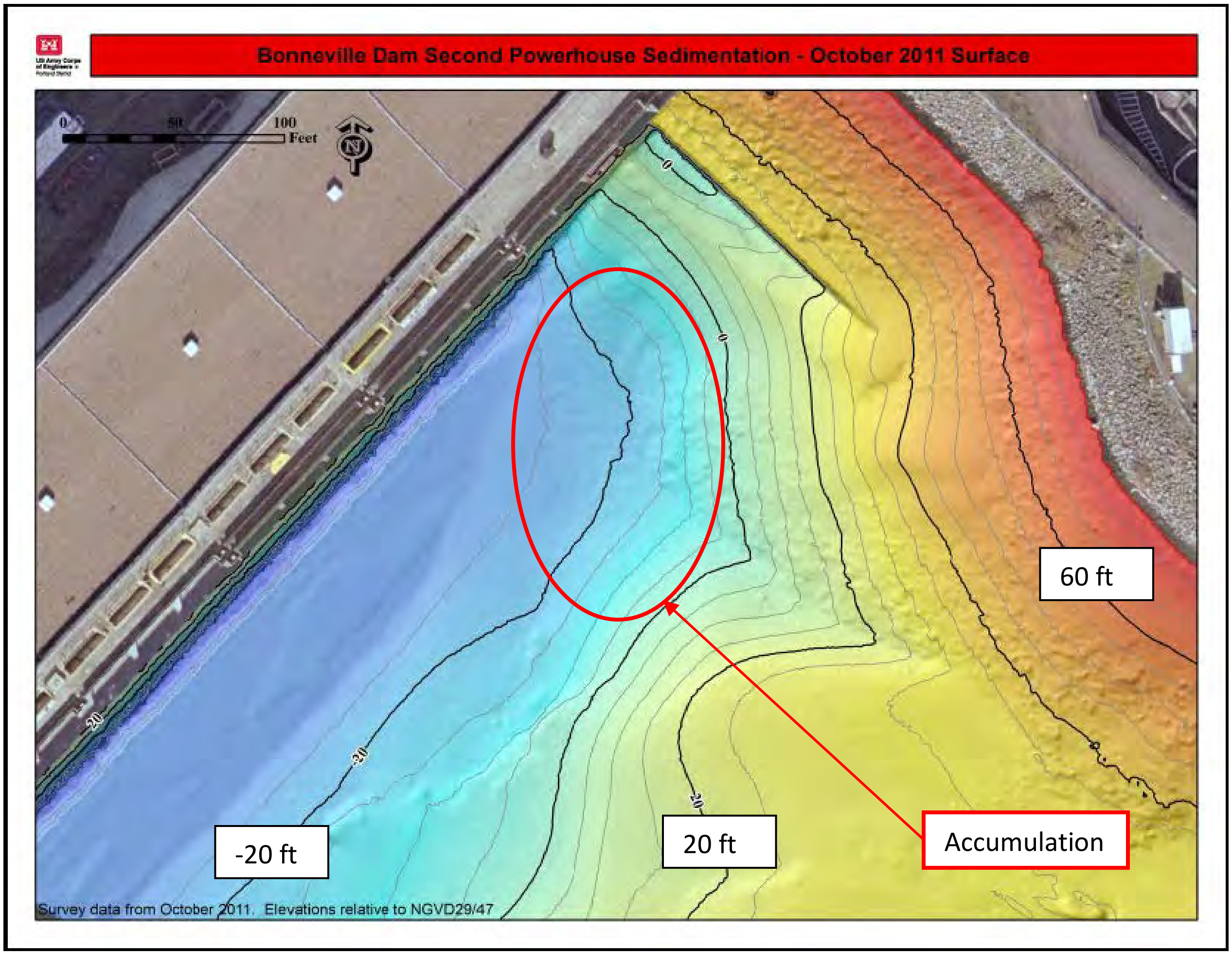



Figure 2-8: October 2011 Forebay Bathymetry

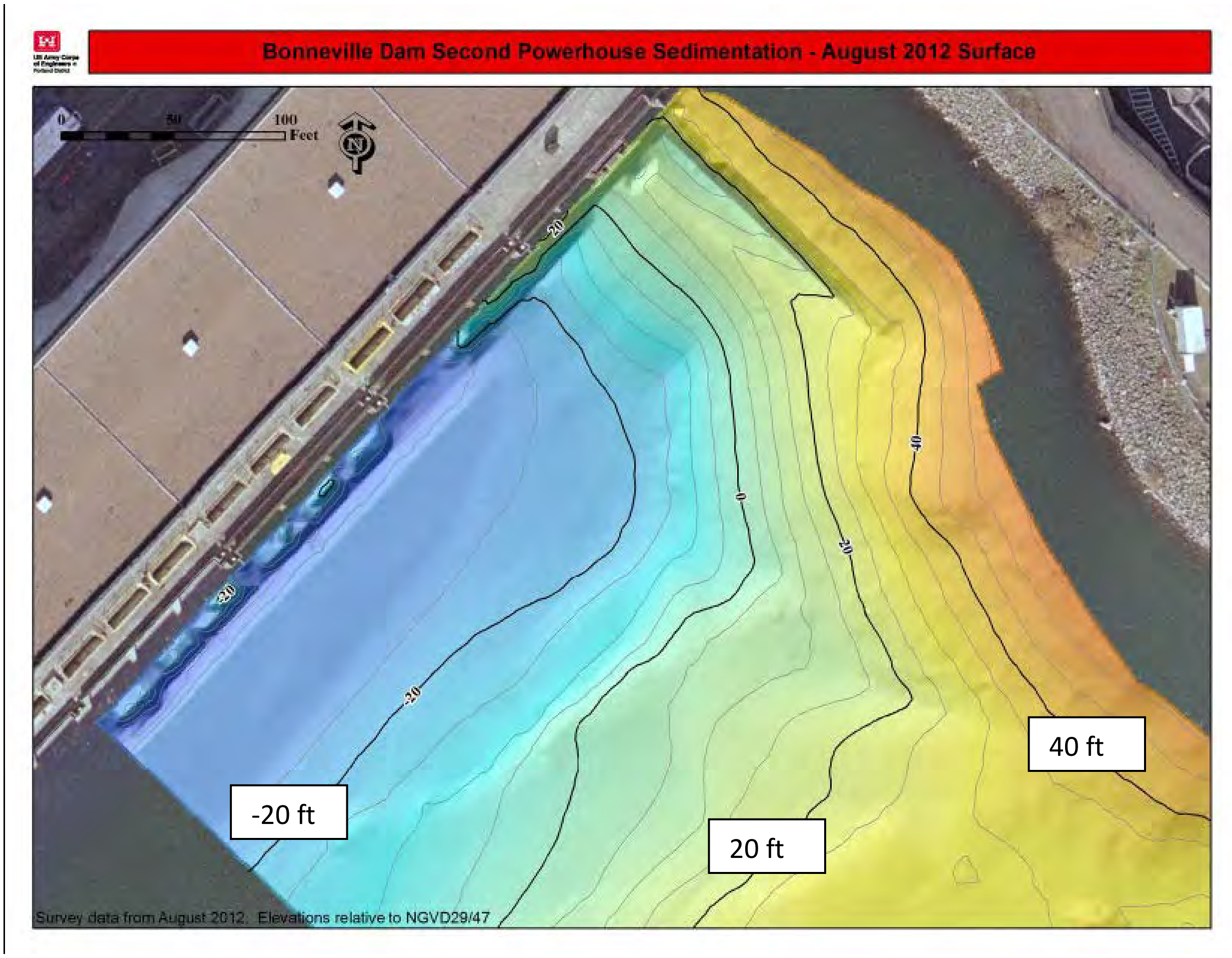



**Figure 2-9:** August 2012 Forebay Bathymetry

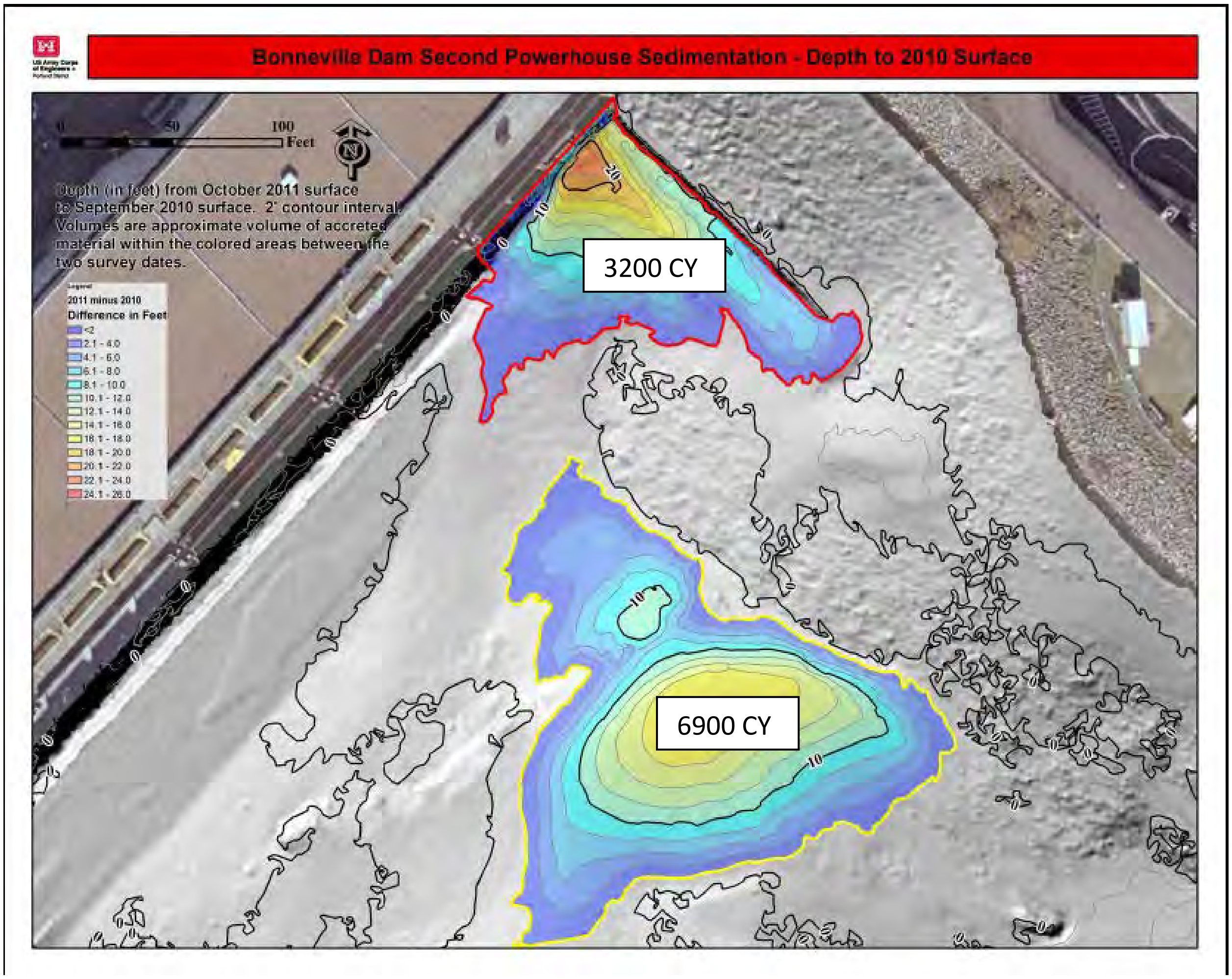
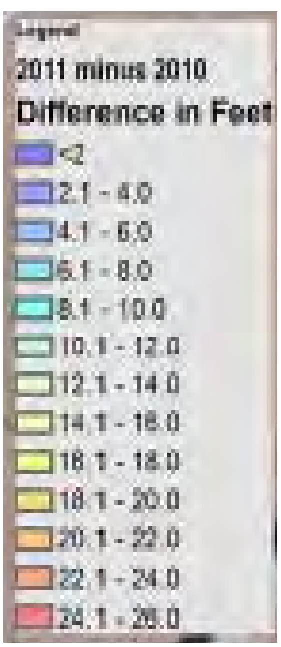



**Figure 2-10:** Depth in Feet From October 2011 Surface to September 2010 Surface and Associated Cubic Yards of Infill



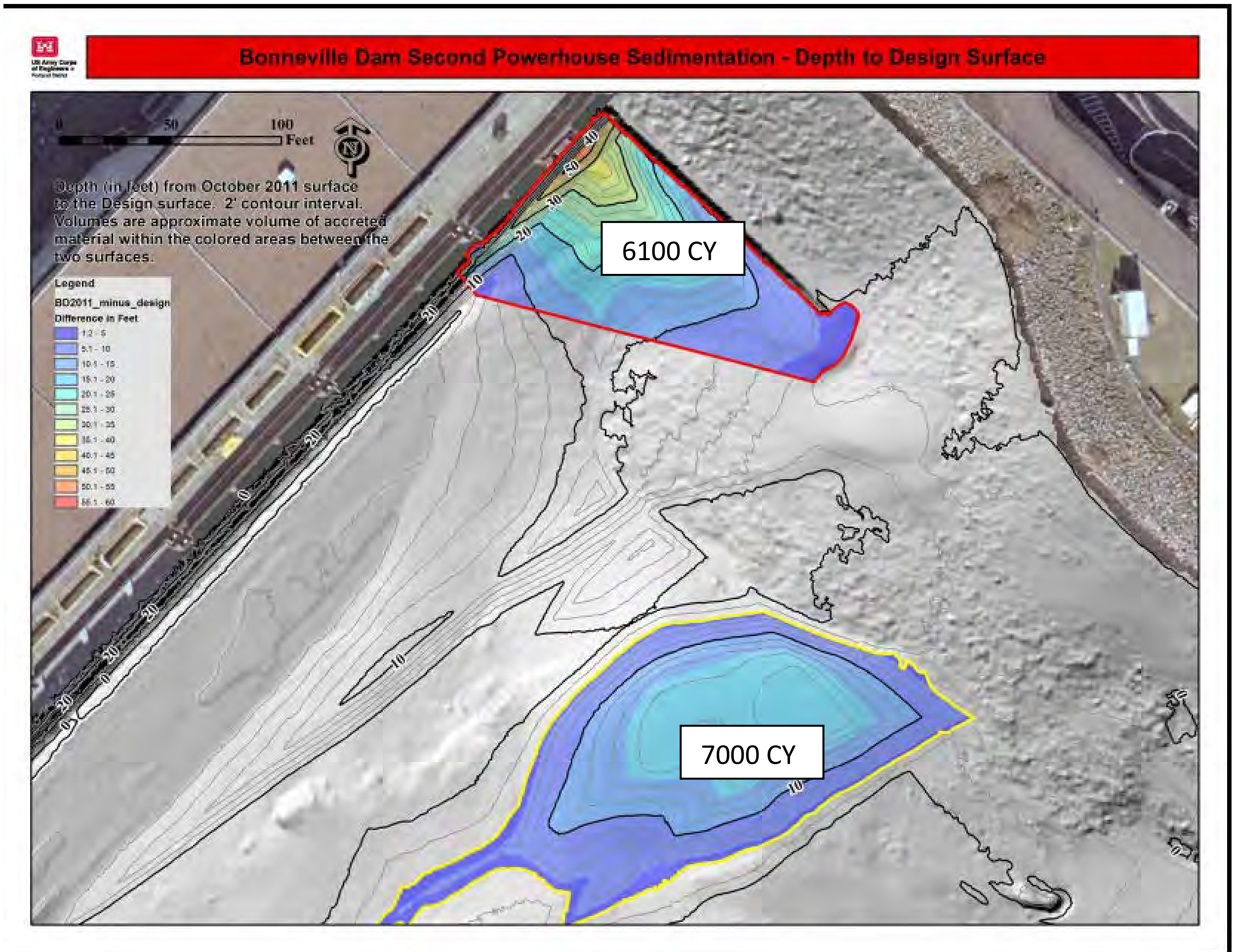



**Figure 2-11:** Depth in Feet From October 2011 Surface to the Design Surface and Associated Cubic Yards of Infill

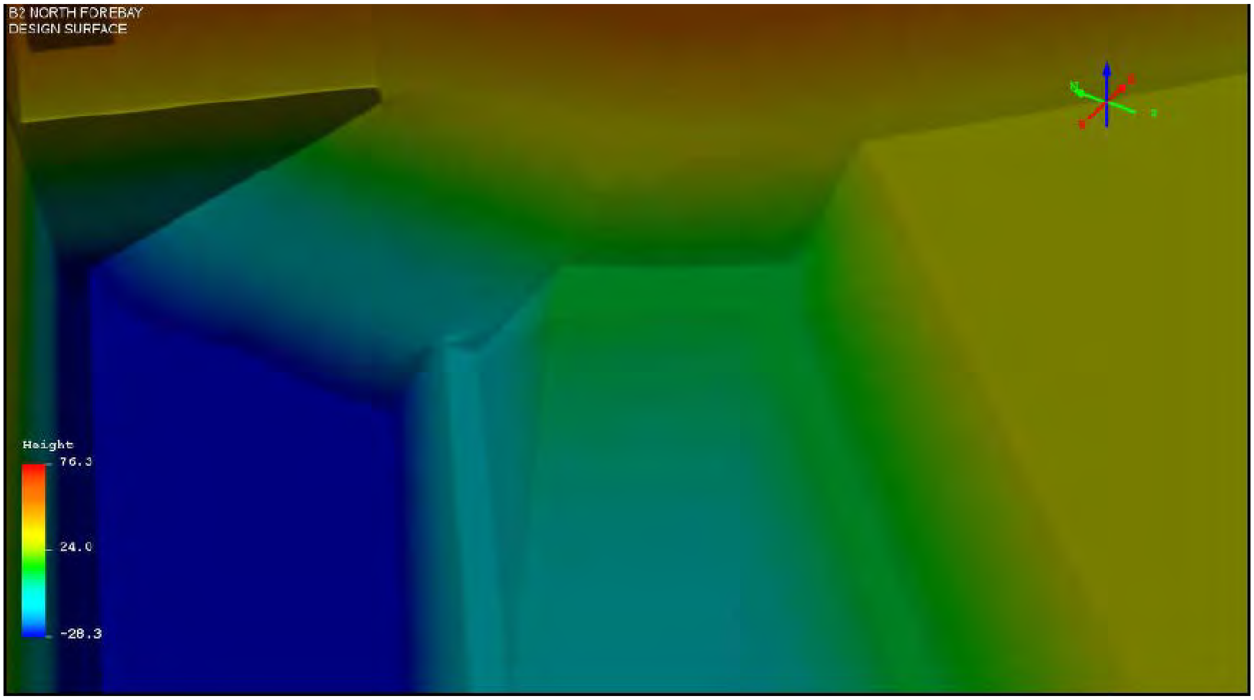



**Figure 2-12:** In Front of Fish Units, Design Bathymetry (See Legend following figure 2-14)

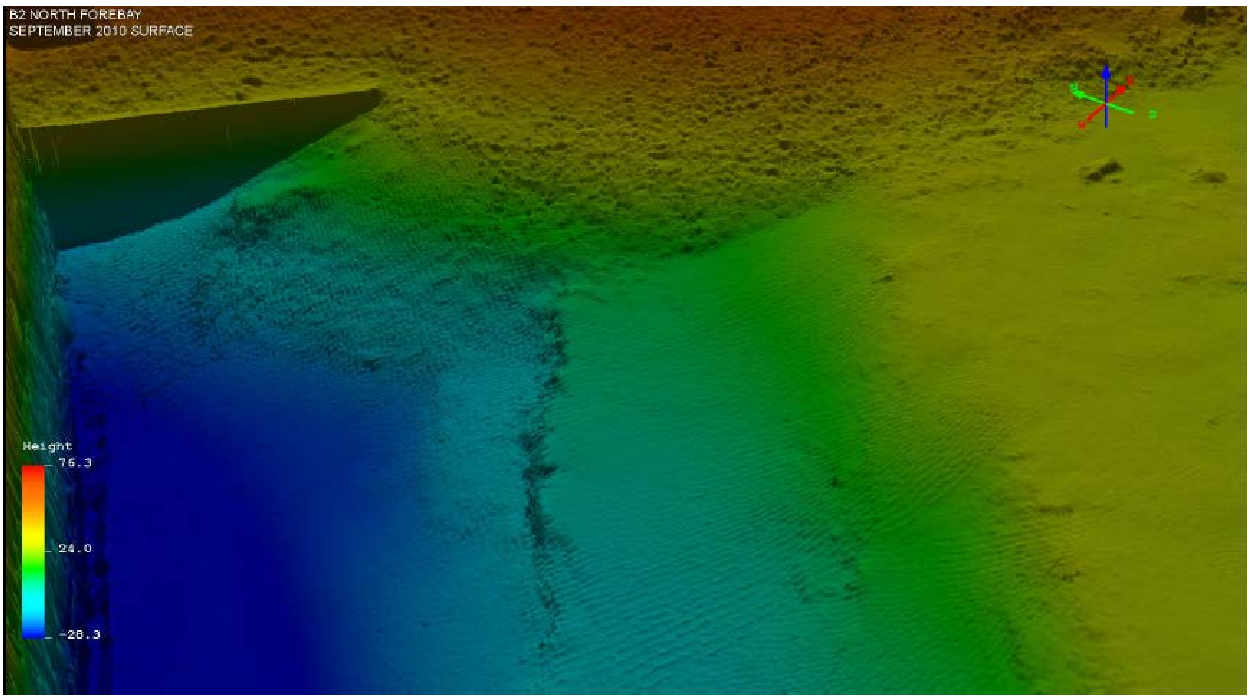



**Figure 2-13:** In Front of Fish Units, December 2010 Bathymetry (See Legend following figure 2-14)

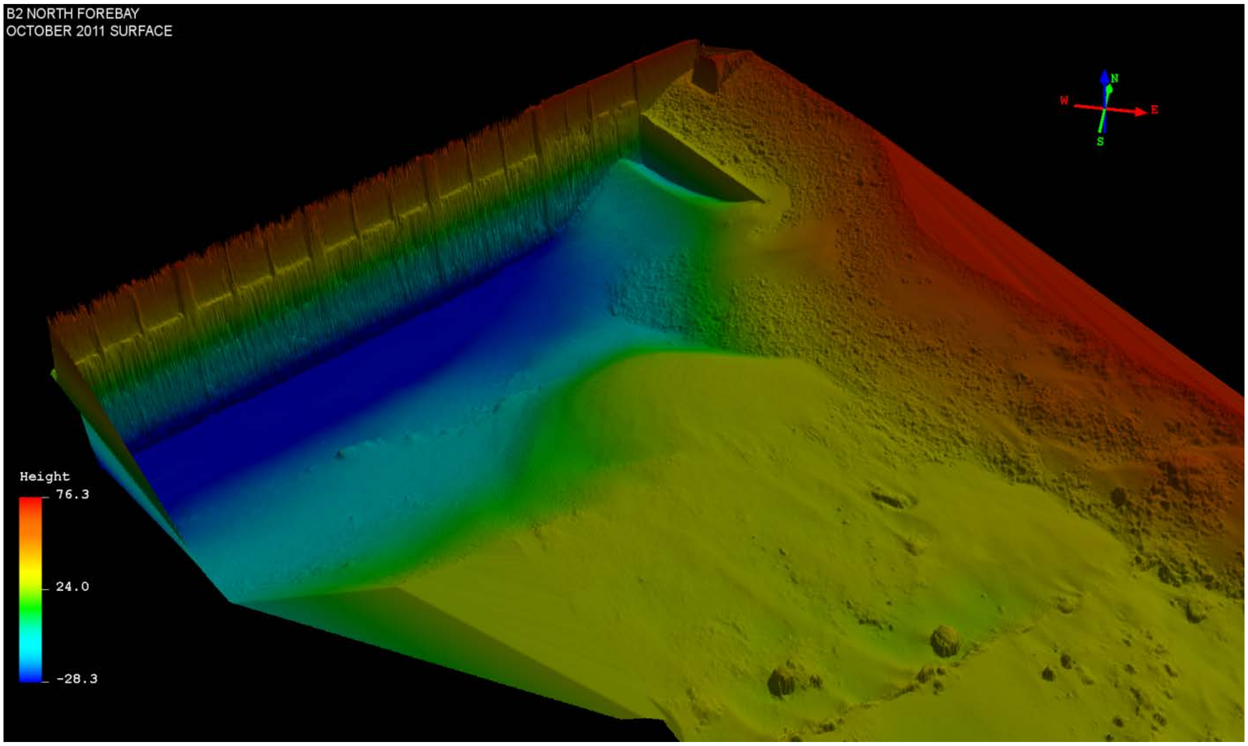
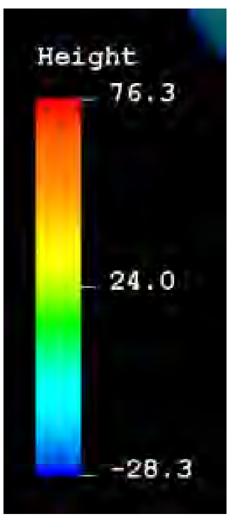



**Figure 2-14:** In Front of Units, December 2011 Bathymetry



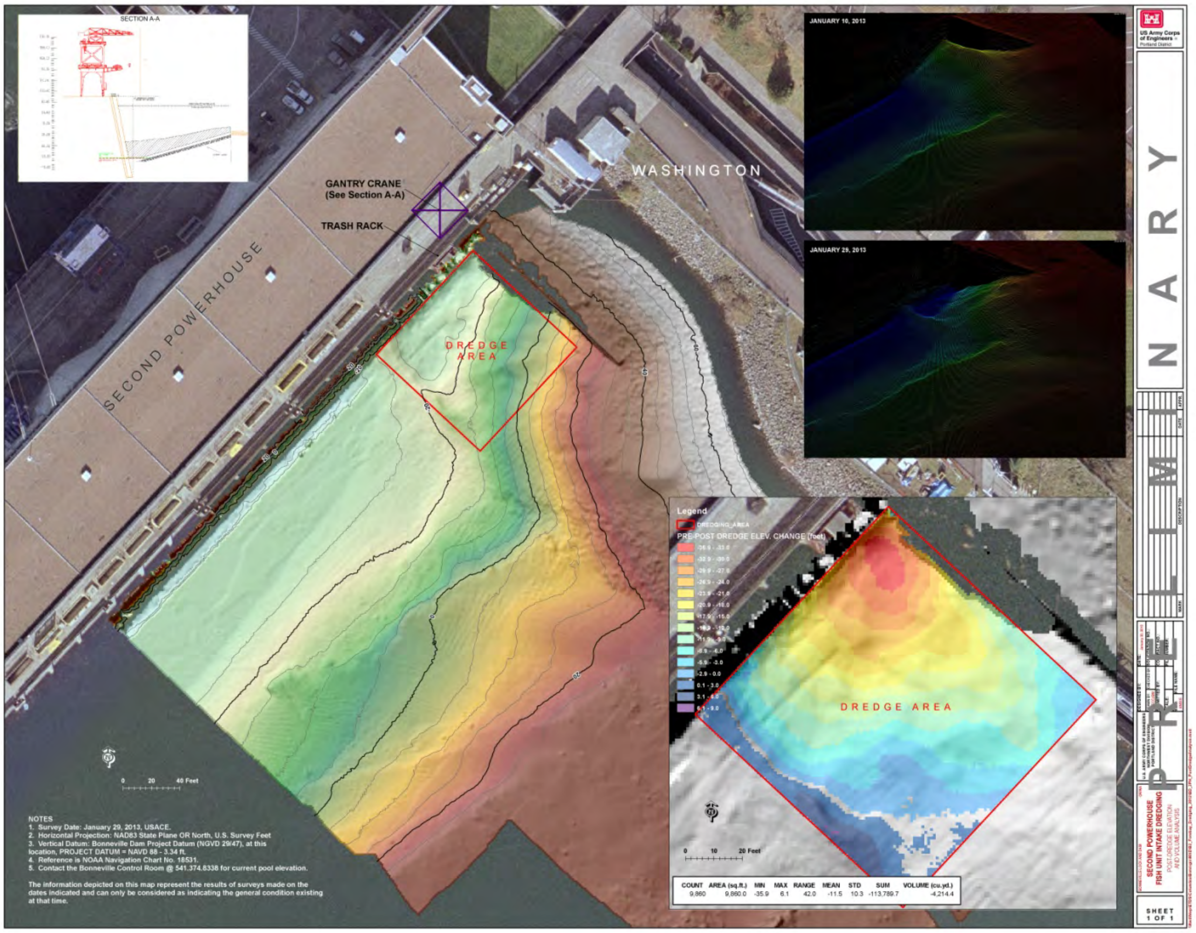



**Figure 2-15:** B2 Forebay Hydrosurvey Pre and Post Dredging Images – 2013

Project personnel entered the AWS system again in the fall of 2012 and removed an estimated 600 cy of debris that accumulated since the 2011 AWS system debris removal. During winter 2012/2013, approximately 8000 cy of debris was removed from the Bonneville Forebay in front of the fish units to bring the immediate area back to 1982 bathymetry.

Conclusions

The previous figures show how the area in front of the fish units tends to collect sediment and debris. As sediment and debris accumulate, project staff noticed a significant increase in floating trash and raking effort to maintain head differential criteria at the fish unit trash racks. Regular maintenance dredging will provide a catch basin for debris since the lower fish unit trash racks have been blocked with solid panels. This catch basin will allow debris, which cannot be captured by the trash rake, to build up in front of the fish units and reduce the need to stop the operation of the fish units to float debris away.

# SECTION 3
# VALUE ENGINEERING (VE) STUDY/DESIGN CHARRETTE AND ALTERNATIVES EVALUATION

## 3.1 GENERAL

The team decided, because of the extensive project history already available, that the VE study could be performed as a design Charrette. It was held as a workshop in two parts: 7-8 November 2012 at Bonneville Dam and 13-15 November 2012 at the Portland District Offices. The VE team was comprised of USACE staff from the PDT and the re-Employed Annuitants Program representing the disciplines of Hydraulics, Structures, Mechanical, Electrical, Fisheries Biology, Environmental Compliance, Cost, Construction, and Operations. The VE Study Report, Bonneville Dam Second Powerhouse Adult Fishway Auxiliary Water Supply Trash Rake, can be found in Appendix E. During the study the following designs were evaluated using rating criteria developed by the VE Team.

a. Automated Trash Rake. This alternative was initially recommended in the Bonneville Second Powerhouse Auxiliary Water Supply backup System DDR, November 2001, and the team decided that it still has merit and is worth investigating. It should be noted that in lieu of implementing the automated rake design, a new manual rake was constructed in 2005 that is currently not in use because of the following issues (see Figure 2-2):

(1) It currently exceeds the auxiliary hoist's load capacity during raking.
(2) It does not retain enough debris while raking; multiple passes must be used to clean each set of racks.
(3) Composite teeth are broken; they could not remove debris between the rack bars.
(4) The rake cannot be moved into the rake slot without exceeding auxiliary hoist upper limit.

Given these problems the new rake is not used and further modification of the rake will be cost prohibitive when compared to modification of the "old" manual rake.

The automated trash rake should have the following attributes:

(1) The new trash rake will see a higher number of cycles as debris will tend to accumulate on the screens at a faster rate due to lower trash rack porosity. The rake should be able to clean all racks in approximately 1.5 hours.
(2) It must be capable of raking operations while the fish turbines are running.
(3) The rake must not occupy areas of the deck that are currently used by existing equipment.
(4) A larger volume of raked debris will need to be transported to a disposal area.
(5) The rake spacing must be matched to the trash racks.
(6) The rake must be capable of raking to a depth of 120 feet.
(7) Capable of remote monitoring.
(8) Capable of detecting and removing large logs or fitted with a log diversion device so that operations staff can retrieve the logs at a specific location.

New trash racks would be needed with the automated system. The racks should have the following attributes:

(1)  A bar spacing so that there is 0.75 inch clear space between bars.
(2) Water velocity normal to the rack must not significantly increase beyond current conditions.
(3) Each rack must be designed for a water head of 20 feet.  This is a structural design consideration based on Project Personnel knowledge of sediment/debris levels in front of the trash racks on operating units.
(4) Construction, detailing, and sizing to avoid damage from frequent raking
(5) Maximum 50 percent debris occlusion.

This concept received the second highest score based on the evaluation criteria (See VE appendix E). The team chose not to pursue this design due to the implementation risk and operations personnel feedback associated with the gripper rake design.  The gripper rake met the specified design criteria based on manufacturer feedback however the manufacturer could not provide multiple examples of working designs that fit our design criteria.  Other automated rakes were researched, but none met the specified design criteria.

b.   Forebay Debris Barrier.  The forebay debris barrier concept would be fabricated from flexible floats that are anchored to the face of the dam and the opposite shore line.  The flexible floats would be filled with water to control their draft.

In this concept the barrier would direct debris that normally deposits on the fish unit intake racks into unit 18.  It was thought that it could also affect the characteristic eddy that is known to form at the second powerhouse.

In using flexible floats and a cable anchorage system, the team felt the project could be completed at a reasonable cost and could be constructed during the in-water work period with minimal impacts to fish passage and power generation.

This concept received the highest rating deserving further investigation (See VE appendix E). The team decided to model multiple flexible float configurations using Computational Fluid Dynamics (CFD) software.  The modeling results showed that any structure placed in the forebay as a debris diversion wall will likely prove ineffective.  See appendix G to for the full report.  Below is a summary of the CFD modeling of flow in the forebay in the area of the fish units and unit 18 at B2.

The VE study recommended a wall perpendicular to the powerhouse, placed north of unit 18, with a goal of blocking debris from moving into the fish units.  The recommendation was based on the large eddy that forms along the North Shore containing various forms of debris. This debris may encounter the trash rack, settle and accumulate in front of fish units, or pass through the fish units.  Thus the design intent of the wall was to keep the debris and the flow direction of the river in this area focused toward the main units rather than circulating in front of the fish units.

Computational Fluid Dynamics modeling was used to evaluate the various alternatives.  For this project, streamlines (equivalent to neutrally-buoyant particles, or particles without mass) were used to visualize the flow paths upstream of the AWS units.  We know debris suspended in the water column is an issue, and a large recirculation area of floating and suspended debris has been observed upstream of the AWS units. If buoyant particles were used to describe the surface flows, those particles would remain on the surface and not interact with the AWS units. However as observed, buoyant debris can become waterlogged and pass down through the water column where it can be deposited in front of the units or swept into the units due to the turbine flow. The use of streamlines, especially in these complex flow regions, can improve our understanding of the fate and deposition of the debris whether through the AWS or Unit 18 for different flow conditions or structural scenarios. The CFD modeling effort is documented in Appendix G and the key findings are summarized here.

The B2 forebay CFD model bathymetry depicted in Figure 3-1 was derived from multibeam bathymetric surveys conducted in 2010 and further updated 2013 surveys along the northern half of the B2 forebay. The 2013 survey was performed after dredging immediately in front of the fish units in February of that year and covered the northern half of the forebay to include the northern main units, the fish units and the shoreline. Forebay invert conditions of note include the abrupt change in bathymetry as you approach the turbine intakes, the expansion of the forebay channel to the north just upstream of the fish units and the fish unit invert elevations being higher than the invert elevation of the main units. The steep slope and the angle of the approach flow exacerbate the rotation of the flow both horizontally and vertically.

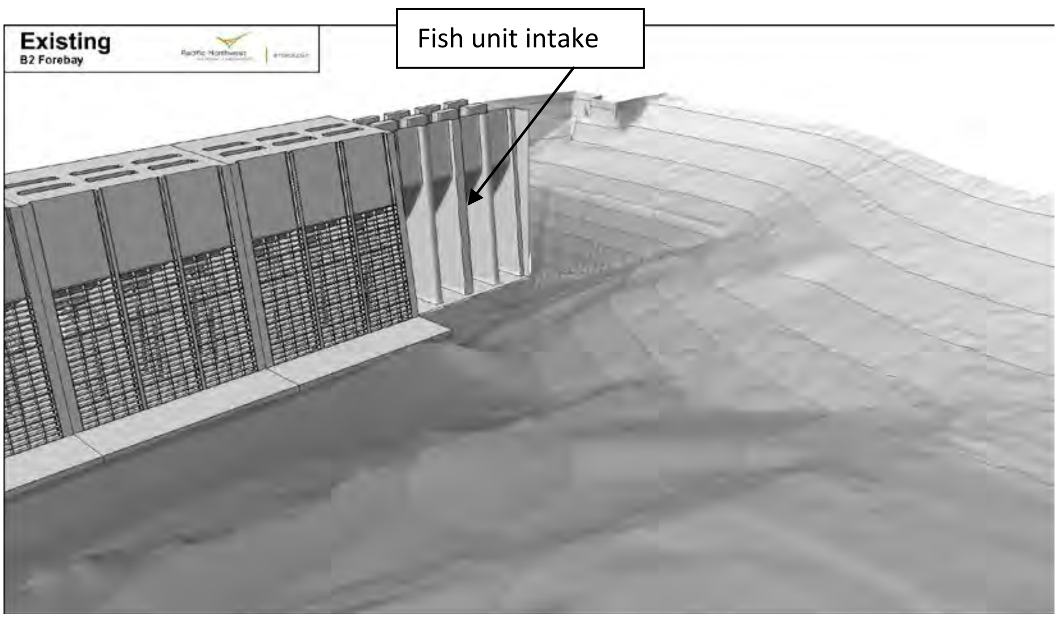



**Figure 3-1:** B2 CFD Model Geometry Near the Fish Units

A single river flow of 178.9 kcfs was used for comparisons of the existing condition forebay and several structural options. The structural options included various combinations of wall shapes to better understand the underlying flow characteristics in the area of interest. Figure 3-2 shows the building blocks for the wall configurations that were evaluated in the CFD model.

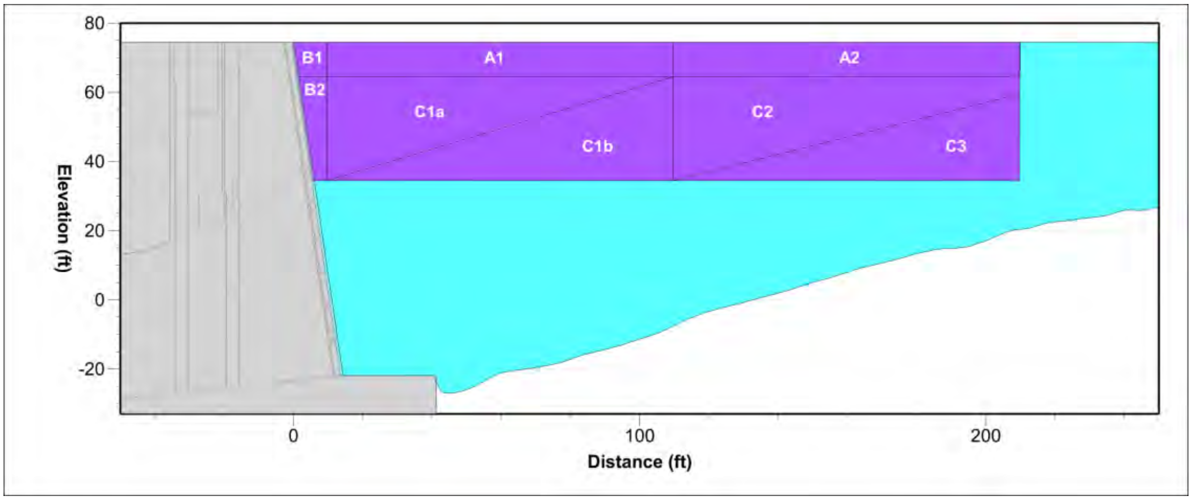
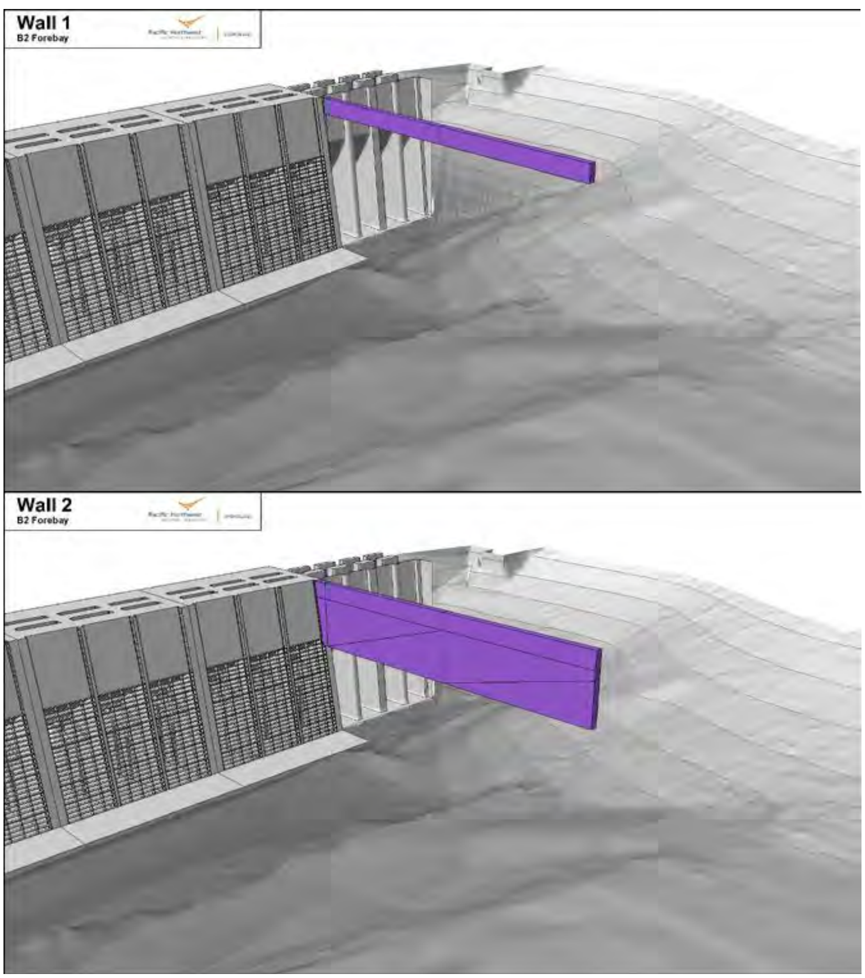



**Figure 3-2:** Wall Configuration Sections

Alternative wall shapes were modeled with multiple seed elevations to better understand the potential path of subsurface debris. Wall configurations tested included: Wall 1 - a combination of sections A1+A2; Wall 2 - a combination of all sections, and Wall 3 - a combination of sections A1+A2+ B1+B2 + C1a. Combinations are shown below in Figure 3-3.



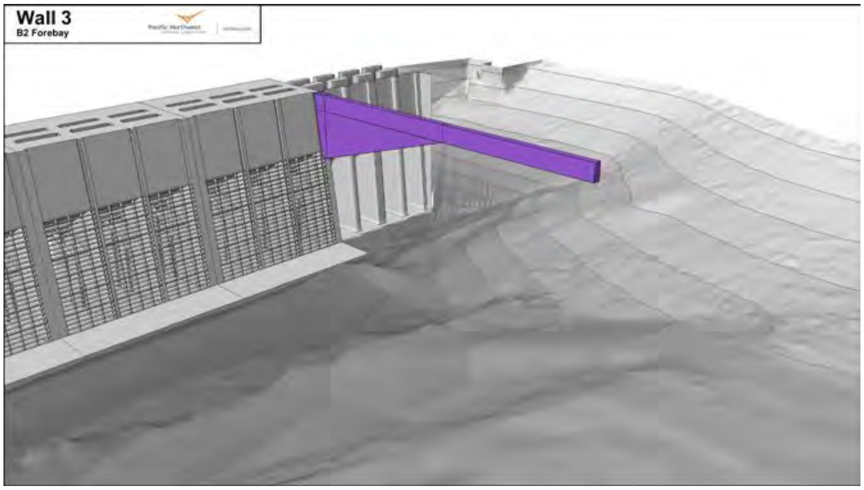



**Figure 3-3:** Wall Shapes Evaluated

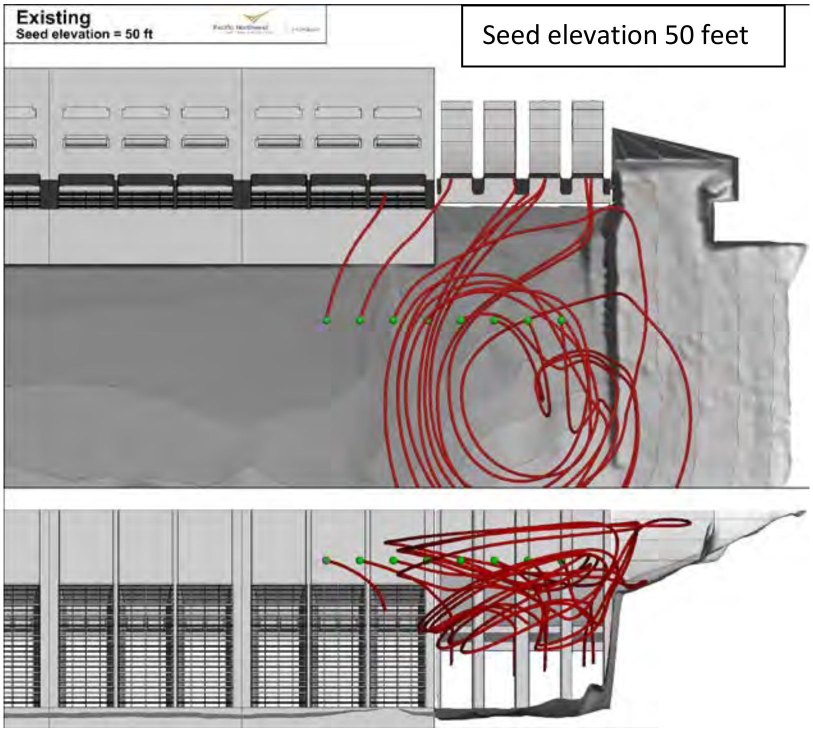
In addition to the three wall shapes above, a combination of Wall 1 and a berm initiated at the upstream end of Wall 1 extending to the north shore was modeled. Also runs were made with a potential low volume (50 cfs) sluiceway to the north of the fish units to see if it might be effective at reducing the surface eddy.

Plots for the runs made included:

- Velocity contours with streamlines seeded at the surface (EL 74) upstream of the Washington shore eddy.
- Forebay streamtraces seeded at elevations 70, 50, 30, and 10 ft. for vertical and horizontal views.

The streamlines plots visualize the complex three dimensional nature of the near-dam flow near the Washington shore eddy. In general the results were similar for all configurations tested. The various wall shapes do not appear to decrease or eliminate the Washington shore eddy. The walls appear to starve the available flow to the fish units such that flow dives under the wall. The horizontal flow under the wall then tends to enhance the recirculation in the vertical plane resulting in a corkscrew type rotation pattern. Figure 3-4 depicts streamtraces for the existing forebay (no walls, existing condition) and Figure 3-5 depicts streamtraces with Wall 3 (the variable depth wall).

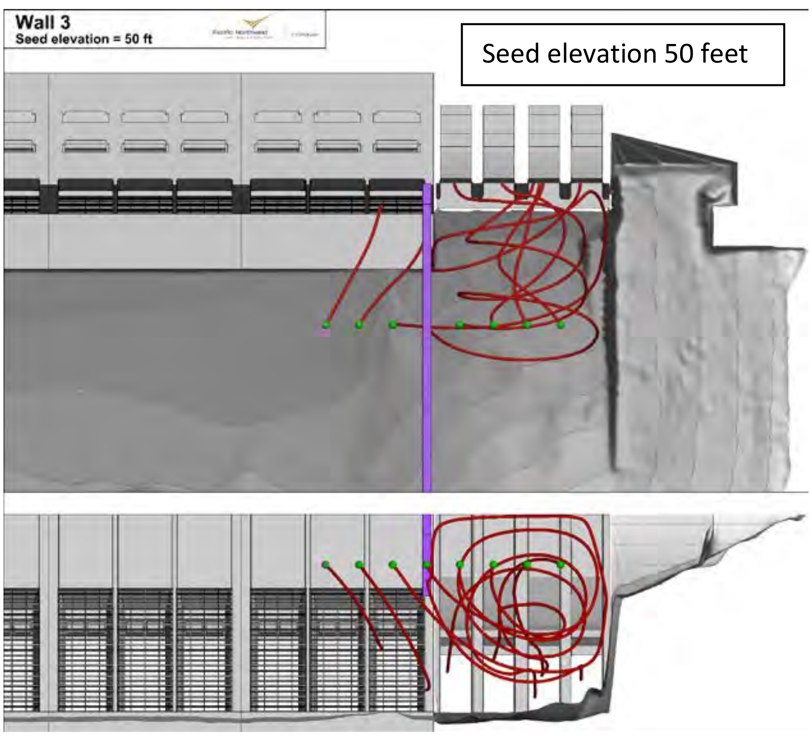
Generally the streamtraces at all elevations end up in the north shore eddy and pass through the fish units. Assuming that submerged debris is moved by the overall velocity patterns, the patterns generated with and without modifications from this study do not lend themselves to debris movement towards the main units where debris loads are not an issue. The wall alternatives can complicate the rotational nature of the neutrally buoyant seeds but in the end the flow path reaches the same final destination.




**Existing Condition**

**River Flow=178.9kcfs**
**Spill=100.9kcfs**
**Powerhouse=U11,12,17,18,@17kcfs**
**Fish Units=2.5kcfs each**
**B2CC=5kcfs**

**Figure 3-4:** Streamtraces For Existing Condition With No Upstream Walls or Berms.




**Wall 3**

**River Flow=178.9kcfs**
**Spill=100.9kcfs**
**Powerhouse=U11,12,17,18,@17kcfs**
**Fish Units=2.5kcfs each**
**B2CC=5kcfs**

**Figure 3-5:** Streamtraces With Variable Depth Wall In Place.

Generally the streamtraces at all elevations end up in the north shore eddy and pass through the fish units. Assuming that submerged debris is moved by the overall velocity patterns, the patterns generated with and without modifications from this study do not lend themselves to debris movement towards the main units where debris loads are generally not an issue. The wall alternatives can complicate the rotational nature of the neutrally buoyant seeds but in the end the flow path reaches the same final destination.

Given these results for different wall alternatives, a full depth wall scenario is expected to starve the fish units of flow due to the abrupt expansion of the forebay and abrupt change in the flow depth just upstream of the fish units. In turn this would impact the turbine efficiency. Additionally, any fish north of the wall would then be trapped with the only exit being through the fish unit. The CFD results suggest that the flow conditions along the approach to the fish units are controlling the dynamics of flow in front of the units. There may be potential to improve the flow conditions along the north shore of B2 by excavating the channel to the fish units providing a smoother flow path with reduced vertical and horizontal recirculation. See Appendix G for the full report.

c. Modify Existing Rake. This concept received the third highest score based on the evaluation criteria (see appendix E). If it is determined that, after a trash rack inspection, the racks need to be replaced; the rake may need minor modifications, depending on any design changes to the racks, to ensure it can be used to clean the racks.

In general the rake was inspected and is in satisfactory condition. It will need some non-structural weld repair and paint touch up. Operations staff can repair these items as resources become available.

During a recent ROV inspection of the fish unit racks it was observed that the rake to rack clearance was allowing grasses to build up on the intake racks. The rake should be modified to remove the matted grasses.

Raking will need to occur often enough to keep the intake rack differential below 20 feet. This is a structural design concern as sediment and debris should not reach above this height. Historical data has shown that differentials have reached this before. This may require additional labor resources during times of heavy debris inflow.

Given the results from the debris diversion structure and the high implementation risk of the automated rake, the team decided to move forward with the modification of the existing rake. This modification will increase confidence in the use of the rake and the capture percentage of debris from the racks.

# SECTION 4
# BIOLOGICAL AND HYDRAULIC DESIGN, CONSIDERATIONS AND CRITERIA

## 4.1 General

This section lists the biological and hydraulic criteria for fish unit trash rake design improvements as well as AWS system operation and maintenance. These biological criteria are based primarily upon potential AWS system impacts to salmonids (genus *Oncorhynchus*), Pacific lamprey (*Entosphenus tridentatus)*, white sturgeon *(Acipenser transmontanus)*, and bull trout (Salvelinus confluentus). Debris events as well as passage data from research and observation since the 2001 DDR highlights the importance of minimizing operations that restrict migratory fish movement. The criteria stated below describe current operations at Bonneville Dam as well as hydraulic requirements. These operations and requirements need to be considered during trash rake design in order to minimize fish unit downtime and risk of system failure. In addition, federal mandates set forth a legal requirement to consider biological impacts, as stated in the National Oceanic and Atmospheric Administration (NOAA) Biological Opinion and Columbia Basin Fish Accords.

The 2014 Supplemental and 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) lists Reasonable and Prudent Alternatives (RPAs) that NOAA Fisheries concluded were sufficient to avoid jeopardy of ESA-listed salmon and steelhead.

RPA #32 states **–**

*"The Corps will annually prepare a Fish Passage Plan (FPP) in coordination with NOAA Fisheries and the Regional Forum through Fish Passage Operations and Maintenance (FPOM). The Corps will operate its projects year round in accordance with criteria in the FPP."*

The 2008 Columbia Basin Fish Accords Memorandum of Agreement (MOA) between the Three Treaty Tribes and FCRPS Action Agencies states **–**

**"***The Corps will continue improving adult lamprey migratory conditions at mainstem FCRPS hydropower projects. This will include investigating and identifying potential problem areas and implementing both physical and operational changes to adult ladders."*

## 4.2 Biological and Hydraulic Criteria for Fish Unit Operations

The Corps FPP is a living document of the Corps operational policy pertaining to the fish passage systems of the Columbia and Snake River projects. The hydraulic criteria in the FPP have been agreed to by regional agencies to be beneficial for fish passage through the projects. The document is dynamic with annual review considering new research. At the time of this writing the turbine operation and maintenance includes **–**

a. 2013 FPP Criteria for Bonneville Second Powerhouse (B2) Fish Unit Operations.

   (1) B2 has priority during fish passage season March 1-Nov. 30 and during the Bradford Island winter maintenance period.
   (2) Head on all fish ladder entrances should be: 1 foot to 2 feet (1.5 feet preferred).
   (3) During daytime spill hours (see Table BON-5 in FPP), operate all north (NUE and NDE) and south (SUE and SDE) entrances. Operate weir crests at elevation 1 foot

(fully lowered) for tailwater elevations up to 14 feet. For tailwater elevations greater than 14 feet, operate weir crest 13 feet or greater below tailwater.

(4) A water velocity of 1.5 to 4 fps (2 fps preferred) shall be maintained for the full length of the powerhouse collection channel.
(5) Operate all 12 active B2 floating gate fishway entrances.
(6) Inspect and ensure that optimum passage conditions are maintained at fishway entrances, exits, and in the count slots.
(7) Certain turbine and spillway discharges at the projects are secondarily used to attract adult fish to fishway entrances, to keep predator fish from accumulating near juvenile release sites, and to move juveniles downstream away from the project. During the fish passage season, do not take fish units 1 and 2 and units 11 and 18 out of service, when practicable.
(8) Measure fish unit gatewell drawdown at least once per week. When the head across trash racks exceeds 1.5 feet, the trash racks will be cleaned that day. This may be done by raking late in the workday or by turning the unit off at night and letting the debris float off the racks. However, if the head exceeds 3 feet or if the adult fishway head is reduced, the unit's racks will be raked immediately, even if it is early in the day. When debris accumulation is persistent, unit 18 may be operated while the fish unit is off at night to help draw loosened debris away. [NOTE: Bonneville Project's gatewell drawdown monitoring program is more stringent, and measurements occur at least once per day.]
(9) Routine maintenance - Bonneville Project auxiliary water systems consist of gravity flow and hydroelectric generating systems. Preventive maintenance and normal repair are carried out as needed throughout the year. Trash racks for the AWS system intakes will be raked when drawdown exceeds criteria. When practicable, rake trash racks during the time of day when fish passage is least affected.
(10) Winter maintenance - Remove debris from forebay, trash racks, and gatewell slots such that these areas are free of debris.

b. <u>2013 FPP B2 Fish Unit Lamprey Operations.</u> Lamprey Operations from June 1 - August 31: During nighttime spill hours (see Table BON-5 in 2013 FPP), reduce fish unit output to operate all north (NUE and NDE) and south (SUE and SDE) entrances at 0.5 feet of entrance head. To ensure proper function of the fish units, B2 fish unit output can be further reduced or placed on standby to float debris as necessary between 2200-0400 hours.

c. <u>2013 FPP Routine Diffuser Maintenance.</u> If a diffuser grating is known to have or is suspected of having moved, creating an opening into a diffuser chamber, efforts must immediately be taken to correct the situation and minimize impacts on adult fish in the fishway. If possible, a video inspection should be made ASAP to determine the extent of the problem. If diffusers gratings are found to be missing or displaced, creating openings into the diffuser chambers, a method of repair shall be developed and coordinated with the fish agencies and tribes through the established FPOM coordination procedure. Repairs shall be made as quickly as possible unless coordinated differently.

d. <u>Adult Passage and In Water Work Period.</u> Adult fish passage occurs at Bonneville Dam throughout the entire year. Bonneville Dam continuously operates all adult ladder system from March 1 through Nov 30 period per the Fish Passage Plan guidelines. The In Water Work period begins on Dec. 1 and ends Feb. 28. Winter maintenance during this time consists of annually alternating dewatering and maintenance of B1 and B2 so there is always an adult ladder operating for winter fish passage.

## 4.3 Biological Considerations of not Operating a fully functional B2 AWS System

a. Adult Passage - Salmonids, Bull Trout, and Lamprey Passage. During periods of high debris accumulation, the fish units are not operated in an effort to reduce drawdown. Significant resultant impacts include:

(1) Passage delay in the tailrace outside the ladder.
(2) Passage delay in the transition from the collection channel to the ladder.
(3) Fallback from the ladder to the tailrace.
(4) Marine mammal predation – Marine mammals have been more prevalent in the tailrace at Bonneville Dam since the writing of the 2001 DDR. Delay or loss of salmonid and lamprey entry into the collection channel when sea lions are present may lead to elevated predation mortality and injury.
(5) Potential reduction in lamprey passage - Understanding of lamprey passage data, low passage efficiency compared to salmon, and behavior at the B2 adult ladder has received much more research effort over the last decade. Large scale fishway velocity experiments in recent years have furthered our understanding of the low entrance efficiency for lamprey during fish unit standby conditions, indicating poor attraction. Point estimates of fishway exit ratios were highest during standby operations during two of the three study years (Johnson et al. 2012). Any reduction in fish unit downtime during times when lamprey are present at B2 would probably benefit lamprey passage.

b. Impacts to Fish from Dislodged and Open Diffuser Gratings. Section 2.4 and the 2001 DDR provide detail regarding the effort to re-secure diffuser grating and fish salvages under gratings and in the AWS system. The B2 powerhouse is the priority powerhouse and larger proportions of adult salmon and lamprey tend to pass this powerhouse compared to B1. The efforts and time to access this area can potentially result in significant impacts to fish. Project resources needed to support this effort are extensive. In addition, the large number of fish in the B2 ladder means they are at greater risk from incurring injury due to shifted grating and exposed metal corners and surfaces.

White sturgeon are an important cultural, recreational, and commercial resource in the Columbia River Basin. Large aggregations of white sturgeon have been reported in the Bonneville Dam B2 ladder system in recent years. The highest visually observable densities of sturgeon during fish passage season occur when shad are present and during dewatering. They are located primarily in the collection channel and junction pools. Project personnel have encountered large densities of sturgeon (in excess of 1000) in the B2 collection channel during dewatering for winter maintenance, typically in early December (USACE, BON Annual Report, 2011). It is unknown how long they may reside in the B2 collection channel and lower ladder or the B2 movement patterns between tailrace and ladder system.

c. Juvenile Salmonids and Juvenile Lamprey. Unit 18 gatewells and debris accumulation: Debris accumulation on the VBS and in the gatewell is linked to elevated descaling and mortality of juvenile fish as recorded by the Fish Passage Center Smolt Monitoring Program operated by Pacific States Marine Fisheries Commission at Bonneville Dam's B2 Juvenile

Bypass System's Smolt Monitoring Facility. As described in Section 2.2, unit 18 gatewells accumulate debris on the Vertical Barrier Screens (VBS) at a more rapid rate than any of the other B2 main units. Floating trash off the Fish Units and the hydraulic conditions in the forebay may contribute to the elevated rate of debris accumulation on the unit 18 VBSs. Project Operators may reduce main unit flow at times when the VBS's accumulate debris and exceed drawdown criteria between cleanings. Having the ability to better manage debris at the Fish Units may reduce the rate of debris accumulation in the unit 18 gatewell, as well as the incidence of juvenile fish descaling and mortality.

### 4.4 ADULT SALMONID DESIGN CRITERIA

The B2 ladder system hydraulic criteria is also the current FPP criteria, and is described in Section 2.1 and HELCRABS, 2005. NMFS criteria for design of fish passage facilities are described in *Anadromous Salmonid Passage Facility Design, NMFS, July 2011*. The NMFS guidelines should be followed in fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. NMFS criteria that are considered to meet the objectives of this DDR:

a. A fish passage criterion for Horizontal Diffusers with a maximum of 1 inch spacing is 0.5 ft/s.
   (1) The actual design criteria were 0.85 ft/s (pg.39 HELCRABS). The B2 collection channel exceeds NOAA criteria (Table 15 and 16 in B2 HELCRABS). There have been no observed problems with salmonid delay in the collection channel of the ladder under normal operation based on current data.

b. Transport velocity criteria between the fishway entrance and first fishway weir must be between 1.5 and 4.0 ft/s.
   (1) The current system meets this requirement.

c. Hydraulic drop across entrance (also called entrance head) must be maintained between 1 and 1.5 feet and designed to operate from 0.5 to 2.0 feet of hydraulic drop.
   (1) The current system meets this requirement.

d. Each diffuser must include access for removal of debris, unless the AWS system intake is equipped with a juvenile criteria fish screen.
   (1) The current system meets this requirement.

### 4.5 JUVENILE SALMONID DESIGN CRITERIA

The Bonneville Second Powerhouse Auxiliary Water Supply Backup System 2001 DDR described juvenile salmonid design criteria at the fish unit intakes. The intake trash racks and forebay hydraulics in 2013 have not changed since 2001. The fish units are protected by trash racks with a clear space of 0.875 inches. The top of the fish unit intake is at elevation 44 fmsl and the bottom of the intake is at elevation -21.9 fmsl. The typical forebay water surface operation range is between 71.5 and 76.5 fsml.

Theoretically, a juvenile migrant could enter the AWS system through the intake and wind up on the wrong side of the diffuser gratings. The total volume of water entering both Fish Unit intakes is approximately 6000 cfs and a small percentage (4 percent) of total powerhouse flow when all eight main units are running near their maximum of approximately 145,000 cfs, typical during the freshet and spring migration. Route-specific juvenile salmonid passage evaluations from 2008-2012 indicated that a very small proportion of fish actually pass through the fish units (PNNL, pers. comm., 2013). This is likely due to passage distribution through the various B2 routes including; the juvenile screened bypass system, B2 turbines, as well as the B2 Corner Collector which is a surface bypass route (~5000 cfs) with high collection efficiency that is located on the south end of the powerhouse. Hence, additional fish protection screening at the fish unit intakes would not have a measureable impact on juvenile survival, and therefore are not required.

### 4.6 Adult Lamprey Passage Design Criteria

a. Design criteria to consider for lamprey under the 2008 Columbia Basin Fish Accords MOA. The MOA states – "*Begin replacement of existing gratings with new gratings with ¾ inch spacing in those areas of the fish ladders with the most identified problems.*"

Recommendations for changes to diffuser grating bar spacing at mainstem dam fish ladders can be found in the COE Bonneville/The Dalles/John Day Improvements for Lamprey, 99% Letter Report. The adult fish ladder at B2 WA shore has diffuser grating bars spaced with a 1 inch clear opening between the bars. The existing 1 inch clear space diffuser grating would be replaced with 0.75 inch grating to exclude lamprey from being able to pass through to the diffusion chamber and AWS system. The report states the twenty Fish Unit trash racks will be replaced as originally designed, except that the vertical bars will be spaced with a 0.75 inch clear opening between the bars. [Please see the full report for additional information regarding hydraulic and structural design requirements, schedule, and funding]

These criteria were carefully examined and weighed during the evaluation of alternatives following the design charrette for the trash rake improvements. The theory behind the new criteria is that any debris that passes through a trash rack should be able to pass through the diffuser grating; therefore, the trash rack clear spacing should be equal to or less than the diffuser grating clear spacing. The DDR team analyzed the AWS system beginning at the B2 forebay through the system to the tailrace and considered:

(1) Bonneville Project observations of the chaotic alignment, size, and quantity of woody debris accumulation under the diffuser grating.
(2) Debris seasonality and presence at Bonneville including the rate of debris accumulation on the trash racks, upstream of the trash racks in the forebay, and in the AWS system.
(3) Maintenance frequency.
(4) The existing Fish Unit and fish ladder hydraulic demands and performance. (HELCRABS, 2005)
(5) Forebay hydraulics and bathymetry.
(6) Performance of past floating events, turbine shutdown, and raking events.
(7) Diffuser grating and trash rack inspections including a ROV inspection at the trash racks during raking.
(8) Structural design, fabrication limitations and repairs of 0.75 inch clear spaced racks.
(9) Exclusion of debris in the AWS system with the existing 0.875 inch trash rack vs. the expected benefit of a reduction of 0.125 inch to 0.75 inch trash rack.

(10) The preferred alternative selection to improve the existing trash rake. See Figure 2-1 and plates 1-4.
(11) The expected performance of the upgraded trash rake.
(12) Cost to replace racks.
(13) Additional hydraulic concerns related to a reduced clear space of vertical members of the trash rack include: reduced porosity, additional head loss, increased velocity between bars, potential for vibration issues with possibility of instability of the racks and increased rate of debris accumulation on trash rack.

b. B2 AWS INTAKE BAR CLEAR SPACING DESIGN CRITERIA

The DDR team agreed that each AWS system intake at each main stem project should be analyzed individually due to their unique configurations. Each system exhibits variability in hydraulic conditions around the intakes and demands of the system as well as variability in debris management.

The DDR team concluded that the B2 AWS system fish unit trash racks should continue to be used and remain at their current 0.875 inch clear spacing until new evidence requires a change.

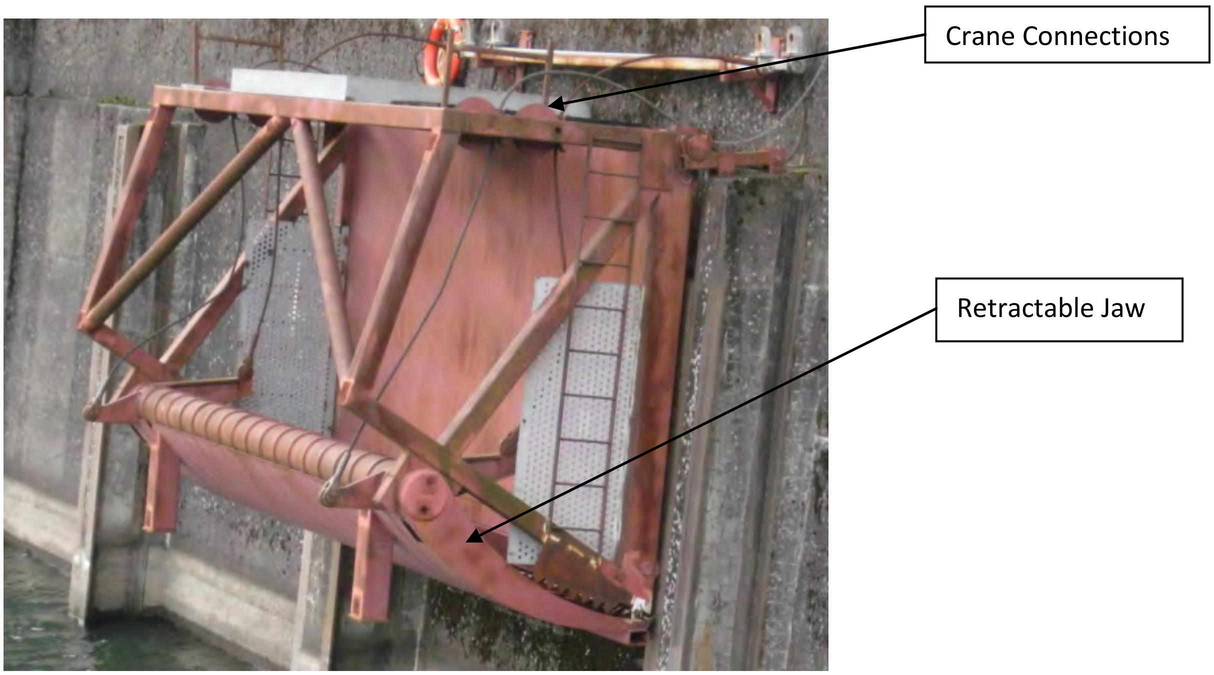
c. B2 ADULT LADDER DIFFUSER GRATING CHANGES FOR LAMPREY

Plans and Specifications for diffuser grating improvements for adult Pacific lamprey at Bonneville fish ladders are not yet available. The B2 ladder will be assessed independently during the plans and specifications phase where further scope and cost refinements will be made.

Diffuser maintenance and debris removal is expected in the future with both1.0 inch vs. 0.75 inch diffuser clear space dimension. The maintenance frequency at the diffuser grating is not something that can be determined with certainty. Inspections will help determine if the rates of debris accumulation change if the diffuser grates and/or trash rack sizing are modified. It will be up to a future program/project to fund and execute any new trash racks, if deemed necessary, and any associated changes required to modify the trash rake if the DDR trash rake system improvements are implemented and found to be incompatible with 0.75 inch diffuser grating.

## SECTION 5
## MECHANICAL DESIGN

### 5.1 MECHANICAL DESIGN CRITERIA




Existing Leaf Rake

Given that the existing rake will continue to be used; only minor modifications to the rake will be needed for anticipated improvements in debris removal. After careful inspection the following comments reflect the current condition of the rake:

a. The paint system shows some corrosion on wear surfaces.
b. The jaw opens and closes easily.
c. During rake operation the sheaves function as designed.
d. There is some existing damage at the interface between the jaw and the rake teeth; this does not significantly affect the rakes function.
e. The leaf rakes show significant damage; the shaft is bent in a number of locations and the teeth are bent and broken.
f. Some cracked welds exist in non-structural members.

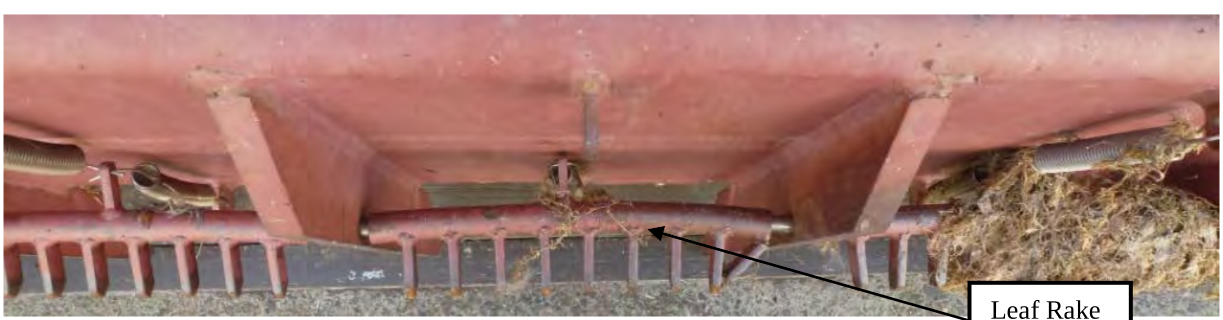



**Figure 5-1:** Leaf Rake Condition


**Figure 5-2:** Front of Existing Rake

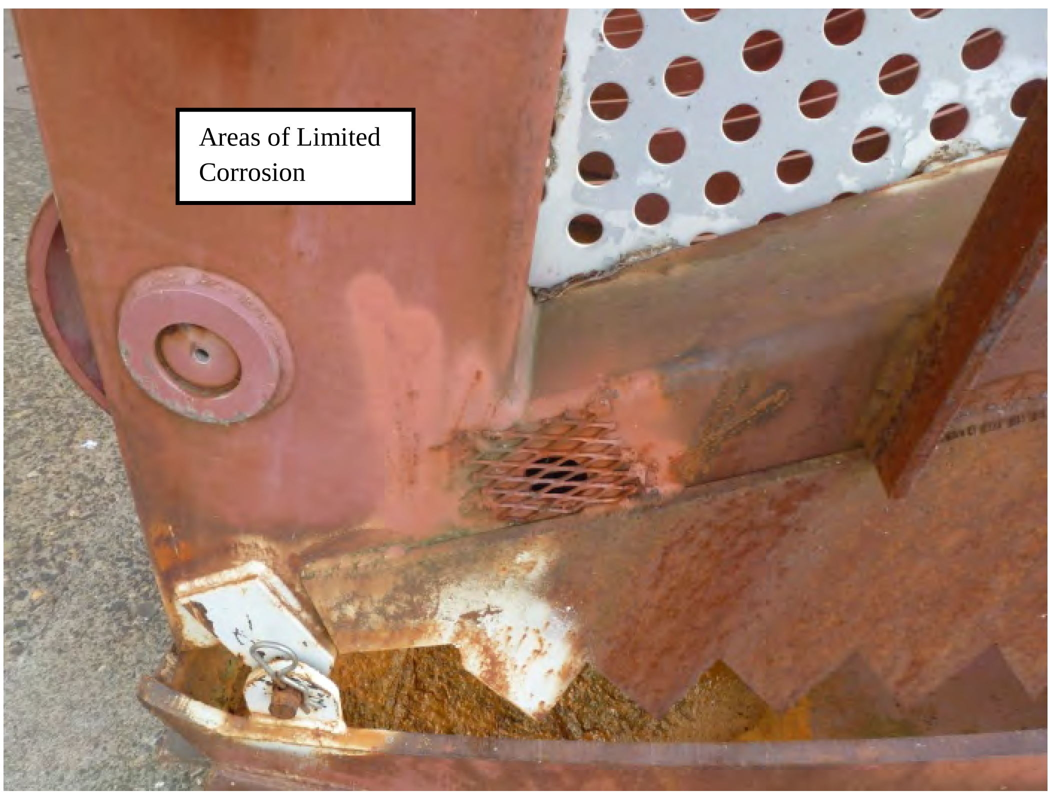



**Figure 5-3:** Rake Left View


**Figure 5-4:** Rake Left View


**Figure 5-5:** Rake Back View

## 5.2 Proposed Changes

It is evident, based on project feedback and ROV inspection, that the rake is generally successful in removing large woody debris from the surface of the racks but has problems removing grasses matted on the surface of the rack. Mechanical design assumes that in the original design the leaf rake assemblies were used to clean the grasses from the surface of the racks.

a) Rack Scraper

A ramp will be constructed on the front edge of the rake at the interface between the rake and the rack. The ramp will consist of a plate welded to the top of the existing tines. The ramp will have slotted holes to allow for UHMW plate adjustment. The slot length will allow the UHMW plates to closely interface with the fish unit intake racks. The UHMW plates will absorb damage and can be replaced as needed. Four sacrificial 0.1875 inch diameter stainless steel rods will be used to field verify the distance from the rack to the rake. The rods will be threaded into the bottom of the existing tines and will be long enough to be bent by the racks as the rake is being used. This action will be performed only once and then the bent rods will be removed and measured to estimate the rake to rack clearance. The UHMW plates will be installed leaving a 0.5 inch gap between the leading edge of the UHMW plate and the trash racks.

b) Leaf Rake Improvements

Currently the leaf rake assemblies are damaged beyond repair and if a similar design is implemented it will likely experience similar problems. To improve the design, bolt on replaceable brush assemblies will replace the leaf rake assemblies. The bristles length will be long enough to engage the rack by 0.5 to 0.25 inches. Each assembly can be shimmed providing for bristle wear. Bristles will be stainless steel or nylon 6.

c) Rake Containment Area

The rake containment area requires additional perforated plates to retain the matted grasses during cleaning. The perforated plate will be 0.25 inch thick A36 carbon steel with oval holes. The hole size will be 1.75 by 4.5 inches staggered. The pattern is optimized to provide 55 percent porosity and to minimize machine time. Due to the shapes of the plates and the need to maintain a clear edge at the perimeter of each plate, the pattern must be made by using a water-jet or laser cutting machine. The plates will be welded to the structure using a staggered stitch weld and then painted using a 5-A-Z vinyl coating system. Stainless steel plate with the same perforation pattern may be used but must be bolted to and isolated from the interior structural members.

The top, right, and left sides of the rake will have the perforated plate installed to provide a bin that will capture milfoil and grasses during the downward travel of the rake. To promote debris entry, additional perforated plates will be installed on the bottom, bin area of the rake. Additional structure will be added to support the plates and they will be bolted in place for ease of removal (see plates 1-4).

Weights:

Existing rake weight- 16,600 lbs (dry)

Estimated modified rake weight -19,100 lbs (dry)

Auxiliary hoist capacity- 30,000 lbs

# SECTION 6
# STRUCTURAL AND ELECTRICAL DESIGN

## 6.1 STRUCTURAL DESIGN CRITERIA

Structural design evaluated the rake for deficiencies. Currently it does not have any issues that would preclude it from being used to rake debris. Cracks have propagated from the corners of the vertical angles bracing the back plate. These cracks were likely formed from fatigue loading either caused from vibration or frequency of loading. The fix submitted to the project consists of a cope at the corner between the two perpendicular connections. This will limit the stress concentration in this region. Welds in these corners do not significantly add to the strength of the stiffeners so removal of them will not decrease the ability of the angles to resist loads.

With the recommended additions of perforated plate the weight of the rake increases. From a simple analysis of the structure it was determined that there will be no issues regarding weight with the strength of the lifting attachments.

The other structural components of concern are the trash racks. The racks were originally designed for 7 feet of head differential, per the 2$^{nd}$ Powerhouse Trash Structure Design Memorandum No. 25. However, project personnel have recorded differentials of 20 feet. No structural damage was apparent during the underwater video inspection of the racks in 2013. Therefore, it has been determined that leaving the existing racks installed poses no serious threat to the structure. Future designs of the racks should take into account the added head differentials.

## 6.2 ELECTRICAL DESIGN CRITERIA

There are no electrical design components on the rake and there are no recommendations to add electrical components to the rake so, at this time electrical design is not required.

# SECTION 7
# CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Recommendations

The team recommends the following design changes and actions:

*Construction:*

a. Existing rake should be modified to improve its ability to strip and retain matted grasses from the surface of the intake racks.

*Operations and Maintenance:*

b. Rake as needed to maintain acceptable rack differentials.

c. Maintain design bathymetry in front of the Fish Units by maintenance dredging the forebay. Develop criteria to initiate action to dredge based on results of annual monitoring of sediment accumulation.

d. Rake as needed based on rate of debris accumulation and known high debris periods.

e. Conduct annual sediment buildup monitoring upstream of the fish units following peak spring river flows based on bathymetry and soundings so that a dredging contract can be executed for the next in water work period.

f. Monitor water height differential at each trash rack before and after cleanings and floating of debris. These events should be logged with date, time, duration, and any other information deemed necessary by the operator.

g. Annually remove intake racks and manually remove wedged in woody debris.

h. Biennial rack inspection of the structure, coating system, and damage repair.

i. Periodically exercise Auxiliary Water Supply (AWS) system diffuser gates that are not used regularly.

j. Continue to operate with the existing trash racks and maintain intake rack bar to bar spacing of 0.875 inch until new evidence requires a change.

k. Float debris only in emergency situations.

## 7.2 Construction

Recommendations listed will not require a construction contract. Project staff at Bonneville will complete the existing rake modifications based on the DDR plates. Fabrication can begin in summer 2014 barring unforeseen emergency resourcing by project staff. Portland District design staff will support the fabrication effort as needed.

### 7.3 Rake Modification Cost Estimate

An engineering cost estimate is provided in appendix F that shows a breakdown of material cost, labor cost, and support cost. The estimate includes a ten percent contingency cost. A summary of the cost estimate is shown in Table 7-1 below.

**Table 7-1:** Cost Estimate

| **Item** | **Cost** |
|---|---|
| Materials | $20,618.00 |
| Labor | $42,240.00 |
| Contingency | $6,286.00 |

### 7.4 Operations and Maintenance

a. Bathymetry and Soundings. A hydro survey will need to be performed to determine the current levels of sediment. This survey will be used to estimate the amount of material that will be removed to get the area back to levels consistent with the original design criteria. The survey will cost approximately 15,000 dollars and will require interpretation costing 5,000 dollars. Project staff support cost will be approximately 5,000 dollars.

b. Maintenance Dredging. The team concurs with the 2001 DDR recommendation that reoccurring maintenance dredging must be performed in the area directly in front of the fish units. If the design bathymetry is not maintained, debris will have a tendency to accumulate on the intake racks and in the AWS system at an accelerated rate. The benefit of the maintenance dredging is observed by operations and maintenance personnel as debris is more manageable at the trash racks after a significant dredging event. Cost is approximately 30 dollars a cubic yard with an initial 100,000 dollar mobilization cost.

Maintaining the design bathymetry has the added benefit of reducing debris inundation of the AWS system. Less debris in the system will lead to fewer diffuser grating failures and unscheduled dewaterings of the AWS system to remove debris. These problems elevate operations and maintenance costs, consume significant levels of time and resources, and have negative effects on fish passage.

c. Intake Rack Cleaning. The team also supports annual removal of the intake racks for inspection and cleaning. This event was also grouped in with every alternative during the evaluation. It is likely a maintenance necessity due to the complexity involved to fully engage and mechanically remove imbedded debris in season because of the existing trash rack geometry, depths, angles, and hydraulics. The fish unit racks are especially vulnerable to woody debris getting wedged between the bars. The alternatives examined have uncertainty associated with the ability to remove embedded debris. The existing rake does not clean this type of debris so the trash racks should be periodically removed to +90 deck level for manual debris removal until a rake improvement has been proven to eliminate the need. Cost is approximately 12,800 dollars per cleaning.

During cleaning the racks can be inspected for damage and structural integrity. The coating system should also be inspected and repaired as needed. If the coating system shows severe damage, blasting and painting is highly recommended.

d. Trash Rack Inspection. Use an ROV to inspect the Fish Unit trash racks during midseason (early August), for fish ladder inspection of condition, debris accumulation, and in water work (IWW) planning.

e. Blocking of the Lower Trash Racks. The lower intake racks for the fish turbine intakes have been plated off to keep sediment from entering the fishway. These racks will not need to be removed if there is a reduction in rack spacing from 0.875 to 0.75 inch open space between intake rack bars.

f. Internal AWS System Sediment Control. Controlled operation of the AWS system may allow sediment to freely pass through portions of the system and avoid excessive build up within the chimney style B diffusers. Recommend:

(1) Develop operational criteria language for the COE Fish Passage Plan to periodically cycle closed B-diffusers to maintain clear chimney(s) during periods of high debris or when duration of closure is expected to be significant.

(2) Develop criteria to initiate ROV camera inspection of AWS system channel (B2 FU Debris Study July, 2000 recommendation).

g. Raking as needed based on rate of debris accumulation and known high debris periods. Raking is performed at regular intervals to maintain a maximum trash rack differential of 3 feet. A raking log should be kept separate from the crane logs. In the log trash rack differential, time and date, and staff comments should be shown. Cost is approximately 15,000 dollars annually on average. This cost can fluctuate greatly based on debris inflow rates.

## 7.5 FUTURE PROJECT CONSIDERATIONS

a. If diffuser grating in the ladder is changed to 0.75 inch open space between bars further evaluation of the diffuser grating debris loads will be necessary along with further evaluation of fish unit flow requirements.

b. Develop a system to flush debris from the bottom side of the diffuser gratings.

c. Develop alternate trash rack fabrication methods or designs as the closely spaced vertical bars constructability and field repair are problematic. Alternate trash rack designs will need to be coordinated with modifications to the existing rake or fabrication of a new rake.

# APPENDIX A

# LIST OF REVISIONS

# APPENDIX B

# REFERENCES

Johnson, E. L., C. C. Caudill, M. L. Keefer, T. S. Clabough, C. A. Peery, M. A. Jepson, and M. L. Moser. 2012. Movement of Radio-Tagged Adult Pacific Lampreys during a Large-Scale Fishway Velocity Experiment. Transactions of the American Fisheries Society. 141:3, 571–579.

National Marine Fisheries Service Northwest Region. July, 2011. Anadromous Salmonid Passage Facility Design.

Pacific Northwest National Laboratory. Bonneville Powerhouse 2 Fish Unit Sedimentation Studies: CFD Model of the Forebay with Structural Alternatives. August 2013.

U.S. Army Corps of Engineers. Fish Passage Plan. 2013.

U.S. Army Corps of Engineers. ER 1110-2-1150, Engineering and Design for Civil Works Projects. August 1999.

U.S. Army Corps of Engineers. 2nd Powerhouse Trash Structure Design Memorandum No. 25

U.S. Army Corps of Engineers, Portland District. Bonneville 2nd Powerhouse Fish Unit Debris Study Reconnaissance Report, Final, July 20, 2000.

U.S. Army Corps of Engineers, Portland District. Bonneville Second Powerhouse Auxiliary Water Supply Backup System DDR, November 2001.

U.S. Army Corps of Engineers, Portland District. Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems (HELCRABS) Bonneville Second Powerhouse Fishway Evaluation Report, September 2005.

U.S. Army Corps of Engineers, Portland District, Bonneville Lock and Dam. 2011 Annual Reports for Bonneville Dam.

U.S. Army Corps of Engineers, Portland District, Bonneville Lock and Dam. Washington Shore Fishway Structural and Mechanical Work Performed Report, March 2011.

U.S. Army Corps of Engineers, Portland District. Bonneville/The Dalles/John Day Grating Improvements for Lamprey, 99% Letter Report, May 2008

# APPENDIX C

# TECHNICAL REVIEW DOCUMENTATION

Comment Report: All Comments
Project: Bonneville Dam Powerhouse 2 Adult Fishway Auxiliary Water Supply Trash Rake
Review: 90%
Displaying 11 comments for the criteria specified in this report.

| Id | Discipline | Section/Figure | Page Number | Line Number |
|---|---|---|---|---|
| 5492791 | General | n/a | n/a | n/a |

Comment Classification: **Public (Public)**

I made several comments and proposed edits (using track changes) to the report that pertain to general readibility. They are contained in the attachement.

(Attachment: Bonneville_B2_trash_rake_DDR_2013_15JAN14-STS.docx)

Submitted By: Seth Stevens (503.808.4849). Submitted On: Jan 21 2014

**1-0** Evaluation **Concurred**
Almost all comments proposed included. Thank you for your detailed assessment, it improved the clarity of the document.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
These comments were suggested edits for general readibility and grammar - no backcheck required.

Submitted By: Seth Stevens (503.808.4849) Submitted On: Jan 30 2014

Current Comment Status: **Comment Closed**

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| Id | Discipline | Section/Figure | Page Number | Line Number |
|---|---|---|---|---|
| 5492794 | Structural | n/a | n/a | n/a |

Comment Classification: **Public (Public)**

The proposed improvements include adding perforated steel plates to the existing trash rake. Has the existing rake structure been analyzed for the additional loading from the perforated plates? Additional loads will include dead load, drag load, and friciton load.

Submitted By: Seth Stevens (503.808.4849). Submitted On: Jan 21 2014

Revised Jan 21 2014.

**1-0** Evaluation **Concurred**
The rake structure as a whole hasn't been analyzed, but I've included a simple lifting attachment check. The capacity is roughly 3 times the crane load rating of 15 tons.

Submitted By: Jordan Reimer (5038084941) Submitted On: Jan 30 2014 (Attachment:

b2rakeattachment.pdf)

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Seth Stevens (503.808.4849) Submitted On: Jan 30 2014
Current Comment Status: **Comment Closed**

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5492795 Mechanical n/a n/a n/a
Comment Classification: **Public (Public)**

The proposed improvements include adding perforated steel plates to the existing trash rake. Has the existing hoist been analyzed for the additional loading from the perforated plates? Additional loads will include dead load, drag load, and friciton load.

Submitted By: Seth Stevens (503.808.4849). Submitted On: Jan 21 2014

Revised Jan 21 2014.

**1-0** Evaluation **Concurred**
A simple analysis was done and mentioned in report: Section 6, 6.1 Structural Design Criteria, Para 1.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Based on feedback from the PDT, it appears that the hoist has adequate capaicty for the additional loading.

Submitted By: Seth Stevens (503.808.4849) Submitted On: Jan 30 2014
Current Comment Status: **Comment Closed**

---

5492798 Structural n/a n/a n/a
Comment Classification: **Public (Public)**

The proposed improvements include cutting a hole into a solid steel plate of the trash rake to install three perforated plates. Will these modificaitons compromise the structural integrity of the rake?

Submitted By: Seth Stevens (503.808.4849). Submitted On: Jan 21 2014

**1-0** Evaluation **Concurred**
The existing plate uses angles spaced evenly to provide the stiffness. It is likely that these will have to be replaced when the perforated plate is installed. There is no concern for the structural integrity as this is not an area that sees much load other than negative pressure from the turbine.

Submitted By: Jordan Reimer (5038084941) Submitted On: Jan 23 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Seth Stevens (503.808.4849) Submitted On: Jan 30 2014
Current Comment Status: **Comment Closed**

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5492800 General n/a n/a n/a
Comment Classification: **Public (Public)**

The proposed perforations are 1.5"x4.5" ovals. This seems potentially large enough for the grass that is cleaned off of the rack to pass through. Has this been considered as part of the design?

Submitted By: Seth Stevens (503.808.4849). Submitted On: Jan 21 2014

**1-0** Evaluation **Concurred**
An ROV inspection showed that the grasses are very matted and tangled. The ovals are designed, using project personnel feedback, to capture this type of grass accumilation while maintaining a porosity level believed to be sufficient to keep materials from boiling out of the containment area. Free floating grasses that pass through the ovals are concidered a low risk for occluding the trashracks; they will more likely pass through and into the AWS system.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Jan 30 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Seth Stevens (503.808.4849) Submitted On: Jan 30 2014
Current Comment Status: **Comment Closed**

---

5493977 General n/a viii n/a
Comment Classification: **For Official Use Only (FOUO)**

Abreviations, change spelling to Abbreviations

Submitted By: Jordan Reimer (5038084941). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
Done

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 12 2014
Current Comment Status: **Comment Closed**

---

5493979 General n/a viii n/a

Comment Classification: **For Official Use Only (FOUO)**

AWS should be listed as only Auxiliary Water Supply. Too confusing adding American Welding Society on there too.

Submitted By: Jordan Reimer (5038084941). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
Changed.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 12 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5493980 | General | n/a | viii | n/a |

Comment Classification: **For Official Use Only (FOUO)**

HDC is Hydroelectric Design Center

Submitted By: Jordan Reimer (5038084941). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
Changed.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 12 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5493983 | General | n/a | 1-1 | n/a |

Comment Classification: **For Official Use Only (FOUO)**

Auxiliary Water System should be changed to Auxiliary Water Supply System or just Auxiliary Water Supply

Submitted By: Jordan Reimer (5038084941). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
'Auxiliary Water Supply'(AWS)system consistent with 2001 study.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 12 2014
Current Comment Status: **Comment Closed**

---

5493987 General n/a 1-1 paragraph 1.1a
Comment Classification: **For Official Use Only (FOUO)**

Consider changing the sentence starting with "Current operations..." to "Current operations during periods of high debris in the system have required that the fish units be shut down for short intervals."

Submitted By: Jordan Reimer (5038084941). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
Changed.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Jan 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 12 2014
Current Comment Status: **Comment Closed**

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5494330 Mechanical 5.2 45 n/a
Comment Classification: **Public (Public)**

"Each assembly can be shimmed providing for bristle wear; bristles can be stainless steel or nylon 6."

Shims require significant time to adjust. An eccentric shaft or other gross adjustment device would more readily provide wear compensation.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Jan 22 2014

**1-0** Evaluation **Concurred**
This is a good point. however, during conversations with OD-B staff reducing the complexity of rake's mechanical systems is a priority. Shimming is unlikely to occur and is stated to provide a contigency action for brissle wear if replacements are temporarily unavailable. Each brush is about 125 dollars. At this cost, once the brushes become ineffective they will likely be replaced.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Jan 30 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 11 2014

Current Comment Status: **Comment Closed**

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Comment Report: All Comments
Project: Bonneville Dam Powerhouse 2 Adult Fishway Auxiliary Water Supply Trash Rake
Review: DTR
Displaying 78 comments for the criteria specified in this report.

| Id | Discipline | Section/Figure | Page Number | Line Number |
|---|---|---|---|---|
| 5513089 | General | Synopsis | Page i | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 2 Purpose, DDR recommendations item b. clarify the type of 'differential' being proposed in the log that must be maintained.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
Clarified the statement: "p. Monitor water height differential at each trash rack before and after cleanings and floating of debris."

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014
Current Comment Status: **Comment Closed**

| Id | Discipline | Section/Figure | Page Number | Line Number |
|---|---|---|---|---|
| 5513103 | General | Synopsis | Page i | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 3. Bonneville Dam Location. 4th sentence, doesn't this dam function as a flood mitigation control structure as well?

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
Amended the phrase ". The primary functions of Bonneville Lock and Dam are electrical power generation, flood control, and river navigation."

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014
Current Comment Status: **Comment Closed**

5513108 General Synopsis Page ii n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Delete this page. It has no purpose.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **For Information Only**

After integration of the review comments this page is now needed.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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5513132 General Synopsis Page iii n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 4. Construction. Recommend a projected time frame be stated, probably during Fish Unit Outage for both dredging operations to limit turbidity concerns, and for intial proposed repairs to the screens.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**

Dredging operations have already been performed Feb 2012. This report recommends that, as part of O&M hydrosurveys and dredging is performed at regularly scheduled intervals. Added the phrase" Future dredging and hydro surveys should be coordinated with agencies and will likely occur during normally scheduled fish unit outages."

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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5513229 General Synopsis Page iii n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 5. The total cost of this project will be much greater than the constructed repairs alone. The stated $69,144 appears to only include materials, labor, and engineering support cost for modifying the existing trash racks based on the DDR plates. Maintenance dredging costs for the proposed recommendation have not been included.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**

The team decided not to provide cost for dredging as the CY can vary greatly from year to year. Language has been added that states the hydro survey should occur in the spring so that a dredging contract can be executed for the normal in water work period.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513377 | Cost Engineering | Appendix F | 196 of 589 in the pdf | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**
(Document Reference: Engineering Cost Estimate)

The cost estimate has no pricing for paint prep, paint materials, and paint system application. Verify that other cost elements have not been overlooked.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**

The cost estimate was coordinated with the tech staff and maintenance staff. It was verified to be adequate for the proposed rake modifications.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513405 | Design Team Leader | Appendix H | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**
(Document Reference: Nov 2001 DDR for B2 PH Aux Water Supply Backup)

Not sure why this DDR Report is included in the current 90% package. If relavent language is pertinent, perhaps it should be called out in the synopsis, but it is not evident how it is related based on the proposed recommendations.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **For Information Only**
The team felt that the additional background information will be useful to the reader in understanding the problem. The 2001 DDR studied the same problems as this report.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513725 | Construction Management | Section 6 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 6.1 Structural Design Criteria. Repairs to be made in conjunction with the mechancial work planned for July of 2014 appear to conflicting with the fabrication work planned for August 2014. Is the sequencing of the work properly planned?

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **For Information Only**
The structural repairs are relatively minor compared with the proposed rake modifications; both can be accomplished simultaneously.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513729 | Construction Management | Section 6 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

6.1 second paragraph, the report states the original design of the racks was based on a head differential of 7 feet while project personnel have recorded head differential of 20 feet more than double the original design criteria. At face value, this statement indicates and exceedance of any factor of safety although the report does not address this, nor what the final proposed design will have for it's factor of safety.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
The final design does not modify the trash racks. The original factor of safety still applies. The report does recommend performing inspections and repairs during annual cleanings.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513731 | Construction Management | Section 7 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 7.2 Construction. With project personnel performing the repairs to the trash rack system, what procedures or processes will be used to commission the trash rack/rake modifications?

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
The existing rake will be modified only to capture the matted grasses that lie on the surface of the trash racks. Rake operating proceedures remain unchanged.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513732 | Construction Management | Section 7 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Once the modifications have been made, what provisions are being considered for As-Built and Record Drawings? The DDR is silent on this issue.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
As-builts will be coordinated by the Bonneville project staff. DDR updates will be performed after the rake has been modified.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513733 | Construction Management | Section 7 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 7.3 Cost Estimate. The engineers estimate does not include all recommended work as stated earlier in the synopsis nor in Appendix F. Dredging, system for data logging of head loss, etc are not mentioned.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
The team decided that cost to modify the rake is the closest to a true construction cost. Dredging costs will vary based on the hydrosurveys. Headloss recording is something the project already does but is not regularly recorded.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5513734 | Cost Engineering | Section 7 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Paragraph 7.4 Bathymetry and Soundings. There are several items of cost here that are related to the dredging effort planning that have not been included in the totatl project cost as stated in the synopsis and later in the Engineers Cost Estimate.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
The report was written to include a cost estimate for the construction effort only. The team felt survey costs could be easily obtained or estimated as it is something the COE does regularly.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

| | | | | |
|---|---|---|---|---|
| 5513735 | General | n/a | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**
(Document Reference: 90% DDR documents)

No design standards or design criteria were found for work that is contemplated in the recommendations.

Submitted By: Joe Russell (503-808-4917). Submitted On: Feb 06 2014

**1-0** Evaluation **Concurred**
COE rake design standards, for this specific application, could not be located. The remaining recommendations are O&M related and can only be changed if site specific SOP's are amended.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Open Comment**
Standards establish the quality level of the work that is to be performed. If design standards aren't provided, then call out the level of quality expected.

Submitted By: Joe Russell (503-808-4917) Submitted On: Feb 27 2014

**2-0** Evaluation **For Information Only**
welding codes and fabrication tolerance is called out on the plates; these refernces can be added to the text; are there other specific standards that you are looking for?

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**2-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Joe Russell (503-808-4917) Submitted On: Mar 03 2014
Current Comment Status: **Comment Closed**

| | | | | |
|---|---|---|---|---|
| 5515617 | Design Team Leader | n/a | i | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Synopsis, introduction. Should mention that project is to support the B2 AWS Trash rake.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

**1-2** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Mar 05 2014

Current Comment Status: **Comment Closed**

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5515618 Design Team Leader n/a i n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Under PURPOSE, DDR recommendations. Should note here which of the improvements, a through e, this report focuses on as there is not enough documentation for all. i.e. maybe the PDT recommends dredging but this report does not focus on that aspect of the O&M.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
The items a through e fall under the previous DDR. The team evaluated the items and provided additional information specfic to items g through p. Some of those items are recommendations from the previous DDR that needed to be reiterated for implementation purposes.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closing the comment but doesn't look like it was addressed; it was mainly for clarity and I think it would eliminate some confusion to add a little explanation in regard to these items.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5515619 Design Team Leader n/a ii n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Remove this page.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
After revisions this page is needed

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014
Current Comment Status: **Comment Closed**

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5515620 Design Team Leader n/a iv n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

TOC: Incorrect page references for introductory items.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **For Information Only**
Corrected through added revisions

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014
Current Comment Status: **Comment Closed**

---

5515621 Design Team Leader n/a vi n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

APPENDICES instead of APPENDIX

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **Concurred**
corrected

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014
Current Comment Status: **Comment Closed**

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5515622 Design Team Leader n/a vi n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Figure 2-2: Personal preference, I wouldn't refer to 'bone yard' in the report TOC.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Corrected

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 13 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

---

5515623 Design Team Leader 1.1a 1-1 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

[**Critical/Flagged.**]

What environmental events since 2001?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Environmental events include Sediment infiltration, grasses and milfoil inundation, woody debris fouling.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Will close comment since it's just informational, but this brief description in your evaluation should be added to the text.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

**2-0** Evaluation **For Information Only**
Text added in section 1.1 to clarify.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Feb 27 2014

*Backcheck not conducted*

Current Comment Status: **Comment Closed**

---

5515625 Design Team Leader 1.4 1-2 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Agency reviews occurred at, rather than occur at 90% DDR.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5515627 | Design Team Leader | 2.1a | 2-1 | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

level transducers: did you describe information from 2001 level transducer installation that informed decisions for this project?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Early in the project the team decided that the level transducers are not in our scope. After talking the Bonneville project staff: Generally speaking this idea was not feasible because of the large diffuser area. Project staff did not implement it for that reason.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Would be good to have included something in the report to back up as it is not clear in original that 2001 info. was not implemented/used.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5515630 | Design Team Leader | 2.1c | 2-1 | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Under # 2: What was learned new rake and why it didn't work?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised with the following:
•Rake does not capture and retain debris (Logs or Grasses)
•Rake trips upper crane limit switch
•Rake intermittently trips the maximum load cell switch during rake retrieval
•Rake teeth, fabricated using composite bearing material are damaged beyond repair after three rake events

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

---

5515632 Design Team Leader 2.4d 2-7 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

UMT should be defined in acronyms section

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

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5515633 Design Team Leader Figure 2-6 2-9 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Label as 1986 and figure has no legend.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised; will add depth notes to the survey lines

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

---

5515634 Design Team Leader Figure 2-6 2-9 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Text refers to accumulation in front of unit 18; it would be helpful to label it on the figure.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised see 2-11

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014
Current Comment Status: **Comment Closed**

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5515635 Design Team Leader Figure 2-7 2-10 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Figure needs legend and labeling fish units on the figure would be helpful.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515636 Design Team Leader n/a 2-11 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

No title on figure.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **For Information Only**
Page 2-11 has figure 2-8 labled "October 2011 Forebay Bathymetry". Perhaps the page number provided is a typo

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
I believe when I printed it, that the title printed on the following page.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515637 Design Team Leader Figure 2-10 2-13 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Legend is unreadable.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Legend has been enlarged

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5515639 | Design Team Leader | Figure 2-11 | 2-14 | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Figure has unreadable legend and volumes marked on bath. are hard to read.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5515640 | Design Team Leader | Figure 2-12-2-15 | n/a | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**

Unreadable legends...

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515641 Design Team Leader n/a 3-2 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**
[**Critical/Flagged.**]

Criteria should be listed and in section earlier than it is. Especially in this case, with bar spacings need to have criteria clearly defined and possible changes to AWS diffuser grating bar spacings. Explain why .75 if we go to new racks and how current bar spacing measures to criteria.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
The criteria listed is specific to the automated rake as the trash racks would be replaced if it was determined that the system should be installed. This determination was not made until after the VE study was performed.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
This should be conveyed in the report.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515642 Design Team Leader n/a 3-2 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

What was done to study the eddy at B2? Maybe this is included in the CFD appendix, but should be described some here.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Please provide additional details. Pages 3-2 through 3-4 provide a summary of the results and the reader can then go to appendix G to get a more detailed explanation.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515643 Design Team Leader Fig. 3-1 3-3 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

A legend and labeling of units would be helpful.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515644 Design Team Leader n/a 3-3 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

"Wall configurations tested include all sections, just A sections...". Sentence doesn't make sense.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Added a colon to introduce a list. There were three wall configurations tested: (A1+A2)/(B1+B2+A1+A2)/(C1a+B1+B2+A1+A2)

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014
Current Comment Status: **Comment Closed**

---

5515646 Design Team Leader n/a 3-3 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Liza reviewing CFD but for general, last sentence should specify that flow passes through fish units for clean forebay and that 'clean forebay' means existing condition, because it could be mistaken for dredged.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5515648 Design Team Leader Figures 3-3 and 3-4 3-4 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Specify that plane was cut at 50 feet for these figures; a figure in the report showing the 'slice' would be helpful.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5515649 Design Team Leader c. first para. 3-5 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

'If it is determined that racks need to be replaced'... explain here under what conditions, if AWS diffuser gratings are replaced, etc.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5515650 Design Team Leader 4.2a, 4.4a, 4.5 4-2/4-4 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Rack and grating bar spacing criteria needs to be indluded

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

Revised Feb 08 2014.

**1-0** Evaluation **For Information Only**
The team was unable to locate specific criteria for trash rack bar spacing as it pertains to diffuser grating bar spacing. Lamprey spacing for retro fit of existing grating is 3/4" open bar to bar.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5515667 Design Team Leader 4.5, 4.6 4-5 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Describe here the significance of different bar spacing between diffuser grating and trash racks. It is described in more detail later but a brief explanation here would help to clarify.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
There is additional information on 4-6. Please review.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
I still don't see what I was asking about...

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5515673 Design Team Leader Criteria Sections n/a n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Suggestion, it may be easier if only criteria is listed out in criteria sections and discussion of impacts of meeting/not meeting in other sections.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Operations criteria is followed by biological considerations of not operating a fully functional AWS system. Design criteria follows this.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Thanks, this looks better

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5515689 Design Team Leader n/a n/a n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

General: How likely is it that diffuser grating will be changed out? If this happens we will need to re-look at this because of potential for increased impingement of debris on diffuser gratings? So, if it is happening, should include in this ddr as it would affect the rake modifications too.

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Currently the team does not have a timeline for diffuser grating replacement. Early in the project, because of this issue and the charter verbiage, the team did not study grating replacement in great detail. The team treated the grating replacement and it's affect on the AWS as a much larger and more complex separate problem.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 26 2014

Current Comment Status: **Comment Closed**

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5515698 Design Team Leader 6.1 n/a n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

I would think that much additional head differential could be a big issue. Maybe no deformation noted this year, but could happen in the future. Another DDR?!

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
Correct it could be a problem; this is why we have recommended annual trash rack inspections and differential pressure logs maintained. Floating the fish units is still an option in an emergency we just want to minimize it as much as possible.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5515703 Design Team Leader 7.1a 7-1 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Is the team recommending a schedule for dredging to ensure design bathymetry remains?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **For Information Only**
The team recommends that a survey is performed early in the season so a dredging contract can be executed for the following in water work period.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5515705 Design Team Leader 7.1c 7-1 n/a
Comment Classification: **Sensitive But Unclassified (SBU)**

Is annually enough?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014
**1-0** Evaluation **For Information Only**
Based on Bonneville project staff feedback annually should be enough; it really depends on the water year and how much debris comes down the river. It should be treated as indeterminate.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014
**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5515710 Design Team Leader c 7-2 n/a

Comment Classification: **Sensitive But Unclassified (SBU)**

Is hydrosurvey scheduled? Backup documentation for cost of survey?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

Revised Feb 08 2014.

**1-0** Evaluation **For Information Only**
A hydrosurvey was performed for 2012. Bonneville project staff have this information.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5515720 | Design Team Leader | 7.5c | 7-3 | n/a |

Comment Classification: **Sensitive But Unclassified (SBU)**
[**Critical/Flagged.**]

Why would they become fabrication and repair problems?

Submitted By: Marie Phillips (503-808-4812). Submitted On: Feb 08 2014

**1-0** Evaluation **For Information Only**
The typical trash rack has vertical bars. The fish units have a bar spacing of 0.875". This spacing according to project staff makes it very difficult to repair damaged bars. Initial fabrication is reasonable because each bar can be welded side by side but once the weld is broken the repair must be made with a bar on each side. proper welds are very difficult at this spacing.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
This should be mentioned in the report.

Submitted By: Marie Phillips (503-808-4812) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5517332 | Operations | n/a | n/a | n/a |

Comment Classification: **Public (Public)**

Paragraph 7.4 - It may be worthwhile to capture the maintenance costs associated with these recommendations.

Submitted By: Mike Adams (541.374.4573). Submitted On: Feb 10 2014

**1-0** Evaluation **For Information Only**
will Revise to add
12800 pulling racks and cleaning
15000 for raking
30$ a CY plus 100K to mob for dredging

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
NO COMMENT

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Mar 03 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5517353 | Operations | n/a | n/a | n/a |

Comment Classification: **Public (Public)**

Paragraph 7.1 - need more information about monitoring the intake rack differential. What is the purpose? Who will review the logs? Is there a set differential we will be expected to rake the trash at?

Submitted By: Mike Adams (541.374.4573). Submitted On: Feb 10 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mike Adams (541.374.4573) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5519727 | Mechanical | Fig. 5-1 | 5-1 | n/a |

Comment Classification: **Public (Public)**

No overview drawing of existing rake provided. Recommend adding a drawing of the rake and pointing out the location of the salient features.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

---

5519732 Mechanical 5-2 5-4 n/a
Comment Classification: **Public (Public)**

Section 5-2 discusses adding bristles to the rake.
Include cut sheets for the proposed brushes.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **For Information Only**
The brush specified is custom sized and fabricated. A fabrication quote was obtained from American Brush Company.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5519737 Mechanical 5-2 5-4 n/a
Comment Classification: **Public (Public)**

Brush modification is secondary to leading edge modification. Recommend starting section with leading edge modifications.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5519742 Mechanical 5-2 5-4 n/a

Comment Classification: **Public (Public)**

Four sacrificial 0.1875 inch diameter aluminum rods will be used to field verify the distance from the rack to the rake. The rods will be threaded into the bottom of the existing tines and are long enough to bent by the racks as the rake is being using (ed).

Do not advise adding aluminum to the rake. A soft steel rod bent into a loop will deform and provide clearance information needed.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5519758 | Mechanical | 5-2 | 5-4 | n/a |

Comment Classification: **Public (Public)**

What will happen if the operator gets aggressive and manages to completely fill the rake with woody debris and milfoil such that the load is beyond the capacity of the crane?

Recommend only adding perforated plate part way up after calculating allowable load. A dump device may also be required.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **For Information Only**
The raking occurs with the jaw in the open position on the downward stroke. At the bottom the jaw is closed and debris grabbed or trapped in the cup area of the jaw. If the load is too large for the crane the operator can open the jaw and try to grab a smaller load. Feedback from gantry crane 7 load cell will provide the information.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Open Comment**

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014

**1-2** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Mar 03 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5519836 | Mechanical | 5-2 | 5-4 | n/a |

Comment Classification: **Public (Public)**

All the changes appear to add weight to the rake. The aux hoist has a limited capacity for lifting the combined load of the rake and the debris. A table showing current limits and proposed capacity would be helpful.

Submitted By: Steven Sipe (503-808-4957). Submitted On: Feb 11 2014

**1-0** Evaluation **Concurred**
Added table

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Steven Sipe (503-808-4957) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5520889 | General | n/a | i | n/a |

Comment Classification: **For Official Use Only (FOUO)**

3. Bon location: River mile (146.1) does not match rm (145.2) listed in the table on p. viii

Submitted By: Fenton Khan (503.808.4777). Submitted On: Feb 12 2014

Revised Feb 12 2014.

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 18 2014

**1-1** Backcheck Recommendation **Close Comment**
NO ADDITIONAL COMMENT BY EMAIL CONFIRMATION

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Mar 03 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5520972 | General | n/a | 4-5 | n/a |

Comment Classification: **For Official Use Only (FOUO)**

4.6: ADULT LAMPREY
First paragraph, last sentence;
The report states the twenty Fish Unit trash racks. Believe this is a typo. Verify it is twenty and not actually two.

Submitted By: Fenton Khan (503.808.4777). Submitted On: Feb 12 2014

Revised Feb 12 2014.

**1-0** Evaluation **For Information Only**
The two fish units have twenty total trashrack sections. Additional text added in DDR to clarify.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Mar 03 2014

**1-1** Backcheck Recommendation **Close Comment**
NO ADDITIONAL COMMENT BY EMAIL CONFIRMATION

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Mar 03 2014

Current Comment Status: **Comment Closed**

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5533246 Hydraulics Section 1.1 n/a n/a

Comment Classification: **Public (Public)**

Section 1.1 Third para, the sentences describing the goals are redundant with paragraph b. System Improvement Goals. Suggest removing most of third paragraph.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5533248 Hydraulics Section 3.1 n/a n/a

Comment Classification: **Public (Public)**

Section 3.1 b. Reference to Figure 3-1 in the text states "Figure 3-1 shows the bathymetry in and around the north shore". Suggest stating more clearly whether this is based on as-designed, based on CFD model geometry for as-designed conditions, or? I assume it is CFD model geometry for existing conditions, based on recent survey data as described in Appendix G. If so, state this.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5533249 Hydraulics Section 3.1 n/a n/a
Comment Classification: **Public (Public)**

1. Section 3.1.b. 6th Para should start Computational Fluid Dynamics, rather than Computation. Also I think this is not the first use of CFD, so suggest defining the abbreviation at first use.

2. Same paragraph, second sentence refers to the use of neutrally bouyant particles and streamlines to describe debris movement. Unless this is done somewhere else, please provide a discussion of the limitations of using neutrally bouyant particles to describe the floating debris and how this was considered in interpreting the CFD model results.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
1.) Corrected
2.) Have added text to explain why we chose neutrally bouyant particles for flow characteristics and why we think it should be a reasonable representation of submerged debris. Let me know if this does not answer your concerns.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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5533250 Hydraulics Figure 3-3 n/a n/a
Comment Classification: **Public (Public)**

Figure 3-3 and several other locations refer to "clean forebay". I'd suggest changing this term to something else or clearly defining what is meant. With all the reference to debris and dredging it isn't necessarily clear to all readers that it means a forebay with existing structures.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5533251 Hydraulics n/a Page 3-3 n/a

Comment Classification: **Public (Public)**

Paragraph on Page 3-3 summarizing the results is choppy and the description of the wall configurations isn't clear. Suggest first clearly describing the wall/berm configurations tested, then summarizing the results. When summarizing the results, please include a description of the general flow patterns and some description of the expected debris patterns (see previous comment).

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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5533252 Hydraulics Section 7.1 Page 3-3 n/a

Comment Classification: **Public (Public)**

Is a frequency or threshold for maintenance dredging identified in the report? Suggest identifying one or the other to provide guidance for funding purposes.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **For Information Only**
The synopsis and section 7.1 have been updated to read - "Maintain design bathymetry in front of the Fish Units by maintenance dredging the forebay. Develop criteria to initiate action to dredge based on results of annual monitoring of sediment accumulation."

FPOM has already identified and approved criteria.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533253 | Hydraulics | App G p. 2.2 | n/a | n/a |

Comment Classification: **Public (Public)**

Section 2.2.2 Para 3 refers to the separate regions for the wall and berm before the types of alternatives for wall and berm configurations are described. this is a little confusing. suggest describing the purpose for the regions more clearly.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
Revised based on previous comment to provide clarity that three wall configurations were modeled.

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533376 | Hydraulics | Section 2.2 | n/a | n/a |

Comment Classification: **Public (Public)**

Section 2.2 last paragraph. Refers to the extrusion of the prism layers "from the wall boundaries in 0.5m". In 0.5 m thick layers, total, each? Please confirm and edit text. Also, is the prism layer thickness constant throughout the model domain? Is this consistentwith the STAR CD model grid? Also, without checking the references for the previous model grid, I think the use of polyhedral cells is a change now that the model is in Star CCM. The use of polys is noted, but if it is specifically a difference in the models, it should be noted as such. Suggest stating briefly the method or type of cells used in the Star CD version of the model and that polyhedral cells were used for the Star CCM grid.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
This comment is being answered through PNNL.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533379 | Hydraulics | Section 3.1.1 | n/a | n/a |

Comment Classification: **Public (Public)**

Last paragraph Section 3.1.1 refers to R2 values for the various runs. It isn't clear where these values are from. Similar values are discussed in other sections.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
This comment will need feedback from PNNL.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533381 | Hydraulics | Figure 3.2 | n/a | n/a |

Comment Classification: **Public (Public)**

Suggest adding a description of the run/flow condition to the captions

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
This comment may need PNNL's assistance.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Open Comment**
I understand this comment will be addressed by PNNL.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014

**1-2** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533382 | Hydraulics | Page 3.2.2 | n/a | n/a |

Comment Classification: **Public (Public)**

Second paragraph has a reference to (Need a Figure). Please include missing figure or reference.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
This comment may need assistance from PNNL.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5533383 | Hydraulics | Section 3.2.5 | n/a | n/a |

Comment Classification: **Public (Public)**

Suggest adding a brief description of the results as was included for other alternatives. This one just has a sentence describing what we hoped would happen.

Submitted By: Elizabeth Roy (503-808-4835). Submitted On: Feb 23 2014

**1-0** Evaluation **Concurred**
This comment may need PNNL assistance.

Submitted By: Karen Kuhn ((503) 808-4897) Submitted On: Feb 28 2014

**1-1** Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Elizabeth Roy (503-808-4835) Submitted On: Feb 28 2014
Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536478 | Structural | n/a | 1 | n/a |

Comment Classification: **For Official Use Only (FOUO)**

The document appears to discuss all components and alternatives to improve the Trash Raking System or Trash Removal Operations at B2. The report includes discussion of a manual trash rake, automatic trash rake, sediment accumulation, operational changes, etc. Change the title to make it more accurate as to what the report addresses.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Non-concurred**
This has been considered, but to maintain continuity it will remain the same.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 26 2014

**1-1** Backcheck Recommendation **Open Comment**
The title should include something about the trashracks, trash in front of the entrance, the duffuser grating decisions, etc. The "AWS trash rake" title says nothing about that. I expect the title should be about B2 AWS trash cleaning system improvements, or alternative study, or something more than the rake improvement which was what the final solution was.

I am more interested in a title that reflects the information in the report. In the future, if someone was looking for information, they might find it from the title.

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

**2-0** Evaluation **Concurred**
Will change the title to "Bonneville second powerhouse auxillary water supply trash raking system"

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 28 2014

**2-1** Backcheck Recommendation **Close Comment**
Thanks

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Mar 03 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536485 | Structural | Section 2.2 | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

Add a statement as to why a new automated rake was built or what the problems were with the old rake that needed to be improved.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**
Done. at the end of paragraph a in Existing Conditions.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**
Concur

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536497 | Structural | Section 2 general | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

I was confused slightly as to how many bays have trashracks that are cleaned by the rake. I know there are two units, but, how many racks are there per unit? Also, how many times a day or month is the rake used? That may be in the report, but, I am not sure if it is.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**

There are two columns of racks. A total of 20 racks. 4 are covered by plates, and 16 are used. I will add this to the general section.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**

Thanks

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536506 | Structural | End of Section 3 (my draft page 3-5) | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

Add conclusions or recommendations, for improvement or refer to the section where it takes place. I am not sure if you ruled everything out but one alternative, and you should state if the selected implementation meets all the improvement goals stated on Page 1-1.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**

This is the last paragraph of Section 3. I will add the part about meeting improvement goals.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**

Concur

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536512 | Structural | Section 4 | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

There is much biolgical information that does not seem to pertain to the AWS trash rake system. I expect this section should be reduced to a statement of criteria, how the existing system does not meet criteria.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**

Some of the biological information has been reduced. Section 4 sets the stage for current BiOp requirements to operate to Fish Passage Plan criteria, followed by the existing 2013 criteria as written in the FPP for the WA shore ladder system. I wanted to capture the 2013 criteria in the DDR for convenience now and in the future as this criteria changes and the Fish Passage Plan updated based on new biological information. An effective trash management plan and system on the upstream side is essential for maintaining all hydraulic and operating criteria through the entire ladder system.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Close Comment**

Thanks Jon.

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536539 | Structural | Section 4.6 | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

The third to last paragraph says 0.875" clear, page 4-5 says 0.75" clear. Is this a different rack? Make a statememt about the connection between the trash rack spacing and the diffuser spacing. I am not sure i understand the reason that the team concluded that the 0.875 spacing was adequate. Maybe the team meant that the diffuser grating will be replaced in the future anyway, and we will live with extra trash build up in the meantime as long as the main trashrack gets cleaned regularly??

I was basically confused on what the final conclusion was.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Non-concurred**

It is a discussion of two different racks. One is the diffuser grating. The other is the trash racks. The discussion was whether there would be benefit from changing one rack dimension to preclude trash from sticking on the second rack.

Submitted By: Jordan Reimer (5038084941) Submitted On: Feb 27 2014

**1-1** Backcheck Recommendation **Open Comment**

So is my statement true? or did you explain it better in a version in the document. My concern was that I read the entire document and was confused at the end. If the objectives are clear, I shouldn't be confused. Was it written clear, and I missed it?

in your response, you didn't state why the team made the decision to leave the rack as is....

is it possible to add some clarifying statements?

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

**2-0** Evaluation **Concurred**

The team concluded that reducing trash rack clear spacing from .0875 inch to 0.75 inch would not provide enough change in dimension to show a significant difference in debris accumulation at the diffuser regardless of 1.0 inch vs. 0.75 inch diffuser sizing when operating to the DDR recommendations. Langauge added to clarify in the Synopsis, Biological Section 4, and in Conclusions and Recommednations section 7.

Submitted By: Jonathan Rerecich (503-808-4779) Submitted On: Feb 27 2014

**2-1** Backcheck Recommendation **Close Comment**

Thanks

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 28 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536543 | Structural | Section 5 | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

reformat this section to include titles for each feature improvement.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**

Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 26 2014

**1-1** Backcheck Recommendation **Close Comment**

Concur

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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| | | | | |
|---|---|---|---|---|
| 5536549 | Structural | drawings | n/a | n/a |

Comment Classification: **For Official Use Only (FOUO)**

Edit drawings per notes provided to Ben Filan.

Submitted By: Matthew Hanson (503-808-4934). Submitted On: Feb 25 2014

**1-0** Evaluation **Concurred**

Revised

Submitted By: Benjamin Filan (503-808-4925) Submitted On: Feb 26 2014

**1-1** Backcheck Recommendation **Close Comment**
Concur

Submitted By: Matthew Hanson (503-808-4934) Submitted On: Feb 27 2014

Current Comment Status: **Comment Closed**

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# APPENDIX D

# AGENCY COORDINATION

CENWP-PM-E 05 September 2013

MEMORANDUM FOR THE RECORD

Subject: FINAL minutes for the 05 September 2013 FFDRWG meeting.

The meeting was held in NWP RDP 3rd Floor Meeting Room, Portland OR. In attendance:

| Last | First | Agency | Office/Mobile | Email |
|---|---|---|---|---|
| Ament | Jeff | USACE-NWP | | |
| Bettin | Scott | BPA | | swbettin@bpa.gov |
| Bissel | Brian | CENWP-OD-B | | Brian.m.bissel@usace.army.mil |
| Conder | Trevor | NOAA Fisheries | | Trevor.conder@noaa.gov |
| Ebner | Laurie | USACE-NWP | | |
| Eppard | Brad | CENWP-PM-E | | Matthew.b.eppard@usace.army.mil |
| Fredricks | Gary | NOAA | 503-231-6855 | Gary.fredricks@noaa.gov |
| Hausmann | Ben | CENWP-OD-B | 541-374-45998 | Ben.j.hausmann@usace.army.mil |
| Kostow | Kathryn | ODFW | | |
| Lee | Randy | USACE-NWP | | Randall.t.lee@usace.army.mil |
| Langeslay | Mike | CENWP-PM-E | 503-808-4774 | Mike.j.langeslay@usace.army.mil |
| Lorz | Tom | CRITFC | 503-238-3574 | lort@critfc.org |
| Mackey | Tammy | CENWP-OD-TF | 503-961-5733 | Tammy.m.mackey@usace.army.mil |
| Medina | George | USACE-NWP | 503-808-4753 | George.J.Medina@usace.army.mil |
| Rerecich | Jon | CENWP-PM-E | 541-374-7984 | Jonathan.g.rerecich@usace.army.mil |
| Richards | Natalie | USACE-NWP | 503-808-4755 | Natalie.A.Richards@usace.army.mil |
| Royer | Ida | CENWP-OD-B | | |
| Schlenker | Steve | USACE-NWP | 808-503-4881 | Stephen.j.schlenker@usace.army.mil |
| Traylor | Andrew | CENWP-OD-TF | | Andrew.w.traylor@usace.army.mil |
| Warf | Don | PSMFC | | dwarf@psmfc.org |
| Weiland | Mark | PNNL | | |

Hausmann, Kostow, Warf called in.

All documents may be found at http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/FFDRWG/FFDRWG.html

1. **Final Actions or recommendations from the 05 September 2013 NWP FFDRWG.**
   - **1.1.** June minutes were approved.
   - **1.2.** BON Spillway repairs (major rehab) will be an update at each NWP FFDRWG.
   - **1.3.** Special FFDRWG- FGE/orfices. **After further conversation, NOAA, CRITFC and BPA agreed with the reassessment of alternatives.**
   - **1.4.**

2. **Action Items from 05 September 2013 NWP FFDRWG.**
   - **2.1.** BON Spillway repair. **ACTION:** Ebner will provide a summary for FFDRWG.
   - **2.2.** BON AWS Trashrake. **ACTION:** Rerecich will send the report to attendees.

3. **Action Items from Last FFDRWG Meeting (06 June, 2013):**
   - **3.1. BON AFF:** J. Rerecich will take the lead in getting a "Lessons Learned" and future meeting/actions coordinated. *Discussed later in the agenda.*
   - **3.2. Avian Predation:** S. Ruckwardt will schedule and avian meeting with the region including NWW and NWD
   - **3.3. BON PH2 FGE:** BON Project Fisheries to get photos of the VBSs prior to the riggers cleaning the screens. *Completed.*

- **3.4. TSP BIT Report:** Rerecich will send out revised BIT report to the region. *Sent by Trumbo on 27 June.*
- **3.5. BON Trashrake:** Rerecich will send out the VE report and schedule a special FFDRWG to present and discuss. *To be discussed after the NWP FFDRWG meeting.*

**4. Bonneville Spillway (Stilling Basin Erosion) .** Ebner reported they are in the process of scheduling a spillway survey. Preferred dates would be 30 September – 11 October. Should only take about a day for both north and south sides of the spillway. Primary concern is the B-Branch side and the repairs completed last fall. Fredricks asked about the long term plan. Ebner said NWP is pushing for major rehab. Major rehab is a very slow process but we are moving forward. **Fredricks requested this be an update at each NWP FFDRWG.** Ebner said the erosion and rock moving write up should be available at the end of September. Fredricks said we really need to fix the spillway. We can talk about fish survival and moving flow through bays to help improve survival but this is a fish and a dam safety issue that needs to be fixed. He would like to know what the plan of action is and the anticipated schedule for repair. He doesn't want to see us continue to alter spill patterns and potentially negatively impact fish. **ACTION:** Ebner will provide a summary for FFDRWG.

**5. Lower Columbia River Survival Study.** Eppard provided a brief background.

- **5.1. BON Multi-year Synthesis Analysis.** Weiland gave a .ppt presentation.
  - **5.1.1.** Powerhouse Turbines. Weiland noted they used the fifth order polynomial to get the data to fit. Data was binned by the quarter % of the 1% range and Open Geometry. Comparisons may be made at PH1. At PH2, there were not many fish at the Open Geometry since there is no operating capacity above 1%. FFDRWG asked if Open Geometry was truly open geometry or generator limit. Fredricks said there is a specific definition for "open geometry". Rerecich said for this analysis, he thought "open geometry" was the upper 1% and beyond. Bettin requested that we look at both open geometry and generator limit to see if they can detect a survival difference. FFDRWG discussed whether we would want to lump spring migrants or split them for analysis. Lumping or splitting would be partially determined by tailwater impacts and whether survival is similar between species. Lorz said he isn't as concerned about lumping with the turbine data but we should not do that with the spillway unless survival between species is similar. Ebner said it would be interesting to see if the 2011 data was statistically different than the rest since that was a high year. Weiland said he will have to go back and slice and dice the data a little more. **NWP FFDRWG said to look at survival across tailwater elevations. If there is no difference, then lump.**
  - **5.1.2.** Spillway bays. Fish pass through every bay. Analysis was by bay and then by lumping bays. Bays were lumped 1-3 (higher deflectors), 4-7, 8-12, 13-15, and 16-18 (higher deflectors). The middle bays were lumped based on bathymetry and how flow moves through. Ebner prefers grouping the bays rather than looking at individual bays.
    - 5.1.2.1. FFDRWG discussed potential surface passage at the BON spillway. Ebner and Bettin said it would be difficult. Ebner said there are structures (cables, concrete, etc) in the spillway that prevent the shape of the spillway weir; limitations to spillway capacity create a dam safety issue; forebay fluctuations create potential difficulties. Fredricks and Lorz didn't see these issues as show stoppers, just issues that would need to be worked around with design.
    - 5.1.2.2. Fredricks and Langeslay discussed whether BON has or has not met the Performance Standards. Langeslay said there are no plans to go in and do work on the spillway for survival improvements at this time.
- **5.2. BON. Refine scope based on sample sizes.**
  - **5.2.1.** Spillway survival v. TW. First by species and then by groupings if appropriate. Analysis would be by bay and then by groupings noted above.

- **5.2.2.** PH1 grouping by generation (generator limit, BOP, Q1-Q2, Q3-Q4) and potential lumping of species.
- **5.2.3.** PH2 grouping by generation (as currently split out in the .ppt). No OG analysis. (Ebner will provide guidance as to why OG is not valid). Look at potential for lumping species.
- **5.2.4.** TDA. Analysis of each bay; bays 1-8 and 9-12 and 13-22; 2011 bays 9-22 v 2012 bays 9-22; survival through bays 1-8 at 10K increments. May need to lump species to get enough fish.

**5.3. TDA spillwalls.** Looking at bays 1-8 and 9-22. Weiland reported there were more fish going through Bays 9-22 than he anticipated. Ebner asked how many of those fish passed in 2011 (high flow year). Fredricks would like to see inside the wall and outside the wall with a group of 9-12 and then 13-22. Fredricks would like to see more pressure on getting Bays 9-12 repaired. Ebner would like to see a comparison of 2011 bays 9-22 and 2012 bays 9-22. She would also like to see analysis of survival through bays 1-8 and flow. Weiland said he could do 10K increments if the GDACS data is correct. Ebner hesitated, said it would work for this analysis, but the accuracy is not at the same level as BON and JDA. She also stated that 24 kcfs increments would be all that is necessary since that is the amount of water that passes through 1 foot of gate opening on a spillway.

**6. Bonneville Adult Fish Facility Mods**. Rerecich provided a handout. The number of AFF MFRs was mentioned. Rerecich said it seemed the mortalities are fish that are coming in overnight and haven't been the sampled fish. He revisited the decision to remove the lower section of the return pipes; explaining the pipes were submerged due to the numbers of shad building up on the Valve 15 trash rack. This winter, the pipe sections will be reinstalled and slightly raised if possible, the baffle will be modified with overflow sections for fish to pass through, and the access to the Valve 15 drain will be modified to allow for easier cleaning. He noted any modifications may be challenging due to the space and configuration of the AFF. Rerecich noted there have been a lot of lamprey mortalities as well. These fish have fallen back since lamprey do not use the false weirs. Ament noted that the baffle went in at the same time the floor plating went in. If the shad plug Valve 15, there is no other route for the water to go with the plates in place. He said they will remove one and then the other to test this winter. Fredricks said he is concerned about the slope of the exit pipes, regardless of whether the pipes are submerged or not. Rerecich said they are going to test the piping for Valve 8 (south fish flume which is no longer used) to see if there is enough flow there to help push fish out of the return pipes.

- **6.1.** Weiland suggested we could use acoustic deterrents to keep shad out of the AFF. Shad hear at a higher frequency range than salmon (150-200 kHz). Lorz suggested checking the hearing level of lamprey before sticking anything in there. Weiland said tests showed shad avoided the noise while salmon were not affected. Fredricks seemed willing to try this at the entrance of the AFF ladder.
- **6.2.** Hausmann added that cormorants are in the upper section of the ladder and these birds are not bothered by people. The fish counter has reported more dead jacks floating downstream this year than in previous years.
- **6.3.** Fredricks asked if the flap could be modified so fish could get through easier.

**7. B2 Orifices.** This will be discussed in further detail later this afternoon. Medina provided a handout. The EDR is under review.

- **7.1.** Alternatives report

**8. JDA Configuration and Operation Plan.** Medina provided a handout.

- **8.1.** Permanent Top Spillway Weir (TSW) (Hanson)

**9. B2 Corner Collector.** Medina provided a handout.

- **9.1.** Corner Collector Repairs

**10. Turbine Survival Program.** Medina provided a handout.

11. **The Dalles East Adult Fish Ladder AWS Backup System.** Medina provided a handout. Lee reported the alternatives are being evaluated. DDR bumped to the end of the calendar year. Fredricks asked when the system would be constructed. He has heard rumors about there being some significant concerns with the design. Medina and Lee said there are questions but nothing that has indicated any show-stoppers. Medina said there may be a need for two continuous years for construction and cost seems to be creeping up. Despite those concerns, Medina still believes the goal can be accomplished.

12. **Lamprey Passage Projects**
    - **12.1.** **JDA South Count Station Lamprey Collection Structure.** Medina provided a handout. It should be completed the first week of September.
    - **12.2.** **Bonneville WA Shore Lamprey Flume System.** N. Richards provided a handout. Rerecich and Richards asked about the status of the BON ITS. Hausmann said it will be back in service in about two weeks. The cable will need to be replaced and the gate unjammed. 13BON51 will be finalized at the 12 September FPOM. Richards said the dive work will be completed this year and anything else will have to wait until the following winter work window. Bettin asked about the liability for the faulty design. Richards said NWP is going after the A&E firm for the costs. Costs include the foregone power.
    - **12.3.** Lamprey 10-year Plan Update (Langeslay/Tackley)
    - **12.4.** Lamprey Minor Fishway Modifications (Gibbons/Yazdani/Tackley)
    - **12.5.** Lamprey Passage Structure (LPS) development PDT (Tackley)

13. **The Dalles Adult PIT Detection Alternatives Study.** N. Richards provided a handout. The temporary detectors are working great. The PDT will work on making this permanent. Lorz and Fredricks asked if the PDT will be re-directed to work on JDA now. This had been discussed in SCT, but there was no resolution. Bettin noted that if we want to get it in this year, we will need to make a decision soon, before the lead time necessary to get contracts in place for installation next in water work period passes.

14. **John Day North Ladder Improvements**. N. Richards provided a handout. AWS pumps are still not working properly. The motor for pump 2 has been sent out for repair. Turns out the contractor didn't provide the equipment in the specs and the non-spec equipment has been failing.

15. **Avian Predation Actions.** Eppard reported for Ruckwardt. Fredricks said there needs to be a discussion as to whether or not birds should be discussed at FFDRWG. Lorz asked where the issues would be discussed, if not here. Eppard said there has been talk of moving it to the SRWG forum. Conder suggested changing the "Inland Avian group" to the "Basin Avian Group". Fredricks said sinking islands would still need to be discussed in FFDRWG, since it wasn't designed well in the first place, but research should go to SRWG.
    - **15.1.** **Malheur Island.** Essentially done and can be removed from the agenda.
    - **15.2.** **Summer Lake Island.** Fredricks and Eppard debated whether the island sunk first or just broke free and then was removed by NWP. Lorz, playing mediator, suggested we could agree the island is no longer. Fredricks said there were issues with owls and predation.
    - **15.3.** **S.F. Bay (Hayward and Don Edwards locations).** USACE has given up on Hayward but Don Edwards is on USFWS land so it may be promising. Fredricks said the Bear River NWR in Utah is looking promising as is a National Wildlife Refuge in the San Juan islands. Eppard noted that NWP is still seeking alternatives for potential coastal sites.
    - **15.4.** Estuary monitoring. Eppard said the final proposal isn't available until the management actions have been settled. Lorz said research on cormorants could continue. Eppard said there is a plan to select a management action and once one is selected, a proposal will be tailored to fit that. Fredricks clarified that Lorz is talking only about research. Lorz has requested that someone stop hovering over the toilet and make a decision one way or another.

**Next NWP FFDRWG Meeting: Thursday October 3rd, 2013**

Subject: FINAL minutes for the 05 September 2013 FFDRWG meeting.

The meeting was held in NWP RDP 3rd Floor Meeting Room, Portland OR. In attendance:

| **Last** | **First** | **Agency** | **Office/Mobile** | **Email** |
|---|---|---|---|---|
| Bettin | Scott | BPA | | swbettin@bpa.gov |
| Bissel | Brian | CENWP-OD-B | | Brian.m.bissel@usace.army.mil |
| Conder | Trevor | NOAA Fisheries | | Trevor.conder@noaa.gov |
| Ebner | Laurie | USACE-NWP | | Laurie.l.ebner@usace.army.mil |
| Eppard | Brad | USACE-NWP | | Matthew.b.eppard@usace.army.mil |
| Filan | Ben | USACE-NWP | | Benjamin.j.filan@usace.army.mil |
| Fredricks | Gary | NOAA | 503-231-6855 | Gary.fredricks@noaa.gov |
| Henrie | Gary | USACE-NWP | | Gary.s.henrie@usace.army.mil |
| Kostow | Kathryn | ODFW | | |
| Lee | Randy | USACE-NWP | | Randall.t.lee@usace.army.mil |
| Lorz | Tom | CRITFC | 503-238-3574 | lort@critfc.org |
| Mackey | Tammy | CENWP-OF-TF | 503-961-5733 | Tammy.m.mackey@usace.army.mil |
| Medina | George | USACE-NWP | 503-808-4753 | George.J.Medina@usace.army.mil |
| Rerecich | Jon | CENWP-PM-E | 503-808-4779 | Jonathan.g.rerecich@usace.army.mil |
| Roy | Liza | USACE-NWP | | Elizabeth.W.Roy@usace.army.mil |
| Royer | Ida | CENWP-OD-B | | Ida.M.Royer@usace.army.mil |
| Stricklin | Eric | USACE-NWP | | Eric.t.stricklin@usace.army.mil |
| Traylor | Andrew | CENWP-OD-TF | | Andrew.w.traylor@usace.army.mil |

Kostow called in.

All documents may be found at http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/FFDRWG/FFDRWG.html

1. B2-FGE. Powerpoint available on the FFDRWG website. Rerecich gave a brief background on how we got to our current situation.
    1.1. Review/discussion of 2013 Hydraulic and Biological results. Ebner discussed the model data and results. CFD model calibrated to the 1:12 model. When conducting field tests; found fish in the areas with just wedge wire and not perf plate behind. Found hotspots across the panel when looking at field data. The discovery of hot spots was a shock. Prototype data matched model data really well until we look at the upper two panels. Now the CFD model will need to be calibrated to the prototype instead of to the 1:12 model.
    1.2. Ebner said the team would like to alter the porosity of the upper two panels and test with 16-18 kcfs going through the unit. Bettin asked how much flow goes up the gatewell without a STS. No one knew of any measurements taken without the STS. Bettin and Fredricks agreed that there are a lot of fish that pass through the JBS without the STSs, however, the numbers of fish are still reduced than when STSs are installed. Ebner asked about pulling screens from A slot but leaving them in the B and C slots. ERDC will conduct the model test. Fredricks was not opposed to the idea but he was curious about how that flow would affect the other screens in the unit. Eppard asked if pulling screens would be a viable alternative. Fredricks said he thinks it would be since survival through the turbines is good for Chinook. Survival isn't as good for steelhead but steelhead survival through the B2CC is higher. Lorz asked when Unit 11 would return. Fredricks said Unit 11 would be a huge benefit, especially if it were designed properly.
    1.3. Ebner resumed her presentation. She stressed the need to establish a hydraulic baseline to work from. Without that, there isn't much to move forward on. Alternatives would be assessed once the hydraulic baseline is determined. Alternatives could include pulling all or just some screens, further modifications to the gatewell environment, etc. Fredricks said the work should be completed prior to the next Performance Standard test.

1.3.1. Fredricks asked if it was necessary to go down the path presented. What about a flow control structure? He said he was willing to take the hit on FGE if it reduces the turbulence in the gatewell and increases survival.

1.3.2. Medina pushed for working through the issues in a systematic manner, as laid out by Ebner. FFDRWG discussed the merits of waiting to get the hydraulic baseline v a flow control structure. Fredricks said waiting another five years to fix the problem is unacceptable. Bettin asked why the turbine couldn't be used as the model. Ebner said the data from the bottom two panels couldn't be gathered due to the lack of strength in the frame. That could be fixed. The other problem with testing in the prototype is that is allows testing of only one condition, part of a unit, etc.

1.4. Path forward: investigation of alternatives (short/long term).

1.4.1. NOAA Fisheries does not concur with the proposed path forward. Fredricks wants NWP to cut flows so that when the unit runs at 17K flows up the gatewell are equivalent to running the unit at 15K.

1.4.2. Bettin asked about modifying one of the existing turning veins as a prototype. Once modified it would be allowed to be used in a slot and not returned to previous shape. NOAA was not opposed to this alternative. .

**1.4.3. After further conversation, NOAA, CRITFC and BPA agreed with the reassessment of alternatives.**

2. B2 Trashrake. Filan went through a powerpoint presentation. He provided a background on the project and explained why the new Trashrake built in 2004 was never put in service. He also discussed that their findings were that the project was not using the trashrake on a regular basis. . Lorz questioned if there would be funding for dredging. Mackey explained dredging has been classified as a routine maintenance activity and it has been added to the Fish Passage Plan as a required activity. There were concerns voiced by many that the O&M fund was already spread too thin.

2.1. Review/discussion of VE report. **ACTION:** Rerecich will send the report to attendees.

2.2. Path forward. Filan presented the DDR recommendations. Fredricks recommended make the cleaning teeth changeable in the event the trashracks are replaced with lamprey spacing. Everyone seemed to be comfortable with the plan to move forward with the DDR recommendations. The recommendations for BON to rake on a regular basis and to do a survey annually to determine if dredging is needed, will be included in the 2014 Fish Passage Plan.

**OFFICIAL COORDINATION REQUEST FOR**
**NON-ROUTINE OPERATIONS AND MAINTENANCE**

**COORDINATION DATE-** 31 August 2011
**PROJECT-** Bonneville Lock and Dam
**RESPONSE DATE-** 8 September 2011 (FPOM meeting)

**Description of the problem-** Project Fisheries found eight blown grates in the Washington Shore (WS) fishway during the 3August mid-season ROV inspection. The blown grates are presumed to have been a result of the high flows and high debris seen at BON during the spring.

The WS ladder was taken to tailwater on 16 August to prepare for divers on 17 August. Divers and Project maintenance replaced grates, however, more extensive inspection, debris removal and repairs are needed.

**Type of outage required-** BON would like to dewater the WS ladder from the UMT to below tailwater from October to late November.

**Impact on facility operation-** PH1 would be the priority powerhouse starting on 1 October. The WS ladder would go to orifice flow on 1 October, with the ladder dewatering starting on 3 October. The WS ladder would be dewatered from the UMT, leaving the WS exit and the UMT in operation.

PH1 turbine units will be operated at the best geometry. PH1 unit outages will be minimized during this time.

**Length of time for repairs-** 6-8 weeks. Two weeks for dewater, four weeks for debris removal and repairs and one to two weeks for water up.

The WS fishway would return to normal service prior to the Bradford Island fishway going out of service for winter maintenance.

**Expected impacts on fish passage-** Historically, adult fish passage numbers steadily drop in October. By the third week of October there are generally less than 1000 adult salmonids passing each day.

Taking the WS fishway entrances out of service in early October may delay some adults, however, with the switch in powerhouse priority, it is expected more fish will approach the Bradford Island fishway, which will remain in operation during the WS outage.

In addition, the Main Dam fishways (Cascades Island and B-Branch) will remain in operation. The only outage will be the WS fishway entrances, and AWS.

Juvenile impacts are expected to be minimal as their numbers steadily decrease during October. The switch in powerhouse priority may move juveniles from the screened bypass at PH2 to the surface bypass through the ITS at PH1.

**Comments from agencies**

**NOAA-** -----Original Message-----
From: Gary Fredricks [mailto:Gary.Fredricks@noaa.gov]
Sent: Wednesday, August 31, 2011 2:14 PM
To: Mackey, Tammy M NWP
Cc: Trevor Conder; Ritchie Graves; Lorz, Tom; Wills, Dave; Russ Kiefer; Kruger, Rick; Klatte, Bernard A NWP
Subject: Re: FPOM: MOC- BON WS dewatering in Oct

I agree that this work needs to be done as soon as possible to assure the WA Shore system is ready for next season and to be able to get the Bradford Is. ladder work done this winter. Moving powerhouse priority will reduce impacts to passing adult salmon, however, I am concerned with any operation of the second powerhouse units during at least the first month of this action. With the Washington Shore ladder down, there will be no way for fish approaching this powerhouse to pass directly. They will have to backtrack out of the channel and pass one of the other ladder entrances. Given that this is late in the season, any delay could reduce the likelihood of successful spawning for fall chinook and coho passing during this time. We will need to see a more thorough analysis of potential impact to listed salmon (run composition, expected passage numbers, expected delay, mitigative options, etc.) before we can fully agree with the operation as outlined in the MOC.

In short, I support the need for the work starting October 1, however, there may need to be some mitigation for adult salmon passing during at least the first two or three weeks of October.

Thanks, Gary

**NOAA-** Fredricks provided additional comments in a Memo. Excerpts are provided below.

September 7, 2011 F/NWR-5

**FILE MEMORANDUM**

**FROM:** Gary Fredricks, NOAA Fisheries

**SUBJECT:** Portland District Memorandums of Coordination (MOC) for the 8 September FPOM Meeting

First, I've noticed a couple of issues with the MOC form that could be improved. 1. The forms sometimes do not include the dates of the action being coordinated. To remedy this, I recommend including a specific line for "dates of action". I realize that the exact dates aren't always known but at least a range of dates can be presented. 2. The other issue is document identification. The current MOC's have no reference number or title which makes them difficult to refer to in coordination response memos.

The following comments refer to those MOCs that were included in Tammy Mackey's September 6, 2011, email:

- The MOC refereeing to Bonneville Dam Washington Shore. I responded to this one earlier by email sent to Tammy Mackey on 8-31-11: "I agree that this work needs to be done as soon as possible to assure the WA Shore system is ready for next season and to be able to get the Bradford Is. ladder work done this winter. Moving powerhouse priority will reduce impacts to passing adult salmon, however, I am concerned with any operation of the second powerhouse units during at least the first month of this action. With the Washington Shore ladder down, there will be no way for fish approaching this powerhouse to pass directly. They will have to backtrack out of the channel and pass one of the other ladder entrances. Given that this is late in the season, any delay could reduce the likelihood of successful spawning for fall Chinook and coho passing during this time. We will need to see a more thorough analysis of potential impact to listed salmon (run composition, expected passage numbers, expected delay, mitigative options, etc.) before we can fully agree with the operation as outlined in the MOC.

  In short, I support the need for the work starting October 1, however, there may need to be some mitigation for adult salmon passing during at least the first two or three weeks of October."

**BON Fisheries-** -----Original Message-----
From: Traylor, Andrew NWP
Sent: Thursday, September 01, 2011 2:40 PM
To: Mackey, Tammy M NWP
Cc: Hausmann, Ben J NWP; Rerecich, Jonathan G NWP
Subject: Oct count/flow analysis (UNCLASSIFIED)

T-mack,
Here's what Jon discussed with you yesterday. Counts for chinook, coho, and stealhead matched with flows for October of the last three years. For the 2010 tab I've included the Oct 2011 forecast flow.

The ladder split varies considerably but an average of all species is roughly 20/80 for BI/WA shore.

Thanks,-Andy

**WDFW-** -----Original Message-----
From: Stephenson, Ann E (DFW) [mailto:Ann.Stephenson@dfw.wa.gov]
Sent: Wednesday, August 31, 2011 4:55 PM
To: Mackey, Tammy M NWP
Subject: RE: FPOM: MOC- BON WS dewatering in Oct

If this could be done later in October or after November 1, that would be preferable.
Ann

**September 2011 FPOM-** Klatte explained what he saw when he helped dewater the ladder in August. He said the grates are nearly completely clogged with wood, there were lots of shells and sand. The emergency repairs were completed but it became very obvious that more involved debris removal is needed. Mackey and Hausmann explained that 1 October is the latest the Project can take the ladder down and still get it back before BI comes down for maintenance. Lorz suggested waiting until the second week of October. WDFW asked for a delay until 14 October. Mackey stressed the importance of getting the work done and getting the ladder back. Fredricks didn't agree with Lorz about pushing the BI outage into March. Fredricks also said he does not want to see PH2 operating without an operating fishway in October. Bettin said we need 120K for chum in November. Fredricks says if the BI fishway is out in March then PH1 units may not be operated. Fredricks and Lorz continued to debate the merits of starting 1 October or delaying a week and pushing BI winter maintenance into March. **Klatte said we will move forward with a 1 October dewater date. A unit return to service update will be provided as soon as possible. If the units at PH2 will return to service by February, there may be room for a week delay in dewatering and moving BI into March.** Fredricks suggested the BI maintenance could be compressed. Mackey piped up and suggested compressing the BI maintenance would not be a good idea. She stressed that the BI schedule should not be compressed as that ladder is crumbling, with exposed rebar and spalling concrete.

**Final results-** Klatte said we will move forward with a 1 October dewater date. A unit return to service update will be provided as soon as possible. If the units at PH2 will return to service by February, there may be room for a week delay in dewatering and moving BI into March.

Bottom Line:
Unfortunately, due to the poor reliability and projected unavailability of Bonneville powerhouse II turbine units in late February/March combined with the risk of impacting fish passage, the project will start dewatering Washington Shore ladder on 1 October.

Justification:

During the September FPOM meeting we discussed Bonneville Dam was planning on starting the dewatering/maintenance of the Washington Shore Ladder on 1 October in order to complete this unscheduled work (result of the high flow/debris and emergency dewater and diffuser grate repairs last month), as well as keeping to our planned winter maintenance on Bradford Island ladders.

We talked about the possibility of pushing out the start date to 10 October to reduce some of the impacts on the ongoing research at the AFF (CRITFC and WDFW) only if the BON II turbine units would be available in late February/March to reduce impacts to fish passage while Bradford Island ladder is dewatered for the additional 10 days on the tail end. Since I did not have the most recent status report on B-II turbines at the meeting I agreed to discuss with the project and get back to everyone with our decision.

Currently turbine units 11,15,16,17, at BON powerhouse II are out of service. It's possible that units 15 and 16 will become available in October. However units 11 and 17 are much more unpredictable. Unit 11 still has multiple unsolved issues and is not expected to return to service at the earliest in mid-February. Unit 17 is currently a wildcard with some unknowns. To date, Hydraulic Design Center has stated that they are not comfortable with us running the unit until dynamic monitoring equipment has been procured and installed. If this is the case, it is "possible" that the unit will not be returned to service until March or later. BON II is pretty unreliable at the moment.

Accommodating anticipated flows assuming the above scenario: 6 units available with units 11 and 17 unknown in March. At 15KCFS per unit this leaves us passing only 90K. Looking at recent years, March flows have been between 120K and 175K with increased expected flows this year.

Please contact Tammy Mackey or myself if you need more information.

Thanks,
Bern

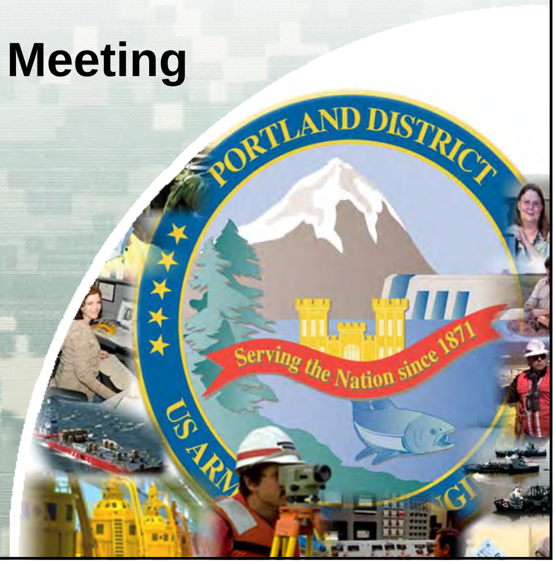
Bernard Klatte
US Army Corps of Engineers
Operations Division
Chief of the Fisheries Section
w: 503-808-4318
c: 503-705-8817

Please email or call with questions or concerns.
Thank you,
Tammy

Tammy Mackey
NWP Operations Division Fishery Section
Columbia River Coordination Biologist
503-961-5733
Tammy.m.mackey@usace.army.mil

# Bonneville Second Powerhouse B2 Auxiliary Water supply Trash Rake Special FFDRWG Meeting

5 September 2013

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## Bonneville Second Powerhouse B2 Auxiliary Water supply Trash Rake

- Background
- VE Study
- CFD Analysis
- Recommendations

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# Background

- November 2001 – DDR Bonneville Second Powerhouse Auxiliary Water Supply Backup System

Proposed Improvements

- Stockpile Spare Parts
- Block off the lower fish unit trashrack panels
- Replace existing trashracks and trashrake with new continuous bar trash racks and automatic gripper rake
- Place a log barrier in front of the fish units
- Install two sets of level transducers across the diffuser grating at the A and B diffuser gates to monitor clogging



# Background

Operations plan

- Perform annual soundings immediately upstream of the fish unit intakes and dredge during the in-stream work window (December through February if required)
- Outfit the floating orifice gates with aluminum sliding closure plates that can be installed into guides mounted around the orifices. Plates would be installed by raising the floating orifice gates up to the EL 55 deck level.
- Test and verify the recommended operations plan after modifications to the floating orifices have been made.
- Implement the proposed operations plan, in the event of a Fish Unit turbine failure, to modify gate settings, close floating orifices, closes selected gates, and regulate flow at the remaining Fish Unit Turbine
- Abandon use of the Ice and Trash Sluiceway as a backup to the AWS.

# Background

## Implemented recommendations pertinent to this project

- Blocked off lower trashracks
- 2004- New manual trashrake fabricated and delivered to project

## General Operations Feedback

- Blocked racks create a bin for debris
- Infrequent dredging allows the bin to fill beyond the top of the blocked rack; at this point debris seems to collect on the racks at a higher rate
- New rake is ineffective at removing debris
- New rake trips upper crane limits because of its height
- New rake trips the load cell limits because of its weight



# Design Constraints

## Project Goal

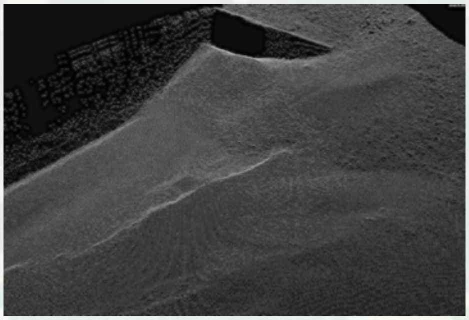
- Eliminate the need to float trash
  - ESA salmon passage impacts during recent high flow years
  - Lamprey passage impacts identified based on new data
  - Reduce wear and tear on Fish units
  - Evaluate if proposed design will work with ¾" open diffuser grating

## Current rack cleaning and Inspection

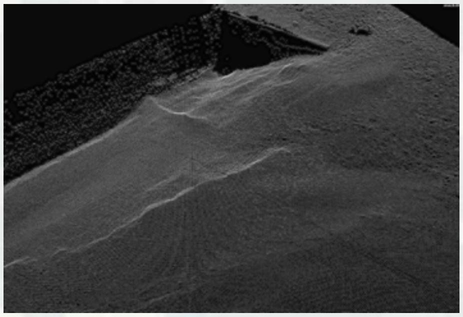
- Differential across the intake rack reaches 1 ft
- Nighttime floating of trash (approximately 3 hrs)
- Raking or floating as needed during the day in emergencies
- Racks are inspected and cleaned once every four years
- Hydrosurvey is performed as monies can be allocated

# Dredging Effort

Before Dredging



After Dredging



Feb 1997- 2,850 CY Removed
Fall 1997- 4,550 CY Removed
Fall 2004- 2,000 CY Removed
Jan 2013- 6,000+ CY Removed



# VE Study

## Design Charrette

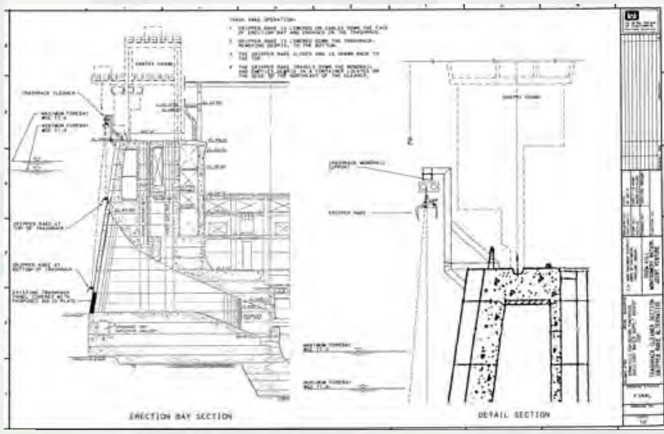
- Evaluation criteria:

| | |
|---|---|
| Flow Delivery | Supply Power |
| "Fish" Friendly | Labor intensity |
| Schedule | Durable |
| Operability | Constructability |
| Maintainability | Flexibility |
| Reliability | High Confidence of success |
| Compatibility | Redundancy |

- Alternatives
  - ► Debris Diversion Wall and Berm
    - Highest score; preferred alternative during preliminary rankings
    - 10 to 40 foot floating wall anchored between unit 18 and FU2
    - Berm placed at most upstream end of wall bridging the river area between the wall and the bank
    - Modeled by PNNL using Computational Fluid Dynamics
    - Modeling shows that the diversion wall is likely ineffective and may worsen debris loads at the trash racks

# VE Study

- Semi-automated Trash Raking System
  - Second highest score during preliminary rankings
  - Operator initiated and process is observed
  - Operations personnel does not want the system installed
  - High implementation risk (Untested design depth and bar spacing)



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# VE Study

- Manual Rake Modifications as necessary with new racks
  - Preliminary ranking closely follows semi-automated raking system
  - New or old rake is modified for use with the new racks
  - Rack replacement highest cost and uncertainty of benefits
  - Rack constructability issues with close bar spacing

New Rake

Old Rake

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# Top Alterative Investigation

## Concept: Debris Diversion Wall Assumptions

- Draft 10-40 feet to minimize costs
  - Minimal biological impacts
  - Positively buoyant structures anchored together to form a wall
  - Berm may be used to improve sediment retention
  - Assumed to be low maintenance and easily repaired
  - Could be moved to support future dredging efforts
  - Minimize raked debris processing as it would be diverted to unit 18

- MIPR to PNNL to perform the modeling
- Used the recent bathymetric survey results from 2013
- Used STAR-CCM+
- Validated using field measured velocity data

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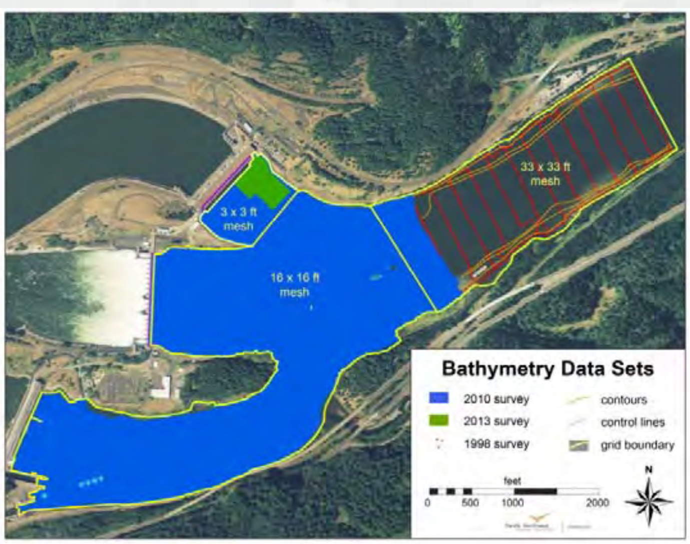
# CFD Analysis




Survey Data Map

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# CFD Analysis

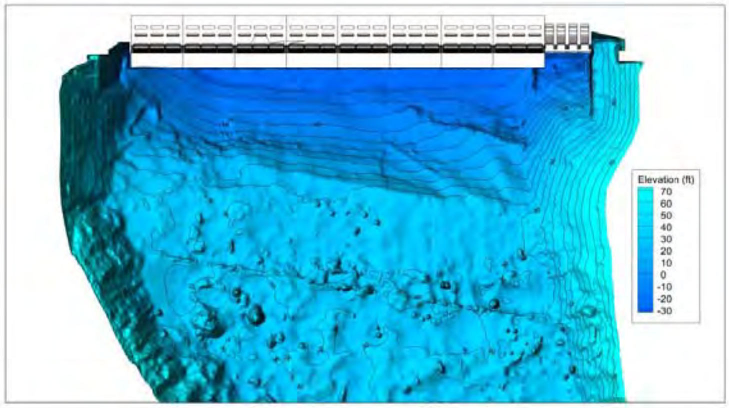



**Figure 2.2.** Bathymetric surface near B2.



# CFD Analysis

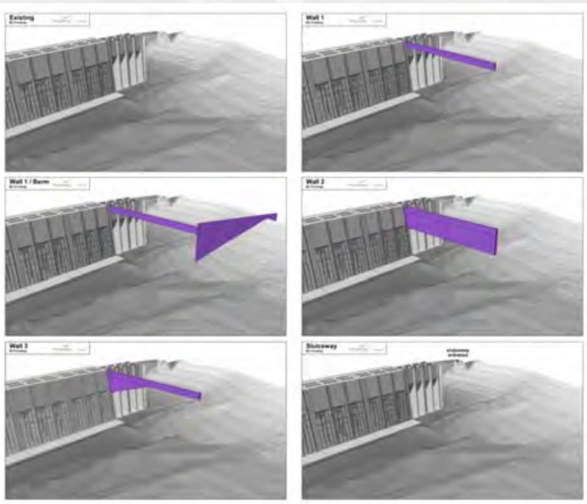


**Figure 2.4.** Wall Configurations Tested

Configurations Tested

# CFD Analysis

Four Modeling Scenarios

1. Wall and Berm; wall draft is 10 ft.

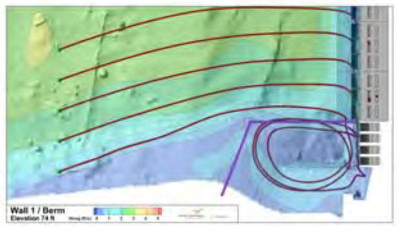



Figure 3.12. Wall 1 plus berm velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

2. Wall only; wall draft is 40 ft

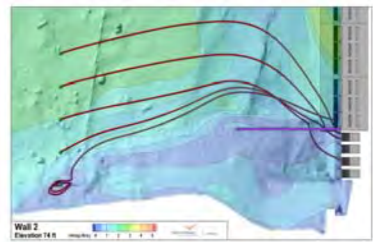



Figure 3.15. Wall 2 velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.



# CFD Analysis

Four Modeling Scenarios cont.

3. Wall only; Wall draft is 40 ft deep at the powerhouse and tapering to 10 ft deep at the upstream end

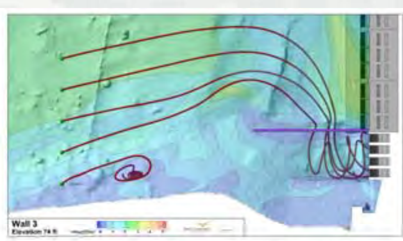



Figure 3.18. Wall 3 velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

4. Simulated sluiceway flow using AFF water supply entrance

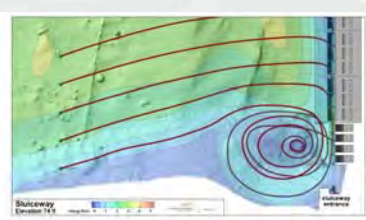



Figure 3.21. Velocity contours for an added sluiceway with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

# CFD Results

- General results
  - In each scenario seeds from the unit 18 side of the flow diversion wall pass beneath the wall to the fish unit side. This suggests that the attempt to modify the flow and direct debris into unit 18 will be unsuccessful.
  - In the fourth case the simulated sluice way was unsuccessful in attracting surface debris prior to entering the fish units.
  - Without significant bathymetric changes in the forebay; the hydraulics set up by main unit flow will continue to create periods of, difficult to manage, high debris inflow.
  - The PDT decided, given this information, this alternative will not be pursued.

The next highest ranked alternative was the semi-automatic rake system.

The team decided not to pursue this alternative due to the following factors:
•Operations and Maintenance uncertainty.
•Experimental nature of implementing the system in a mechanically complex and challenging hydraulic environment



# DDR Recommendations

- Use Existing Racks
  - Evaluate existing racks after new diffusers are installed and debris loads at the diffusers are understood
  - A new way to fabricate intake racks should be explored as current vertical bar construction creates problems with future rack bar and coating system repairs
  - Remove and clean intake racks once a year; inspect for structural problems
  - August ROV inspection of the racks concurrent with AWS diffuser inspection
  - Document water differential before and after raking and floating events
- More Frequent Raking
  - Raking should occur concurrent with VBS cleaning or at least once a week
  - Minor modifications to the rake should be performed to improve its ability to remove matted grasses
- Periodic Maintenance Dredging
  - Annual hydro survey for area in front of the fish units
  - Bi-annual maintenance dredging or as deemed needed by survey results
  - Exercise B diffuser gates to reduce sediment build-up

# APPENDIX E

# VALUE ENGINEERING STUDY

US Army Corps of Engineers®
Portland District

**Value Engineering Study Report**

ARIMS 800C

# Bonneville Dam Second Powerhouse Adult Fishway Auxiliary Water Supply Trash Rake

Bonneville Dam

30% Design Documentation Report

P2 No.: 353716
NWP VE Study No: FY13-02
Workshop Dates: 7-8 & 13-15 Nov 2012
Report Date: 30 September 2013

Submitted by

Jason M. Weber, SE, AVS
CENWP VEO

**Forward**

The US Army Corps of Engineers, Portland District (CENWP), sponsored this Value Engineering (VE) Study to assist the CENWP Project Manager and Project Delivery Team by developing Alternatives and Design Suggestions which address the risks, performance, schedule and costs issues related to the functional needs of the project. The workshop was held in two parts: 7-8 November 2012 at Bonneville Dam and13-15 November 2012 at Portland District Offices.

This report is presented in a rolling narrative format to illustrate the sequence of activities that took place during the VE workshop. The workshop was facilitated in accordance with the SAVE (Society of American Value Engineers) International VE methodology standards and the U.S. Army Corps of Engineers (USACE) VE Regulation, ER 11-1-321, Change 1, dated 1 January 2011, and facilitated by an Associate Value Specialist (AVS).

The VE team was comprised of USACE staff from the PDT and the re-Employed Annuitants Program (HQ), representing the disciplines of: Hydraulics, Structures, Mechanical, Electrical, Fisheries Biology, Cost, Environmental Compliance, and Construction. In addition, Operations staff participated in the first two days of the workshop.

Jason Weber, AVS

CENWP EC-T

# EXECUTIVE SUMMARY

## Value Engineering Study Data

| **Project: Bonneville 2nd Powerhouse** | | **Product: Auxiliary Water Supply Trash Rake** | |
|---|---|---|---|
| **Project Location:** | Bonneville | **VE Study #:** | FY13-02 |
| **P2#:** | | **Division/District:** | NWD/NWP |
| **Product Status:** | 30% DDR | **VEO:** | Jason Weber |
| **Workshop Dates:** | 7-8, 13-15 November 2012 | **Workshop Duration (hrs):** | 40 |
| **Estimated Total Project Cost (PA)*:** | $4.0 mil | **Study Cost **:** | $60,000 |

* Includes all project costs: PDT Labor & Materials; A/E Services; Studies; Investigations; Construction; etc.
** Includes cost for VEO + VE Team + Contract action. Does not include PDT cost labor.

## Reporting Results

| | | |
|---|---|---|
| **Total Number of Alternatives and Design Suggestion/Comments** | DEVELOPED: | 9 |
| | **ACCEPTED:** | **3** |
| **Total Number of Alternatives (Quantitative)** | DEVELOPED: | 9 |
| | **ACCEPTED:** | **3** |
| **Total Number of Design Suggestion/Comments (Qualitative)** | DEVELOPED: | 0 |
| | **ACCEPTED:** | **0** |
| **Maximum Credible Potential Cost Avoidance** (Sum of exclusive Alternatives; First Cost, not Life Cycle; Excludes Cost Adding Alternatives) | PROPOSED: | $800,000 |
| | **ACCEPTED:** | **$2.4 mil** |
| **Return on Investment (ROI) :** (Accepted Cost Avoidance/Study Cost) | | **40:1** |

## Additional Results

| | | |
|---|---|---|
| **Number of Alternatives that Add First Costs** | DEVELOPED: | 3 |
| | **ACCEPTED:** | **0** |
| **Maximum Credible Potential Added Cost** (Sum of exclusive Alternatives; First Cost, not Net Life Cycle) | PROPOSED: | $3.3 mil |
| | **ACCEPTED:** | **0** |
| **Number of Alternatives that Developed Life Cycle Costs** | DEVELOPED: | 4 |
| | **ACCEPTED:** | **0** |
| **Maximum Credible Potential Net Life Cycle Savings** (Sum of exclusive Alternatives) | PROPOSED: | 0 |
| | **ACCEPTED:** | **0** |

**Product Description**

The Auxiliary Water Supply (AWS) is a major component of the upstream fish passage system at the Bonneville Dam Second Powerhouse. The AWS supplies most of the attraction flow for the entrance-bay openings. The AWS is charged by two turbines at the north end of the powerhouse (fish units). Trash racks installed at the intake have a clear space between the rack bars of 7/8 inches. The trash rakes clean the racks manipulated by the gantry crane and four Operations staff.

While raking is a normal part of maintaining most intakes, these units have a particular challenge because of their location and the volume of material. Typically, the frequency of raking is greatest for three months in the fall and three months in the spring. In the fall, the aquatic vegetation dies off and is released into the water column. In the spring, flows are the highest and terrestrial and aquatic debris rapidly accumulates on the fish unit trash racks.

Since completion of the 2001 DDR, there has been a recommendation for reduced diffuser grating spacing requirements. The diffusers are not in the scope of this project; however, this design criteria was considered during the VE investigation including potential impacts to the trash rack grate spacing design. The grating clear spacing on diffusers has been recommended to be reduced from one inch (1”) to three quarters inch (3/4”) to exclude lamprey from the AWS system.

**VE Workshop Highlights**

There are several unique aspects of the VE workshop for this project. This project has gone through several starts since the initial DDR was completed in 2001, so the PDT decided to integrate the VE effort to ‘jump-start’ the design process. In order to inject independence in the VE team, two senior staff (Mechanical and Hydraulic) from the USACE Re-employed Annuitant program and a senior staff member from the CENWP-EC Structural members were added to the team as well as a mechanical engineer from the Hydroelectric Design Center (HDC). In addition, the first two days of the workshop were held on-site so Operations staff could participate and supply input into the phases of the effort.

The PDT went into the study with a ‘strawman’ solution of an automatic raking system, recommended in the 2001 study. Operations staff was not comfortable with that solution, as there was only one company that made a system that could reach 100 feet and the system is not yet proven in similar real-world applications. In addition, they were not comfortable with a fully automated system due to the variety of debris that collects at the racks. A large log or debris could damage the system if it operated solely on remote sensors and camera from the control room. They appreciated the concepts of the automated system that was independent of the gantry crane, however, they wanted more control. A semi-automatic system, one which they turned on and off based on drawdown monitoring, was preferred. A semi-automatic system would need at least two staff managing the operation.

The team spent time understanding the basic requirements or functions of the project. Based on a team exercise and discussion, the overriding purpose of the project was to maintain flow and the basic approach was to manage debris. From this point the team developed a logic diagram of how the project ought to work; this effort is documented in the Function Analysis Systems Technique (FAST) diagram (Appendix C).

From the 65 brainstormed ideas, nine Alternatives were developed. Three of the alternatives were unique solutions to the basic function of "Manage Debris:" automatic/semi-automatic raking, manual raking, and forebay modifications. Four alternatives addressed enhancements to these three options or partial implementation of the forebay modification. Two alternatives evaluated systems: rack construction and diffuser modifications. This last alternative was outside the scope however important because it is a situation that may need to be addressed in a future project.

The team developed a weighted evaluation matrix to evaluate the alternatives. The scores indicated about equal benefits for either raking system. The forebay modification showed significantly better benefits, primarily because it would nearly eliminate the need to rake as well as solve several other issues at the end of the powerhouse. When the scores were divided into the first cost, the manual system was found to be more beneficial than the automatic system and the opposite results when compared to life cycle cost. The switch in benefit between the two systems is because of the significant increase in labor to operate the manual system.

The forebay modification has the most intriguing potential and the PDT decided it was important to understand if the concept would work. A computational fluid dynamics (CFD) model was run which showed that the geometry of the area and its influence on forebay hydraulics was beyond what the forebay modifications could overcome.

**Implementation**

Since the forebay modification concept was not successful, this left the team with the choice of the 'strawman' of an automatic raking system or continuing with the existing manual raking system.

The decision was made easier with two pieces of new information that came to light while the modeling of the forebay modifications was going on.

First, the assumed requirement to change the rack bar spacing to match the spacing of the diffusers downstream was based on preliminary data and still considered a recommendation, if feasible. Replacing the racks would be a significant cost ($1.5mil) to either option. The criteria for lamprey passage over the diffuser grating, not a debris management issue. Debris collection at the diffusers is an issue and with the future narrower bar spacing it will become even more of an issue. Alternative 08 addressed a way to mitigate the situation, so the trash rack may not have to go to a narrow bar spacing.

Second, the forebay was dredged for the first time in several years and the debris that collected on the trash rack was significantly reduced to the point that raking frequency was also reduced with observed increases in effectiveness. The dredging confirmed the belief by staff that most of the debris was pushed to the bottom of the forebay. If Operations continues regular dredging of the forebay, the debris issues and need for raking may become more manageable and effective. Operations further identified that it has small clamshells to perform limited dredging from the gantry crane which could reduce the frequency of getting dredge equipment in the area.

The team decided to move forward with a modified version of Alternative 02, the manual rake system. This essentially means a reduction to the assumed complexity and magnitude for system modifications to achieve the goal. The manual system functions adequately, in light of the new information. Operations needs to maintain regular dredging of the forebay and maintenance of the trash racks and raking system. This means a $2.9 million first cost savings since Alternative 01 will not be constructed. In addition, the team accepted Alternative 06, evaluation of trash rack types, and Alternative 08, modify the diffusers, for future project consideration.

**Accepted Alternatives**

| ID | Alternative Title | First Cost ('+' = Save; '-' = Add) | Present Worth Savings | Net Life Cycle Cost Savings |
|---|---|---|---|---|
| **ALT.02** | Use existing rake system with new racks (Accepted/Modified) | $2.9mil | Not determined | $2.9 mil |
| | **Future Project Consideration** | | | |
| **ALT. 06** | Evaluation of trash rack types | N/A | N/A | N/A |
| **ALT. 08** | Modify the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | N/A | N/A | N/A |

**Rejected Alternatives**

The team rejected Alternatives 01, 03, 04, 05, 07 and 09 for the following reasons

| ID | Alternative Title | Reason for Rejection |
|---|---|---|
| **ALT.03** | Forebay modification to redirect/block debris | The modeling indicated modification would not be effective in changing the flow. Alternatives 07 and 09 are components of alternative 03. Since alternative 03 was found effective, by extension Alt. 07 and 09 will be ineffective |
| **ALT.07** | Construct flow deflecting berm in forebay to redirect flow and subsurface sediment | |
| **ALT.09** | Add flow vane | |
| **ALT.01** | Automated/semi-auto trash raking system | Rejected because ALT.-02 selected and not a preferred option by Operation |
| **ALT.04** | Add trash rack with traveling screen in draft tube. Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks | Rejected by VE team as not effective solution during the VE Workshop. Included for reference |
| **ALT.05** | Add trash racks in fish unit bulkhead slots | This is a way to mitigate trash buildup on diffuser by capturing more material before it gets to the diffuser. Since regular maintenance dredging appears to be the most effective approach, the additional trash collected by this system is felt not to be worth the cost of installing and maintaining it. |

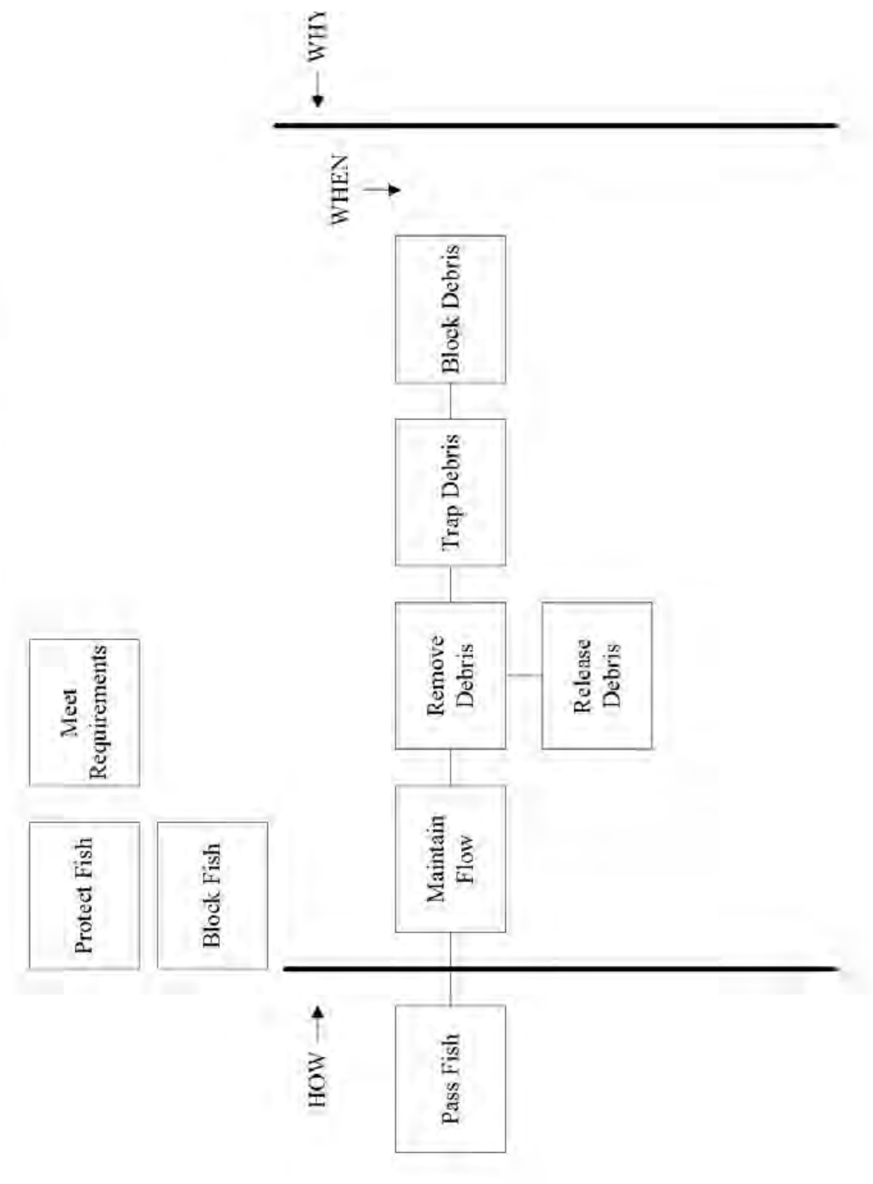
Value Engineering Team Roster

| Team Member Name | Company | Role |
|---|---|---|
| Jason Weber | CENWP-EC-T | Facilitator |
| Eric Stricklin | CENWP-PM-FP | Project Manager |
| Ben Filan | CENWP-EC-DM | TL/Mechanical |
| Jordan Reimer | CENWP-EC-DS | Structural |
| Karen Kuhn | CENWP-EC-HD | Hydraulics |
| Scott McFarlane | CENWP-EC-DE | Electrical |
| Rick Russell | CENWP-EC-CC | Cost |
| Don Courson | CENWP-HDC | Mechanical |
| Jerry Maurseth | CENWP-EC-DS | Sr. Structural |
| Don Sachs | CECO-C-RAO | Sr. Mechanical |
| Dave Wingerd | CECO-C-RAO | Sr. Hydraulics |
| Jon Rerecich | CENWP-PM-E | Fish Biologist |
| Carolyn Schneider | CENWP-PM-E | Environmental |

**Function Analysis/FAST Diagram**

On the following page, is the Function Analysis System Technique (FAST) diagram. The team defined the project in terms of its functions (active verb/measurable noun) and arranged them in a logical, not sequential format. It is from understanding the functions and their relationship that the team developed the brainstorming ideas and from those the developed alternatives.

# B2 Trash Rake FAST DIAGRAM



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## INTRODUCTION

Reliably supplying water to the fish ladders that does not impact salmonids has been a long term issue. The 2001 Design Documentation Report (DDR) recommended a multi-part solution to address the diffuser and rack clogging:

AWS Improvements

1. Stockpile crucial spare parts for the fish units (turbines).
2. Block off the lower trash rack panels at the fish unit intakes to better control sediment transport into the AWS.
3. Replace the existing trash racks and trash rake with new continuous bar trash racks and an automatic traveling gripper rake system.
4. Place a log barrier in front of the fish unit intakes.
5. Install two sets of level transducers across the diffuser grating at the A and B Diffuser gates in order to monitor clogging

Operations Plan

6. Perform annual soundings immediately upstream of the fish unit intakes and dredge during the in-stream work window (December through February, if required).
7. Outfit the floating orifice gates with aluminum sliding closure plates that can be installed into guides mounted around the orifices. Plates would be installed by raising the floating orifice gates up to the EL 55 deck level.
8. Test and verify the recommended operations plan after modifications to the floating orifices have been made.
9. Implement the proposed operations plan, in the event of a fish unit turbine failure, to modify gate settings, close floating orifices, closes selected gates, and regulate flow at the remaining fish unit Turbine.

So far only blocking off the lower trash rack panels at the fish units has been accomplished. In January 2013, dredging begins upstream of the fish units.

A new Project Delivery Team (PDT) is in the process of updating the 2001 DDR to address the repair/upgrade of the trash rack/rake system to an automatic system. In addition, the team is addressing the potential design criteria to decrease bar spacing of racks upstream of the diffusers.

In order to 'jump start' the process, the PDT determined a Value-based Design Charrette would be the best approach for this project. The PDT represents the disciplines of Mechanical, Structural, Hydraulic, Electrical, Fisheries Biology, Environmental Compliance, and Cost Engineering. In addition, to the PDT senior staff from the Re-employed Annuitant Office were included as Design Charrette team members. They represented the disciplines of Mechanical, Hydraulic, and Structural Engineering. In addition, a staff person from the Mechanical branch of the Hydraulic Design Center (HDC) participated because the project involved a fish unit.

The Design Charrette process was conducted for a total of five days over a two-week period: 7-8 November 2012 and 13-15 November 2012. The first two days were spent on site, discussing the project with Operations and Construction staff to learn about the project site conditions, staff issues and concerns about the project as well as developing the functional understanding of the project. The PDT/VE team spent three days the next week implementing the balance of the value methodology.

The baseline solution coming into the Design Charrette was upgrading to an ‘automatic’ raking system to reduce the labor resource requirements while increasing the opportunities to rake the trash rack. In addition, the trash rack would be replaced with racks of closer bar spacing to address diffuser grating improvements for lamprey defined in a 2008 99% Letter Report that stated “The trash racks in the fish ladders also need to be upgraded to match the 0.75 inch gap grating recommended.” Operations and the PDT/VE team identified several alternative solutions including one that was modeled before it was rejected.

**Project Description**

The Auxiliary Water Supply (AWS) is a major component of the upstream fish passage system at the Bonneville Dam Second Powerhouse. The AWS supplies most of the attraction flow for the entrance-bay openings. In addition, it augments flow and velocities in the lower fishway. The AWS supplies water from the forebay through two pressurized conduits; passing through diffuser chambers; and, into the ladder and collection channel to maintain proper hydraulic head over weirs and entrances over the range of tailwater elevations. The AWS is charged by two turbines at the north end of the powerhouse (fish units). Trash racks installed at the intake have a clear space between the rack bars of 7/8 inches. The trash rakes clean the racks manipulated by gantry crane and four Operations staff.

While raking is a normal part of maintaining most intakes, these units have a particular challenge because of their location and the volume of material. The intakes are located in an inlet at the north end of the second powerhouse where there are significant cross-currents and a high level of sediment deposits downstream. In addition, milfoil type aquatic vegetation captured in this area, either by the rack or the downstream diffuser. There are logs and other debris that get blocked by the racks and needs to be removed. Typically, the frequency of raking is greatest for three months in the fall and three months in the spring. In the fall, the aquatic vegetation dies off and is released into the water column. In the spring, flows are the highest and terrestrial and aquatic debris rapidly accumulates on the fish unit trash racks.

Since completion of the 2001 DDR, there has been a change to the grating spacing recommendations at the diffusers. The diffusers are not in the scope of this project; a change in the diffuser spacing would likely impact the trash rack grate spacing. The diffuser grating recommendation is that trash racks upstream of the diffusers must be the same. The clear bar spacing on diffusers is being looked at as a method to improve Lamprey passage by shaping one inch (1")  to three quarters inch (3/4") clear space.  The understanding is that the upstream trash rack clear spacing between bars must be no farther apart than the diffuser grating.  It is assumed the closer spacing will increase the debris collection and increase the likely raking requirements.

## WORKSHOP RESULTS

### Designs Charrette, Part 1: 7-8 November 2013

The first two days of the Design Charrette the VE team met with Operations and Construction staff at Bonneville Dam in order to maximize their participation in the product development. The focus was on three efforts: explanation the preliminary solution of an 'automated' raking system; and exchange of information on the project criteria, issues and concerns; and, establish consensus for a successful project.

**Information Phase**:  The first day the team met at the auditorium conference room at Bonneville Dam.  After introductions and an outline of the agenda to be accomplished over the next two days the PDT described the proposed solution:  Automated trash rake.  This system was one component of the overall solution proposed in the 2001 Design Documentation Report (DDR). The automated trash rack is described in detail in Alternative 01 located in Appendix A.  Simply, sensors mounted near the racks would identify when the head across the rack increase to a certain level, which would activate the rake to perform the cleaning.  After the rake cleaned a rack section, it would take the debris along a rail to the north and dispose of the debris in a container at the end.  The rake would return and rake another section of the racks until the rakes were clean.

Operations staff had concerns about allowing the rake to operate automatically using sensors and cameras from a control room.  First, the unit would operate whenever the sensor detected debris, however, it could not identify the type of debris, like logs and other large debris, which could damage/disable the unit.  Operations would prefer that the system be semi-automatic operated by a two person crew.  The crew would evaluate if it was safe to rake after the sensor indicated the significant head differential.  If it was safe, the crew completes the cleaning process.  In addition, Operations staff wanted the system designed so it would not interfere with the gantry crane movement or its access to the forebay so it can operate as a back-up.  These two changes add costs to the system design and construction.

Construction staff and others had concerns that only one manufacture had been identified capable of completing the effort because the rake would be in operation over a 100 foot depth from the top of the deck.  This manufacturer was still in the process of building the system in Arizona, so it will be important to verify their claims since this might end up a sole source procurement

The PDT/VE team visited the site with Operations staff leading the tour.  The team saw the newer rake in the 'bone-yard' abandoned because it weighed too much when operating under load.  Operations returned to using the old smaller rake a few months after receiving the new rake around 2004.  The team saw the existing rake in place and learned that it was somewhat successful at collecting debris. This was new information as the team has understood that the rake was ineffective and not used.

Riggers work Monday through Thursday which mean there is no staffing for raking operations during the weekend  (Friday through Sunday), unless called in.  If the racks get too clogged overnight or on the weekends then the fish units are ‘shut down’ so the trash will ‘float off.’  In reality the trash does not float, rather 90% of it sinks so when the fish units are turned on the debris to drawn back on and sometimes through the rack.  It was reported that during the high debris seasons in fall and spring that the fish units can be shut down for 3 hours each days.  This is a significant issue as it is lost water to the fish ladder and power generation and a primary goal is to not shutdown the units except in the most unusual situations.

With narrower rack spacing, there is concern that the debris will build up more quickly requiring more time from Operations staff to operate the rake more and for a longer time period than currently anticipated.

According to Operations staff, current operation of the manual rake system requires about 380 man-hours per year scheduled for raking with an additional 380 man-hours of overtime raking on nights and weekends.  In addition, about 160 hours on rack maintenance each year: removing and cleaning racks; repairing/replacing rack bars; reinstalling the racks; and maintaining the rack. An additional 80 man-hours are identified for debris maintenance which is for efforts not related to the rake operations but still required keep debris away from the racks.   The VE team considered design criteria to narrow the rack spacing from 7/8 inches to 3/4 inches. This represents a decrease of 15% of the area to pass flow.  In order to evaluate the alternative system later, the VE team assumed this decreased spacing would increase raking efforts by at least 30% based on simply squaring 1.15 (1 plus 15% decrease in area) and rounding up.

A great deal of information was gathered during this two days and a complete list of the documented information can be found in Appendix B.   The list of the information relates to assumptions, constraints, risks, and criteria.

**Function Analysis**:  The VE team along with the Operations and Construction staff began the function analysis by focusing on the question, “What is the problem?”  The VE team and Operations staff were broken up into three multi-discipline teams to come up with one response each.  The responses were:  Keeping the ‘fish’ protection maintained, shutting down fish units; and Debris Management.  The team discussed the meaning of these phrases and derived the higher order function, Maintain Flow and the basic function, Manage Debris.  The team used a series of how and why questions and associating functions to the components of the rake and rack system.  The initial FAST Diagram was established in the first part of the Design Charrette and refined during the second part of the Design Charrette.

**Designs Charrette, Part 2: 13-15 November 2013**

Part 2 of the Design Charrette occurred at Portland District Offices. The morning was spent reviewing the information from the week before; adding new information missed; and refining the function analysis.

**Creativity/Brainstorming:** Once the review was complete, the team started brainstorming. Some initial brainstorming took place at project during Part 1 of the Design Charrette. The team continued general brainstorming followed by brainstorming specific functions. The team reviewed the ideas developed to make sure there were ideas addressing each functions. The team generated 65 ideas. The ideas addressed both the immediate project and considered the issue with the diffusers. The team reviewed and clarified the ideas, so the team had the same understanding of each.

**Evaluation-Step 1:** The evaluation process was multi-step. In the first step, the team identified and defined criteria based on the project background; and, information from the Design Charrette Part 1. Some of the 14 criteria have overlapping meanings; however, the team believed these criteria were important to evaluate the idea and the ultimate solution.

- Flow Delivery: Water passing through the turbine and into the fish ladder will be adequate to meet fish ladder and fish unit operations criteria
- Schedule: The project can be constructed within a reasonable time frame
- Operability: Minimize the effort required for the project function as intended
- Maintainability: Minimize effort required to keep the project functioning
- Flexibility: System functions in concert with existing system components
- Reliability: System consistently produces similar results
- Compatibility: System works with existing systems and does not interfere with operation of other systems
- Supply Power: Power generation requirements must be maintained (need not be the fish units)
- “Fish” Friendly: System maintains fish survivability (forebay and ladder)
- Durability: System to resist wear and deterioration
- Constructability: Ease of building the system
- High Confidence of Success: System is proven
- Redundancy: Back-up systems (or sub-systems) in place
- Labor Intensity: Amount of staffing required to manage the system

The team was given time to review the ideas and identify which they thought best met some or all of the evaluation criteria. The team identified 23 Preliminary Alternatives, which are listed in Appendix D.

The team further evaluated these ideas based on the evaluation criteria to identify nine Alternatives they wanted to develop.

**Development/Presentation:** The nine Alternatives developed are:

ALT. 01: Automated/semi-auto trash raking system (Initial Concept)

ALT. 02: Use Existing Rake System with new racks

ALT. 03: Forebay Modification to redirect/block debris

ALT. 04: Add Trash rack with traveling screen in draft tube. Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks

ALT. 05: Add trash racks in fish unit bulkhead slots

ALT. 06: Evaluation of Trash Rack Types

ALT. 07: Construct flow deflecting berm in forebay to redirect flow and subsurface sediment

ALT. 08: Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating

ALT. 09: Install a flow directing vane between fish units and unit 18

As this was a Design Charrette, team members wrote each alternative based on its own merits and not related to any existing design. They were told that comparison would be part of the evaluation for a preferred solution (s). They worked in one and two person teams developing each Alternative. Each Alternative required description of the concept; a list of advantages and disadvantages; a discussion/justification for implementing the Alternative; a rough first cost estimate and a life cycle estimate. Depending on the alternative, some do not include costs, so further research is necessary on those should they move forward at a future point.

It is important to understand that the costs generated are order of magnitude costs, not final cost. Life cycle costs are based on a 50 service life.

After 4 hours working on the alternatives, each team member briefly presented their Alternative to the group. Since there was not a separate PDT, this approach allowed the team to outline each Alternative in 5 minutes, and let the remaining team member comments and help with some additional input. The team took a break from developing Alternatives, and switched to developing more detailed Evaluation criteria for the Alternative.

**Evaluation-Step 2:** The facilitator utilized semi-quantitative weighted paired-comparison method to refine the Evaluation. In this method, an evaluation criterion is compared against each of the other criteria, one at a time. This is repeated until each criterion has been compared to each of the other criteria. The team answered the following two questions for each pairing: "Assume an Alternative meets these two criteria, which criteria is more important to improve for the project? The second question was, "How much more important is it to improve that particular criteria: 1= slightly more important; 3= significantly more important; and 2= somewhere in between. For example, the team compared Flow Delivery to Schedule. They determined it would be more important to improve Flow Delivery than Schedule because as long as the project met schedule, then completing it sooner was not as beneficial as improving the Flow Delivery. Again the focus is on which criteria is more important to improve assuming both meet that project minimum requirements.

The team found improving schedule was never more important than any of the other criteria for this project. This was because design/construction schedules were not defined in enough detail to make improving the schedule a more important issue. Later in the project, it may become a more significant issue.

In Appendix E is a table of the weighted paired comparison results. Five of the 14 criteria account for more than 60% of the weight of the matrix. These criteria are: High Confidence of Success (16.7%); Reliability (14.9%); Maintainability (10.7%); "Redundancy (10.1%); Fish Friendly (9.5%). An Alternative that scored high in these five criteria would most likely be a preferred solution. The weighted scoring were not revealed to the team until they had completed their Alternatives Evaluations (Evaluation-Step 3)

**Presentation**: Once the Alternatives were developed, each Alternative was presented to the team by its developer(s). Comments and questions from the team were addressed. Once the team understood the Alternatives, they moved onto the final evaluation step.

**Evaluation-Step 3**: Starting with Alternative 01, the base concept, the team went through evaluating six of the nine Alternatives. The team dropped Alternative 04 from consideration as it proved not to be feasible to construct and operate. The information remains in the report for reference. Alternatives 06 and 08 were not evaluated as they were evaluations of components and would be addressed further in another part of the project or a future project.

Each Alternative was rated on a scale of one to 10 on how well it addressed each criterion. Ten was the best score and one the worst score. The goal was to reach consensus score for each evaluation criteria on each Alternative. The score represented how well the Alternative addressed the criteria. A perfect score on Flow Delivery would mean no impedance of the flow. For example, a project that did not require racks and with no debris passing into the inlet would be considered perfect (10). Typically, the Alternative developer stated a score and the team discussed it. After Alternative 01 was completed, the remaining Alternatives were assessed based on the criteria score of that Alternative 01.

Once the raw scores were entered in the table (Appendix E), the weighted values for each criterion were multiplied by the related score. The weighted value was the weighted percentage for each criterion, calculated earlier, multiplied by 100. The greater the number of points, the more benefits the alternative brings to the project.

These points come at a cost, so the points of an Alternative are divided into its first and lifecycle cost. This determines a cost per point per Alternative. The lower the cost per point the better value the Alternative is to the project.

Alternatives 01 and 02 scored about the same points (577 and 571 respectively). Alternative 02, upgrading the existing system, has the lowest first cost and the highest lifecycle costs ($1.6 mil and $7.1 mil). Alternative 03, forebay modification, scores the most points (729) and had the highest first cost. Alternatives 05, 07, and 09 were additions in conjunction with Alternative 01 and/02. When compared to Alternative 02 alone, none indicated a significant increased benefit and were eliminated from further consideration.

If only evaluating based on first cost then Alternate 02 is the clear preference. However, when evaluating the life cycle cost, the high costs due to labor to operate the system show this Alternative to have the lowest value. Alternative 01indicates a lot of potential for base on life cycle cost, however, it was not the preferred option for the operations staff.

Operations and the PDT preferred Alternative 03, forebay modifications. They believe this alternative would significantly reduce the amount of rack raking and the need for annual dredging as the vast majority debris and sediments would flow through Unit 18. In addition, the several other operating issues in the area would be solved by eliminating the strong circular flow.

## IMPLEMENTATION

The PDT felt it was important to model Alternative 03 before they completed a cost estimate and life-cycle analysis of the Alternative. The PDT understood this Alternative would cost significantly more than either Alternative 01 or 02, however, the life cycle savings potential for the entire Bonneville Project was believed to be so significant they wanted to model the condition to verify the assumptions.

The modeling indicated that the forebay modification would not significantly change the existing conditions (see Appendix F), so the team decided to re-evaluate the remaining options.

Since the forebay modification concept would not work that left the team with the choice of the 'strawman' of an automatic raking system or continuing with the existing manual raking system, upgraded to the rack requirements.

The decision was made easier with two pieces of new information that came to light while the modeling of the forebay modifications was going on.

First, the assumed requirement to change the rack bar spacing to match the spacing of the diffusers downstream was based on preliminary data and still considered a recommendation, if feasible. Replacing the racks would be a significant cost ($1.5mil) to either option. The criteria for lamprey passage over the diffuser grating, not a debris management issue. Debris collection at the diffusers is an issue and with the future narrower bar spacing it will become even more of an issue. Alternative 08 addressed a way to mitigate the situation, so the trash rack may not have to go to a narrow bar spacing.

Second, the forebay was dredged for the first time in several years and the debris that collected on the trash rack was significantly reduced to the point that raking frequency was also reduced with observed increases in effectiveness. The dredging confirmed the belief by staff that most of the debris was pushed to the bottom of the forebay. If Operations continues regular dredging of the forebay, the debris issues and need for raking may become more manageable and effective. Operations further identified that it has small clamshells to perform limited dredging from the gantry crane which could reduce the frequency of getting dredge equipment in the area.

The team decided to move forward with a modified version of Alternative 02, the manual rake system. This essentially means a reduction to the assumed complexity and magnitude for system modifications to achieve the goal. The manual system functions adequately, in light of the new information. Operations needs to maintain regular dredging of the forebay and maintenance of the trash racks and raking system. This means a $2.9 million first cost savings since Alternative 01 will not be constructed. In addition, the team accepted Alternative 06, evaluation of trash rack types, and Alternative 08, modify the diffusers, for future project consideration.

# APPENDIX A

## Developed Alternatives

**DEVELOPED ALTERNATIVES**

| ALTERNATIVE | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **ALT #01:** Automated/semi-auto trash raking system | $2.4mil | $2.9mil | $5.3mil |
| **ALT #02:** Use Existing Rack System with new racks and modified Rake | $1.6mil | $5.5mil | $7.1mil |
| **ALT #03:** Forebay Modification to redirect/block debris | $5.7mil | $0.31mil | $6.0mil |
| **ALT #04:** Add Trash rack with traveling screen in draft tube. Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks | N/A | N/A | N/A |
| **ALT #05:** Add trash racks in fish unit bulkhead slots | $0.34mil | $0.58mil | $0.92mil |
| **ALT #06:** Evaluation of Trash Rack Types | N/A | N/A | N/A |
| **ALT #07:** Construct flow deflecting berm in forebay to redirect flow and subsurface sediment | N/A | N/A | N/A |
| **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating. | N/A | N/A | N/A |
| **ALT #09:** Install a flow directing vane between fish units and unit 18 | N/A | N/A | N/A |
| | | | |

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #01:** Automated/semi-auto trash raking system | **Page No.**<br>1 of 5 |

**CONCEPT:** This is the case from which all other alternatives will be compared.

The automated trash rake system is made up of a rake, rack, and disposal system:

The rack would be a standard configuration with open space between bars set at 3/4". The bars would be vertical and the rack would be configured to allow the automated rake head smooth passage to the bottom of the racks. The rack would be galvanized steel or stainless steel.

The rake will have an open clam shell shape with teeth that engage the rack. Raking will be done as the rake head moves down the rack; at the bottom it will close, capturing the debris and bringing it to the deck. Each rack would require two passes by the rake. A rail system will allow the raking head to move north along the face to a disposal site where the debris can be dumped into a container. The rail is supported by cantilevered structural members fixed to the face of the dam.

This Process can be automated/semi-automated/manually actuated.

Logs can be removed manually, up to 6600 lbs in weight.

**ADVANTAGES:**

- Operating labor reduced by about half
- Increased raking frequency
- Operated in manual/semi-auto/automatic
- Pressure transducer- differential monitored remotely
- Eliminates need to use Gantry Crane for this operation

**DISADVANTAGES:**

- Unproven reliability at project depth
- Limited to a load of 6600 lbs
- More equipment to maintain
- Only one manufacturer indicated their product can reach project depths
- System needs to be designed so gantry crane can access racks and operate manual rake

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **$ 2.4 mil** | $ 2.9 mil | **$ 5.3 mil** |

**DISCUSSION / JUSTIFICATION:**

Maintainability

The rake equipment has a manufacturer provided maintenance schedule. Operations will need to factor in the costs for recommended maintenance into their budget. If the system is properly maintained this budget amount will be minimal.

Operability

With the new rack bar spacing of 3/4" it is assumed there will be a higher debris load at the intake racks. An automated rake can perform raking multiple times a day while staying clear of the gantry crane operation. Per operations, the rake would have two staff to visually monitor the rake during operations. This is half the staff currently required to operate the manual system. The rake can also be manually operated to remove large debris in the event a log is stranded in front of a fish turbine intake. Debris will be delivered to a container without occupying any deck space.

Reliability

With the application of manufacturer recommended options the operation of the unit will likely have a long service life. The system will be designed so the gantry crane can be used to access the racks and potentially operate its own manual rake, if this system breaks down, providing a redundant method to clear the racks.

High Confidence of Success

The rake manufacturer has extensive raking experience; it makes it likely that the automated rake will successfully clean the racks. The depth of the raking and forebay hydraulic conditions may create unforeseen operational challenges which will need to be addressed during the Plans and Specifications phase. The racks and the rake will be a single matched product from the manufacturer.

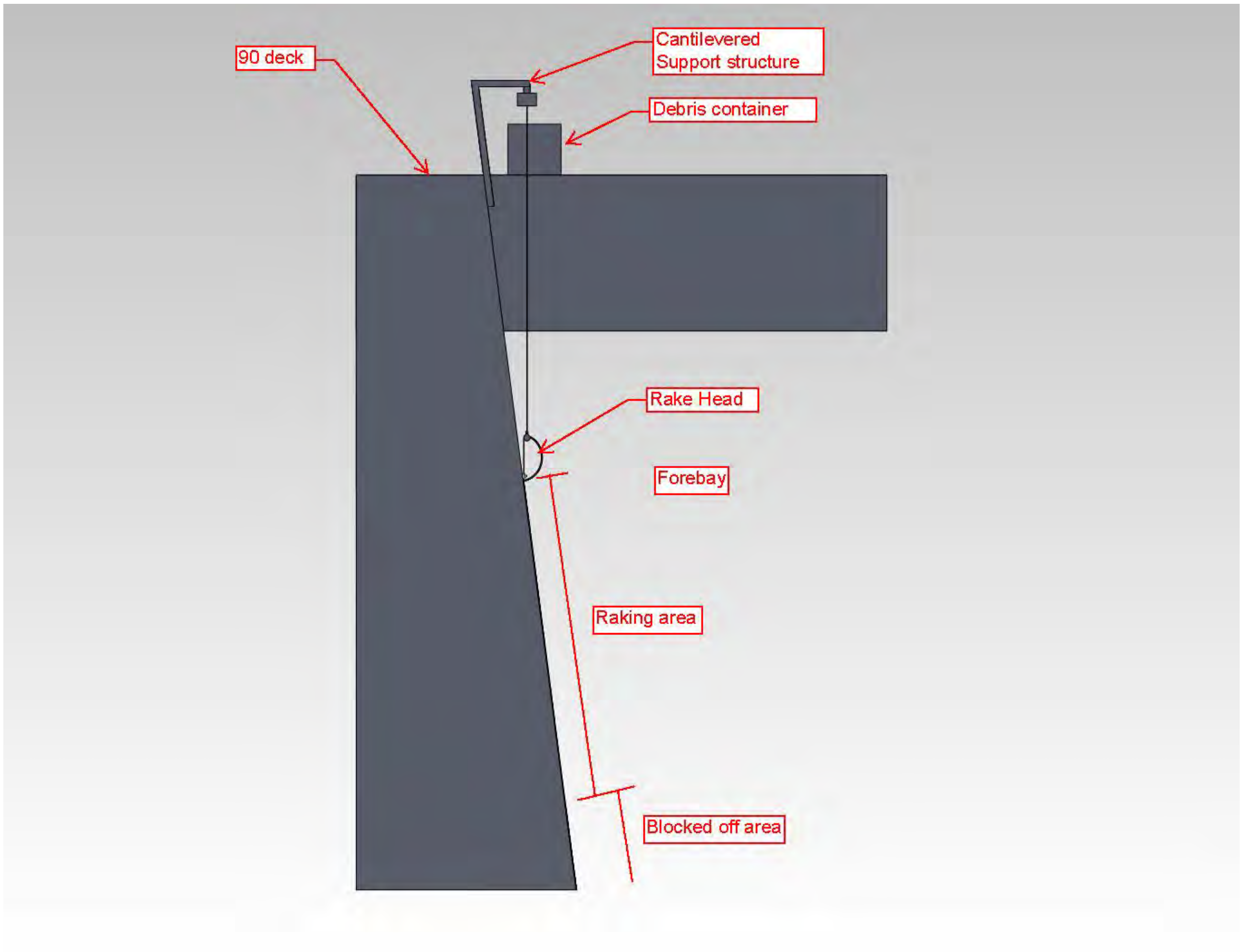
Redundancy

The redundancy for this system is limited to operations. In the event of a break down the debris can be removed by floating it off the intake racks. This would be a temporary action until the rake could be repaired. It is likely that the old rake could be used. However, the new system will need to provide clearance for the old rake to access the racks and remove intake racks for annual cleaning.

**IMPLEMENTATION CONSIDERATIONS:**

Installation will require that structural bracing is attached to the forebay face of the dam. The racks will need annual maintenance and inspection regardless of debris removal options selected. Power and SCADA feedback will need to be coordinated with the project. Power use is approximately 20 HP. Debris container location must be accessible by truck.

**CONCEPT**

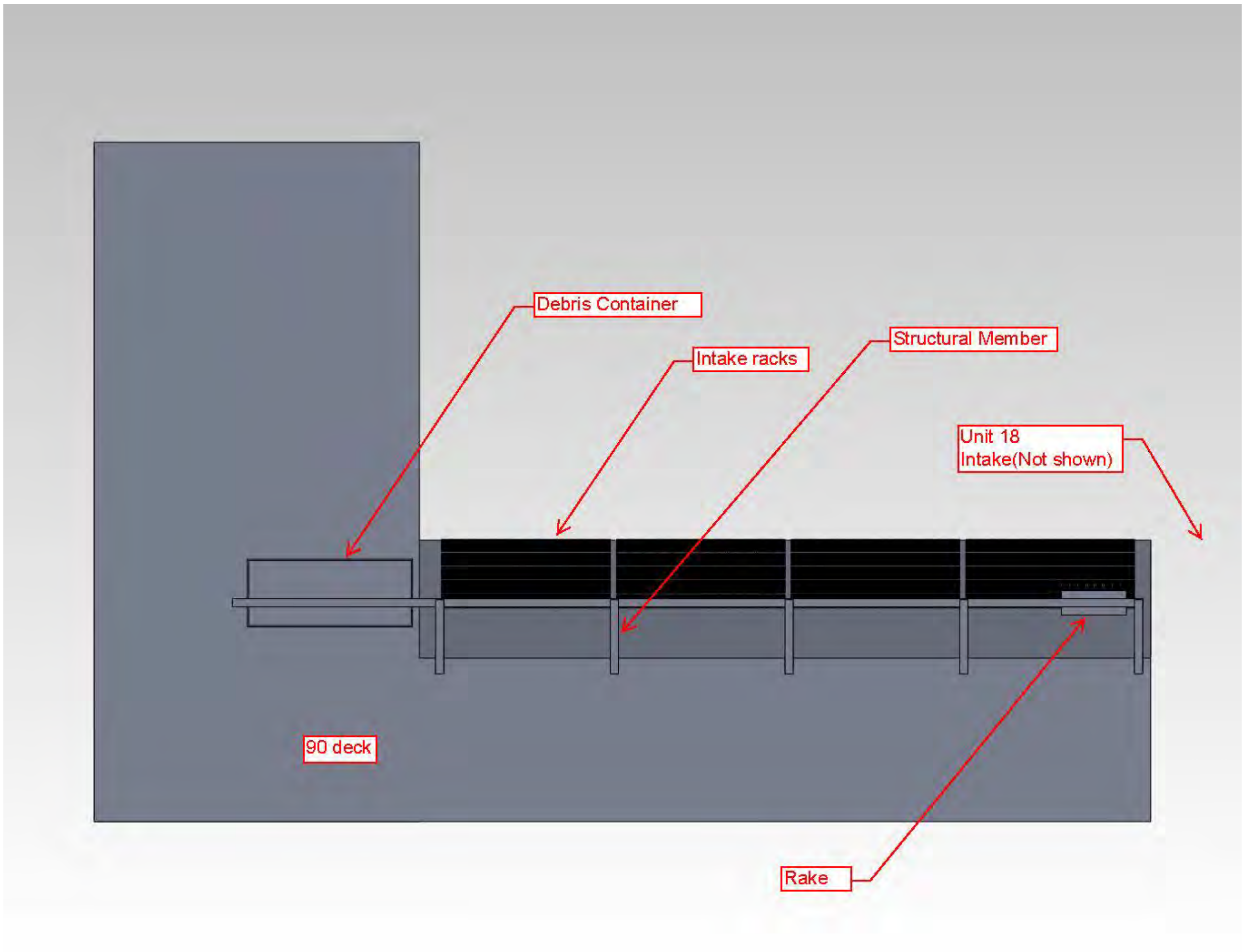



Section View of Deck, Rake, and Debris Container

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #01:** Automated/semi-auto trash raking system | **Page No.**<br>4 of 5 |
|---|---|---|

**CONCEPT**




Plan View of Deck, Racks and Rake

**GENERAL WORKSHEET**

Risks:

- Design Life is generally unspecified for off the shelf items. Contractor's warranty will extend for one year after installation.
- Debris accumulation may require more than two rakings per day during high debris periods. This affects design life and labor requirements.
- Maintenance will not be performed regularly on the racks and the rake.
- Custom weight.
- Guide system likely required to overcome forebay hydraulics and operation depth.

General:

- Given the racks accumulate more debris and there is an increased demand for use of the gantry crane for VBS cleaning, an automated rake system would function independently. This would allow cleaning of the fish unit intakes without interrupting use of the gantry crane to clean the vertical barrier screens.
- Minimal amount of moving parts; maintenance is reduced or equal to current levels.
- Most of the equipment is placed over the forebay leaving the deck unoccupied and mostly unmodified. This equipment would need to be removed to access racks for maintenance.
- Debris removal is directly deposited into a container; project personnel would only be responsible for dumping the container.
- Minimal power consumption (20HP max).

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| Idea No: | **ALT #02:** Use existing rake system with new racks | Page No.<br>1 of 3 |

**CONCEPT:**

The existing system with the rake and gantry crane will be used. However, there are recommended enhancements to the system to address deficiencies. They include modifications to the rack and rake and the additional personnel required to perform raking during higher debris periods.

The rack bar spacing will be decreased from 7/8" to 3/4" to match diffuser grating and meet lamprey passage requirements.

Due to an eddy near the fish units it has been observed that lateral flows tend to push debris out of the rake, reducing its debris collection. It is proposed that grating be installed on the existing rake to prevent the loss of the debris while allowing water to evacuate the bucket. The "boiling over" effect would also be greatly diminished. The bar spacing of the grating could also be 3/4". The side grating would span the entire side of the rake where debris buildup is likely to occur, near the lower portion of the rake. The teeth spacing on the rake would be adjusted to accommodate the new 3/4" spacing on the rack.

The current operations for debris relocation and disposal, which entails using a 20 yard container to dump debris where it is hauled off to a mulching site, will remain in place.

During high debris periods in the Spring and Fall, a crew of 4 will be employed to perform debris collection in the evening or as a second day shift. This crew would consist of 2 riggers, a crane operator, and overseer. This will help to promote consistent unobstructed flow through the fish units without needing to shut down the units.

**ADVANTAGES:**

- Minimal design effort
- Low technical complexity
- The system is already deemed effective by staff
- Very constructible
- No additional power requirements and fish units can remain running
- A proven reliable and durable system as old as the powerhouse itself
- No impact to deck structure
- Same rate of raking compared to Alt 01

**DISADVANTAGES:**

- Significant labor required to operate
- No sensory feedback to alarm control room of increased differential pressure
- Doesn't address problem with debris being compacted by the rake at the bottom

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **$ 1.6 mil** | $ 5.5 mil | **$ 7.1mil** |

**DISCUSSION / JUSTIFICATION:**

The design effort is minimal and would require no additional structural or mechanical features that could cause increased maintenance activities. The design is low impact. The debris collection system is already a proven design that has been shown to work relatively effectively for the past 30 years. The project only clears out the racks once every other year and it is unknown how often bars are damaged on the rack but it is not a significant issue. This is the preferred system by operations unless an overwhelmingly proven 'automatic' system can be identified.

**IMPLEMENTATION CONSIDERATIONS:**

There are few issues with implementation of this alternative since the suggested modifications to the rake have no appreciable impact on its operation. This alternative improves an already effective trash collecting system.

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #02:** Use existing rake system with new racks | Page No.<br>3 of 3 |
|---|---|---|

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #03:** Forebay modification to redirect/block debris | Page No.<br>1 of 6 |
|---|---|---|

**CONCEPT:**

Build a new trash directing fence in the forebay that is approximately perpendicular to the dam and begins between the fish unit and unit #18. The upstream end would connect back to the bank. The lower level of the fence would be a solid (non-flow-through) section such as a berm or solid wall beginning at the invert (EL -30 ft. at the dam) to a height of approximately EL 30 ft. closer to the dam and increasing in elevation as it steps up the bank to about EL +60 ft. The bulk of the upper portion of the fence would anchor to the solid sections and consist of a series of vertical vanes similar to picket leads at approximately 7/8 in. spacing. This upper flow through section would start approximately 20 ft. upstream of the dam and extend 300 ft. further upstream and maintain an upper elevation of about EL 80 ft. The vanes would be angled at a 45 degree angle downstream to encourage the trash to float or drag toward and go through Unit 18. In addition there will be two solid sections as part of the upper section that extend from either end of the vaned section. At the downstream end a large vane (approximately 50 ft. high by 20 ft. wide) would bridge the gap between the face of the powerhouse and the downstream end of the flow vanes (to reduce circulating flow at the dam face). Attached to the upstream end of the vane section a solid portion would angle to the north connecting to the bank.

The size of the picket lead section (approximately 12,000 square ft.) and approximate spacing of 7/8 inch would reduce the velocities from about 3 fps at the trash rack to about 0.5 fps through the fence. Very little debris (if any) will encounter the fish unit trash racks and instead slide along the picket leads towards unit 18. The lower solid portion of the trash directing fence should direct the sediment load that currently builds up in front of the fish units towards the main units.

Optional items and/or potential modifications that may be needed:

- Deflector vane attached to powerhouse could be fixed or movable (angle to flow) to allow for prototype modeling in the field for additional confidence in the hydraulic modeling results.
- Angle of the fence structure.
- Use a screen rather than picket leads.
- Add a nylon roller brush if beneficial.
- Modify depth of the fence.
- More area for picket vanes could be made in the no-flow lower section.

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | $ **5.7 mil** | $ 310,000 | $ **6.0 mil** |

**ADVANTAGES:**

- High velocities and differential head (pressure) through a trash rack is what causes trash to get stuck on the trash rack. The reduced velocities through the new trash fence reduces incidence of trash.
- The flow toward unit 18 may self clean the picket leads.
- Takes away the need to develop a new trash rack cleaner for a new trash rack design.
- The existing trash rack and rake could be used.
- System is reliable due to no moving parts, low maintenance.
- Reduction in headloss through fish unit trash racks resulting in reduced interruption of fish passage and emergency shut down time.
- No need to collect and remove debris as it will go through unit 18 and pass downstream reducing O&M resource needs for dredging in front of the fish units.
- Redundancy as the existing trash raking system remains in place.
- Velocity is low enough that harmonic vibration is not a concern.

**DISADVANTAGES:**

- Major effort to construct.
- Hydraulic modeling needed.
- Need authorization to design and construct.

**DISCUSSION / JUSTIFICATION:**

No moving parts:

Most alternatives require a considerable number of mechanical or electrical devices. The simplicity of the proposed system with no moving parts is a major advantage over all other systems. Minimum Maintenance.

Environmentally Friendly:

Without moving parts there is no need for grease or oil needed in the vicinity which could otherwise discharge contaminants into the water.

Reduced Velocities:

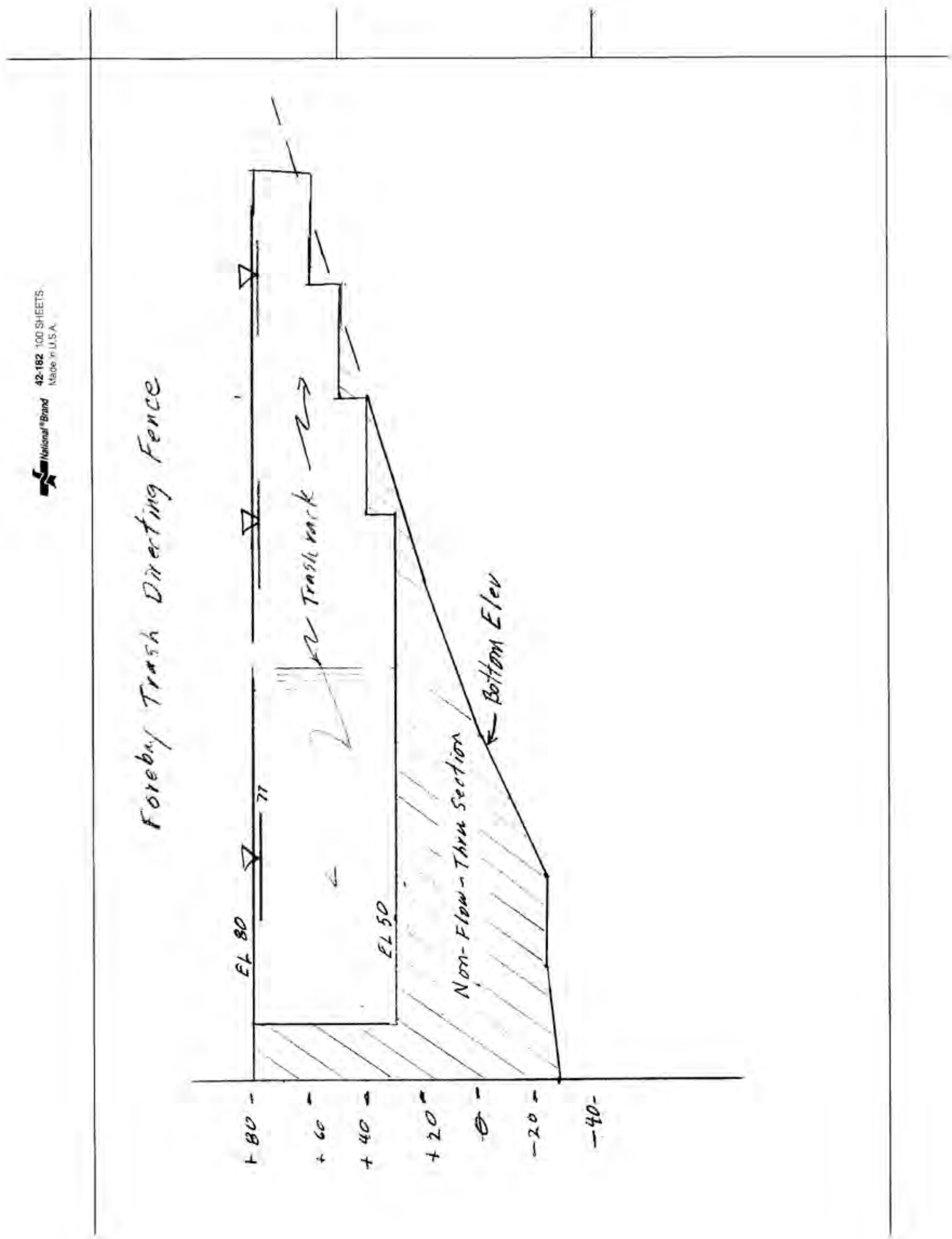
Unlike other alternatives the velocity through the trash rack vertical leads is reduced to about 0.5 fps compared to about 3.0 fps for turbine based alternatives.

**IMPLEMENTATION CONSIDERATIONS:**

- A model study is recommended to validate the flow assumptions.
- Modeling the flow deflector could determine the size, shape, angle of the deflector and whether it should be fixed or moveable.
- There are four major components to the FTDF:
  - Flow deflector: Located between unit 18 and the fish units, it could be built first and used immediately. See discussion of this item as separate alternatives.
  - Tie-back berm: It is located at the upstream end of the picketed lead screen and connecting to the shore. This could be built early in the construction and could have an immediate positive effect on the flow pattern.
  - Non- flow-through Section: Construction could be made of any materials, such as steel (sheet piles) or other alternatives. All of this feature need not be constructed of the same material. Its major function is to support the vertical leads.
  - Fish screens (also referred to as fish leads, or picket leads, vertical bars or turning vanes): The vertical bar construction is similar to the fish leads at the counting station. The spacing is on one-inch centers with 7/8 inch clear space openings. The angle on the leads is 45 degrees or as revised by model study data. The overall size of the screen should be about 12,000 square feet to produce an average flow velocity of about 0.5 fps. The screen is assumed to be modular panels that fit into slots supported by the non-flow-through section.

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #03:** Forebay modification to redirect/block debris | **Page No.**<br>4 of 6 |

**CONCEPT**



**GENERAL WORKSHEET**

1. Hydraulic Assumptions:
   a. Low velocities at the trash rack leads reduce the probability of trash adhering to the rack.
   b. The angled leads (45 degrees) in the FTDF reduce chance of trash catching on the leads.
   c. River flow toward unit 18 is perpendicular to the leads and will have a sweeping cleaning action on the leads to carry the trash through unit 18.

2. Reliability Increased:
   The FTDF employs no moving parts. Therefore there is less potential for breakdown.

3. Maintenance Reduction:
   The sweeping velocity of the river flow diverted toward unit 18 provides a natural cleaning action on the leads. The velocity through the leads is reduced to about 0.5 fps. It is assumed that no mechanical cleaning equipment is necessary.

4. Confidence of Success Increased:
   The confidence of success appears high because :
   a. There is little stress on the facility. Its major challenge is to simply stand in place.
   b. Velocities are very low.
   c. The sweeping action of the river flow needed toward unit 18 should remove most of the trash from the leads.

5. Redundancy Provided:
   a. The FTDF is a new added feature to the project. The existing trash rack and trash rack rake will remain in place and provide backup should some debris reach the fish units.

6. Fish Friendly:
   Adult fish are kept far away from the fish turbines and the flow velocities in the area of the FTDF are very low. Therefore adult fish should easily be able to navigate near the FTDF, yet be blocked from entering the forebay in front of the fish turbines. The structure may help exclude juvenile fish from the area in front of the fish turbines because velocity may be sweeping toward unit 18.

7. Cost Considerations:
   The FTDF may be initially more expensive to build than other mechanical devices. However, a cost analysis of the life cycle costing may show the long term benefits outpace a quick-fix short term solution. The following are considerations:
   a. Minimal Maintenance – The savings of manpower could be considerable. Currently 2-4 maintenance people are needed to operate the existing system.
   b. Energy Loss/Fish Unit Downtime – Currently the fish units often need to be shutdown to allow the debris to disperse and flow to unit #18.

   Energy Loss/Headloss – The project reports that trash buildup on existing trash racks can cause drawdown as much as 20 ft. A 20-ft. head loss is significant resulting in much less power generation for the unit.

**GENERAL WORKSHEET**

Concept Development – Options

1. Lead spacing. The concept is to use 7/8 clear space between leads, the same as used on the existing trashrack. However this could be changed if justified by subsequent information
2. Replace non-flow-through area with more fish leads. The principle is to develop approximately 0.5 fps flow through the fish leads. Additional fish screens would further reduce the flow velocity, which is assumed to be a further benefit.
3. Trashrack Shape. The trashrack is shaped to minimize the depth of the rakes for maintenance purposes. Working nearer to the surface is considered preferable. However, if there is a reason to do otherwise, the configuration of the shape is not important as long as the overall size is maintained.
4. Rotating Brush. The sweeping flow along the leads is assumed to clean and carry debris away. However, especially at the water surface, floating debris may collect. If this becomes a problem, a mechanical rotating brush could be added.
5. Replace Existing Trashracks. Assuming the FTDF is successful, the existing trashracks should see minimal use. However, if the FTDF proves to be not very successful in removing the trash at such time as when the existing trashrack needs to be replaced via normal maintenance, wider spacing could be used.
6. Access to the forebay immediately upstream of the fish units. The construction of FTDF will cut off floating access from the normal forebay to the forebay immediately upstream of the fish units. If access is deemed necessary, a section of the picketed leads could be hinged and opened to accommodate access.
7. Notch in trash diversion vane. The trash diversion vane blocks floating trash from the fish units. A notch could be put in the top of the vane to allow floating debris to move across this barrier.

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #04:** Add trash rack with traveling screen to intake bulkhead slot Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks. | Page No.<br>1 of 4 |
|---|---|---|

**CONCEPT:**

NOTE: After development, the VE team determined this alternative was not a viable solution do to constructability issues and costs.

This Alternative has three features:

1. For the new intake trash racks with bar spacing at 2" and increase the bar thickness.
2. Continue cleaning the new trash rack manually using the intake gantry crane with main unit rake.
3. Add secondary trash racks in the fish unit intake bulkhead slots. These trash racks would be a traveling screen type featuring a flexible grate with 3/4 in openings to capture smaller debris that goes through the primary intake trash racks. The flexible grid/traveling screen would be moved by powered sprockets at the top and idler sprockets at the bottom. It would be self-cleaning, dropping debris at the intake deck, with the staff clearing the material on a regular basis.

This Alternative does not preclude Alternatives 06 and 07 from being implemented at the same time which would provide even more redundancy.

**ADVANTAGES:**

- Use one rake type for all trash racks on the powerhouse, so less equipment to maintain
- Redundant system to trap debris before it gets to the fish unit and diffuser grate, so less material to trap at diffuser
- Similar system (traveling screen) like at main units, so similar maintenance experience required
- Less raking with wider bar spacing on main intake
- Intake rack easier to maintain and repair with wider spacing
- Most clean up of debris from traveling screen can be completed by lower skilled position

**DISADVANTAGES:**

- Increased equipment maintenance required with additional mechanical equipment in use
- It is not known if the system is constructible
- Reduced area on intake deck to perform other work
- Would need to be continually manned during 'debris season' do to high loading from debris requiring clean up.

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **N/A** | N/A | **N/A** |

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #04:** Add trash rack with traveling screen in intake bulkhead slot. Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks. | **Page No.**<br>2 of 4 |

**DISCUSSION / JUSTIFICATION:**

This Alternative would appear to have a number of positive aspects. However, it has a number of serious risks so there is not a high degree of confidence it could actually be implemented and if it could function reliably. A 100+ foot high traveling screen would appear to be so stressed from its own weight that functioning reliably would be in question and maintenance would probably be high. Failure could result in significant fish unit downtime and divers being required to make a significant portion of the repair effort as the bulkhead slot area could not be unwatered.

**IMPLEMENTATION CONSIDERATIONS:**

It may not be possible to design a 100+ foot high traveling screen type trash rack with adequate factors of safety in regard to strength and wear and tear on the moving parts. A significant portion of the installation effort would need to be done by divers. A long unit outage would likely be required.

NOTE: After development, the VE team determined this alternative was not a viable solution do to constructability issues and costs.

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #04:** Add trash rack with traveling screen in intake bulkhead slot.  Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks. | **Page No.**<br>3 of 4 |

**CONCEPT**

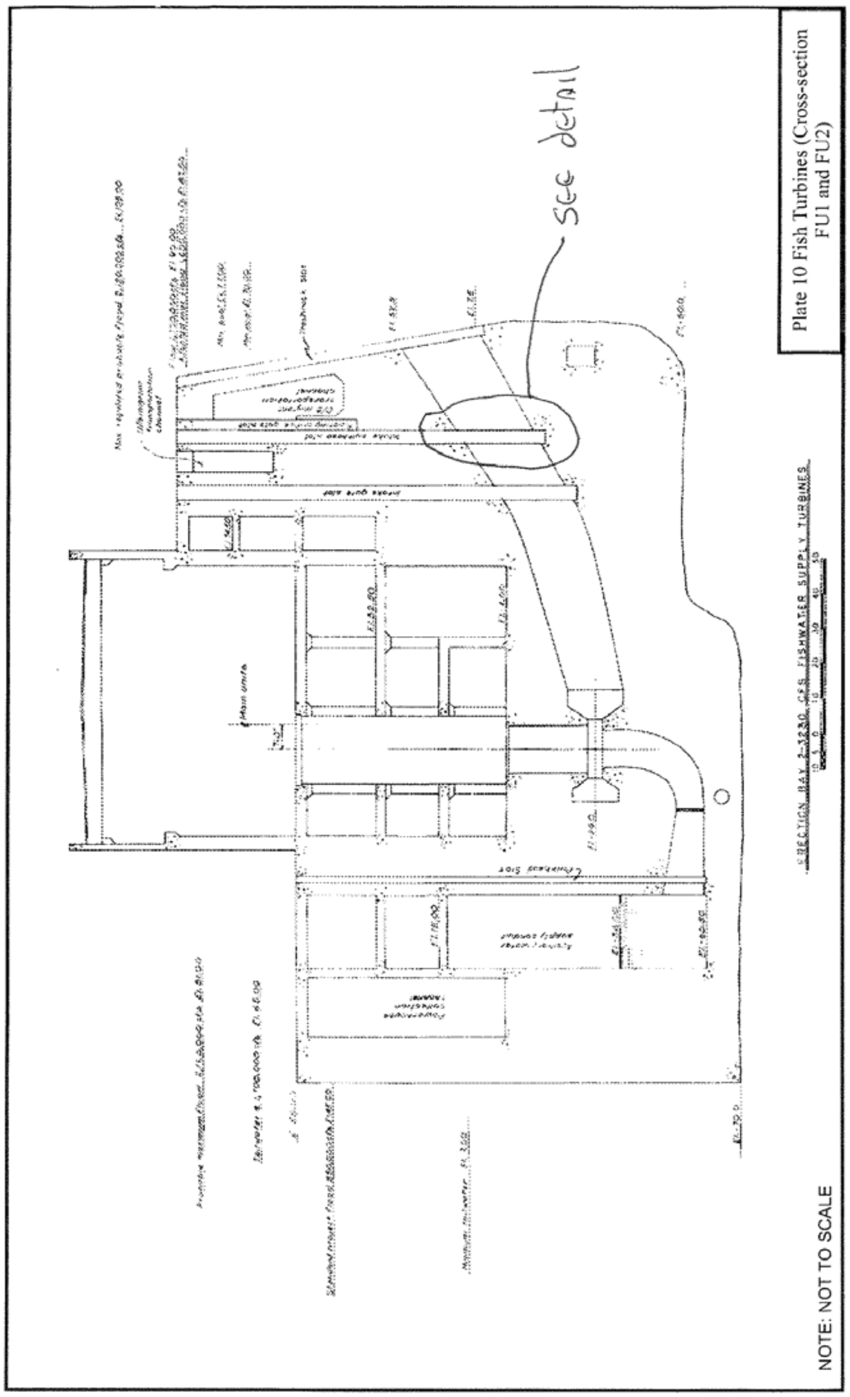
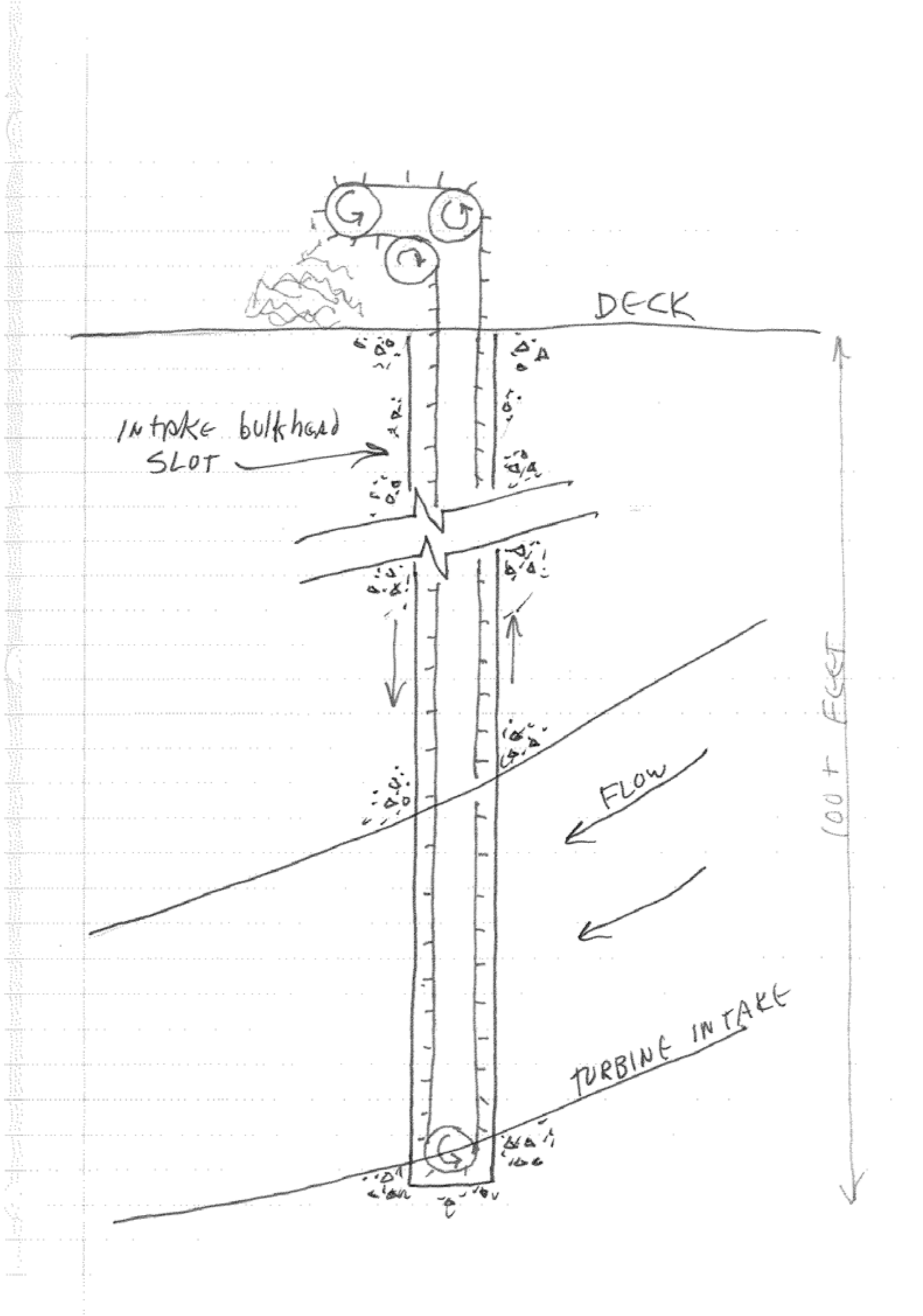



Plate 10 Fish Turbines (Cross-section FU1 and FU2)

| VE ALTERNATIVE<br>**B2 Trash Rack** | | **USACE<br>PORTLAND DISTRICT** |
|---|---|---|
| **Idea No:** | **ALT #04:** Add trash rack with traveling screen in intake bulkhead slot. Change the intake rack bar spacing to 2" and use main unit rake to clean intake racks. | **Page No.**<br>4 of 4 |

**CONCEPT**



| VE ALTERNATIVE<br>B2 Trash Rack | | | USACE<br>PORTLAND DISTRICT |
|---|---|---|---|
| **Idea No:** | **ALT #05:** Add trash racks in fish unit bulkhead slots | | **Page No.**<br>1 of 6 |

**CONCEPT:**

For the most part, debris that gets through the trash rack ends up collecting on the diffuser grating. This grating is not readily accessible, so can only be cleaned on an irregular basis. Several times the diffusers have failed (at connections) due to the debris block the flow through the grating and the water pressure building to the point that the connections fail.

This alternative addresses the issue by adding trash racks in the bulkhead slots of the fish units. These trash racks would feature 3/4” x 3/4” gating to capture debris, the same opening size as the diffuser grates; and, some type of lip at the bottom(s) to capture debris falling from the grates when they are lifted from the bulkhead slots. The new trash racks, or trash rack sections would be as wide as the intake passage way, including the bulkhead slots and of a height the gantry crane could accommodate. The trash racks would be removed periodically, maybe four times per year for manual cleaning.

This Alternative can be used with Alternative #01 or #02. The main trash rack bar spacing for #01 and # 02 would at 7/8” (existing condition), instead of the 3/4”. The secondary rack would have 3/4” or closer spacing. This would allow the main trash rack, which are exposed to more damaging debris to be repairable rather than require possible entire replacement of the rack if damaged and at the smaller spacing.

| **COST SUMMARY** | **Initial Cost** | **Life Cycle** | **Total Cost** |
|---|---|---|---|
| **Original Concept** | **$ 340,000** | $ 580,000 | **$ 920,000** |

**ADVANTAGES:**

- Reduced maintenance at the diffuser grating.
- Increase in debris captured prior to past through the fish unit, minimizing damage to the actual units.
- Main trash rack bar spacing remains as existing so easier to repair.
- Possibility of increasing the bar spacing of the main trash racks with secondary rack behind.
- Raking frequency would remain the same.
- Reduced maintenance at the diffusers.
- Reduced likelihood of diffuser grate failure requiring emergency repair.
- Cleaning the bulkhead slot rack can be scheduled as part of the workload.

**DISADVANTAGES:**

- Three systems require maintenance (main trash rack, secondary trash rack and diffuser) rather than two.
- Cleaning the racks would take place on the deck which could impact other operations in the area.
- Need to add monitoring system since observing the build-up would not be possible.
- Overall, may be more laborious than just having the main trash rack system with closer bar spacing to maintain.
- May be considered outside of scope of the effort requiring authorization to proceed.
- Increased maintenance related to the bulkhead slot..
- Debris could accumulate in the slot jamming the bulkhead in place. Debris removal in this area is challenging and will likely require significant effort to remove.
- There may be more efficient ways to address the needs for diffuser maintenance than adding an entirely new system. The diffuser grates will need to be replaced in the future and systems discussed in Alternative #08.

**DISCUSSION / JUSTIFICATION:**

Based on the issues with the diffuser gratings, it seems highly likely that the system of two trash rack systems is a workable solution in terms of protecting the fish units and diffusers. It has the chief advantage of allowing the main trash rack bars to remain at the current spacing or possibly wider. This would significantly improve the maintainability of that system by allowing repairable rather than a replacement system. In addition it would protect the diffuser gratings from failure by collecting significantly more debris before the fish units.

The primary drawback to the system is the need for maintenance at a second location which in area of the deck of the powerhouse. It is not known how often these screens would need to be cleaned and it may actually add to the maintenance schedule. In addition, the diffusers need to be replace due to other requirements and they may be a way to address the issue at the diffuser grating like are described in Alternative #08.

If this Alternative is not implemented at this time it can be added later with not impact or changes to the other components of the debris collection.

**IMPLEMENTATION CONSIDERATIONS:**

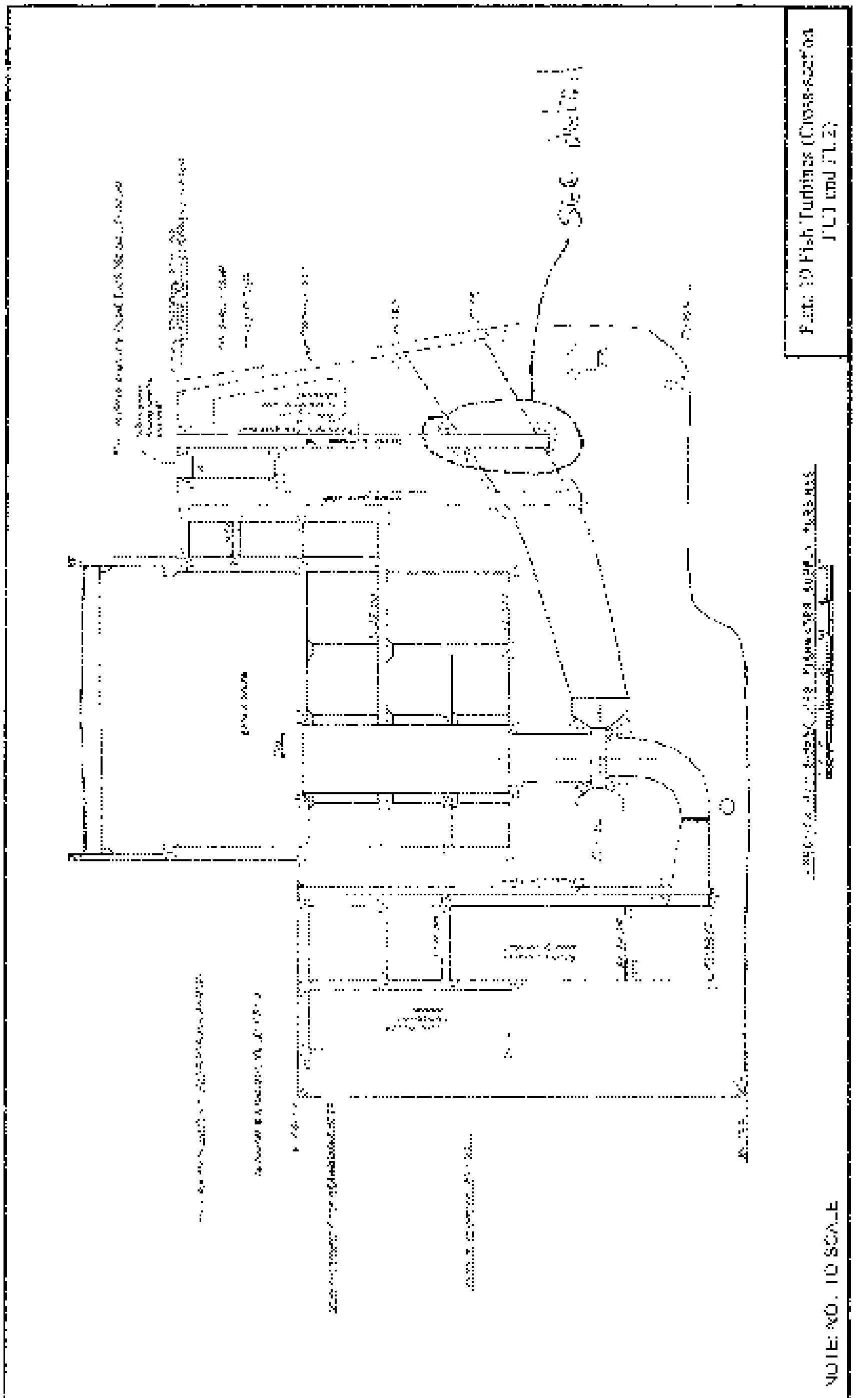
No special technology would be required to fabricate the proposed trash racks and design would not be more complicated than for any trash rack. Installing the new trash racks (or rack sections) should be similar to installing the bulkheads.

**VE ALTERNATIVE**
**B2 Trash Rack**

**USACE**
**PORTLAND DISTRICT**

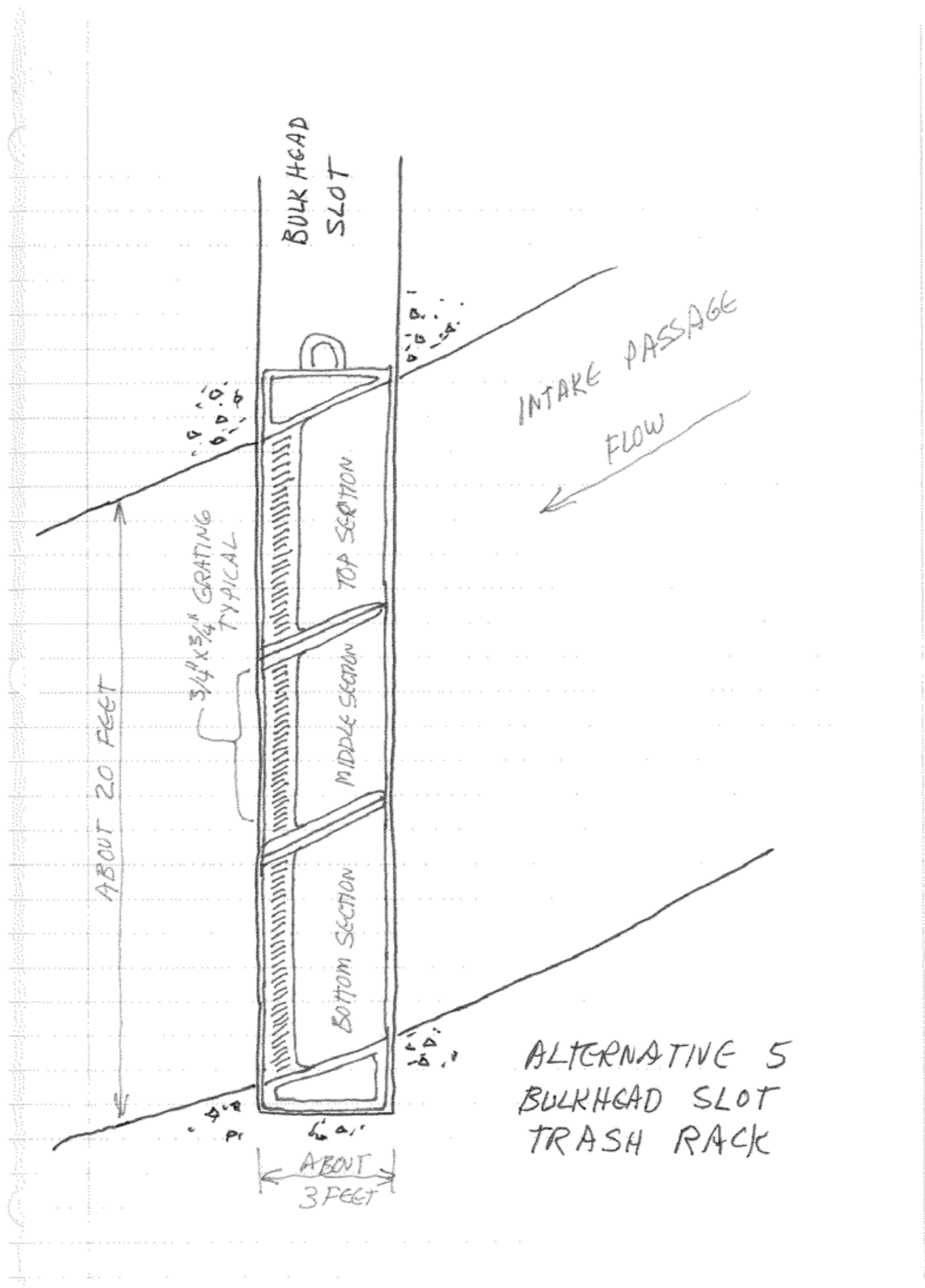
| Idea No: | ALT #05: Add trash racks in fish unit bulkhead slots | Page No. 4 of 6 |
|---|---|---|

**CONCEPT**
**Location Plan**



| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #05:** Add trash racks in fish unit bulkhead slots | **Page No.**<br>5 of 6 |

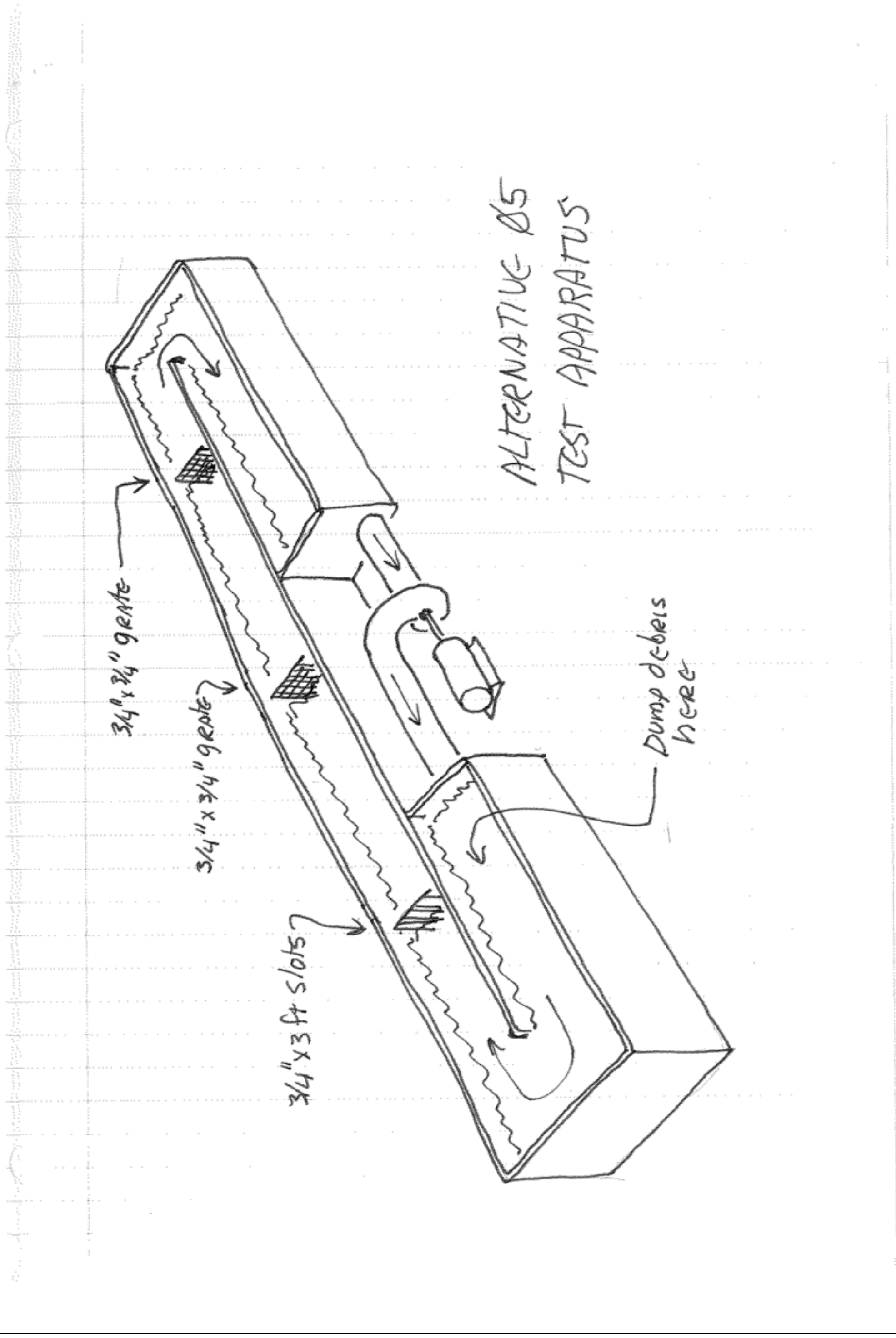
**CONCEPT**



| VE ALTERNATIVE<br>**B2 Trash Rack** | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #05:** Add trash racks in fish unit bulkhead slots | **Page No.**<br>6 of 6 |

**CONCEPT**

It may be necessary to test to show the effectiveness of the system. Below is a simply device that could be constructed to test the effectiveness



| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #06:** Evaluation of trash rack types | Page No.<br>1 of 6 |
|---|---|---|

**CONCEPT:**

Evaluation of the following trash rack types:

1. Existing. The existing trash rack type consists of a series of rectangular bars welded adjacent to one another to a series of further spaced backing/support members. Due to the close required spacing of the rectangular bars there can only be a weld on one side.
2. Wedge Wire. Typically consist of extruded bars in wedge or triangular shapes that are welded to a series of small backer support bars, which are usually spaced close together due to their limited strength.
3. Profile. Mechanically combined bars with various spacing shaping to exclude passage of large debris trapping smaller debris between bars. The method of assembly is mechanical rather than welded.
4. Modular/Panels. Similar to existing trash rack construction, except panels are made to be replaced rather than individual bars.
5. Sinusoidal. The sinusoidal shape would consist of either bent perforated plate of bent panels of the existing system.
6. Pleated. The pleated system would consist of profile bars used in a zig-zag pattern.
7. Offset Vertical Pipes. This is similar to the existing design except instead of rectangular bars a double row of pipes would be used.

**ADVANTAGES:**

1. Existing Type:
   - Meets hydraulic requirements
2. Wedge Wire and Profile Type:
   - Meets hydraulic requirements
   - Profile Type does not have fatigue fracture problem
3. Modular/Panels Type:
   - Meets hydraulic requirements
4. Pleated & Offset Vertical Piles Type:
   - Increased surface area

**DISADVANTAGES:**

1. Existing Type:
   - One side weld limits strength
   - Bar shape traps debris/worse with rust
   - Trapped debris traps additional debris
   - Repair welding difficult
2. Wedge Wire and Profile Type:
   - Vibration causes Wedge Wire Type weld fatigue fracture
3. Modular/Panels Type:
   - Facilitates maintenance.
4. Pleated & Offset Vertical Piles Type:
   - Unproven concepts
   - Major design and development required

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **N/A** | **N/A** | **N/A** |

**DISCUSSION / JUSTIFICATION:**

The existing trash racks are marginally acceptable. Trash that cannot be dislodged by the trash rake is trapped between bars causing additional trash build up. Rust is a contributing factor in causing debris to get stuck between trash rack bars and making it difficult for the trash rake to dislodge debris. Debris that does go through the rack collects under the diffuser gratings, which are blown off when pressures exceed the grating anchorage strength.

The existing trash racks have been damaged by the rake and are difficult to repair due to the close spacing of the rectangular trash rack bars. The close bar spacing does not adequately allow for a damaged bar to be removed and a new bar to be replaced, since there is insufficient space for a welder to place an acceptable weld.

A revised trash rack design is needed to address these performance and maintenance issues. Modular design are suggested to allow for segments of the trash rack to be removed and replaced by replacement modules that are on hand and allow for the repair of the damaged modules.

New and proven technology should be considered, such as Profile Bar systems. The existing design can be improved by considering bar spacing that allows for acceptable welding and/or modular designs that are mechanically installed.

Consideration of the new unproven concepts is not recommended.

**IMPLEMENTATION CONSIDERATIONS:**

Implementing a new system at the B2 Trash Racks could have advantages and disadvantages. As mentioned in the discussion and justification section the existing racks collect a large amount of debris. Decreasing the spacing drastically between the bars, even if the bars are profiled, would likely result in more debris collecting. It may be most beneficial to consider a slightly smaller opening meeting the requirements set forth by the diffuser grating dimensions. Using profile bars with this smaller opening could decrease the number of debris collecting and limit the amount of debris collecting on the diffuser gratings as well.

Another advantage of using mechanically installed profile bars is that replacement is simplified. If a bar is bent or broken, the bar can simply be removed and replaced with replacement parts that would need to be kept on hand.

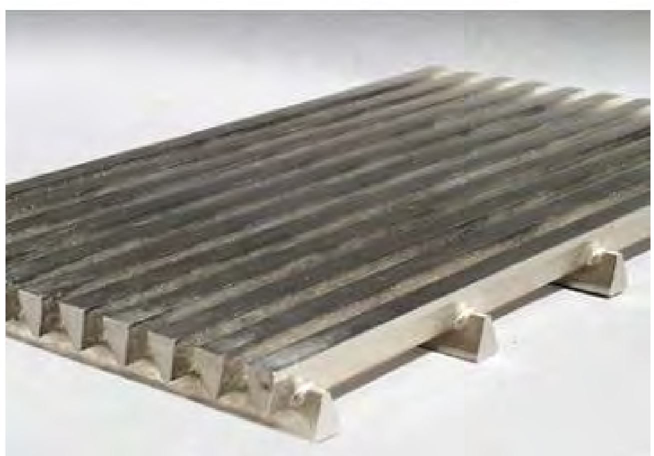
Disadvantages to this system include the need for a new rake, or a modification of the existing rake to work with new trash racks. Lining the racks up so that there is no interference when the rake passes could also be an installation issue. It may be difficult to line up the racks exactly in line with each adjacent rack.

Going to this type of system could also decrease the number of personnel required for maintenance and cleaning assuming it limits the number of racks that have to be removed for cleaning and removing of debris.

**CONCEPT**

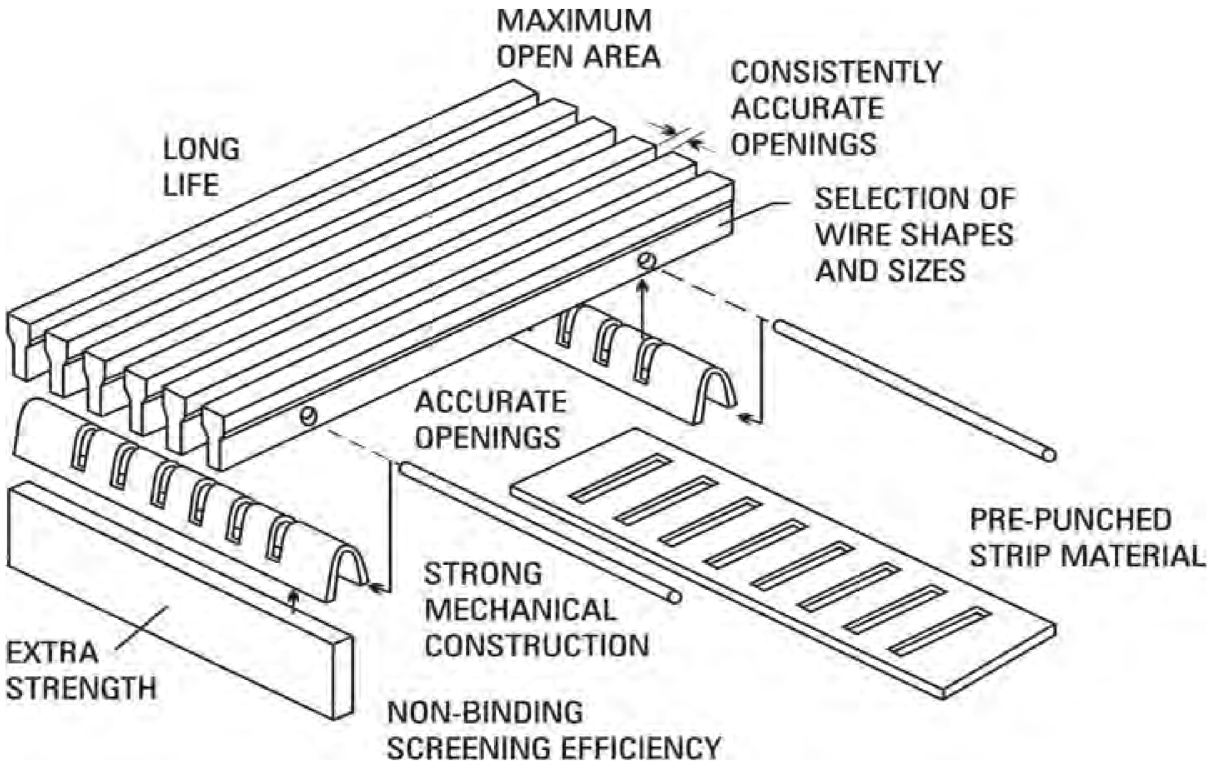
Existing Style Trash Racks

Wedge Wire Trash Racks



**CONCEPT**

Profile Bar Trash Racks



**GENERAL WORKSHEET**

Modular Panel Racks:

This design incorporates the existing style of trash rack and assumes that the racks will be made in of smaller panels that can be replaced as a whole rather than trying to replace single bars at a time. The close bar spacing makes it extremely difficult to weld together effectively. Additional structure would be required to support the smaller panels however the shorter span would require less material for the individual bars requiring an estimated 10% more material for support a structure and racks, than the long span racks. This system could also be used with the mechanically fastened rack systems as well.

**Concepts Removed from further Analysis**

Sinusoidal Trash Racks:

These racks are experimental at best. Due to the nature of the design and that they are untested they are further removed from this alternatives analysis.

Pleated Trash Racks:

The pleated system is also an untested design that would require heavy design to configure a rake to work. This is not a feasible alternative and is further removed from this alternatives analysis.

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| Idea No: | **ALT #07:** Construct flow deflecting berm in forebay to redirect flow and subsurface sediment | Page No.<br>1 of 4 |

**CONCEPT:**

As recommended in the "Bonneville Second Powerhouse (B2) Fish Unit Debris Study Reconnaissance Report Final July 20, 2000" a large rock berm placed in the north side of the forebay would be a structural improvement for the reliability of the AWS system. Currently sediment builds up in front of the fish unit intakes allowing sediment to enter the AWS system requiring shut down and sediment removal of the AWS and ladder as well as expensive O & M costs to periodically remove the built up sediment from the forebay.

A previous physical model study was undertaken as part of the debris study report (2001) and the recommended berm placement for trapping the sediment upstream of the fish units was angled from SE to NW. The function of the concept provided here is to redirect the flow near the floor of the forebay that carries the sediment to the fish units and instead direct the sediment to Unit 18. The potential alignment is shown in the attached figure angled from NE to SW much like the upstream portion of concept #03 Trash Directing Fence.

**ADVANTAGES:**

- Redirecting the flows that move sediment along the forebay floor in front of the fish units will reduce the amount of debris that needs to be removed periodically.
- The existing trash rack and rake could be used.
- System is reliable due to no moving parts, low maintenance.
- Redundancy as the existing trash racking system remains in place.
- Rock berms have been used in the past and have a history of positive results with a relatively easy installation.
- This alternative may allow the trash racks currently blocked at the floor to be opened thereby decreasing velocities through the racks and subsequently reduce the rate of trash buildup on the racks.
- It may be more economical to place an off-the-shelf concept such as concrete barrier(s). The advantage would be the ability to replace/reposition the flow directing device if needed.

**DISADVANTAGES:**

- Hydraulic modeling will need to be used to determine the appropriate location, length and depth.
- The percentage of debris that will be diverted into Unit 18 and/or 17 will be difficult to estimate.
- As conditions change (ie: change of unit priority), the berm's effectiveness may change. Modeling multiple scenarios could help but is not definitive.
- If large amounts of sediment deposit upstream of the berm, it may become less effective over time in redirecting the flow to the main units. Modeling for placement, height and length will need to consider this.
- This concept alone does not address the floating trash issues at the fish units.

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **N/A** | **N/A** | **N/A** |

**DISCUSSION / JUSTIFICATION:**

There are no moving parts:

Most alternatives require a considerable number of mechanical or electrical devices. The simplicity of the proposed system with no moving parts is a major advantage over all other systems. Minimum Maintenance.

Environmentally Friendly:

Without moving parts there is no need for grease or oil needed in the vicinity which could otherwise discharge contaminants into the water.

Once modeled for multiple project operations, we should have confidence in the effectiveness of a berm in the forebay to divert flow and sediment moving along the forebay floor. This could be used in conjunction with Idea No. #09, B2 Flow Directing Vane. Compared to Concept #03, Trash Directing Fence, it may replace the need for constructing a solid or semi-porous wall on the forebay floor from the face of the powerhouse to the shore. This alternative may prove to be far easier to design and construct. Multiple materials could be explored to identify the most economical and easily implementable solution: rock, concrete, metal etc.

**IMPLEMENTATION CONSIDERATIONS**

- This idea should not be too difficult to implement. It could potentially be lowered or dropped using a barge crane. It could be monitored by periodic surveys to track its effectiveness and if needed, adjust or replace. Overall weight will be constrained by equipment for placement, however it could be designed to be placed in pieces.
- A model study is recommended to validate the flow assumptions that create the sediment and debris issues and the alternative to resolve or decrease these issues.
- Modeling the sediment berm will determine the size, shape, angle of the deflector and whether it should be fixed or moveable.
- Modeling will need to consider potential future powerhouse operations that may impact its effectiveness.
- If the flow directing vane/curtain located between unit 18 and the fish units (Alt #09) will be constructed in conjunction with the flow deflecting berm, either alternative could be built independently at different times and still achieve positive effects individually.

| VE ALTERNATIVE<br>**B2 Trash Rack** | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #07:** Construct flow deflecting berm in forebay to redirect flow and subsurface sediment | **Page No.**<br>3 of 4 |

**CONCEPT**

**GENERAL WORKSHEET**

1. Reliability Increased:
   No moving parts. Therefore there is less potential for breakdown.
2. Maintenance Reduction:
   Deflecting sediment to Unit 18 will reduce/delete the need to dredge the sediment in front of the fish units.
3. Redundancy Provided:
   a. The Flow Directing Vane is a new added feature to the project. The existing trash rack and trash rack rake will remain in place and provide backup should some debris reach the fish units.
4. Fish Friendly:
   The adult fish exit is far enough away from the proposed changes such that the adult fish should not be impacted by their implementation. If they are currently being caught in the overall circulation at the north end, the berm may reduce this as velocities should be reduced.

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | Page No.<br>1 of 6 |
|---|---|---|

**CONCEPT:**

Currently, water from the discharge of the Bonneville Second Powerhouse (B2) fish turbines is channeled through the Auxiliary Water Supply (AWS). The B2 AWS provides water to both the North Fish Ladder and Cascades Island Fish Ladders. The water enters the ladders through channels in the AWS. The channels are located along the fish ladder and at the end of each of the fish ladders downstream from the powerhouse. These channels essentially diffuse water into the fish ladder, and have been logically name "diffusers". To prevent salmon and other creatures from improperly exiting the ladders and entering the diffuser channels, fixed grating has been placed over the openings. The grating is a framed grating that is stationary and bolted to supports anchored to the concrete channel. Access to this grating is only possible by underwater cameras and divers. There has been a history of the stationary diffuser grating building up debris collected from the AWS supply water. The build-up has overloaded the grating and failures have occurred.

A potential solution to reduce the risk of failing the diffuser grating while still providing the barrier for fish and other creatures is to install non-stationary grating that either automatically or can be commanded to open and close to allow debris build up on one side of the grating to be discharged into the fish ladders and ultimately downstream. The self clearing and mechanized concepts both have the same options for frame in frame motion. The internal framed granting can: a) Single Pivot - swing open from a single pivot point on one side, similar to a single door; b) Folding Grating - fold open from the center; c) Double Pivot - swing open from the middle, similar to double doors; d) Revolving Pivot - flip open from a point in the center e) Center Lift.

The self clearing diffuser grating can be returned to the closed position (providing barrier protection) by way of a spring return, a weight return, or combination. The mechanized diffuser grating can utilize a jack-screw, hydraulic or pneumatic cylinders, rope and pulley system, or geared motor.

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | N/A | N/A | N/A |

**Idea No:** **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating



**ADVANTAGES:**

- Significantly reduces risk of diffuser grating from physically failing
- Allows for the fish unit intake grating to increase in spacing reducing the accumulation of trash at the unit intakes.
- Allows for minimal changes to intake trash removal process.

**DISADVANTAGES:**

- Increase of debris in fish ladder may present new functional and maintenance issues
- Numerous diffusers would need to be modified
- Fish and lamprey kills possible if mechanism fails to return to a fully protected channel
- Mechanical Components located underwater may have life issues
- Underwater components will present access for maintenance issues
- There may not be enough sweeping flow present at all times during the year during all flow conditions to clean the grating
- Concerns with consistent functionality of moving components such as a risk of binding.
- Concerns with structurally supporting grating system, including reactive forces from impact load from reseating for the self clearing version
- For self clearing, identifying balance of weight to flow to delta pressure to have system open and close properly.
- None of the variations are known proven systems in a proven application

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | **Page No.**<br>3 of 6 |

**DISCUSSION / JUSTIFICATION:**

The main motivation for this concept is that it addresses the primary issue of keeping the barrier protection of the diffusers while addressing the known issue of debris accumulation on the diffuser grating which will only increase when the spacing is reduced for lamprey.

However the disadvantages impact the reliability and maintainability of the system. There are multiple ways the system could fail to operate which could lead to either catastrophic failure of the equipment or diffusers without barriers. The location of equipment underwater will impede monitoring and preventative maintenance. Overall this is a high risk approach of not providing the minimum functionality.

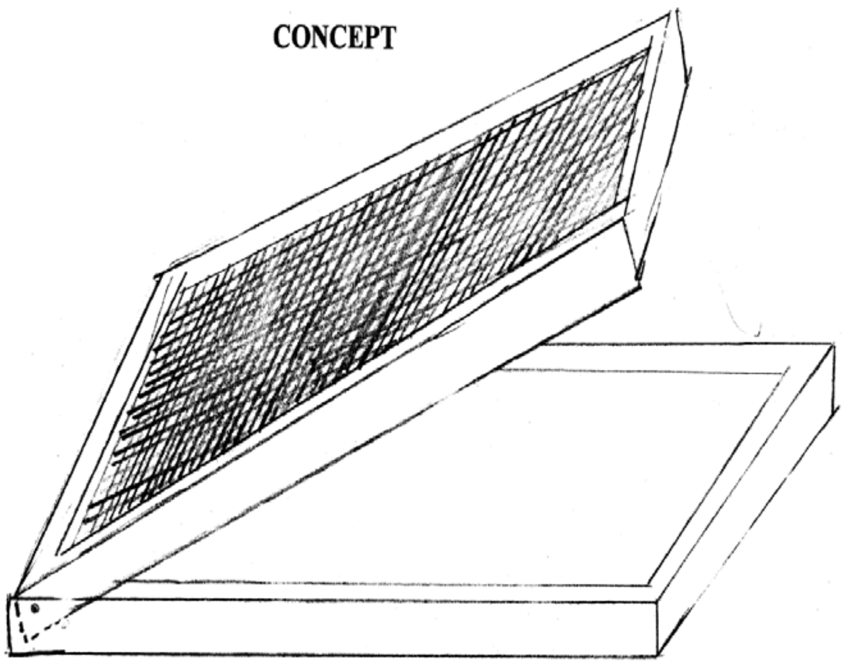
**IMPLEMENTATION CONSIDERATIONS:**

If this system was pursued, it is highly recommend that the AWS channel be modified to allow for isolation of these diffusers in the dry. Preliminary ideas for isolation include the addition of slots for stop logs and either permanent or portable drainage pumps.

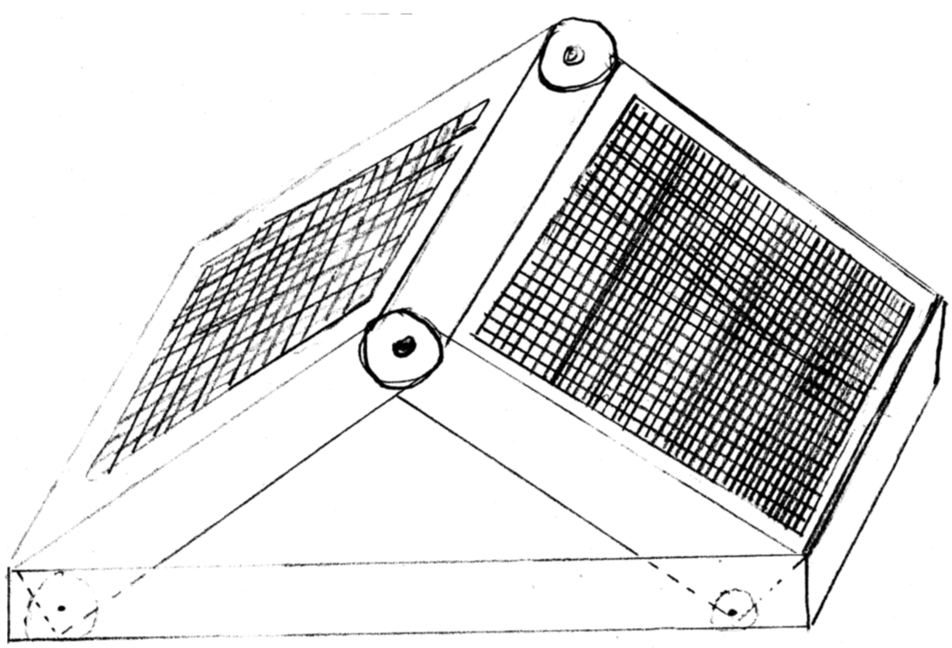
Equipment must operate submerged. Some form of monitoring is recommended to periodically verify operation. Redundant operating and driving systems should be utilized to increase overall system reliability.

It is recommended that the project for replacing the stationary grating be done first as a pilot project for a small number of the diffuser gratings in order to establish a proven solution which then can be copied to the other diffusers with less risk of costly retrofitting.

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | **Page No.**<br>4 of 6 |



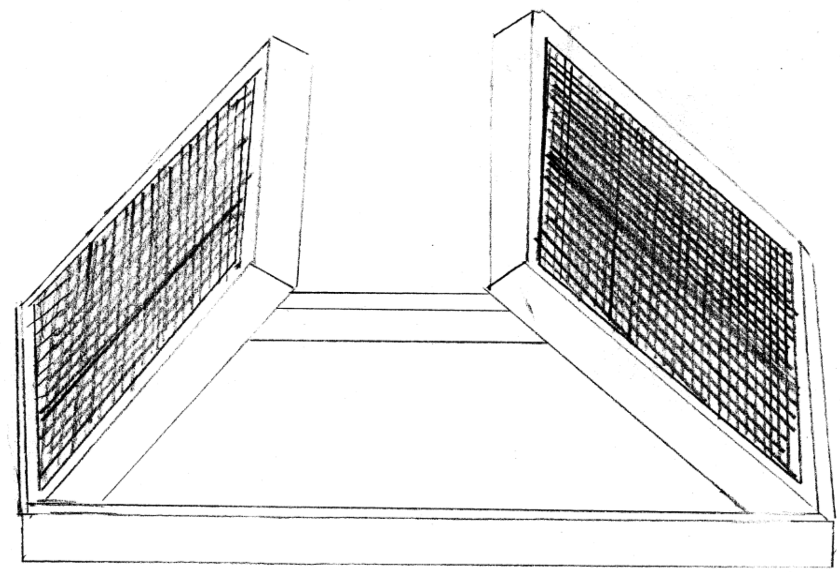

**Single Pivot**



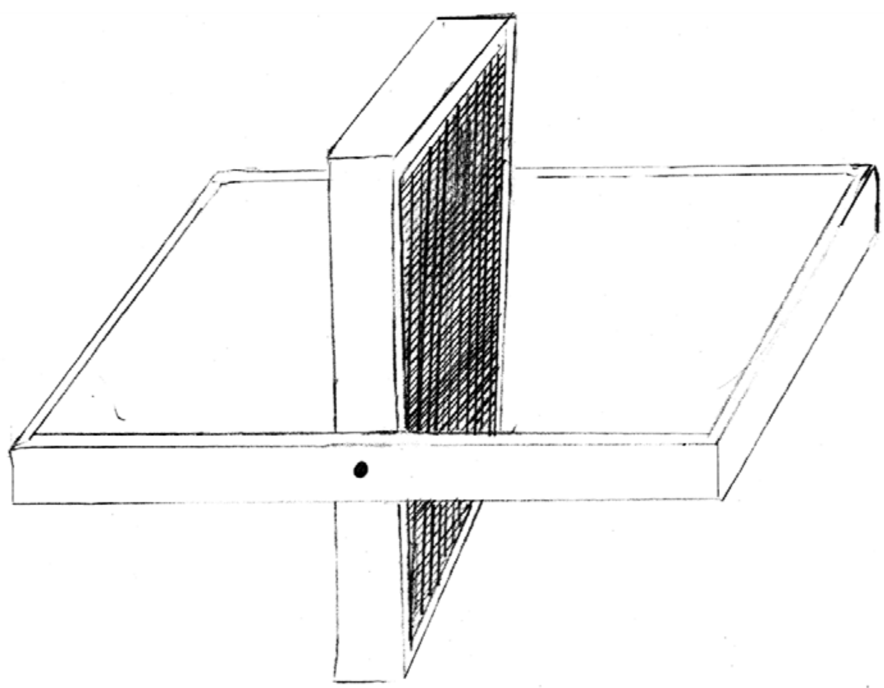
**Folding Grating**

| Idea No: | **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | Page No.<br>5 of 6 |
|---|---|---|

**PIVOTING CONCEPTS**

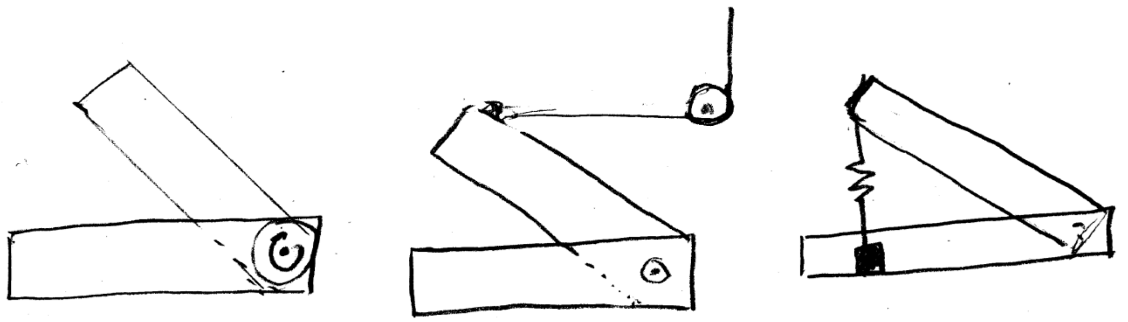


**Double Pivot**

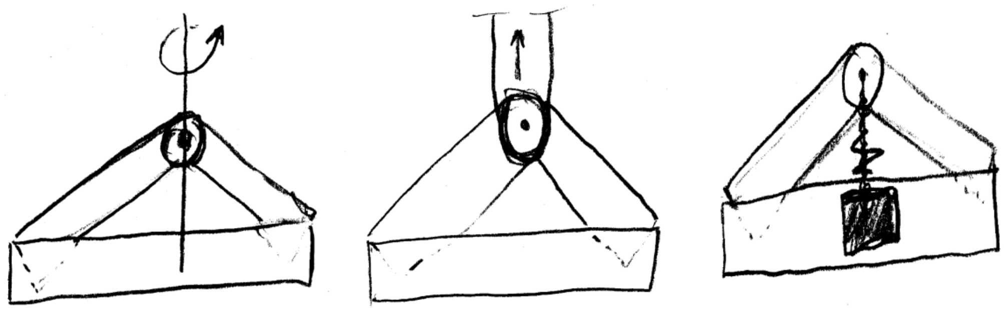


**Revolving Pivot**

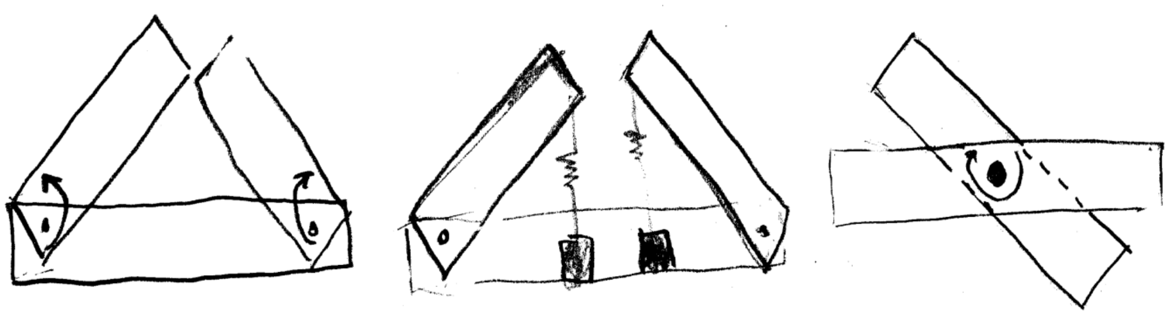
| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #08:** Modifying the diffusers to reduce potential of clogging failure with a self-clearing and/or mechanized diffuser grating | **Page No.**<br>6 of 6 |



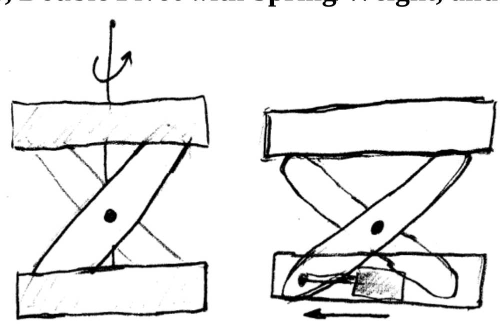
**Single Pivot with Motor, Rope and Pulley, and Spring/Weight**



**Folding Rate with Jack Screw/Motor, Rope and Pulley, and Spring/Weight**



**Double Pivot with Motor, Double Pivot with Spring/Weight, and Center Pivot with Motor**



**Center Lift with Jack Screw/Motor, and Actuator**

| VE ALTERNATIVE<br>B2 Trash Rack | USACE<br>PORTLAND DISTRICT |
|---|---|

| Idea No: | **ALT #09:** Install a flow directing vane between fish units and unit 18 | Page No.<br>1 of 3 |
|---|---|---|

**CONCEPT:**

This concept is an option or subset of the #03 Trash Directing Fence concept. It would provide the flow directing function of concept #03 at the interface with the dam in the upper water column. The goal would be to block and redirect the current upper flow rotation at the north side of the forebay. It would likely connect to the dam approximately perpendicular to the dam between the fish unit and unit #18 (see potential alignment in figure attached). This large vane or curtain would serve to redirect the surface flow that currently tracks the powerhouse face northward towards the fish units allowing floating debris and suspended sediment to collect in the relatively slower velocities in front of the fish units. The actual depth and length will need to be designed through hydraulic modeling.

**ADVANTAGES**

- Redirecting the flow will reduce the amount of debris that has been known to plug the trash racks, reducing the need to shut the units down during fish passage season.
- The existing trash rack and rake could be used.
- System is reliable due to no moving parts, low maintenance.
- Reduction in headloss through fish unit trash racks thus savings in energy and reduced interruption of fish passage and emergency shut down time.
- Redundancy as the existing trash racking system remains in place.
- There are off the shelf concepts that could be used (ie: Tuff Boom).

**DISADVANTAGES**

- Hydraulic modeling will need to be used to determine the appropriate location, length and depth.
- The percentage of debris that will be diverted into Unit 18 and/or 17 will be difficult to estimate.
- The current recommended location of this alternative should reduce suspended debris being moved along by the existing water currents. However, without an upstream berm to trap the heavier sediment load that is being carried towards the dam, the heavier sediment load will continue to travel towards the fish units.

| COST SUMMARY | Initial Cost | Life Cycle | Total Cost |
|---|---|---|---|
| **Concept** | **N/A** | **N/A** | **N/A** |

**DISCUSSION / JUSTIFICATION:**

There are no moving parts:

Most alternatives require a considerable number of mechanical or electrical devices. The simplicity of the proposed system with no moving parts is a major advantage over all other systems. Minimum Maintenance.

Environmentally Friendly:

Without moving parts there is no need for grease or oil needed in the vicinity which could otherwise discharge contaminants into the water.

Once modeled for multiple project operations, we should have confidence in the effectiveness of a vane or curtain in the forebay to direct the flow and consequently the floating debris that gets trapped in front of the fish units. This could be used in conjunction with Idea No. #07, B2 Flow Deflecting Berm. Compared to Concept #03, the Trash Directing Fence, it would replace the picket leads. This alternative may prove to be far easier to design and construct. Multiple materials could be explored to identify the most economical and easily implementable solution: rock, concrete, metal etc

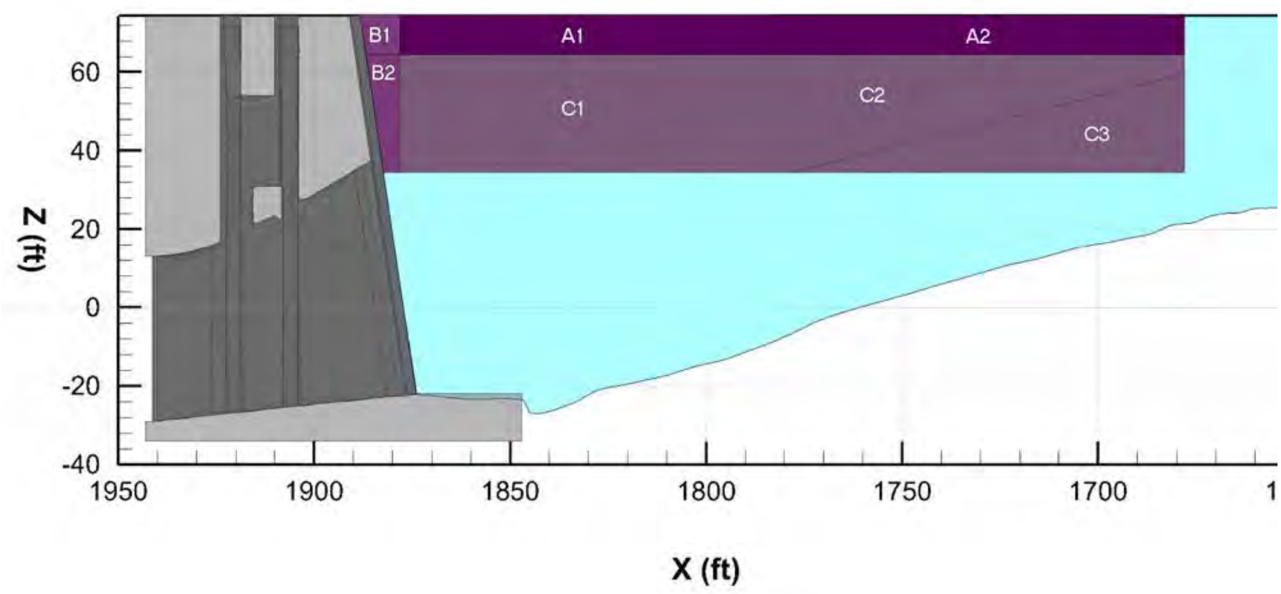
**IMPLEMENTATION CONSIDERATIONS:**

- A model study is recommended to validate the flow assumptions that create the sediment and debris issues and the alternative to resolve or decrease these issues.
- Modeling the flow directing vane/curtain could determine the size, shape, angle and whether it should be fixed or moveable. Modeling will need to consider potential future powerhouse operations that may impact its effectiveness.
- If flow deflecting vane or curtain located between unit 18 and the fish units will be constructed in conjunction with the upstream flow deflecting berm (Alt #07), either alternative could be built independently at different times and still achieve positive effects individually.
- Construction could be made of any number of materials including off the shelf floating walls (ex: Tuff Boom) that can be floated in and tethered as needed.

| VE ALTERNATIVE<br>B2 Trash Rack | | USACE<br>PORTLAND DISTRICT |
|---|---|---|
| **Idea No:** | **ALT #09:** Install a flow directing vane between fish units and unit 18 | **Page No.**<br>3 of 3 |

**CONCEPT**

**The Flow Directing Vane is B1/B2**



## B2 Trash Rack: VE Study Alternatives Cost Estimates

| ALT | MATRIX | A<br>0 | B<br>1 | 2 | C<br>3 | 4 | 5 | 6 | 7 | 8 | 9 | VAR | Present Value Total Life Cycle Cost Stream Over 50 years Annual Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Current System | x | | | | | | | | | | A | $206,911 |
| 1 | Use 'Automatic'/'Semiautomatic' Rack System (Initial Concept) | | x | | | | | | | | | B | $197,463 |
| 2 | Use existing Rack system with new rack and modified rake | x | | x | | | | | | | | A | $267,270 |
| 3 | Forebay modifications to redirect/block debris | | | | x | | | | | | | C | $223,333 |
| 4 | DELETED | | | | | x | | | | | | | |
| 5 | Add trash rack to draft tube or bulkhead slot manually pull and clean. | r | | r | | | x | | | | | B or C | $34,301 |
| 6 | Evaluation of rack types: standard; | r | | | | | | x | | | | | |
| 7 | Construct Berm in Forebay (Recommended in 2001 DDR) | | | r | | | | | x | | | Part C | |
| 8 | Evaluation of Defuser Improvements | r | | | | | | | | x | | | |
| 9 | Add Flow Vane between fish units and unit 18 | | | | | | | | | | x | | |
| | VARIATIONS | | | | | | | | | | | | |
| A | Current System with Modifications using Gantry Crane | x | | x | | | x | x | | x | | | |
| B | 'Automatic'/'Semiautomatic' Rack System with Modifications | | x | | | | | x | | x | | | |
| C | Forebay modifications to redirect/block debris | x | | | x | | | | x | | x | | |

Notes:
There are essentially 3 major alternatives (#1, #2 and #3), with variations on each of the alternatives.
My Alt #0 is using the current system with no upgardes.
Alt #1 is installation of an automatic rake system with new racks.
Alt #2 is a variation on Alt #0
Alt #3 is a completely different system.
Alt #5 is a variation of (can be added to) #0 or #2
Alt #6 is essentially the same as Alt #2; the difference is using a different type of rack and rake than the current design using welded racks.
Alt #7 is essentially a variation of #3; except than the fence would not be installed.
Alt #8 is independent of the above Alternatives but it is assumed it would not be needed if other Alts are installed.
Alt #9 is essentially a variation of #3; except than the fence and the berm would not be installed.

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Use Current System - Manual Rack System

**Summary of Work**. Currently operated system using existing trash rack and manual operation of existing rake and gantry crane

**Plan of Operation**. The current sysetm requires 4 workers to operate.

**Analysis of Time**: This work takes approximately 1,300 hrs/yr (as per Ben Filan estimate).

| **Summary** | | | | | |
|---|---|---|---|---|---|
| Labor (USACE per year) | | | $ | 130,000.00 | See Note 1. |
| Equipment | | | $ | - | |
| Supplies/Materials | | | $ | - | |
| Total Costs | | | $ | 130,000.00 | |
| Prime Contractor G&A @ | | 0.0% | $ | - | See Note 2 |
| | Subtotal | | $ | 130,000.00 | |
| Prime Contractor Profit | | 0.0% | $ | - | See Note 2 |
| | Subtotal | | $ | 130,000.00 | |
| Bond | | 0.0% | $ | - | See Note 2 |
| | | **Total** | **$** | **130,000.00** | |

Notes:
1. Assumes USACE labor costs as per Alternative 01 Charrette
2. Assumes Supplies/Materials cost, which were derived from Alternative 01 Charrette, includes markups.

| | **Labor (USACE per year)** | | | | |
|---|---|---|---|---|---|
| Hours | Title | $/Hr | | | Cost |
| | O&M Supervisor | $120.00 | | $ | - |
| 1300 | O&M Worker | $100.00 | | $ | 130,000.00 |
| | | | **SUBTOTAL** | **$** | **130,000.00** |

| | **Equipment** | | | | | |
|---|---|---|---|---|---|---|
| Units | Equipment | Op Rate | Operating | units | | Cost |
| 1 | | | | days | $ | - |
| 1 | | | | | $ | - |
| | | | **SUBTOTAL** | | **$** | **-** |

| | **Supplies/Materials** | | | | |
|---|---|---|---|---|---|
| Qty | Item | Unit Price | Delivery Charge | | Cost |
| | | | $0.00 | $ | - |
| | | | $0.00 | $ | - |
| | | | **SUBTOTAL** | **$** | **-** |

**B2 Trash Rack: VE Study Alternatives Cost Estimates**

**Use Current System - Manual Rack System**

| Project Year | Description Costs | Capital Cost in 2012 dollars Costs | O&M Cost in 2012dollars Costs | FV Factors Costs | Inflated cost to dollars year expended Costs | PV Factors | PV Present Value Total Life Cycle Cost Stream | PV Capital Cost Stream | PV O&M Cost Stream |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| 0 | | | $130,000 | 1.0000 | $130,000 | 1.0000 | $130,000 | $0 | $130,000 |
| 1 | | | $130,000 | 1.0200 | $132,600 | 0.9728 | $128,988 | $0 | $128,988 |
| 2 | | | $130,000 | 1.0404 | $135,252 | 0.9463 | $127,985 | $0 | $127,985 |
| 3 | maintenance 2*2*8hr | | $133,200 | 1.0612 | $141,353 | 0.9205 | $130,114 | $0 | $130,114 |
| 4 | | | $130,000 | 1.0824 | $140,716 | 0.8954 | $126,000 | $0 | $126,000 |
| 5 | | | $130,000 | 1.1041 | $143,531 | 0.8710 | $125,020 | $0 | $125,020 |
| 6 | maintenance 2*2*8hr | | $133,200 | 1.1262 | $150,005 | 0.8473 | $127,100 | $0 | $127,100 |
| 7 | | | $130,000 | 1.1487 | $149,329 | 0.8242 | $123,081 | $0 | $123,081 |
| 8 | | | $130,000 | 1.1717 | $152,316 | 0.8018 | $122,124 | $0 | $122,124 |
| 9 | maintenance 2*2*8hr | | $133,200 | 1.1951 | $159,186 | 0.7799 | $124,156 | $0 | $124,156 |
| 10 | | | $130,000 | 1.2190 | $158,469 | 0.7587 | $120,230 | $0 | $120,230 |
| 11 | | | $130,000 | 1.2434 | $161,639 | 0.7380 | $119,295 | $0 | $119,295 |
| 12 | maintenance 2*2*8hr | | $133,200 | 1.2682 | $168,930 | 0.7179 | $121,280 | $0 | $121,280 |
| 13 | | | $130,000 | 1.2936 | $168,169 | 0.6984 | $117,445 | $0 | $117,445 |
| 14 | | | $130,000 | 1.3195 | $171,532 | 0.6794 | $116,531 | $0 | $116,531 |
| 15 | maintenance 2*2*8hr | | $133,200 | 1.3459 | $179,270 | 0.6609 | $118,470 | $0 | $118,470 |
| 16 | | | $130,000 | 1.3728 | $178,462 | 0.6429 | $114,725 | $0 | $114,725 |
| 17 | | | $130,000 | 1.4002 | $182,031 | 0.6253 | $113,832 | $0 | $113,832 |
| 18 | maintenance 2*2*8hr | | $133,200 | 1.4282 | $190,242 | 0.6083 | $115,726 | $0 | $115,726 |
| 19 | | | $130,000 | 1.4568 | $189,385 | 0.5917 | $112,067 | $0 | $112,067 |
| 20 | | | $130,000 | 1.4859 | $193,173 | 0.5756 | $111,195 | $0 | $111,195 |
| 21 | maintenance 2*2*8hr | | $133,200 | 1.5157 | $201,887 | 0.5599 | $113,045 | $0 | $113,045 |
| 22 | | | $130,000 | 1.5460 | $200,977 | 0.5447 | $109,471 | $0 | $109,471 |
| 23 | | | $130,000 | 1.5769 | $204,997 | 0.5299 | $108,619 | $0 | $108,619 |
| 24 | maintenance 2*2*8hr | | $133,200 | 1.6084 | $214,244 | 0.5154 | $110,427 | $0 | $110,427 |
| 25 | | | $130,000 | 1.6406 | $213,279 | 0.5014 | $106,935 | $0 | $106,935 |
| 26 | | | $130,000 | 1.6734 | $217,544 | 0.4877 | $106,103 | $0 | $106,103 |
| 27 | maintenance 2*2*8hr | | $133,200 | 1.7069 | $227,357 | 0.4744 | $107,869 | $0 | $107,869 |
| 28 | | | $130,000 | 1.7410 | $226,333 | 0.4615 | $104,458 | $0 | $104,458 |
| 29 | | | $130,000 | 1.7758 | $230,860 | 0.4490 | $103,645 | $0 | $103,645 |
| 30 | maintenance 2*2*8hr | | $133,200 | 1.8114 | $241,273 | 0.4367 | $105,370 | $0 | $105,370 |
| 31 | | | $130,000 | 1.8476 | $240,187 | 0.4248 | $102,038 | $0 | $102,038 |
| 32 | | | $130,000 | 1.8845 | $244,990 | 0.4133 | $101,244 | $0 | $101,244 |
| 33 | maintenance 2*2*8hr | | $133,200 | 1.9222 | $256,041 | 0.4020 | $102,929 | $0 | $102,929 |
| 34 | | | $130,000 | 1.9607 | $254,888 | 0.3911 | $99,674 | $0 | $99,674 |
| 35 | | | $130,000 | 1.9999 | $259,986 | 0.3804 | $98,899 | $0 | $98,899 |
| 36 | maintenance 2*2*8hr | | $133,200 | 2.0399 | $271,713 | 0.3700 | $100,544 | $0 | $100,544 |
| 37 | | | $130,000 | 2.0807 | $270,489 | 0.3600 | $97,365 | $0 | $97,365 |
| 38 | | | $130,000 | 2.1223 | $275,899 | 0.3502 | $96,608 | $0 | $96,608 |
| 39 | maintenance 2*2*8hr | | $133,200 | 2.1647 | $288,344 | 0.3406 | $98,215 | $0 | $98,215 |
| 40 | | | $130,000 | 2.2080 | $287,045 | 0.3313 | $95,110 | $0 | $95,110 |
| 41 | | | $130,000 | 2.2522 | $292,786 | 0.3223 | $94,370 | $0 | $94,370 |
| 42 | maintenance 2*2*8hr | | $133,200 | 2.2972 | $305,993 | 0.3135 | $95,940 | $0 | $95,940 |
| 43 | | | $130,000 | 2.3432 | $304,615 | 0.3050 | $92,907 | $0 | $92,907 |
| 44 | | | $130,000 | 2.3901 | $310,707 | 0.2967 | $92,184 | $0 | $92,184 |
| 45 | maintenance 2*2*8hr | | $133,200 | 2.4379 | $324,722 | 0.2886 | $93,718 | $0 | $93,718 |
| 46 | | | $130,000 | 2.4866 | $323,259 | 0.2807 | $90,754 | $0 | $90,754 |
| 47 | | | $130,000 | 2.5363 | $329,725 | 0.2731 | $90,048 | $0 | $90,048 |
| 48 | maintenance 2*2*8hr | | $133,200 | 2.5871 | $344,598 | 0.2657 | $91,547 | $0 | $91,547 |
| 49 | | | $130,000 | 2.6388 | $343,046 | 0.2584 | $88,652 | $0 | $88,652 |
| 50 | | | $130,000 | 2.6916 | $349,906 | 0.2514 | $87,962 | $0 | $87,962 |
| TOTAL PRESENT VALUE COST | | | | | | | **$5,532,013** | $0 | $5,532,013 |
| | Amort. Factor: | | | | | x | 0.0374 | 0.0374 | 0.0374 |
| **Average Annual Costs** | | | | | | = | **$206,911** | $0 | $206,911 |
| | | | | | | | **Total** | **Capital** | **O&M** |

Assumes maintenance every 3 years take 2 people 2 x 8-hr days

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 01 - Use ‘Automatic’/’Semiautomatic’ Rack System (Initial Concept)

**Summary of Work**. Replace currently operated system with a new trash rack and an automated rake.

**Plan of Operation**. Operate automated trash rack with 2 workers instead of 4.

**Analysis of Time**: This work takes approximately 650 hrs/yr (as per Ben Filan estimate).

| **Summary** | | | | |
|---|---|---|---|---|
| Labor (USACE per year) | | $ | 275,904.00 | See Note 1. |
| Equipment | | $ | - | |
| Supplies/Materials (including installation) | | $ | 2,109,040.00 | |
| Total Costs | | $ | 2,384,944.00 | |
| Prime Contractor G&A @ | 0.0% | $ | - | See Note 2 |
| Subtotal | | $ | 2,384,944.00 | |
| Prime Contractor Profit | 0.0% | $ | - | See Note 2 |
| Subtotal | | $ | 2,384,944.00 | |
| Bond | 0.0% | $ | - | See Note 2 |
| **Total** | | **$** | **2,384,944.00** | |

Notes:

1. Assumes USACE labor costs as per Alternative 01 Charrette
2. Assumes Supplies/Materials cost, which were derived from Alternative 01 Charrette, includes markups.

**Labor (USACE per year)**

| Hours | Title | $/Hr | | Cost |
|---|---|---|---|---|
| | O&M Supervisor | $120.00 | $ | - |
| 650 | O&M Worker | $100.00 | $ | 65,000.00 |
| | S&A at 10% of ktr cost | | $ | 210,904.00 |
| | **SUBTOTAL** | | **$** | **275,904.00** |

**Equipment**

| Units | Equipment | Op Rate | Operating | units | | Cost |
|---|---|---|---|---|---|---|
| 1 | | $10.00 | | days | $ | - |
| 1 | | | | | $ | - |
| | | | **SUBTOTAL** | | **$** | **-** |

**Supplies/Materials (including installation)**

| Qty | Item | Unit Price | Delivery Charge | | Cost |
|---|---|---|---|---|---|
| 16 | 3/4" space trash rack panel | $81,250.00 | $0.00 | $ | 1,300,000.00 |
| 16 | Salvage old rack panel | -$60.00 | $0.00 | $ | (960.00) |
| 1 | Automated Rake | $750,000.00 | $0.00 | $ | 750,000.00 |
| 1 | SCADA Interface | $20,000.00 | | $ | 20,000.00 |
| 4 | Pressure Transducers | $10,000.00 | | $ | 40,000.00 |
| | | | **SUBTOTAL** | **$** | **2,109,040.00** |

Assumes cost of 3/4"-space trash rack panel includes installation (from Ben Filan's estimate)

**B2 Trash Rack: VE Study Alternatives Cost Estimates**

**Alt. 01 - Use ‘Automatic’/’Semiautomatic’ Rack System (Initial Concept)**

| Project Year | Description Costs | Capital Cost in 2012 dollars Costs | O&M Cost in 2012dollars Costs | FV Factors Costs | Inflated cost to dollars year expended Costs | PV Factors | PV Present Value Total Life Cycle Cost Stream | PV Capital Cost Stream | PV O&M Cost Stream |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| 0 | Install new system | $2,384,944 | $65,000 | 1.0000 | $2,449,944 | 1.0000 | $2,449,944 | $2,384,944 | $65,000 |
| 1 | | $181 | $65,000 | 1.0200 | $66,485 | 0.9728 | $64,674 | $180 | $64,494 |
| 2 | | $222 | $65,000 | 1.0404 | $67,857 | 0.9463 | $64,211 | $219 | $63,992 |
| 3 | maintenance 5*2*8hr | $1,888 | $73,000 | 1.0612 | $79,472 | 0.9205 | $73,154 | $1,845 | $71,309 |
| 4 | | $403 | $65,000 | 1.0824 | $70,794 | 0.8954 | $63,391 | $390 | $63,000 |
| 5 | | $403 | $65,000 | 1.1041 | $72,210 | 0.8710 | $62,897 | $387 | $62,510 |
| 6 | maintenance 5*2*8hr | $181 | $73,000 | 1.1262 | $82,414 | 0.8473 | $69,830 | $173 | $69,657 |
| 7 | | $181 | $65,000 | 1.1487 | $74,873 | 0.8242 | $61,713 | $172 | $61,541 |
| 8 | | $181 | $65,000 | 1.1717 | $76,371 | 0.8018 | $61,232 | $170 | $61,062 |
| 9 | maintenance 5*2*8hr | $181 | $73,000 | 1.1951 | $87,459 | 0.7799 | $68,213 | $169 | $68,043 |
| 10 | | $5,168 | $65,000 | 1.2190 | $85,535 | 0.7587 | $64,895 | $4,780 | $60,115 |
| 11 | | $181 | $65,000 | 1.2434 | $81,045 | 0.7380 | $59,814 | $167 | $59,647 |
| 12 | maintenance 5*2*8hr | $181 | $73,000 | 1.2682 | $92,812 | 0.7179 | $66,632 | $165 | $66,467 |
| 13 | | $181 | $65,000 | 1.2936 | $84,319 | 0.6984 | $58,887 | $164 | $58,723 |
| 14 | | $181 | $65,000 | 1.3195 | $86,006 | 0.6794 | $58,428 | $163 | $58,266 |
| 15 | maintenance 5*2*8hr | $7,306 | $73,000 | 1.3459 | $108,081 | 0.6609 | $71,425 | $6,498 | $64,928 |
| 16 | | $181 | $65,000 | 1.3728 | $89,480 | 0.6429 | $57,522 | $160 | $57,362 |
| 17 | | $222 | $65,000 | 1.4002 | $91,327 | 0.6253 | $57,110 | $194 | $56,916 |
| 18 | maintenance 5*2*8hr | $1,888 | $73,000 | 1.4282 | $106,959 | 0.6083 | $65,064 | $1,641 | $63,423 |
| 19 | | $403 | $65,000 | 1.4568 | $95,280 | 0.5917 | $56,381 | $347 | $56,033 |
| 20 | | $403 | $65,000 | 1.4859 | $97,185 | 0.5756 | $55,942 | $345 | $55,597 |
| 21 | maintenance 5*2*8hr | $181 | $73,000 | 1.5157 | $110,919 | 0.5599 | $62,108 | $154 | $61,954 |
| 22 | | $181 | $65,000 | 1.5460 | $100,769 | 0.5447 | $54,888 | $153 | $54,735 |
| 23 | | $181 | $65,000 | 1.5769 | $102,785 | 0.5299 | $54,461 | $152 | $54,309 |
| 24 | maintenance 5*2*8hr | $181 | $73,000 | 1.6084 | $117,708 | 0.5154 | $60,670 | $150 | $60,519 |
| 25 | | $5,168 | $65,000 | 1.6406 | $115,119 | 0.5014 | $57,719 | $4,251 | $53,467 |
| 26 | | $181 | $65,000 | 1.6734 | $109,076 | 0.4877 | $53,200 | $148 | $53,051 |
| 27 | maintenance 5*2*8hr | $181 | $73,000 | 1.7069 | $124,913 | 0.4744 | $59,264 | $147 | $59,117 |
| 28 | | $181 | $65,000 | 1.7410 | $113,483 | 0.4615 | $52,375 | $146 | $52,229 |
| 29 | | $181 | $65,000 | 1.7758 | $115,752 | 0.4490 | $51,967 | $145 | $51,822 |
| 30 | maintenance 5*2*8hr | $7,306 | $73,000 | 1.8114 | $145,462 | 0.4367 | $63,527 | $5,779 | $57,748 |
| 31 | | $181 | $65,000 | 1.8476 | $120,429 | 0.4248 | $51,161 | $142 | $51,019 |
| 32 | | $222 | $65,000 | 1.8845 | $122,914 | 0.4133 | $50,795 | $173 | $50,622 |
| 33 | maintenance 5*2*8hr | $1,888 | $73,000 | 1.9222 | $143,953 | 0.4020 | $57,869 | $1,459 | $56,410 |
| 34 | | $403 | $65,000 | 1.9607 | $128,234 | 0.3911 | $50,146 | $309 | $49,837 |
| 35 | | $403 | $65,000 | 1.9999 | $130,798 | 0.3804 | $49,756 | $306 | $49,449 |
| 36 | maintenance 5*2*8hr | $181 | $73,000 | 2.0399 | $149,282 | 0.3700 | $55,240 | $137 | $55,103 |
| 37 | | $181 | $65,000 | 2.0807 | $135,622 | 0.3600 | $48,819 | $136 | $48,683 |
| 38 | | $181 | $65,000 | 2.1223 | $138,335 | 0.3502 | $48,439 | $135 | $48,304 |
| 39 | maintenance 5*2*8hr | $181 | $73,000 | 2.1647 | $158,419 | 0.3406 | $53,961 | $134 | $53,827 |
| 40 | | $5,168 | $65,000 | 2.2080 | $154,935 | 0.3313 | $51,336 | $3,781 | $47,555 |
| 41 | | $181 | $65,000 | 2.2522 | $146,802 | 0.3223 | $47,317 | $132 | $47,185 |
| 42 | maintenance 5*2*8hr | $181 | $73,000 | 2.2972 | $168,116 | 0.3135 | $52,711 | $131 | $52,580 |
| 43 | | $181 | $65,000 | 2.3432 | $152,733 | 0.3050 | $46,583 | $130 | $46,453 |
| 44 | | $181 | $65,000 | 2.3901 | $155,787 | 0.2967 | $46,221 | $129 | $46,092 |
| 45 | maintenance 5*2*8hr | $7,306 | $73,000 | 2.4379 | $195,773 | 0.2886 | $56,502 | $5,140 | $51,362 |
| 46 | | $181 | $65,000 | 2.4866 | $162,081 | 0.2807 | $45,504 | $127 | $45,377 |
| 47 | | $222 | $65,000 | 2.5363 | $165,426 | 0.2731 | $45,178 | $154 | $45,024 |
| 48 | maintenance 5*2*8hr | $1,888 | $73,000 | 2.5871 | $193,741 | 0.2657 | $51,470 | $1,298 | $50,172 |
| 49 | | $403 | $65,000 | 2.6388 | $172,586 | 0.2584 | $44,601 | $275 | $44,326 |
| 50 | | $403 | $65,000 | 2.6916 | $176,037 | 0.2514 | $44,254 | $273 | $43,981 |
| TOTAL PRESENT VALUE COST | | | | | | | **$5,279,398** | $2,428,997 | $2,850,401 |
| | Amort. Factor: | | | | | x | 0.0374 | 0.0374 | 0.0374 |
| **Average Annual Costs** | | | | | | = | **$197,463** | $90,851 | $106,612 |
| | | | | | | | **Total** | **Capital** | **O&M** |

Capital costs years 1 through 50 from rake manufacturer

Assumes maintenance every 3 years take 2 people 5 x 8-hr days

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 02 - Modify Existing Rack System

**Summary of Work**. Replace rack with 3/4" spaced rack, modify rake.

**Plan of Operation**. The existing rack to be removed. The new rack to be fabricated offsite and installed using gantry crane or contractor rubber-tired crane.

**Analysis of Time**: This work to be completed in approximately two months after off-site fabrication of rack panels.

| **Summary** | | | | |
|---|---|---|---|---|
| Labor for Design (USACE) | | $ | 144,704.00 | See Note 1. |
| Labor for O&M (USACE per year) | | $ | 130,000.00 | |
| Supplies/Materials (including installation) | | $ | 1,339,040.00 | See Note 2 |
| Total Costs | | $ | 1,613,744.00 | |
| Prime Contractor G&A @ | 0.0% | $ | - | See Note 2 |
| Subtotal | | $ | 1,613,744.00 | |
| Prime Contractor Profit | 0.00% | $ | - | See Note 2 |
| Subtotal | | $ | 1,613,744.00 | |
| Bond | 0.00% | $ | - | See Note 2 |
| | **Total** | **$** | **1,613,744.00** | |

Notes:
1. USACE labor costs based on experience
2. Assumes Supplies/Materials cost, which were derived from Alternative 01 Charrette, includes markups.

| | **Labor for Design (USACE)** | | | |
|---|---|---|---|---|
| Hours | Title | $/Hr | | Cost |
| 2 | Chief | $150.00 | $ | 300.00 |
| 10 | PM | $130.00 | $ | 1,300.00 |
| 80 | Engineer | $115.00 | $ | 9,200.00 |
| | S&A at 10% of ktr cost | | $ | 133,904.00 |
| | | **SUBTOTAL** | **$** | **144,704.00** |

| | **Labor for O&M (USACE per year)** | | | |
|---|---|---|---|---|
| Hours | Title | $/Hr | | Cost |
| | O&M Supervisor | $120.00 | $ | - |
| 1300 | O&M Worker | $100.00 | $ | 130,000.00 |
| | | **SUBTOTAL** | **$** | **130,000.00** |

| | **Supplies/Materials (including installation)** | | | | |
|---|---|---|---|---|---|
| Qty | Item | Unit Price | Delivery Charge | | Cost |
| 16 | 3/4" space trash rack panel | $81,250.00 | $0.00 | $ | 1,300,000.00 |
| 16 | Salvage old rack panel | -$60.00 | $0.00 | $ | (960.00) |
| 1 | Modify rake | $40,000.00 | | $ | 40,000.00 |
| | | | | $ | - |
| | | | **SUBTOTAL** | **$** | **1,339,040.00** |

Assumes cost of 3/4"-space trash rack panel includes installation (from Ben Filan's estimate)

**B2 Trash Rack: VE Study Alternatives Cost Estimates**

**Use Current System - Manual Rack System**

| Project Year | Description Costs | Capital Cost in 2012 dollars Costs | O&M Cost in 2012dollars Costs | FV Factors Costs | Inflated cost to dollars year Costs | PV Factors | PV Present Value Total Life Cycle Cost Stream | PV Capital Cost Stream | PV O&M Cost Stream |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| 0 | Replace rack, modify rake | $1,613,744 | $130,000 | 1.0000 | $1,743,744 | 1.0000 | $1,743,744 | $1,613,744 | $130,000 |
| 1 | | | $130,000 | 1.0200 | $132,600 | 0.9728 | $128,988 | $0 | $128,988 |
| 2 | | | $130,000 | 1.0404 | $135,252 | 0.9463 | $127,985 | $0 | $127,985 |
| 3 | maintenance 2*2*8hr | | $133,200 | 1.0612 | $141,353 | 0.9205 | $130,114 | $0 | $130,114 |
| 4 | | | $130,000 | 1.0824 | $140,716 | 0.8954 | $126,000 | $0 | $126,000 |
| 5 | | | $130,000 | 1.1041 | $143,531 | 0.8710 | $125,020 | $0 | $125,020 |
| 6 | maintenance 2*2*8hr | | $133,200 | 1.1262 | $150,005 | 0.8473 | $127,100 | $0 | $127,100 |
| 7 | | | $130,000 | 1.1487 | $149,329 | 0.8242 | $123,081 | $0 | $123,081 |
| 8 | | | $130,000 | 1.1717 | $152,316 | 0.8018 | $122,124 | $0 | $122,124 |
| 9 | maintenance 2*2*8hr | | $133,200 | 1.1951 | $159,186 | 0.7799 | $124,156 | $0 | $124,156 |
| 10 | | | $130,000 | 1.2190 | $158,469 | 0.7587 | $120,230 | $0 | $120,230 |
| 11 | | | $130,000 | 1.2434 | $161,639 | 0.7380 | $119,295 | $0 | $119,295 |
| 12 | maintenance 2*2*8hr | | $133,200 | 1.2682 | $168,930 | 0.7179 | $121,280 | $0 | $121,280 |
| 13 | | | $130,000 | 1.2936 | $168,169 | 0.6984 | $117,445 | $0 | $117,445 |
| 14 | | | $130,000 | 1.3195 | $171,532 | 0.6794 | $116,531 | $0 | $116,531 |
| 15 | maintenance 2*2*8hr | | $133,200 | 1.3459 | $179,270 | 0.6609 | $118,470 | $0 | $118,470 |
| 16 | | | $130,000 | 1.3728 | $178,462 | 0.6429 | $114,725 | $0 | $114,725 |
| 17 | | | $130,000 | 1.4002 | $182,031 | 0.6253 | $113,832 | $0 | $113,832 |
| 18 | maintenance 2*2*8hr | | $133,200 | 1.4282 | $190,242 | 0.6083 | $115,726 | $0 | $115,726 |
| 19 | | | $130,000 | 1.4568 | $189,385 | 0.5917 | $112,067 | $0 | $112,067 |
| 20 | | | $130,000 | 1.4859 | $193,173 | 0.5756 | $111,195 | $0 | $111,195 |
| 21 | maintenance 2*2*8hr | | $133,200 | 1.5157 | $201,887 | 0.5599 | $113,045 | $0 | $113,045 |
| 22 | | | $130,000 | 1.5460 | $200,977 | 0.5447 | $109,471 | $0 | $109,471 |
| 23 | | | $130,000 | 1.5769 | $204,997 | 0.5299 | $108,619 | $0 | $108,619 |
| 24 | maintenance 2*2*8hr | | $133,200 | 1.6084 | $214,244 | 0.5154 | $110,427 | $0 | $110,427 |
| 25 | | | $130,000 | 1.6406 | $213,279 | 0.5014 | $106,935 | $0 | $106,935 |
| 26 | | | $130,000 | 1.6734 | $217,544 | 0.4877 | $106,103 | $0 | $106,103 |
| 27 | maintenance 2*2*8hr | | $133,200 | 1.7069 | $227,357 | 0.4744 | $107,869 | $0 | $107,869 |
| 28 | | | $130,000 | 1.7410 | $226,333 | 0.4615 | $104,458 | $0 | $104,458 |
| 29 | | | $130,000 | 1.7758 | $230,860 | 0.4490 | $103,645 | $0 | $103,645 |
| 30 | maintenance 2*2*8hr | | $133,200 | 1.8114 | $241,273 | 0.4367 | $105,370 | $0 | $105,370 |
| 31 | | | $130,000 | 1.8476 | $240,187 | 0.4248 | $102,038 | $0 | $102,038 |
| 32 | | | $130,000 | 1.8845 | $244,990 | 0.4133 | $101,244 | $0 | $101,244 |
| 33 | maintenance 2*2*8hr | | $133,200 | 1.9222 | $256,041 | 0.4020 | $102,929 | $0 | $102,929 |
| 34 | | | $130,000 | 1.9607 | $254,888 | 0.3911 | $99,674 | $0 | $99,674 |
| 35 | | | $130,000 | 1.9999 | $259,986 | 0.3804 | $98,899 | $0 | $98,899 |
| 36 | maintenance 2*2*8hr | | $133,200 | 2.0399 | $271,713 | 0.3700 | $100,544 | $0 | $100,544 |
| 37 | | | $130,000 | 2.0807 | $270,489 | 0.3600 | $97,365 | $0 | $97,365 |
| 38 | | | $130,000 | 2.1223 | $275,899 | 0.3502 | $96,608 | $0 | $96,608 |
| 39 | maintenance 2*2*8hr | | $133,200 | 2.1647 | $288,344 | 0.3406 | $98,215 | $0 | $98,215 |
| 40 | | | $130,000 | 2.2080 | $287,045 | 0.3313 | $95,110 | $0 | $95,110 |
| 41 | | | $130,000 | 2.2522 | $292,786 | 0.3223 | $94,370 | $0 | $94,370 |
| 42 | maintenance 2*2*8hr | | $133,200 | 2.2972 | $305,993 | 0.3135 | $95,940 | $0 | $95,940 |
| 43 | | | $130,000 | 2.3432 | $304,615 | 0.3050 | $92,907 | $0 | $92,907 |
| 44 | | | $130,000 | 2.3901 | $310,707 | 0.2967 | $92,184 | $0 | $92,184 |
| 45 | maintenance 2*2*8hr | | $133,200 | 2.4379 | $324,722 | 0.2886 | $93,718 | $0 | $93,718 |
| 46 | | | $130,000 | 2.4866 | $323,259 | 0.2807 | $90,754 | $0 | $90,754 |
| 47 | | | $130,000 | 2.5363 | $329,725 | 0.2731 | $90,048 | $0 | $90,048 |
| 48 | maintenance 2*2*8hr | | $133,200 | 2.5871 | $344,598 | 0.2657 | $91,547 | $0 | $91,547 |
| 49 | | | $130,000 | 2.6388 | $343,046 | 0.2584 | $88,652 | $0 | $88,652 |
| 50 | | | $130,000 | 2.6916 | $349,906 | 0.2514 | $87,962 | $0 | $87,962 |

| B2 Trash Rack: VE Study Alternatives Cost Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Use Current System - Manual Rack System** | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | PV | PV | PV |
| Project | Description | Capital Cost in 2012 dollars | O&M Cost in 2012dollars | FV Factors | Inflated cost to dollars year | PV | Present Value Total Life Cycle | Capital | O&M |
| Year | Costs | Costs | Costs | Costs | Costs | Factors | Cost Stream | Cost Stream | Cost Stream |
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL PRESENT VALUE COST | | | | | | | **$7,145,757** | $1,613,744 | $5,532,013 |
| | Amort. Factor: | | | | | x | 0.0374 | 0.0374 | 0.0374 |
| **Average Annual Costs** | | | | | | = | **$267,270** | $60,358 | $206,911 |
| | | | | | | | **Total** | **Capital** | **O&M** |
| | | | | | | | | | |
| Assumes maintenance every 3 years take 2 people 2 x 8-hr days | | | | | | | | | |

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 03 - Forebay Trash Directing Fence (FTDF)

**Summary of Work**. Construct new "fence" in forebay to direct trash away from trash rack.

**Plan of Operation**. The lower level of fence would be solid and the upper level would be a series of vertical vanes with 7/8" spacing. The lower level will be concrete so that it can anchor the vertical vanes. A fair amount of design work will be required, including hydraulic modeling.

**Analysis of Time**: Design work will take several months. Actual construction will take 3 to 4 months; 10 weeks for the lower level, and 5 weeks for the upper level.

| **Summary** | | | | | |
|---|---|---|---|---|---|
| Labor for Design (USACE) | | | $ | 442,242.60 | |
| Labor for O&M (USACE per year) | | | | $6,880.00 | |
| USACE Total | | | $ | 449,122.60 | |
| Contractor | | | | | |
| Labor: Non-Flow-Through Section | | | $ | 710,400.00 | See Note 1 |
| Labor: Flow-Through Section | | | $ | 14,000.00 | See Note 1 |
| Equipment+Materials Non-Flow Through Fence | | | $ | 883,460.00 | See Note 1 |
| Equipment+Materials Flow Through Fence | | | $ | 2,220,566.00 | See Note 1 |
| Total Ktr Direct Costs | | | $ | 3,828,426.00 | |
| Prime Contractor G&A @ | | 15.0% | $ | 574,263.90 | See Note 2 |
| | Subtotal | | $ | 4,402,689.90 | |
| Prime Contractor Profit | | 9.25% | $ | 407,248.82 | see profit calculation |
| | Subtotal | | $ | 4,809,938.72 | |
| Bond | | 1.50% | $ | 72,149.08 | See Note 3 |
| | | **Total Ktr Costs** | **$** | **5,217,187.53** | |
| | | **Total Ktr + USACE Costs** | **$** | **5,659,430.13** | |

Notes:

1. Cost estimate separated for construction of lower solid level and the upper flow-through level.
2. G&A rate assumed at 15%.
3. Bond rate of 1.5% is from estimated

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 03 - Forebay Trash Directing Fence (FTDF)

**Labor for Design (USACE)**

| No. | Title | $/Hr | Hrs | Cost |
|---|---|---|---|---|
| 1 | Chief | $150.00 | 20 | $ 3,000.00 |
| 1 | PM | $130.00 | 80 | $ 10,400.00 |
| 4 | Engineer | $115.00 | 100 | $ 46,000.00 |
| | S&A at 10% of ktr cost | | | $ 382,842.60 |
| | | **SUBTOTAL** | | **$ 442,242.60** |

**Labor for O&M (USACE per year)**

| No. | Title | $/Hr | Hrs | Cost |
|---|---|---|---|---|
| 1 | O&M Supervisor | $120.00 | 4 | $ 480.00 |
| 4 | O&M Worker | $100.00 | 16 | $ 6,400.00 |
| | | **SUBTOTAL** | | **$ 6,880.00** |

**Labor: Non-Flow-Through Section**

| No. | Title | Hr rate | Hrs | Cost |
|---|---|---|---|---|
| 1 | Superintendent (est) | $60.00 | 400 | $ 24,000.00 |
| 1 | Project Manager (est) | $60.00 | 200 | $ 12,000.00 |
| 1 | SSHO/QCM (est) | $50.00 | 400 | $ 20,000.00 |
| 1 | Project Engineer (est) | $50.00 | 400 | $ 20,000.00 |
| 3 | Equipment Operator Group 4 | $54.00 | 400 | $ 64,800.00 |
| 3 | Equipment Operator Group 5 | $53.00 | 400 | $ 63,600.00 |
| 3 | Equipment Operator Group 6 | $49.00 | 400 | $ 58,800.00 |
| 3 | Ironworker | $61.00 | 400 | $ 73,200.00 |
| 4 | Laborer Group 4 | $45.00 | 400 | $ 72,000.00 |
| 5 | Dive Team (5 man incl equip) | $250.00 | 200 | $ 250,000.00 |
| 2 | Tug Tender | $60.00 | 200 | $ 24,000.00 |
| 2 | Pilot | $70.00 | 200 | $ 28,000.00 |
| 29 | | **SUBTOTAL** | | **$ 710,400.00** |

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 03 - Forebay Trash Directing Fence (FTDF)

**Labor: Flow-Through Section**

| No. | Title | Hr rate | Hrs | Cost |
|---|---|---|---|---|
| 1 | Superintendent (est) | $60.00 | 200 | $ 12,000.00 |
| 1 | Project Manager (est) | $60.00 | 100 | $ 6,000.00 |
| 1 | SSHO/QCM (est) | $50.00 | 200 | $ 10,000.00 |
| 1 | Project Engineer (est) | $50.00 | 200 | $ 10,000.00 |
| 3 | Equipment Operator Group 4 | $54.00 | 200 | $ 32,400.00 |
| 3 | Equipment Operator Group 5 | $53.00 | 200 | $ 31,800.00 |
| 3 | Equipment Operator Group 6 | $49.00 | 200 | $ 29,400.00 |
| 3 | Ironworker | $61.00 | 200 | $ 36,600.00 |
| 4 | Laborer Group 4 | $45.00 | 200 | $ 36,000.00 |
| 5 | Dive Team (5 man incl equip) | $250.00 | 100 | $ 125,000.00 |
| 2 | Tug Tender | $60.00 | 100 | $ 12,000.00 |
| 2 | Pilot | $70.00 | 100 | $ 14,000.00 |
| | | | **SUBTOTAL** | **$ 355,200.00** |

**Equipment+Materials Non-Flow Through Fence**

| Units | Equipment | Op Rate | Operating | units | Cost |
|---|---|---|---|---|---|
| 1 | Superintendent's truck, 4wd, 1 ton | $8.26 | 400 | hrs | $ 3,304.00 |
| 1 | SSHO/CQM truck, 2wd, 1/2 ton | $9.89 | 400 | hrs | $ 3,956.00 |
| 1 | Crane and Work Barges | $500.00 | 400 | hrs | $ 200,000.00 |
| 1 | Tug | $65.00 | 400 | hrs | $ 26,000.00 |
| 1 | 60 ton crane (rubber tired) | $123.00 | 400 | hrs | $ 49,200.00 |
| 2 | Job site trailer | $10.00 | 50 | days | $ 1,000.00 |
| 15 | Concrete - precast units | $20,000.00 | 1 | ea | $ 300,000.00 |
| 15 | Concrete - cast-in-place | $20,000.00 | 1 | ea | $ 300,000.00 |
| | | | | | $ - |
| | | | | | $ - |
| | | | **SUBTOTAL** | | **$ 883,460.00** |

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 03 - Forebay Trash Directing Fence (FTDF)

| | Equipment+Materials Flow Through Fence | | | | |
|---|---|---|---|---|---|
| Units | Equipment | Op Rate | Operating | units | Cost |
| 1 | Superintendent's truck, 4wd, 1 ton | $8.26 | 200 | hrs | $ 1,652.00 |
| 1 | SSHO/CQM truck, 2wd, 1/2 ton | $9.89 | 200 | hrs | $ 1,978.00 |
| 1 | Crane and Work Barges | $500.00 | 200 | hrs | $ 100,000.00 |
| 1 | Tug | $65.00 | 200 | hrs | $ 13,000.00 |
| 1 | 60 ton crane (rubber tired) | $123.00 | 200 | hrs | $ 24,600.00 |
| 2 | Job site trailer | $10.00 | 25 | days | $ 500.00 |
| 1536 | 0.375"x1.5"x60' bars | $5.75 | 115 | lbs | $ 1,015,680.00 |
| 1004 | 0.375"x1.5"x37.5' bars | $5.75 | 72 | lbs | $ 415,656.00 |
| 1 | Concrete - cast-in-place | $500.00 | 950 | cy | $ 475,000.00 |
| 1 | Misc Steel guides and stiffeners | $5.75 | 30000 | lbs | $ 172,500.00 |
| | | | | | $ - |
| | | | **SUBTOTAL** | | **$ 2,220,566.00** |

"Raw" data in yellow/gray boxes

**B2 Trash Rack: VE Study Alternatives Cost Estimates**
**Alt. 03 - Forebay Trash Directing Fence (FTDF)**

Prime Contractor Profit

| | | Rate | Weight .03 to .12 | |
|---|---|---|---|---|
| 1 | Degree of Risk | 20 | 0.11 | 2.20 |
| 2 | Relative Difficulty of Work | 15 | 0.11 | 1.65 |
| 3 | Size of Job | 15 | 0.05 | 0.75 |
| 4 | Period of Performance | 15 | 0.09 | 1.35 |
| 5 | Contractor's investment | 5 | 0.10 | 0.50 |
| 6 | Assistance by Gov | 5 | 0.06 | 0.30 |
| 7 | Subcontracting | 25 | 0.10 | 2.50 |
| | | 100 | Total | 9.25 |
| | | | Use | |

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**B2 Trash Rack: VE Study Alternatives Cost Estimates**

**Alt. 03 - Forebay Trash Directing Fence (FTDF)**

| Project Year | Description Costs | Capital Cost in 2012 dollars Costs | O&M Cost in 2012dollars Costs | FV Factors Costs | Inflated cost to dollars year expended Costs | PV Factors | PV Present Value Total Life Cycle Cost Stream | PV Capital Cost Stream | PV O&M Cost Stream |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| 0 | Replace rack, modify rake | $5,659,430 | $6,880 | 1.0000 | $5,666,310 | 1.0000 | $5,666,310 | $5,659,430 | $6,880 |
| 1 | | | $6,880 | 1.0200 | $7,018 | 0.9728 | $6,826 | $0 | $6,826 |
| 2 | | | $6,880 | 1.0404 | $7,158 | 0.9463 | $6,773 | $0 | $6,773 |
| 3 | maintenance 2*1*8hr | | $8,480 | 1.0612 | $8,999 | 0.9205 | $8,284 | $0 | $8,284 |
| 4 | | | $6,880 | 1.0824 | $7,447 | 0.8954 | $6,668 | $0 | $6,668 |
| 5 | | | $6,880 | 1.1041 | $7,596 | 0.8710 | $6,616 | $0 | $6,616 |
| 6 | maintenance 2*1*8hr | | $8,480 | 1.1262 | $9,550 | 0.8473 | $8,092 | $0 | $8,092 |
| 7 | | | $6,880 | 1.1487 | $7,903 | 0.8242 | $6,514 | $0 | $6,514 |
| 8 | | | $6,880 | 1.1717 | $8,061 | 0.8018 | $6,463 | $0 | $6,463 |
| 9 | maintenance 2*1*8hr | | $8,480 | 1.1951 | $10,134 | 0.7799 | $7,904 | $0 | $7,904 |
| 10 | | | $6,880 | 1.2190 | $8,387 | 0.7587 | $6,363 | $0 | $6,363 |
| 11 | | | $6,880 | 1.2434 | $8,554 | 0.7380 | $6,313 | $0 | $6,313 |
| 12 | maintenance 2*1*8hr | | $8,480 | 1.2682 | $10,755 | 0.7179 | $7,721 | $0 | $7,721 |
| 13 | | | $6,880 | 1.2936 | $8,900 | 0.6984 | $6,216 | $0 | $6,216 |
| 14 | | | $6,880 | 1.3195 | $9,078 | 0.6794 | $6,167 | $0 | $6,167 |
| 15 | maintenance 2*1*8hr | | $8,480 | 1.3459 | $11,413 | 0.6609 | $7,542 | $0 | $7,542 |
| 16 | | | $6,880 | 1.3728 | $9,445 | 0.6429 | $6,072 | $0 | $6,072 |
| 17 | | | $6,880 | 1.4002 | $9,634 | 0.6253 | $6,024 | $0 | $6,024 |
| 18 | maintenance 2*1*8hr | | $8,480 | 1.4282 | $12,112 | 0.6083 | $7,368 | $0 | $7,368 |
| 19 | | | $6,880 | 1.4568 | $10,023 | 0.5917 | $5,931 | $0 | $5,931 |
| 20 | | | $6,880 | 1.4859 | $10,223 | 0.5756 | $5,885 | $0 | $5,885 |
| 21 | maintenance 2*1*8hr | | $8,480 | 1.5157 | $12,853 | 0.5599 | $7,197 | $0 | $7,197 |
| 22 | | | $6,880 | 1.5460 | $10,636 | 0.5447 | $5,794 | $0 | $5,794 |
| 23 | | | $6,880 | 1.5769 | $10,849 | 0.5299 | $5,748 | $0 | $5,748 |
| 24 | maintenance 2*1*8hr | | $8,480 | 1.6084 | $13,640 | 0.5154 | $7,030 | $0 | $7,030 |
| 25 | | | $6,880 | 1.6406 | $11,287 | 0.5014 | $5,659 | $0 | $5,659 |
| 26 | | | $6,880 | 1.6734 | $11,513 | 0.4877 | $5,615 | $0 | $5,615 |
| 27 | maintenance 2*1*8hr | | $8,480 | 1.7069 | $14,474 | 0.4744 | $6,867 | $0 | $6,867 |
| 28 | | | $6,880 | 1.7410 | $11,978 | 0.4615 | $5,528 | $0 | $5,528 |
| 29 | | | $6,880 | 1.7758 | $12,218 | 0.4490 | $5,485 | $0 | $5,485 |
| 30 | maintenance 2*1*8hr | | $8,480 | 1.8114 | $15,360 | 0.4367 | $6,708 | $0 | $6,708 |
| 31 | | | $6,880 | 1.8476 | $12,711 | 0.4248 | $5,400 | $0 | $5,400 |
| 32 | | | $6,880 | 1.8845 | $12,966 | 0.4133 | $5,358 | $0 | $5,358 |
| 33 | maintenance 2*1*8hr | | $8,480 | 1.9222 | $16,301 | 0.4020 | $6,553 | $0 | $6,553 |
| 34 | | | $6,880 | 1.9607 | $13,489 | 0.3911 | $5,275 | $0 | $5,275 |
| 35 | | | $6,880 | 1.9999 | $13,759 | 0.3804 | $5,234 | $0 | $5,234 |
| 36 | maintenance 2*1*8hr | | $8,480 | 2.0399 | $17,298 | 0.3700 | $6,401 | $0 | $6,401 |
| 37 | | | $6,880 | 2.0807 | $14,315 | 0.3600 | $5,153 | $0 | $5,153 |
| 38 | | | $6,880 | 2.1223 | $14,601 | 0.3502 | $5,113 | $0 | $5,113 |
| 39 | maintenance 2*1*8hr | | $8,480 | 2.1647 | $18,357 | 0.3406 | $6,253 | $0 | $6,253 |
| 40 | | | $6,880 | 2.2080 | $15,191 | 0.3313 | $5,034 | $0 | $5,034 |
| 41 | | | $6,880 | 2.2522 | $15,495 | 0.3223 | $4,994 | $0 | $4,994 |
| 42 | maintenance 2*1*8hr | | $8,480 | 2.2972 | $19,481 | 0.3135 | $6,108 | $0 | $6,108 |
| 43 | | | $6,880 | 2.3432 | $16,121 | 0.3050 | $4,917 | $0 | $4,917 |
| 44 | | | $6,880 | 2.3901 | $16,444 | 0.2967 | $4,879 | $0 | $4,879 |
| 45 | maintenance 2*1*8hr | | $8,480 | 2.4379 | $20,673 | 0.2886 | $5,966 | $0 | $5,966 |
| 46 | | | $6,880 | 2.4866 | $17,108 | 0.2807 | $4,803 | $0 | $4,803 |
| 47 | | | $6,880 | 2.5363 | $17,450 | 0.2731 | $4,766 | $0 | $4,766 |
| 48 | maintenance 2*1*8hr | | $8,480 | 2.5871 | $21,938 | 0.2657 | $5,828 | $0 | $5,828 |

| B2 Trash Rack: VE Study Alternatives Cost Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Alt. 03 - Forebay Trash Directing Fence (FTDF)** | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | PV | PV | PV |
| Project | Description | Capital Cost in 2012 dollars | O&M Cost in 2012dollars | FV Factors | Inflated cost to dollars year expended | PV | Present Value Total Life Cycle | Capital | O&M |
| Year | Costs | Costs | Costs | Costs | Costs | Factors | Cost Stream | Cost Stream | Cost Stream |
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| | | | | | | | | | |
| 49 | | | $6,880 | 2.6388 | $18,155 | 0.2584 | $4,692 | $0 | $4,692 |
| 50 | | | $6,880 | 2.6916 | $18,518 | 0.2514 | $4,655 | $0 | $4,655 |
| | | | | | | | | | |
| TOTAL PRESENT VALUE COST | | | | | | | **$5,971,067** | $5,659,430 | $311,636 |
| | Amort. Factor: | | | | | x | 0.0374 | 0.0374 | 0.0374 |
| **Average Annual Costs** | | | | | | = | **$223,333** | $211,677 | $11,656 |
| | | | | | | | **Total** | **Capital** | **O&M** |
| | | | | | | | | | |
| Assumes maintenance every 3 years take 2 people 1 x 8-hr days | | | | | | | | | |

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 05 - Bulkhead Trash Rack

**Summary of Work**. Install new 3/4" x 3/4" trash racks bulkhead. Install with gantry crane.

**Plan of Operation**. The new racks to be fabricated offsite and installed in and removed (for cleaning) from the bulkhead using gantry crane.

**Analysis of Time**: Design work relatively simple. Fabrication will take some time. Actual construction will take 1 month.

| **Summary** | | | | | |
|---|---|---|---|---|---|
| Labor for Design (USACE) | | | $ | 34,926.40 | |
| Labor for O&M (USACE per year) | | | | $13,280.00 | |
| USACE Total | | | $ | 48,206.40 | |
| Contractor | | | | | |
| Labor: Install Bulkhead Racks | | | $ | 114,280.00 | See Note 1 |
| Equipment+Materials Bulkhead racks | | | $ | 110,984.00 | See Note 1 |
| Total Ktr Direct Costs | | | $ | 225,264.00 | |
| Prime Contractor G&A @ | | 15.0% | $ | 33,789.60 | See Note 2 |
| | Subtotal | | $ | 259,053.60 | |
| Prime Contractor Profit | | 7.95% | $ | 20,594.76 | see profit calculation |
| | Subtotal | | $ | 279,648.36 | |
| Bond | | 1.50% | $ | 4,194.73 | See Note 3 |
| | | **Total Ktr Costs** | **$** | **300,243.12** | |
| | | **Total Ktr + USACE Costs** | **$** | **335,169.52** | |

Notes:
1. Cost estimate separated for construction of lower solid level and the upper flow-through level.
2. G&A rate assumed at 15%.
3. Bond rate of 1.5% is from estimated

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 05 - Bulkhead Trash Rack

| | **Labor for Design (USACE)** | | | |
|---|---|---|---|---|
| No. | Title | $/Hr | Hrs | Cost |
| 1 | Chief | $150.00 | 4 | $ 600.00 |
| 1 | PM | $130.00 | 20 | $ 2,600.00 |
| 4 | Engineer | $115.00 | 20 | $ 9,200.00 |
| | S&A at 10% of ktr cost | | | $ 22,526.40 |
| | | **SUBTOTAL** | | **$ 34,926.40** |

| | **Labor for O&M (USACE per year)** | | | |
|---|---|---|---|---|
| No. | Title | $/Hr | Hrs | Cost |
| 1 | O&M Supervisor | $120.00 | 4 | $ 480.00 |
| 4 | O&M Worker | $100.00 | 32 | $ 12,800.00 |
| | | **SUBTOTAL** | | **$ 13,280.00** |

| | **Labor: Install Bulkhead Racks** | | | |
|---|---|---|---|---|
| No. | Title | Hr rate | Hrs | Cost |
| 1 | Superintendent (est) | $60.00 | 160 | $ 9,600.00 |
| 1 | Project Manager (est) | $60.00 | 80 | $ 4,800.00 |
| 1 | SSHO/QCM (est) | $50.00 | 160 | $ 8,000.00 |
| 1 | Project Engineer (est) | $50.00 | 160 | $ 8,000.00 |
| 1 | Equipment Operator Group 4 | $54.00 | 160 | $ 8,640.00 |
| 1 | Equipment Operator Group 5 | $53.00 | 160 | $ 8,480.00 |
| 1 | Equipment Operator Group 6 | $49.00 | 160 | $ 7,840.00 |
| 2 | Ironworker | $61.00 | 160 | $ 19,520.00 |
| 2 | Laborer Group 4 | $45.00 | 160 | $ 14,400.00 |
| 5 | Dive Team (5 man incl equip) | $250.00 | 20 | $ 25,000.00 |
| 2 | Tug Tender | $60.00 | | $ - |
| 2 | Pilot | $70.00 | | $ - |
| 20 | | **SUBTOTAL** | | **$ 114,280.00** |

## B2 Trash Rack: VE Study Alternatives Cost Estimates
## Alt. 05 - Bulkhead Trash Rack

| | Equipment+Materials Bulkhead racks | | | | | |
|---|---|---|---|---|---|---|
| Units | Equipment | Op Rate | Operating | units | | Cost |
| 1 | Superintendent's truck, 4wd, 1 ton | $8.26 | 160 | hrs | $ | 1,321.60 |
| 1 | SSHO/CQM truck, 2wd, 1/2 ton | $9.89 | 160 | hrs | $ | 1,582.40 |
| 1 | Crane and Work Barges | $500.00 | | hrs | $ | - |
| 1 | Tug | $65.00 | | hrs | $ | - |
| 1 | 60 ton crane (rubber tired) | $123.00 | 160 | hrs | $ | 19,680.00 |
| 2 | Job site trailer | $10.00 | 20 | days | $ | 400.00 |
| 4 | Racks | $20,000.00 | 1 | ea | $ | 80,000.00 |
| 4 | Rack guides | $2,000.00 | 1 | ea | $ | 8,000.00 |
| | | | | | $ | - |
| | | | | | $ | - |
| | | | **SUBTOTAL** | | **$** | **110,984.00** |

**B2 Trash Rack: VE Study Alternatives Cost Estimates**
**Alt. 05 - Bulkhead Trash Rack**

| Prime Contractor Profit | | | | |
|---|---|---|---|---|
| | | Rate | Weight .03 to .12 | |
| 1 | Degree of Risk | 20 | 0.09 | 1.80 |
| 2 | Relative Difficulty of Work | 15 | 0.09 | 1.35 |
| 3 | Size of Job | 15 | 0.07 | 1.05 |
| 4 | Period of Performance | 15 | 0.07 | 1.05 |
| 5 | Contractor's investment | 5 | 0.08 | 0.40 |
| 6 | Assistance by Gov | 5 | 0.06 | 0.30 |
| 7 | Subcontracting | 25 | 0.08 | 2.00 |
| | | 100 | Total | 7.95 |
| | | | Use | |

FOR OFFICIAL USE ONLY

| B2 Trash Rack: VE Study Alternatives Cost Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Alt. 05 - Bulkhead Trash Rack** | | | | | | | | | |
| | | | | | | | PV | PV | PV |
| Project | Description | Capital Cost in 2012 dollars | O&M Cost in 2012dollars | FV Factors | Inflated cost to dollars year | PV | Present Value Total Life Cycle | Capital | O&M |
| Year | Costs | Costs | Costs | Costs | Costs | Factors | Cost Stream | Cost Stream | Cost Stream |
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| 0 | Replace rack, modify rake | $335,170 | $13,280 | 1.0000 | $348,450 | 1.0000 | $348,450 | $335,170 | $13,280 |
| 1 | | | $13,280 | 1.0200 | $13,546 | 0.9728 | $13,177 | $0 | $13,177 |
| 2 | | | $13,280 | 1.0404 | $13,817 | 0.9463 | $13,074 | $0 | $13,074 |
| 3 | maintenance 2*1*8hr | | $14,880 | 1.0612 | $15,791 | 0.9205 | $14,535 | $0 | $14,535 |
| 4 | | | $13,280 | 1.0824 | $14,375 | 0.8954 | $12,871 | $0 | $12,871 |
| 5 | | | $13,280 | 1.1041 | $14,662 | 0.8710 | $12,771 | $0 | $12,771 |
| 6 | maintenance 2*1*8hr | | $14,880 | 1.1262 | $16,757 | 0.8473 | $14,199 | $0 | $14,199 |
| 7 | | | $13,280 | 1.1487 | $15,255 | 0.8242 | $12,573 | $0 | $12,573 |
| 8 | | | $13,280 | 1.1717 | $15,560 | 0.8018 | $12,475 | $0 | $12,475 |
| 9 | maintenance 2*1*8hr | | $14,880 | 1.1951 | $17,783 | 0.7799 | $13,870 | $0 | $13,870 |
| 10 | | | $13,280 | 1.2190 | $16,188 | 0.7587 | $12,282 | $0 | $12,282 |
| 11 | | | $13,280 | 1.2434 | $16,512 | 0.7380 | $12,186 | $0 | $12,186 |
| 12 | maintenance 2*1*8hr | | $14,880 | 1.2682 | $18,871 | 0.7179 | $13,548 | $0 | $13,548 |
| 13 | | | $13,280 | 1.2936 | $17,179 | 0.6984 | $11,997 | $0 | $11,997 |
| 14 | | | $13,280 | 1.3195 | $17,523 | 0.6794 | $11,904 | $0 | $11,904 |
| 15 | maintenance 2*1*8hr | | $14,880 | 1.3459 | $20,027 | 0.6609 | $13,235 | $0 | $13,235 |
| 16 | | | $13,280 | 1.3728 | $18,231 | 0.6429 | $11,720 | $0 | $11,720 |
| 17 | | | $13,280 | 1.4002 | $18,595 | 0.6253 | $11,628 | $0 | $11,628 |
| 18 | maintenance 2*1*8hr | | $14,880 | 1.4282 | $21,252 | 0.6083 | $12,928 | $0 | $12,928 |
| 19 | | | $13,280 | 1.4568 | $19,346 | 0.5917 | $11,448 | $0 | $11,448 |
| 20 | | | $13,280 | 1.4859 | $19,733 | 0.5756 | $11,359 | $0 | $11,359 |
| 21 | maintenance 2*1*8hr | | $14,880 | 1.5157 | $22,553 | 0.5599 | $12,628 | $0 | $12,628 |
| 22 | | | $13,280 | 1.5460 | $20,531 | 0.5447 | $11,183 | $0 | $11,183 |
| 23 | | | $13,280 | 1.5769 | $20,941 | 0.5299 | $11,096 | $0 | $11,096 |
| 24 | maintenance 2*1*8hr | | $14,880 | 1.6084 | $23,934 | 0.5154 | $12,336 | $0 | $12,336 |
| 25 | | | $13,280 | 1.6406 | $21,787 | 0.5014 | $10,924 | $0 | $10,924 |
| 26 | | | $13,280 | 1.6734 | $22,223 | 0.4877 | $10,839 | $0 | $10,839 |
| 27 | maintenance 2*1*8hr | | $14,880 | 1.7069 | $25,398 | 0.4744 | $12,050 | $0 | $12,050 |
| 28 | | | $13,280 | 1.7410 | $23,121 | 0.4615 | $10,671 | $0 | $10,671 |
| 29 | | | $13,280 | 1.7758 | $23,583 | 0.4490 | $10,588 | $0 | $10,588 |
| 30 | maintenance 2*1*8hr | | $14,880 | 1.8114 | $26,953 | 0.4367 | $11,771 | $0 | $11,771 |
| 31 | | | $13,280 | 1.8476 | $24,536 | 0.4248 | $10,424 | $0 | $10,424 |
| 32 | | | $13,280 | 1.8845 | $25,027 | 0.4133 | $10,342 | $0 | $10,342 |
| 33 | maintenance 2*1*8hr | | $14,880 | 1.9222 | $28,603 | 0.4020 | $11,498 | $0 | $11,498 |
| 34 | | | $13,280 | 1.9607 | $26,038 | 0.3911 | $10,182 | $0 | $10,182 |
| 35 | | | $13,280 | 1.9999 | $26,559 | 0.3804 | $10,103 | $0 | $10,103 |
| 36 | maintenance 2*1*8hr | | $14,880 | 2.0399 | $30,354 | 0.3700 | $11,232 | $0 | $11,232 |
| 37 | | | $13,280 | 2.0807 | $27,631 | 0.3600 | $9,946 | $0 | $9,946 |
| 38 | | | $13,280 | 2.1223 | $28,184 | 0.3502 | $9,869 | $0 | $9,869 |
| 39 | maintenance 2*1*8hr | | $14,880 | 2.1647 | $32,211 | 0.3406 | $10,972 | $0 | $10,972 |
| 40 | | | $13,280 | 2.2080 | $29,323 | 0.3313 | $9,716 | $0 | $9,716 |
| 41 | | | $13,280 | 2.2522 | $29,909 | 0.3223 | $9,640 | $0 | $9,640 |
| 42 | maintenance 2*1*8hr | | $14,880 | 2.2972 | $34,183 | 0.3135 | $10,718 | $0 | $10,718 |
| 43 | | | $13,280 | 2.3432 | $31,118 | 0.3050 | $9,491 | $0 | $9,491 |
| 44 | | | $13,280 | 2.3901 | $31,740 | 0.2967 | $9,417 | $0 | $9,417 |
| 45 | maintenance 2*1*8hr | | $14,880 | 2.4379 | $36,275 | 0.2886 | $10,469 | $0 | $10,469 |
| 46 | | | $13,280 | 2.4866 | $33,022 | 0.2807 | $9,271 | $0 | $9,271 |
| 47 | | | $13,280 | 2.5363 | $33,683 | 0.2731 | $9,199 | $0 | $9,199 |
| 48 | maintenance 2*1*8hr | | $14,880 | 2.5871 | $38,496 | 0.2657 | $10,227 | $0 | $10,227 |
| 49 | | | $13,280 | 2.6388 | $35,043 | 0.2584 | $9,056 | $0 | $9,056 |
| 50 | | | $13,280 | 2.6916 | $35,744 | 0.2514 | $8,986 | $0 | $8,986 |

| B2 Trash Rack: VE Study Alternatives Cost Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Alt. 05 - Bulkhead Trash Rack** | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | PV | PV | PV |
| Project | Description | Capital Cost in 2012 dollars | O&M Cost in 2012dollars | FV Factors | Inflated cost to dollars year | PV | Present Value Total Life Cycle | Capital | O&M |
| Year | Costs | Costs | Costs | Costs | Costs | Factors | Cost Stream | Cost Stream | Cost Stream |
| | | | | **0.0200** | | **0.02800** | ***(int.rate)*** | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL PRESENT VALUE COST | | | | | | | **$917,074** | $335,170 | $581,904 |
| | Amort. Factor: | | | | | x | 0.0374 | 0.0374 | 0.0374 |
| **Average Annual Costs** | | | | | | = | **$34,301** | $12,536 | $21,765 |
| | | | | | | | **Total** | **Capital** | **O&M** |
| | | | | | | | | | |
| Assumes maintenance every 3 years take 2 people 1 x 8-hr days | | | | | | | | | |

# APPENDIX B

## Information Phase

**Introduction**

During the first two days of the Design Charrette, the team documented a variety of relevant information on the project. As the Charrette, other new information became available and the team documented that information as well in the tables below. In addition, the team identified other relevant documents important for review. Below is a list of the relevant documents, followed by the information gathered over the course of the Charrette.

Documents:

1. *Bonneville Second Powerhouse Auxiliary Water Supply Backup Alternative Study* (Alternative Study) dated September 2000. Project # DACVW57-97-D-0004, Task Order No. 0013, Modification No. 001304
2. *Bonneville Second Powerhouse Fish Unit Debris Study Reconnaissance Report*, Final, July 20, 2000. This report was conducted by Walla Walla District (CENWW)
3. *Bonneville Second Powerhouse Auxiliary Water Supply Backup System Design Documentation Report*, November 2001

Issues and Concerns:

1. Need to reduce diffuser size to 3/4" (5/8") from 1", and related issues structural mod. Cost change challenges.
2. What is debris: grass, sticks, limbs, logs, misc.
3. 2001 DDR says need annual dredge.
4. Multi function rake be able to switch functions.
5. Fish Ladder performance needs to be maintained by continuing flow.
6. Current fish units need to shut down 3 hours per day.
7. Goal is to not shut down unit.
8. Fingers need to be strong and flexible to reach into racks and not damage the rack.
9. Concerns about going to a narrower opening. (Faster loads up)
10. Rack needs to be equal to or narrower than the diffuser (rack cannot pass materials that cannot pass the diffuser).
11. Rake cannot drift from rack (clean engagement of rake with rack)
12. Address cross current.
13. Must be able to dump 100% of the load.
14. Collector must hold load with minimum loss.
15. Load limit on capacity on known trash rocks.
16. Alarm for over load.
17. Identify location of trash dump site.
18. Preference not to dump in front of 18.
19. Compatibility with existing systems.
20. Appears like electrical panel adequate.
21. Spare parts readily available.
22. Avoid under water equipment which need maintenance.
23. Consider wind load in design.
24. Verify MFG claims.
25. Look at big picture.
26. Do we need diffusers?
27. What size/configuration can pass dam.

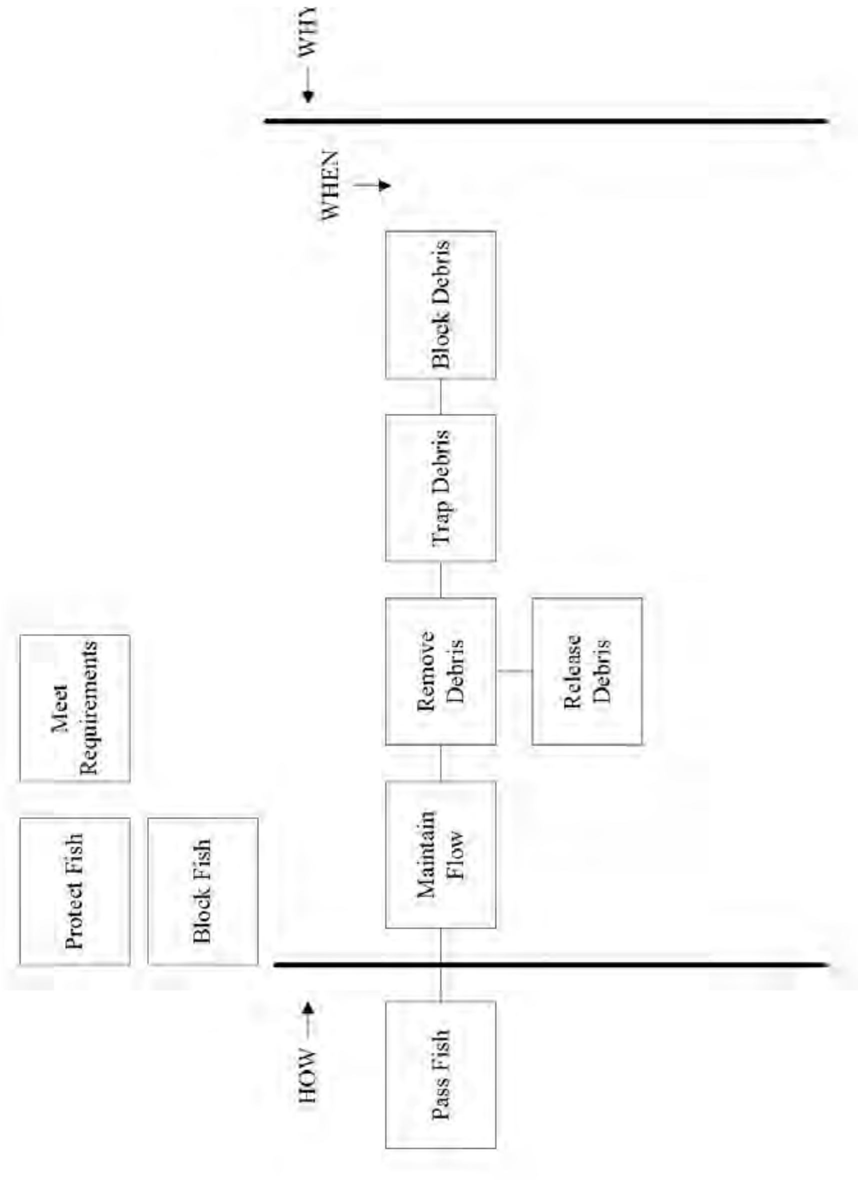
28. Is there another way to supply attraction water?
29. Fish units both generate power and regulate flow.
30. Multiple contracts may be needed to resolve issues.
31. Review lessons learned from JD similar project.
32. System will require monitoring for operation. (Semiautomatic probably preferred by OPS)
33. Collect data on current season collection.
34. Assume lower trash rack will remain plated off for sediment. (Preferred by Scott)
35. Manual operation needs 4 people to operate.
36. At least 2 people required for operating supervising operation of semi-auto/auto system.
37. Operation does not want auto system from safety point.
38. Fail safe system port does not damage the rest of them,
39. Needs manual open if failure.
40. Structural integrity of supporting elements.
41. Can the existing bucket be modified to be made useable?
42. Look at environmental bucket style system.
43. Gantry crane has both load and height restrictions (issue with rake in bone yard)
44. Need attraction water at night for Lamprey.
45. Float debris is not a preferred option.
46. Limit materials getting to AWS.
47. Do not know where material that floats at night. (Does it float?).
48. Clean all racks typical by crew in 5 hours.
49. Charter states trash rack/rack must to be effective.
50. Proven system preferred.
51. When hand cleaned find 10% obstructed.
52. Annual manual clean.
53. Bars 3/8"x1¼", 7/8" spacing (CLR)
54. Bars tear break.
55. Rack with removable panel for easier repair.
56. "Fry" wedge wire criteria screen with brush clean or air burst.
57. Problem: materials that stick between bars.
58. Bar spacing so close (5/8") can only weld one.
59. Shallow teeth may jam small materials between bars.
60. Trash rack bars 3/8" thick bend easily.
61. Bars rust become rough, trap more material.
62. 1" spacing traps pine cones/nuts.
63. Automated rake: Back hoe style with 10ft wide bucket.
    -120ft reach
64. Racks: S.S./plastic/fiberglass construction
65. Zebra mussel potential issue they attach.
66. Automatic.
67. Guide built into racks.
68. Clean manually in winter.
69. Sometimes 20' head differential.
70. Multiple strokes by rake (small areas) on rack rather than one large stroke.
71. Can pull racks in one day clean and reinstall

72. Smaller racks and more panels.
73. Trash that will pass through on diffuser.
74. Fish passage March 1 – Nov 30.
75. Fish units supply station service.
76. During "winter" at least 1 unit runs.
77. Every other year units out of service typically.
78. Will assess debris at diffusers this year.
79. Structural report from FY12 says grating okay 6-8 years.
80. 2 Riggers needed to operate.
81. $3 mil construction.
82. Cannot obstruct Gantry crane
83. OPS keep operation on Gantry preference.
84. Have to pull racks out every 3-4 years to get sticks out.
85. Manually operate main unit rake.
86. Riggers only on site Monday through Thursday
87. Alignment of rack section
88. Rack dimensions – 9' to 44' top about 20' wide.
89. Height to deck for both rack 100'
90. Would like a system that could collect sand as well.
91. Brush system to clear rack.
92. High debris times (Apr-Jun) and (Sept-Nov)
93. Handle trash rake during day. Friday done as call out.
94. Call out during weekend.
95. Adequate light at night.
96. Some PDT to view.
97. Unknowns:
    a. Full length trash rake.
    b. Rack size (narrower increase load)

# APPENDIX C

## Function Analysis

## B2 Trash Rake FAST DIAGRAM



# APPENDIX D

## Creativity/Brainstorming

**FIRST IDENTIFICATION OF ALTERNATIVES**

A. Use existing system 'as is' with new racks per requirements. Modify rake as necessary. Include labor for 2 crews (4 staff each) for 6 months (high raking season) and 1 crew for 6 months (low raking season) in calculations (Ideas 26 and 36)
B. Use sinusoidal 2 layer rack that moves in and out to push debris which is collected by the rake. Additionally, add curtain across forebay to minimize debris getting to fish units (Ideas 23 and 59)
C. Use self-cleaning diffusers or mechanically operated diffusers to prevent diffuser blowout from debris collection. Use existing manual system or new automated rake system with mechanically assembled rack and upgrade existing rake if used. Identify area to unload debris (Ideas 9 and 10 along with either 26/3-8/16 or 27/3/16/28)
D. Use a catenary screen instead of rake with air sparging to get more debris into the existing rake basket along with a mechanically assembled rack (Ideas 11, 3, 12)
E. Along with 'A' above build a hydraulic feature (berm) in the forebay to direct the flow away from the fish units and toward the main units (Idea 39)
F. Consider different ways to construct the racks (Profile Bar; Mechanically Assembled) than welding, since the bar spacing is so close (Idea 3)
G. Develop a Design/Build Specification for a new rake and rack system. Shift the risking to the contractor in ensure it is a system the operators can and will use effectively whether manual; semiautomatic or automatic. (Ideas 27 and 65)
H. Install in the draft tube catenary screens at the required minimum opening and leave the existing rack the same bar spacing or wider and continue the manual rake. Catenary screens would dump material on the deck for disposal like other screens in the main units. (Ideas 1 or 11; 8, 16, 26, and, 45)
I. Construct the rack out of vertical pipe. Use a brush like system rather than a rake to remove debris. Add side grates and a top cover place to the existing rake to better contain material and maximum release of water. Increase the head differential to greater than 10 ft so more material is captured before raking begins. Add a forebay hydraulic feature (berm) to divert the flows away from the fish units. (Ideas 55, 4-7, 32, 37, 39, 44)
J. Install in the draft tube removable rack screens at the required minimum bar spacing and leave the existing rack the same bar spacing or wider and continue the manual rake. Removable rack would be manually pulled and cleaned. Use with an automatic or semi-automatic raking system (Ideas 1, 27, 28)
K. Same as J except, revise construction of racks to be mechanically fastened. (Ideas 1, 27, 28)
L. Create a perforated curtain or wall with foundation berm across the inlet to redirect flow and the debris to the main units and allows water into the fish units (Ideas 23, 53)

M. Install a floating curtain that only goes deep enough (assume 20 ft) to redirect flow and debris to the main units. Tiedowns to the bottom of the forebay would be required to anchor the curtain. (Ideas 23, 42, 52, 54)
N. For either manual or automatic system, design a rack with better draining characteristics, like grating on the sides for drainage. In addition, use Teflon or similar coating on racks so debris is removed more easily. Design a rake system with 'tines' that will not damage the coating (e.g. rubber) yet effectively remove the material (Ideas 6, and 33)
O. Use the automated rake system recommended in the 2001 DDR with mechanical fastened (Ideas 28, 42, 3, 57)
P. Construct and accordion shaped screen out of steel plate with holes rather than slots to pass flow. Rack revised so teeth would clear between the 'folds' of the screen (Idea 59)
Q. Create a screen across the inlet so the debris does not get through to the fish units (Idea 23)
R. Continue use of the manual rake system and upgrade to current requirements. Use a combination of a brush and tooth raking system to get the most material into the rack basket. The rake would engage the rack at the bottom. The brush would initially loosen the material rolling some into the basket. The teeth, on the same roller as the brush would dislodge the remaining material and dispose of it in the rake basket. (Idea 4 and 26)

**BRAINSTORMING**

1. Extra trash racks in draft tubes.
2. Replace diffuser grates with alternate flow element with fish impellor.
3. Use replaceable bars (Mech. Assembled trash rack).
4. Add a roller at top of basket to help remove debris. Modify bucket with roller at top to move the rake more easily.
5. Use plate over basket to contain debris.
6. Grating on side of basket.
7. Revise basket tooth design to better pull debris.
8. Use a roller (high revolution brush) on rake to remove debris.
9. Self cleaning diffuser by popping open and closing based on loads.
10. Mechanized diffuser (manual)
11. Continuous catenaries screen (cleaner) to remove debris that dumps onto deck.
12. Air sparging at base of trash rack to dislodge debris.
13. On diffuser use air burst to dislodge debris.
14. Use side diffuser instead of bottom diffuser.
15. Angle bars on rack in direction of the eddy.
16. Increase bar spacing so they can be repaired.
17. Use angles instead of bars for rack.

18. Find alternate source for attraction water.
19. Like #1, use intake gate slots.
20. Use trash vacuum instead of rake.
21. Open diffuser on upstream side automatic (similar to 9)
22. Use bubbler to scare "fish" (lamprey) from diffuser.
23. Create screen in bay so debris does not get to fish units. (See diagram)
24. Debris eating sharks.
25. Align bars horizontally rather than vertically.
26. Use existing manual rake operating system.
27. Use semi-automatic rake system that requires operator to activate.
28. Use automatic rake system that senses load and cleans.
29. Use swing screens that open toward (see diagram) Unit 18.
30. Use T-screens orient so eddy flow to help clean (see diagram).
31. Use rack with small replaceable sections.
32. Consider fatigue/harmonics of racks potentially use bars of different size and configuration to address issue.
33. Use stainless steel rack coated with Teflon to maintain smoothness so debris easier to remove.
34. Increase bar spacing at trash rack and use with mechanically operated diffuser to pass through system.
35. Add grinders behind trash rack or at diffuser.
36. Keep system as is. Add crew for nights and weekends; coordinate with times when an issue. May require 12 months staffing.
37. Increase head differential (from 10') so more debris can be collected before cleaning required.
38. Change powerhouse operations to enhance debris removal or minimize debris accumulation.
39. Build berm (hydraulic feature) in forebay to change direction of debris flow and direct toward main units.
40. Build intake at 90 (see diagram) angle to current flow
41. Use PLC controls with limit switches, alarms, etc.
42. Flow vane installed between fish units and main units to deflect debris to Unit 18
43. Use "Wedge wire" for racks.
44. Use pins to align rack to each other.
45. Profile bar for rack.
46. Mechanical rack that alternate bars move in and out cleaning the rack
47. Use wider bars for strength of rack (1/2 or 5/8 vs 3/8).
48. Burn/destroy all grass and trees upstream of dam.
49. Use a boat to rake surface material.

50. Use a floating dock to dispose of debris.
51. Use floating dock to mount rake.
52. (Similar to 23) Use curtain with depth to trap debris.
53. Combine 52 with 39.
54. Floating curtain that can be located in various locations.
55. Use staggered vertical pipe screen.
56. Use thicker shorter bars with stronger backing structure so rake does not need to go so deep.
57. Use tooth design on rake so support bars not push on bars.
58. Use a combination guide/brush system that cleans rack.
59. Use accordion system (see diagram) to flow area.
60. Could be sinusoidal instead of triangular.
61. Top hinge rack that rotates up and dumps trash.
62. Extend intake into fore bay (see diagram)
63. Use “fan blade” behind rack to cut/mince grass debris.
64. Submersible rake that floats “up and down”
65. Hire Experts with rakes design/ BLT.

# APPENDIX E

## Evaluation Methodology

## PAIRED COMPARISON SCORING FOR EVALUATION CRITERIA

Preferred Criteria

If both meet criteria, which is more important to improve: Score (1= slightly more important; 3= significantly more important)

| | EVALUATION CRITERIA | A | B | C | D | E | F | G | H | I | J | K | L | M | N | | RAW SCORE | %-AGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | FLOW DELIVERY | | | | | | | | | | | | | | | A | 6 | 3.6 |
| B | SCHEDULE | A 2 | | | | | | | | | | | | | | B | 0 | 0.0 |
| C | OPERABILITY | C 2 | C 3 | | | | | | | | | | | | | C | 14 | 8.3 |
| D | MAINTAINABILITY | D 3 | D 3 | C 1 | | | | | | | | | | | | D | 18 | 10.7 |
| E | FLEXIBILITY | E 1 | E 2 | C 1 | D 2 | | | | | | | | | | | E | 7 | 4.2 |
| F | RELIABILITY | F 3 | F 3 | F 2 | F 2 | F 3 | | | | | | | | | | F | 25 | 14.9 |
| G | COMPATABILITY | G 1 | G 1 | C 2 | D 2 | E 1 | F 2 | | | | | | | | | G | 4 | 2.4 |
| H | SUPPLY POWER | A 2 | H 1 | C 3 | D 3 | E 1 | F 3 | G 1 | | | | | | | | H | 2 | 1.2 |
| I | "FISH" FRIENDLY | I 3 | I 3 | I 1 | D 1 | I 2 | F 1 | I 2 | I 3 | | | | | | | I | 16 | 9.5 |
| J | DURABLE | J 2 | J 3 | J 1 | D 1 | J 2 | F 1 | J 2 | J 2 | J 1 | | | | | | J | 15 | 8.9 |
| K | CONSTRUCTABILITY | A 1 | K 1 | C 2 | D 3 | E 1 | F 3 | G 1 | H 1 | I 2 | J 2 | | | | | K | 1 | 0.6 |
| L | HIGH CONFIDENCE OF SUCCESS | L 3 | L 3 | L 2 | L 2 | L 2 | L 2 | L 2 | L 3 | L 1 | L 1 | L 3 | | | | L | 28 | 16.7 |
| M | REDUNDANCY | M 3 | M 2 | M 1 | M 1 | E 1 | F 1 | M 2 | M 2 | M 1 | M 1 | M 2 | L 2 | | | M | 17 | 10.1 |
| N | LABOR INTENSITY | N 1 | N 3 | N 1 | N 1 | N 1 | F 1 | N 2 | N 2 | N 1 | N 1 | N 2 | L 2 | M 2 | | N | 15 | 8.9 |
| | | | | | | | | | | | | | | | | TOTAL | 168 | 100 |

## ALTERNATIVE RANKING

| EVALUATION CRITERIA | | FACTOR | ALT #01 | ALT #02 | ALT #03 | ALT #04 | ALT #05 | ALT #07 | ALT #09 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TEAM DROPPED | | | |
| A | FLOW DELIVERY | 3.6 | 5 | 4 | 7 | | 4 | 7 | 6 |
| | | | 17.86 | 14.29 | 25 | 0 | 14.29 | 25 | 21.43 |
| B | SCHEDULE | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C | OPERABILITY | 8.3 | 7 | 4 | 9 | | 4 | 9 | 4 |
| | | | 58.33 | 33.33 | 75 | 0 | 33.33 | 75 | 33.33 |
| D | MAINTAINABILITY | 10.7 | 5 | 8 | 5 | | 7 | 5 | 5 |
| | | | 53.57 | 85.71 | 53.57 | 0 | 75 | 53.57 | 53.57 |
| E | FLEXIBILITY | 4.2 | 6 | 6 | 8 | | 6 | 8 | 6 |
| | | | 25 | 25 | 33.33 | 0 | 25 | 33.33 | 25 |
| F | RELIABILITY | 14.9 | 6 | 7 | 8 | | 7 | 7 | 7 |
| | | | 89.29 | 104.2 | 119 | 0 | 104.2 | 104.2 | 104.2 |
| G | COMPATABILITY | 2.4 | 7 | 9 | 8 | | 7 | 8 | 7 |
| | | | 16.67 | 21.43 | 19.05 | 0 | 16.67 | 19.05 | 16.67 |
| H | SUPPLY POWER | 1.2 | 5 | 4 | 6 | | 4 | 6 | 6 |
| | | | 5.952 | 4.762 | 7.143 | 0 | 4.762 | 7.143 | 7.143 |
| I | "FISH" FRIENDLY | 9.5 | 6 | 6 | 8 | | 7 | 8 | 7 |
| | | | 57.14 | 57.14 | 76.19 | 0 | 66.67 | 76.19 | 66.67 |
| J | DURABLE | 8.9 | 4 | 6 | 5 | | 7 | 8 | 4 |
| | | | 35.71 | 53.57 | 44.64 | 0 | 62.5 | 71.43 | 35.71 |
| K | CONSTRUCTABILITY | 0.6 | 6 | 8 | 1 | | 6 | 6 | 6 |
| | | | 3.571 | 4.762 | 0.595 | 0 | 3.571 | 3.571 | 3.571 |
| L | HIGH CONFIDENCE OF SUCCESS | 16.7 | 6 | 6 | 8 | | 7 | 5 | 7 |
| | | | 100 | 100 | 133.3 | 0 | 116.7 | 83.33 | 116.7 |
| M | REDUNDANCY | 10.1 | 6 | 4 | 7 | | 7 | 7 | 4 |
| | | | 60.71 | 40.48 | 70.83 | 0 | 70.83 | 70.83 | 40.48 |
| N | LABOR INTENSITY | 8.9 | 6 | 3 | 8 | | 2 | 8 | 3 |
| | | | 53.57 | 26.79 | 71.43 | 0 | 17.86 | 71.43 | 26.79 |
| TOTAL | | 100.0 | 577.4 | 571.4 | 729.2 | 0 | 611.3 | 694 | 551.2 |
| ORDER OF MAGNITUDE FIRST COST (in $1000) | | | $2,400 | $1,600 | $5,600 | | $2,000 | $2,000 | $2,000 |
| COST PER POINT | | | $4.16 | $2.80 | $7.68 | #DIV/0! | $3.27 | $2.88 | $3.63 |
| ORDER OF MAGNITUDE LIFE CYCLE COST (in $1000) | | | $5,000 | $7,100 | $6,000 | | $8,000 | $7,500 | $7,500 |
| COST PER POINT | | | $8.66 | $12.43 | $8.23 | #DIV/0! | $13.09 | $10.81 | $13.61 |
| | | | | | | | Includes Alt 2 costs | Includes Alt 2 costs | Includes Alt 2 costs |

# APPENDIX F

## Alternative 03

## Summary Modeling Results

The VE study recommended a wall perpendicular to the powerhouse placed north of unit 18 with a goal of blocking debris from moving into the fish units. The recommendation was based on the large eddy that forms along the North Shore with debris circulating and ultimately going through the fish units. Thus the thought of the wall was to keep the debris with the majority of the river which passes through the main units.

Computation Fluid Dynamics (CFD) modeling was used to evaluate the various alternatives. Neutrally buoyant particles and streamlines were used to describe debris movement. The CFD modeling effort is documented in an Appendix to the DDR. The key findings are summarized here. Figure 1 shows the B2 bathymetry in and around the north shore. The things to note are the abrupt change in bathymetry as you move into the turbine intakes, the expansion of the forebay channel to the north just upstream of the fish units and the invert elevation of the fish units are higher than the invert elevation of the main units. The steep slope and the angle of the approach flow exacerbate the rotation of the flow horizontally and vertically.

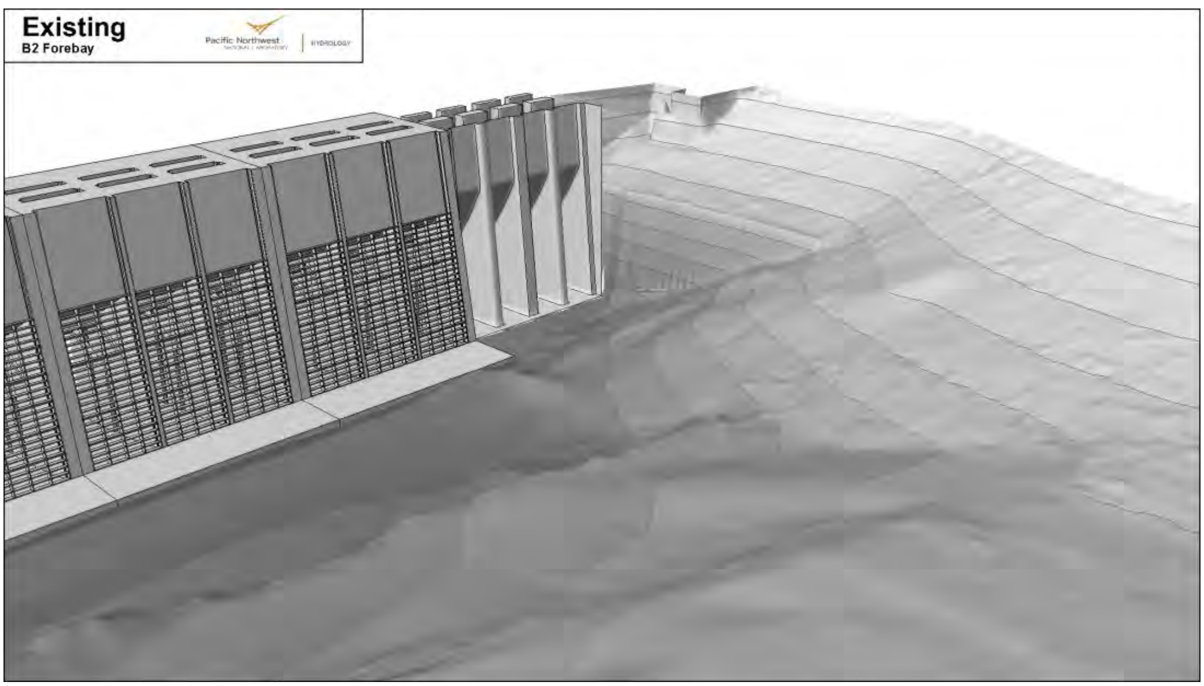



Figure 1 – B2 Geometry near the Fish Units

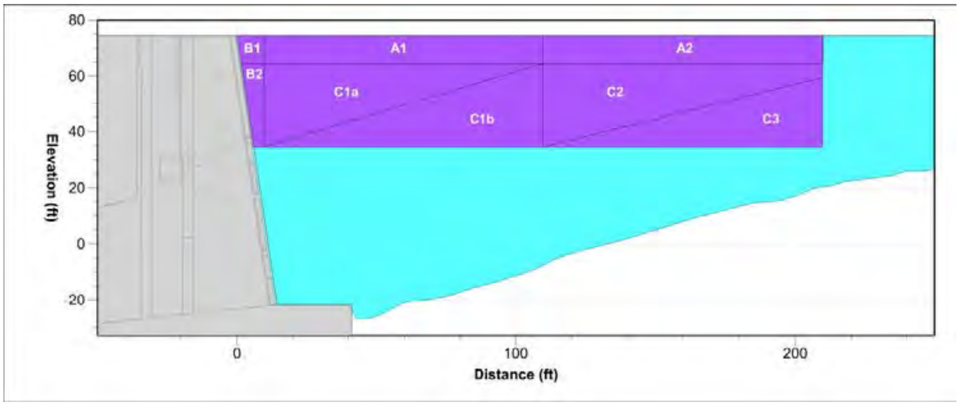



Figure 2 Wall Configurations. See Appendix X for configurations tested in the CFD.

Some of the wall configurations that were evaluated in the CFD model are shown in Figure 2. Generally the results were similar for all configurations tested – the wall tended to starve the available flow to the fish units and flow would dive under the wall. Wall Configuration tested included all sections, just A sections, and A + B + C1a. Details in Appendix X, Figure 2.4. Figure 3 shows streamtraces for clean forebay (no walls) and Figure 4 shows streamtraces with wall 3 (see Appendix x). Generally, the streamtraces end up in the north shore eddy and pass through the fish units.

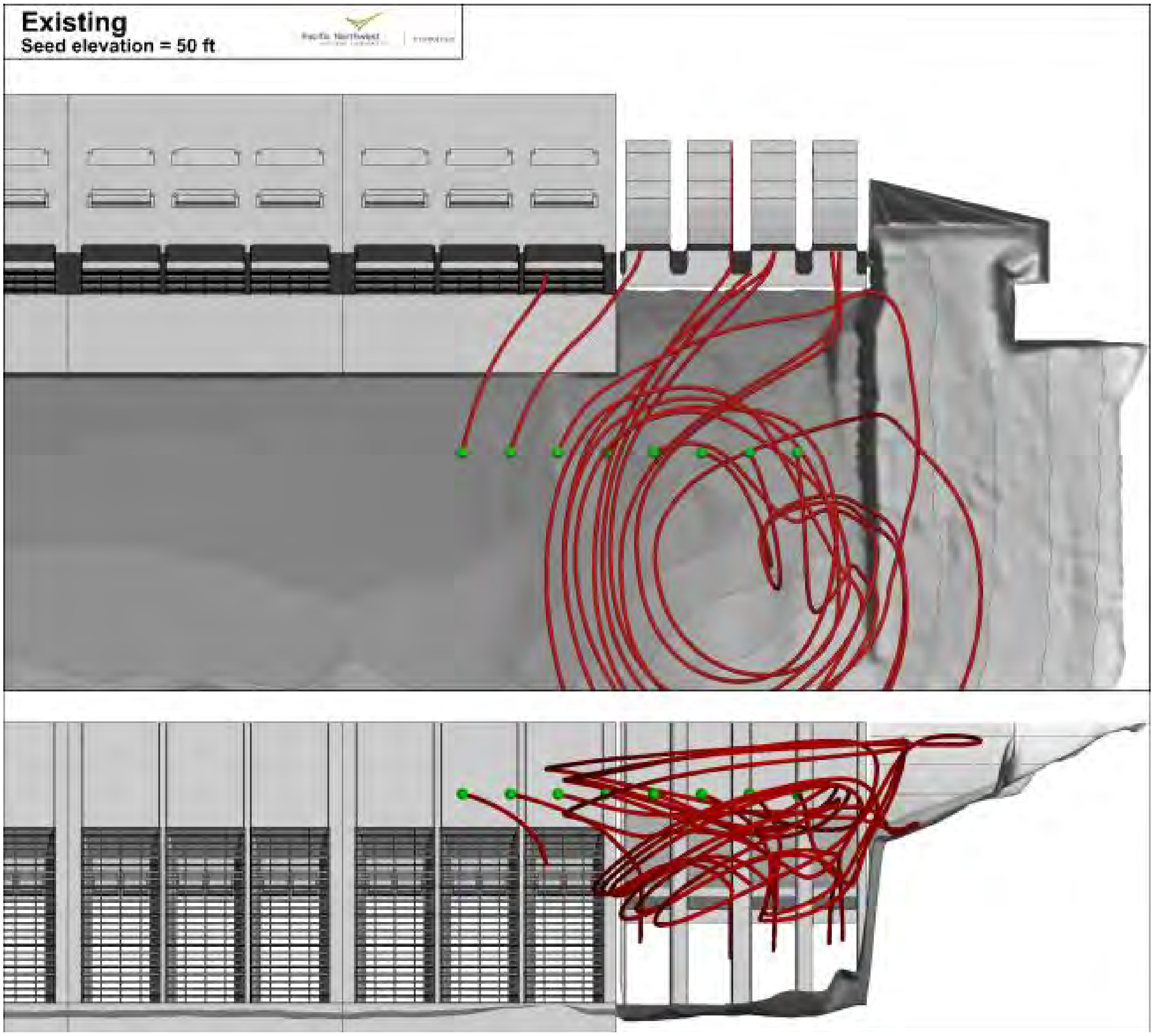



Figure 3 – Streamtraces with clean forebay.

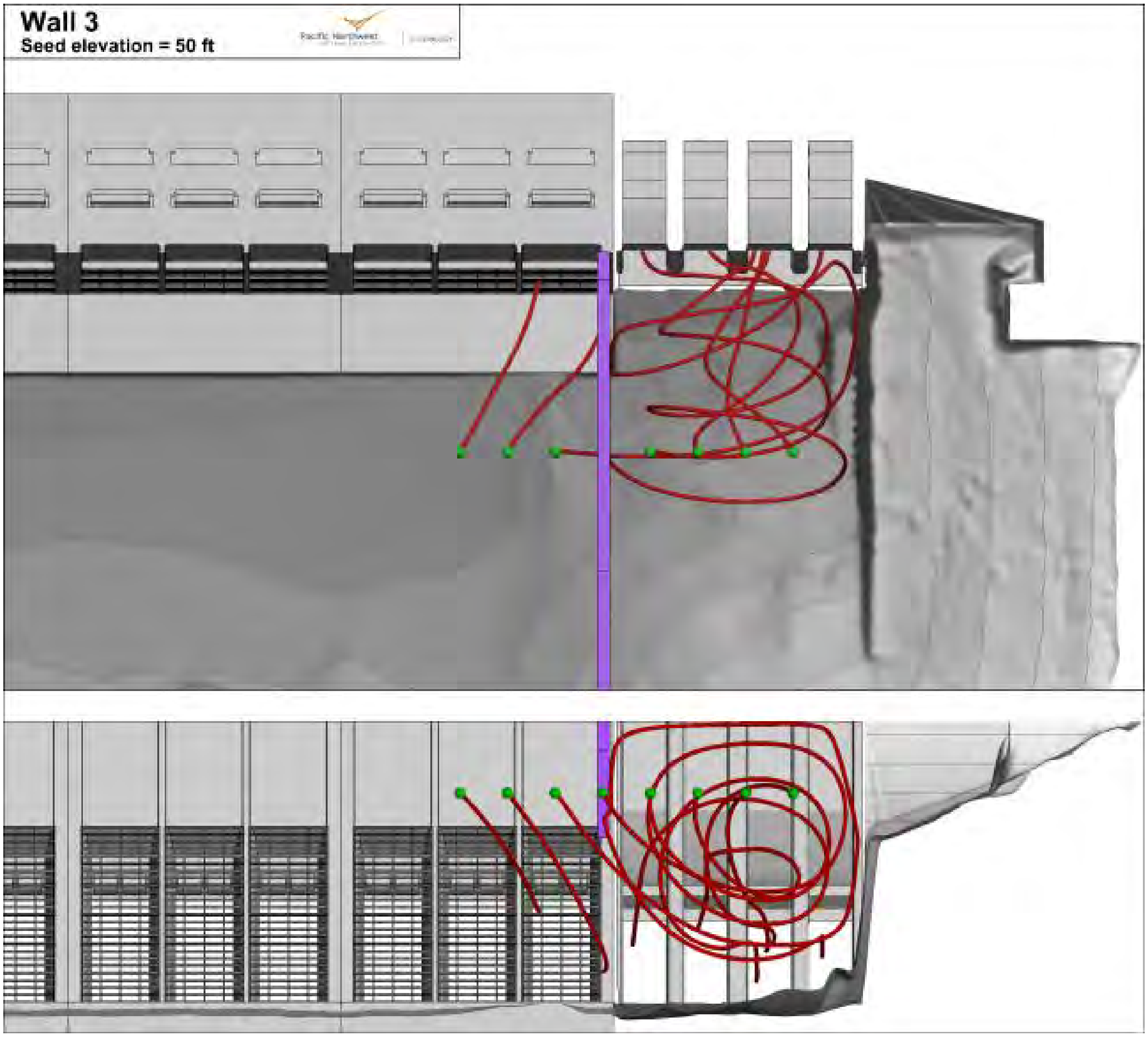



Figure 4 – Streamtraces with variable depth wall in place.

A full depth wall would starve the unit of flow due to the abrupt expansion of the forebay and abrupt change in the flow depth just upstream of the fish units – impacting their efficiency. In addition, any fish north of the wall would be trapped with the only exit being through the fish unit. The CFD results suggest that the way to improve the flow conditions along the north shore of B2 would be to excavate the B2 approach channel to the fish units providing smoother flow conditions with reduced vertical and horizontal recirculation.

# APPENDIX G

## Agenda, Meeting Attendance, and Value Engineering Study Team

# FACILITATED CHARRETTE WORKSHOP AGENDA

| | |
|---|---|
| Projects: | B2 Trash Rack |
| Dates: | 7-8, 13-15 November 2012 |
| Location: | U.S. Army Corps of Engineers<br>NWP |
| Facilitator: | Jason M. Weber, SE, AVS |

| | | | |
|---|---|---|---|
| Team: | Eric Stricklin | Ben Filan | Don Courson |
| | Scott McFarlane | Karen Kuhn | Jon Rerecich |
| | Rick Russell | Carolyn Schneider | Jerry Maurseth |
| | David Wingerd | Donald Sachs | |

## AGENDA

(Times are approximate)

**Wednesday, 7 November 2012: What is the Problem**

0715 **Depart for Bonneville Dam**

For those Traveling to Bonneville, meet in Lobby at Second Street side of Robert Duncan Plaza (RDP)

0830 **Arrive at Bonneville Dam Service Center**

Stop at Auditorium for Badges.

0900-0945 **Introductions**

Jason will lead team introductions and then introduce the process to accomplish the Design Charrette

0945-1015 **Preliminary Concept**

Ben will discuss the preliminary concept

| | |
|---|---|
| 1015-1200 | **Site Visit**<br>Travel to the location of the Proposed Trash Rack |
| 1200-1300 | **Lunch**<br>Working Lunch – General discussion of observations |
| 1300-1400 | **Issues and Concerns**<br>Document the Observations as well as the constraints, assumptions, quality objectives, key agreements, evaluation criteria, action items |
| 1400-1415 | **Break** |
| 1415-1600 | **What is the Problem**<br>A group of activities and exercises led by Jason to answer this question regarding this project |
| 1600 | **Depart for RDP** |

**Wednesday, 8 November 2012: What is the Risk**

| | |
|---|---|
| 0715 | **Depart for Bonneville Dam**<br>For those Traveling to Bonneville, meet in Lobby at Second Street side of Robert Duncan Plaza (RDP) |
| 0815 | **Arrive at Bonneville Dam Auditorium** |
| 0830-0945 | **Review of Previous Day**<br>Add to established information |
| 0945-1000 | **Break** |

| | |
|---|---|
| 1000-1100 | **Review and compile: What is the Problem**<br>Compare and consolidate |
| 1100-1200 | **Evaluation Criteria**<br>Establish rating criteria and determine preliminary weighting |
| 1200-1300 | **Lunch**<br>Lunch –Relax |
| 1300-1430 | **Risk Analysis**<br>Review of what risk is and how the team will address it. Follow with identification of the risks related to the project. |
| 1430-1445 | **Break** |
| 1445-1600 | **Risk Analysis conclude**<br>Brainstorming solutions on risks identified. |
| 1600 | **Depart for RDP** |

**Tuesday, 13 November 2012:** **What is to be Done?**

| | |
|---|---|
| 0800-0900 | **Meet at RDP on Third Floor, Room 3G Review of Previous Day**<br>Review Site visit information |
| 0900-1030 | **Define the Functions**<br>Develop FAST Diagram based on previous weeks Functions |
| 1030-1045 | **Break** |
| 1045-1200 | **Creative Phase**<br>Brainstorm Idea based on the functions without judgment |

1200-1300 **Lunch**

Lunch –Relax

1300-1400 **Creative Phase part 2**

1400-1500 **Evaluations Consensus**

Review ideas developed as a group and determine which are non-starters based on the evaluation criteria

1500-1515 **Break**

1515-1645 **Identify Alternatives and Design Suggestions to Develop**

Based on the evaluation of the brainstorm ideas determine if any can be combined. Identify who will develop which Alternatives and Design Suggestions.

1645-1700 **Review the Day**

1700 **Conclude for the day**

**<u>Wednesday, 14 November 2012:</u> Defining the Alternatives**

0800-1700 **Develop Alternatives**

Team works individually and in groups to develop Alternatives and Design Suggestions

**<u>Thursday, 15 November 2012:</u> Workshop Conclusion**

0800-1100 **Complete Alternative and Design Suggestion Development**

Review Site visit information

1100-1200 **Team Presentations**

Team members present their ideas to the group

1200-1300 **Lunch**

Lunch –Relax

1300-1430 **Evaluation Matrix**

Develop a pair-comparison Evaluation Criteria Matrix

1430-1445 **Break**

1445-1630 **Evaluate Alternatives**

Evaluate each alternative using the Evaluation Matrix. Determine which Alternatives provide the most benefit to the Project

1630-1700 **Review and Conclude**

Review the results of the Charrette. Identify benefits and areas of improvement for the effort. Identify Alternatives or Design Suggestions that need more work to complete and assign team member to complete.

1700 **Conclude Workshop**

## B2 Trash Rack Facilitated Design Charrette Attendance

### 7-8, 13-15 November 2012

| **Name/Email**<br>(usace.army.mil assumed unless otherwise noted) | **Office** | **7** | **8** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|
| **Jason.M.Weber** | CENWP-EC-T | X | X | X | X | X |
| **Eric.T.Stricklin** | CENWP-PM-FP | X | X | | | |
| **Benjamin.J.Filan** | CENWP-EC-DM | X | X | X | X | X |
| **Jordan.D.Reimer** | CENWP-EC-DS | X | X | | X | |
| **Karen.A.Kuhn** | CENWP-EC-HD | X | X | X | X | X |
| **Scott.E.McFarlane** | CENWP-EC-DE | X | X | X | X | X |
| **Ricky.L.Russell** | CENWP-EC-CC | X | X | X | X | X |
| **Jonathan.G.Rerecich** | CENWP-PM-E | X | X | X | | X |
| **Jerome.A.Maurseth** | CENWP-EC-DS | X | X | X | X | X |
| **Donald.R.Courson** | CENWP-HDC | X | X | X | | X |
| **Caroline.B.Schneider** | CENWP-PM-E | X | X | | | |
| **Don Sachs**<br>hijkj@cox.net | CECO-C-RAO | X | X | X | X | X |
| **David Wingerd**<br>david.wingerd@gmail.com | CECO-C-RAO | X | X | X | X | X |
| **Scott Bennett** | OD-B | X | X | | | |
| **Edward.W.Carroll** | OD-B | X | | | | |
| **Michael.D.Adams** | OD-B | X | | | | |
| **Roger.C.Moody** | OD-B | X | | | | |
| **Andy DeBriae** | Construction (Contractor) | | X | | | |

**Value Engineering Team Roster**

| Team Member Name | Company | Role |
|---|---|---|
| Jason Weber | CENWP-EC-T | Facilitator |
| Eric Stricklin | CENWP-PM-FP | Project Manager |
| Ben Filan | CENWP-EC-DM | TL/Mechanical |
| Jordan Reimer | CENWP-EC-DS | Structural |
| Karen Kuhn | CENWP-EC-HD | Hydraulics |
| Scott McFarlane | CENWP-EC-DE | Electrical |
| Rick Russell | CENWP-EC-CC | Cost |
| Don Courson | CENWP-HDC | Mechanical |
| Jerry Maurseth | CENWP-EC-DS | Sr. Structural |
| Don Sachs | CECO-C-RAO | Sr. Mechanical |
| Dave Wingerd | CECO-C-RAO | Sr. Hydraulics |
| Jon Rerecich | CENWP-PM-E | Fish Biologist |
| Caroline Schneider | CENWP-PM-E | Environmental |

# APPENDIX F

# RAKE MODIFICATION COST ESTIMATE

## *Engineering Cost Estimate*

**Bonneville Auxillary Water Supply Trash rake**

| Material | Qty | Cost each | Total |
|---|---|---|---|
| 1/4" A36 plate 5'x10' | 11 | $400.00 | $4,400.00 |
| 5"x5" sqr. Tube 20 ft length | 2 | $300.00 | $600.00 |
| UHMW 3/4" thick plate | 6 | $225.00 | $1,350.00 |
| Misc. Fasteners | 1 | $1,500.00 | $1,500.00 |
| 3/8" plate 4'X8' | 2 | $380.00 | $760.00 |
| Aluminum Rod | 4 | $2.00 | $8.00 |
| | | **Total** | **$8,618.00** |

| | Qty | Cost each | Total |
|---|---|---|---|
| Machine cost for perf plate | 11 | $727.27 | $8,000 |
| Brushes with nylon bristles | 20 | $200.00 | $4,000.00 |
| | | **Total** | **12,000.00** |

| Project Labor | | | |
|---|---|---|---|
| Riggers/Welders/Painters | 400 | $90.00 | 36,000.00 |
| OD-B Tech Staff | 30 | $110.00 | 3,300.00 |
| Design Staff | 30 | $98.00 | 2,940.00 |
| | | **Total** | **42,240.00** |

| | | | |
|---|---|---|---|
| Total Cost | | | **62,858.00** |
| Contingency (10%) | | | 6,285.80 |
| | | Total | ***69,143.80*** |

# APPENDIX G

# CFD ANALYSIS

PNNL-22654

US Army Corps
of Engineers

Prepared for the U.S. Army Corps of Engineers, Portland District,
under an Interagency Agreement with the U.S. Department of Energy
Contract DE-AC05-76RL01830

# Bonneville Powerhouse 2 Fish Unit Sedimentation Studies: CFD Model of the Forebay with Structural Alternatives

CL Rakowski
JA Serkowski
PDJ Romero-Gomez
MC Richmond

August 2013

Pacific Northwest
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PNNL-22654

# Bonneville Powerhouse 2 Fish Unit Sedimentation Studies: CFD Model of the Forebay with Structural Alternatives

CL Rakowski
JA Serkowski
PDJ Romero-Gomez
MC Richmond

Hydrology Group
Pacific Northwest National Laboratory
Richland, WA 99352

Prepared for:
U.S.Army Corps of Engineers, Portland District
Portland, OR

August 2013

# Summary

The U.S. Army Corps of Engineers, Portland District (CENWP) is engaged in a continuing effort to improve passage conditions for anadramous salmon species in the Columbia River. Part of that program includes the operation of fish units and an auxiliary water supply (AWS) at Bonneville Powerhouse 2. A recent maintenance project removed large amounts of sediment and woody debris from downstream of the fish units. CENWP would like to reduce the debris entering the fish units from the forebay to reduce the need for periodic maintenance operations. It is believed that a large quantity of sediment and debris are trapped in the eddy that forms just upstream of the fish units. As floating debris becomes waterlogged and sinks, it passes through the fish units and then is deposited downstream.

In this study, a computational fluid dynamics model was used to simulate forebay flow patterns upstream of the fish units for a single project operation with the existing forebay and for several proposed wall configurations. These walls were expected to reduce the recirculating flows that lead to debris and sediment entering the fish units. Model results indicate that, while the addition of the various walls did change the flow patterns, none of the configurations greatly reduced the recirculating flow as desired.

The bathymetry in front of the fish units makes it difficult to reduce or eliminate recirculation without altering the bathymetry through filling and excavation. Future studies could include evaluating these alternatives.

# Abbreviations and Acronyms

| | |
|---|---|
| 3D | three dimensional |
| ADCP | acoustic Doppler current profiler |
| B2 | Bonneville Powerhouse 2 |
| B2CC | Bonneville Powerhouse 2 corner collector |
| CENWP | U.S. Army Corps of Engineers, Portland District |
| cfs | cubic feet per second |
| CFD | computational fluid dynamics |
| ft/s | feet per second |
| GIS | geographic information system |
| kcfs | thousand cubic feet per second |
| MAE | mean absolute error |
| PNNL | Pacific Northwest National Laboratory |
| RANS | Reynolds-averaged Navier-Stokes |
| s | second |
| STL | stereolithography |
| UD | upwind differencing |
| USACE | U.S. Army Corps of Engineers |
| vmag | velocity magnitude |

# Acknowledgments

Financial support for this study was provided by the U.S. Army Corps of Engineers (USACE) under MIPR W66QKZ30522157. The authors would like to thank Laurie Ebner and Karen Kuhn (USACE, Portland District) for the discussions, support, and insight that improved this study. The Pacific Northwest National Laboratory Institutional Computing (PIC) resources were used for this work.

# Contents

# Figures

# Tables

# 1.0 Introduction

The U.S. Army Corps of Engineers, Portland District (CENWP) is engaged in a continuing effort to improve passage conditions for anadramous salmon species in the Columbia River. Part of that program includes the operation of fish units and an auxiliary water supply (AWS) at Bonneville Powerhouse 2. A recent maintenance project removed large amounts of sediment and woody debris from downstream of the fish units. CENWP would like to reduce the debris entering the fish units from the forebay to reduce the need for periodic maintenance operations. It has been observed that the eddy just upstream of the fish units has large quantities of recirculating debris. It is believed that the debris becomes waterlogged, sinks, and enters the fish units. In addition, large quantities of sediment pass through the fish units and settle just downstream of their exit which has required excavation. Passing the bulk both the woody debris and sediment through the main units is a more desired outcome.

Previously, researchers at Pacific Northwest National Laboratory (PNNL) developed a three-dimensional (3D) computational fluid dynamics (CFD) model of the Bonneville Project forebay (Figures 1.1 and 1.2) for CENWP (Rakowski et al. 2010) to model the effects of project operations and the presence of a behavioral guidance system (BGS) on forebay hydraulics. The CFD model used in Rakowski et al.( 2010) work was used as a guide in this work, however the CFD model was migrated into the modern version of the code, STAR-CCM+ (ADAPCO, Computational Dynamics Limited 2013) from STAR-CD (ADAPCO, Computational Dynamics Limited 2006).

The objectives of this study were as follows:

- Move the Bonneville forebay CFD model from STAR-CD into STAR-CCM+ to increase flexibility for future models.

- Incorporate the most up-to-date bathymetry and turbine intake geometry into the new model.

- Validate the modified CFD model to field-measured acoustic Doppler current profiler (ADCP) data collected in 2000 (ENSR 2000).

- Run operational and structural scenarios and provide an analysis of resulting flow patterns simulated by the CFD model.

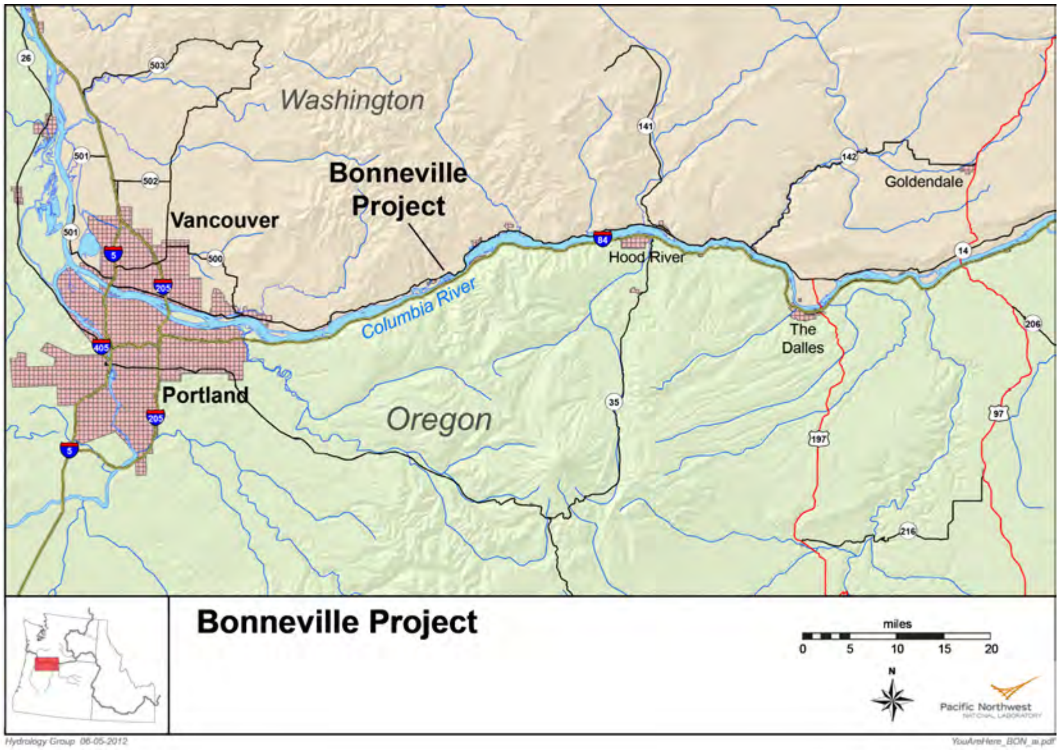


**Figure 1.1.** Location of the Bonneville Project

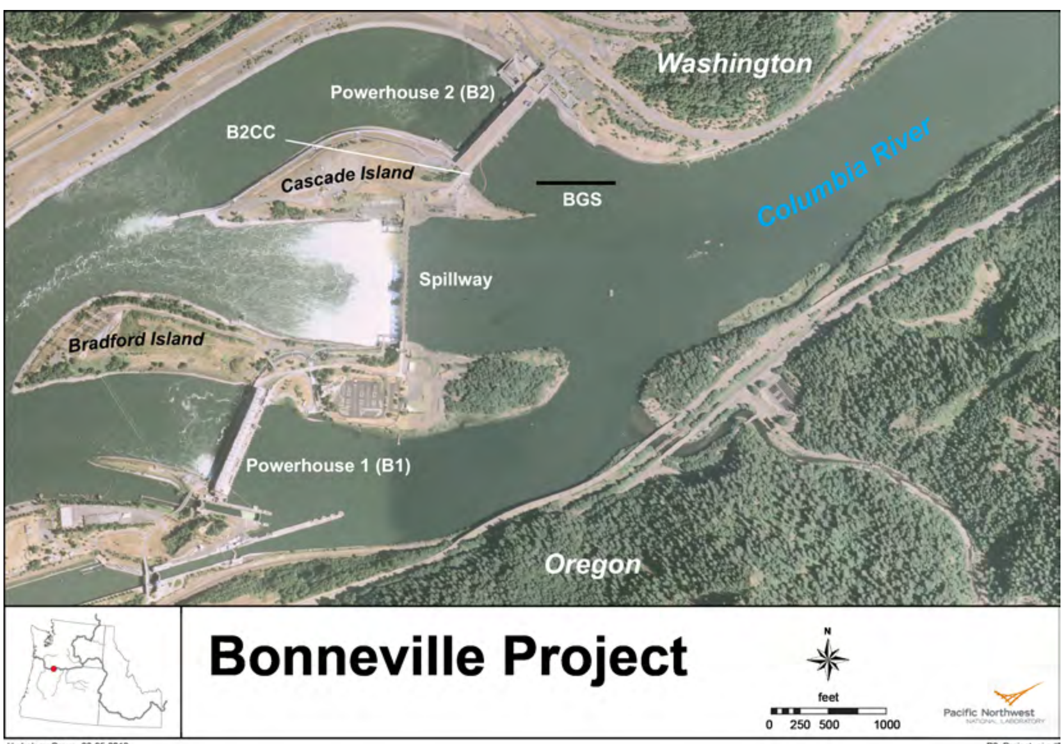


**Figure 1.2.** Detail of the Bonneville Project.

# 2.0 Methods

The methods described below include the CFD modeling approach, mesh development, model validation, operational scenarios, inclusion of the structural alternatives in the model, and analysis of results.

## 2.1 Modeling Approach

The CFD model was generally based on the approach described by Rakowski et al., 2005), but as part of the project it was deemed necessary to bring the existing models forward into the modern version of the CFD solver code. A commercial CFD software, STAR-CCM+ v8.02 (ADAPCO, Computational Dynamics Limited 2013), was used as the flow solver for this study. The code is a Reynolds-averaged Navier-Stokes (RANS) finite volume code. The simulations were performed using the following code options: steady state, RANS, and k-$\varepsilon$ high-Reynolds number turbulence closure with a standard wall function. The model was configured with a specified inflow for the upstream boundary, and the outflows specified for each bay of each turbine at Powerhouse 2 and each bay of the spillway but one. One forebay "outlet" was used as a pressure boundary and the flow volume through that pressure boundary used to check the model configuration. Bonneville Powerhouse 1 turbine intakes were not included and flows in that section of the model were split into two sections: Units 1 through 6 and Units 7 through 10.

Mass fluxes (kg/s) were calculated for each boundary based discharge. Flow splits for the B2 turbine intakes were 37.8, 34.2, and 28% for Bays A, B, and C, respectively. These splits were based on 1:25 reduced-scale physical model measurements (Davidson 2000) and have been used in past CFD studies.

The model was run until residual tolerances were reduced to 1e-4. Both first-order and second-order advection schemes were tested.

## 2.2 Mesh Development

In STAR-CCM+, the mesh can be created by the software if a "watertight" geometry exists of the fluid domain. It is also possible to create and link multiple regions making it possible to speed a given application by removing unneeded portions of the model from the computational domain. For example, as this study was focused on sedimentation near the fish units of B2, it was not necessary to include the vertical barrier screens (VBS, found above the turbine intakes) in the model. This reduces the number of cells in the model without compromising the results for this application. However, the underlying geometry of the vertical barrier screens was preserved in the model file for future applications. Separate regions were created for the B2 powerhouse without VBS, the B2 powerhouse VBS, the B2 forebay, and the rest of the Bonneville forebay (composed of the upstream section, the spillway forebay, and B1 forebay).

### 2.2.1 The Spillway, Turbine Intake, and Full Powerhouse

In previous work, a detailed mesh of the B2 intakes, including trashracks, was created by CENWP for a single B2 intake. That mesh of a single turbine intake was translated and duplicated to create the full B2 powerhouse (Rakowski et al. 2010) for use in a STAR-CD model. The geometry for the powerhouse and fish units was extracted from the STAR-CD model and repaired as needed in STAR-CCM+ and boundary locations assigned. These data were used for the underlying geometry for mesh creation and were integrated into the forebay bathymetry.

Geometry for the full Bonneville spillway was created for another study (Rakowski et al. 2012b). These data for the forebay piers and spill bays up to the ogee crest were included in this model.

### 2.2.2 Forebay Bathymetry and Integration with the Powerhouse Geometry

Newer bathymetric surveys for the Bonneville forebay were provided by CENWP. Those point data were used to create a bathymetric surface using Tecplot tools.

The river-channel bathymetry was modeled from the dam to a point about 6000 ft upstream of the spillway and up to an elevation of 80 feet. The bathymetric surface was created with a geographic information system (GIS) application (ArcGIS$^{TM}$ version 10.1 from ESRI, Inc.). Source data, provided by USACE, included a channel transect survey conducted in 1998, multi-beam bathymetric surveys conducted in 2010 and 2013 (Figure 2.1) and a 2010 LiDAR survey. The 2013 survey was performed after dredging in February of that year of the region immediately in front of the fish unit. The bathymetric survey data was augmented with manually digitized contour and control lines to improve the interpolation in areas where data were lacking and to provide proper connection to the CAD model of the dam structure. The GIS application interpolated the elevation data onto a square-element mesh divided, to reduce file size, into three resolution regions. The finest resolution occurs in the forebay of the second powerhouse, where the mesh size is about 3 ft (1 m). In the forebays of the spillway and first powerhouse, the mesh coarsens to 16 ft. The remainder of the surface has a mesh resolution of 33 ft (10 m). The surface grid was exported to stereolithographic (STL) format for CFD-model mesh generation. The resultant bathymetry surface is shown in Figure 2.2.

In this study, several structural alternatives were considered which included 1) adding a floating wall in several different configurations and 2) modifying the bathymetry by adding a berm upstream of the powerhouse that connected to the Washington shore. To more simply accommodate these alternatives in the CFD model, two areas of the B2 forebay were extracted as separate regions: the berm and the wall. Figure 2.3 shows a sectional view of the wall region extracted the bathymetry below it.

The bathymetry was joined to the "concrete" of the engineered structures of the B2 powerhouse and the spillway. A single "watertight" geometry was created then the volume below elevation 74.5 ft extracted.

The resultant geometry was separated into regions to improve the post-processing performance. The regions included:

- gatewells and VBS area above the B2 intakes,
- the rest of the B2 turbine intakes including the trashracks,

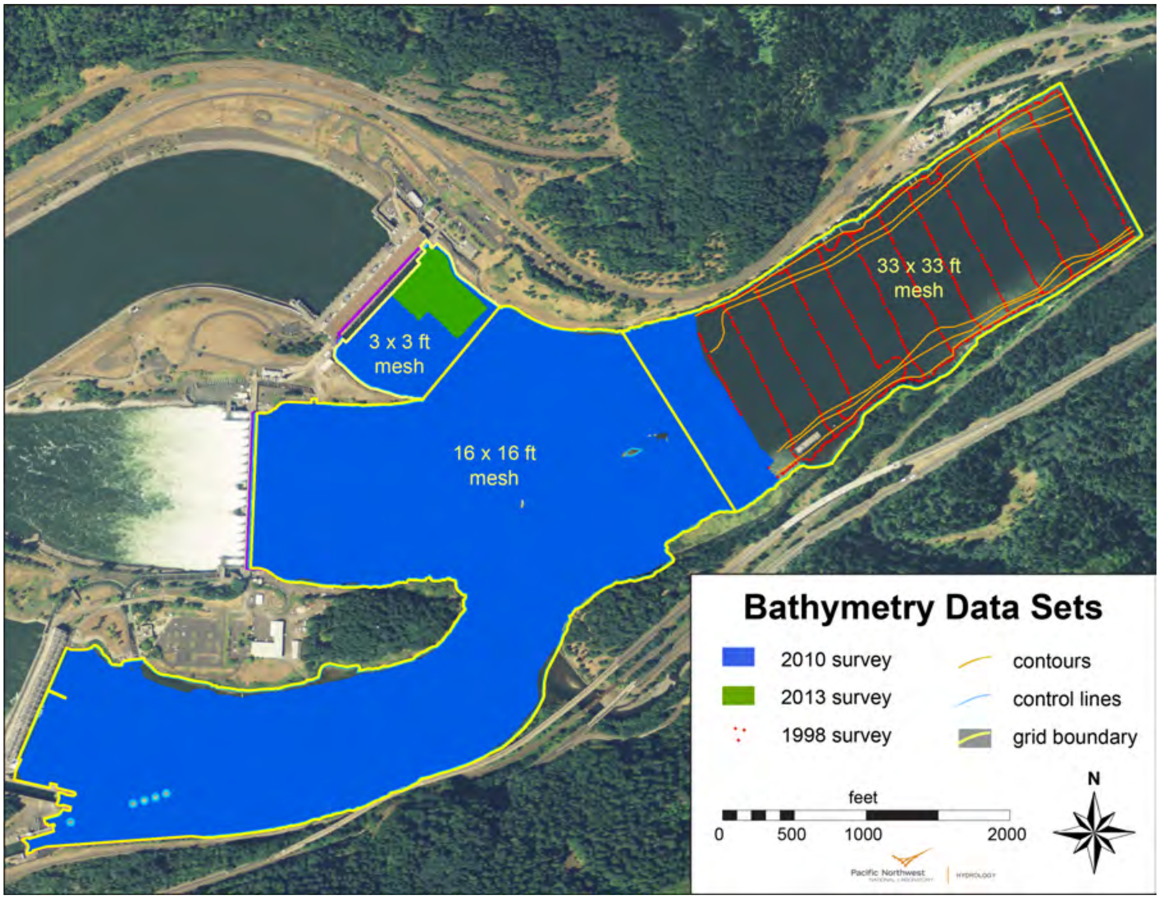


**Figure 2.1.** Surveyed data sets used to create bathymetric surface.

- zones for the wall and berm structural alternatives,
- the B2 forebay, and
- the rest of the Bonneville forebay.

The CFD model computational mesh was composed of polyhedral cells with a three-cell prism layer extruded from the wall boundaries. The prism layer had a 0.5 m total thickness with a stretching factor of 1.7. Although previous Bonneville models in STAR-CD were primarily hexahedral or prism meshes, polyhedral meshing was possible in STAR-CCM+ V8.02. The final mesh had 8.6M cells in the B2 forebay, 5.8M in B2 powerhouse, and 21M in the rest of the Bonneville forebay which extend about 2 km upstream from the spillway.

## 2.3 Model Validation

There were two parts in the validation process. First, to confirm that the new software performs as well as the old software by comparing old and new simulations of the same computational domain with the same boundary conditions and testing the sensitivity of parameter changes. The second was to compare the STAR-CCM+ results to field-measured velocity data.

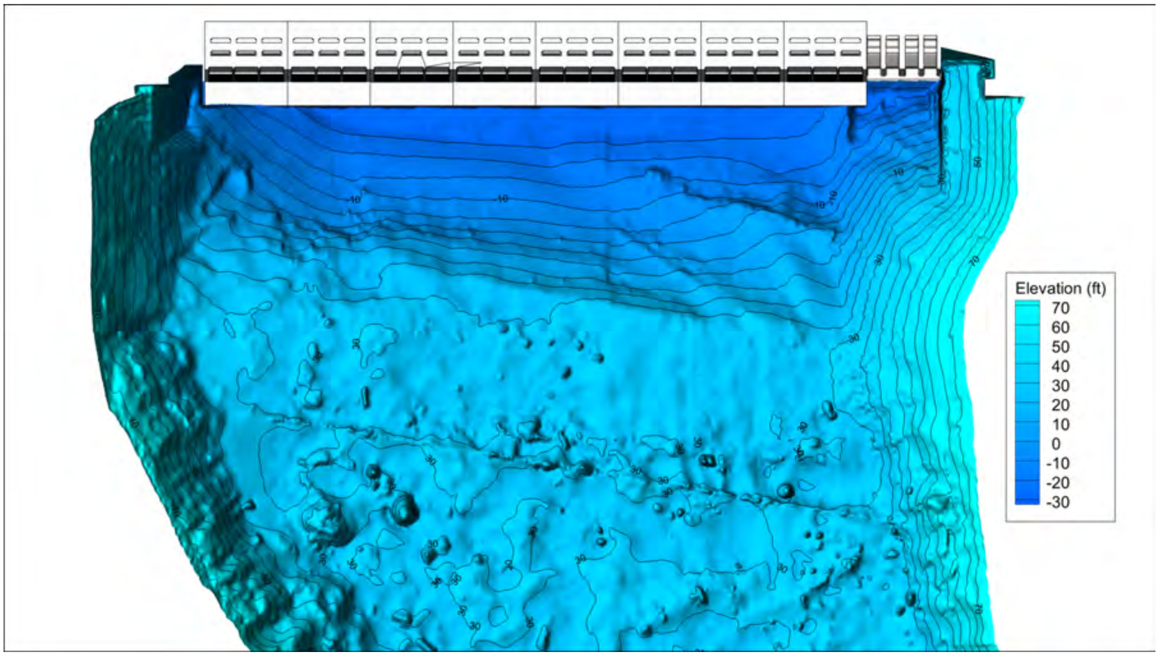


**Figure 2.2.** Bathymetric surface near B2.

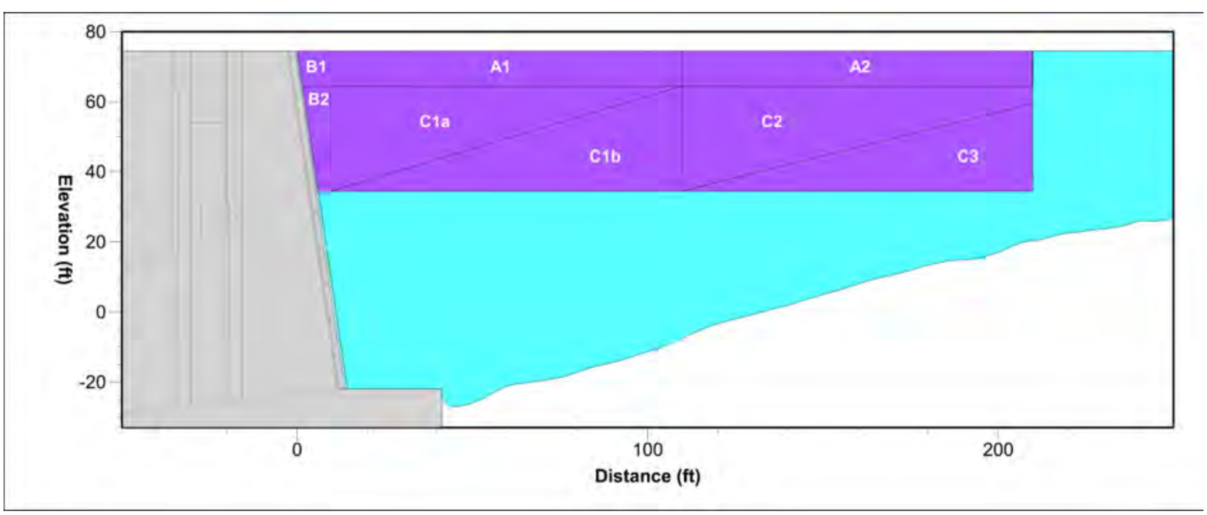


**Figure 2.3.** Wall Configurations Tested and Bathymetry Section

### 2.3.1 Model Migration from STAR-CD to STAR-CCM+

Previous CFD applications for the Bonneville Project forebay used STAR-CD, a legacy code of CD-adapco. Originally, STAR-CD was chosen because it was well suited for large 3D river simulations coupled with hydraulic structures. In recent years, CD-adapco has moved their CFD software into a more modern computing platform with the creation of STAR-CCM+. Most future code innovations will be in STAR-CCM+, so it is desirable to move applications into the newer software.

The migration to STAR-CCM+ required two tasks: comparison STAR-CCM+ and STAR-CD result for the same model, same boundary conditions and testing the sensitivity of the new model parameter setting. First, we simulated the Bonneville forebay in STAR-CCM+ with settings that were the same or the closest possible as in STAR-CD. We obtained and compared the results from simulating the flow conditions in Table 2.2. Table 2.1 summarizes the most important differences that still remained between the two model versions. Second, we tested the sensitivity of simulation results to two CFD settings: the flow solver convection scheme, and the inflow turbulence conditions.

*Convection scheme*

The convection scheme defines the way in which the convective transport of momentum is simulated. In the 1st-order mode, the solver introduces numerical dissipation effect that tends to stabilize the solution, thus helping to achieve solution convergence, but at the cost of over estimating the amount of simulated mixing. The first-order upwind scheme was an adequate choice for the earlier STAR-CD forebay models. STAR-CCM+ CFD modeling guidelines indicate that the 1st-order term is preferred in large-scale models when an initial and robust solution is required. The 2nd-order scheme is the default setting in STAR-CCM+. Although the 2nd-order upwind scheme tends to minimize such dissipative behavior of numerical origin, it does so at the expense of lowering the convergence rate, or preventing the solution from converging in the worst-case scenarios. This test of first- vs. second-order convection schemes was run for the river flow case 233 kcfs in Table 2.2.

*Inflow turbulence conditions*

The RANS k-$\varepsilon$ turbulence model requires two boundary condition settings on the upstream inflow boundary: the turbulent length scale (L, in m) and the turbulence intensity (I, %). In the previous work in STAR-CD, turbulence intensity was set to 5% and the turbulent length scale was 0.02 m. The latter was based on discussions with CD-adapco developers. The inlet boundary was far upstream and the solution in STAR-CD downstream was relatively insensitive to those settings. These turbulence settings are referred to as “Low Turbulence.” This sensitivity analysis used a scenario in which turbulent conditions were obtained from the work of MacMahan et al. (2012) on turbulence conditions in rivers. This scenario is referred as “environmental turbulence inflow,” and the setting values are L = 16.8 m and I = 14.76%. This simulation used the boundary conditions of flow case 233 kcfs in Table 2.2. Both turbulence conditions were run with the 2nd-order convection scheme.

**Table 2.1.** Main differences in modeling settings between STAR-CD and STAR-CCM+ models

| Setting | STAR-CD | STAR-CCM+ |
|---|---|---|
| Boundary condition, turbine intakes | Velocity inlet | Mass outflow |
| Boundary condition, spillways | Velocity inlet | Mass outflow + Bay 9 Pressure |
| Boundary condition, upstream | Pressure | Mass inflow |
| Geometry | No PH1 forebay | Includes PH1 forebay |
| Mesh size, millions of cells | 19.364 | 45.656 |

### 2.3.2 Field-Measured ADCP Velocities

The best available field-measured velocity data for the B2 forebay were collected in February 2000 (ENSR 2000). On-station 10-minute-duration velocity measurements were made at many locations in the forebay. As is characteristic of these types of measurements, the long duration of the on-station measurements was required for the average velocity to stabilize. However, the standard deviation of the measurements was large. This data set has been used for validation in previous Bonneville forebay CFD studies (e.g., Rakowski et al. 2010, 2000). Boundary conditions are detailed in Tables 2.2 and 2.3.

**Table 2.2.** Specified operation for model validation. On February 4, 2000 the flow was distributed across the full powerhouse and the water-surface elevation was 74.5 ft.

| Date | B1 (kcfs) | Spillway (kcfs) | B2 (kcfs) | Total River |
|---|---|---|---|---|
| Feb. 4, 2000 Survey | 85.3 | 2.6 | 145.0 | 233 |
| Feb. 6, 2000 Survey | 102.7 | 2.6 | 71.7 | 177 |

**Table 2.3.** Bonneville Powerhouse 2 flows for ADCP validation runs.

| Data Set | Discharge for Units 11–18 in kcfs |
|---|---|
| Feb. 4, 2000 Survey (ADCP 233 kcfs) | 17.6,17.7,17.7,17.5,17.6,17.4,17.4,16.7, respectively |
| Feb. 6, 2000 Survey (ADCP 177 kcfs) | Units 11,12,17,18 @ 16.3 |

## 2.4 Operations and Structural Scenarios

A single flow was specified (Table 2.4), and comparisons made for a clean forebay and several structural options. The B2 powerhouse was run with flow on both ends and the center units off. This operational pattern has been modeled to increase the extent of the Washington and Cascade Island eddies and the lateral flow on the face of the B2 powerhouse (Rakowski et al. 2010). The spillway was run in the Fish Passage Plan (http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2012/) pattern for 100.9 kcfs.

**Table 2.4.** CFD model flow scenario for all wall cases. Water-surface elevation was 74.5 ft for all runs.

| Operations | B1 (kcfs) | Spillway (kcfs) | B2 (kcfs) (kcfs) | Fish Units (kcfs) | B2CC (kcfs) | Total (kcfs) |
|---|---|---|---|---|---|---|
| All Cases | 0 | 100.9 | Units 11,12,17,18@17 | 2.5 each | 5 | 178.9 |

The structural options included subsets of the sections shown in Figure 2.3, The tested options were: clean forebay (no wall or berm), a floating shallow wall with a gap between the wall and the powerhouse (Wall 1, Sections A1 and A2), Wall 1 with a berm upstream of the fish units (Wall1 + Berm), a deeper wall (Wall 2, All sections in Figure 2.3) and a wall of variable depth (Wall 3, Sections A1, A2, B1, B2, and C1a). In addition, the impact of a 50 cfs sluiceway on the Washington shore eddy was assessed for the clean forebay.

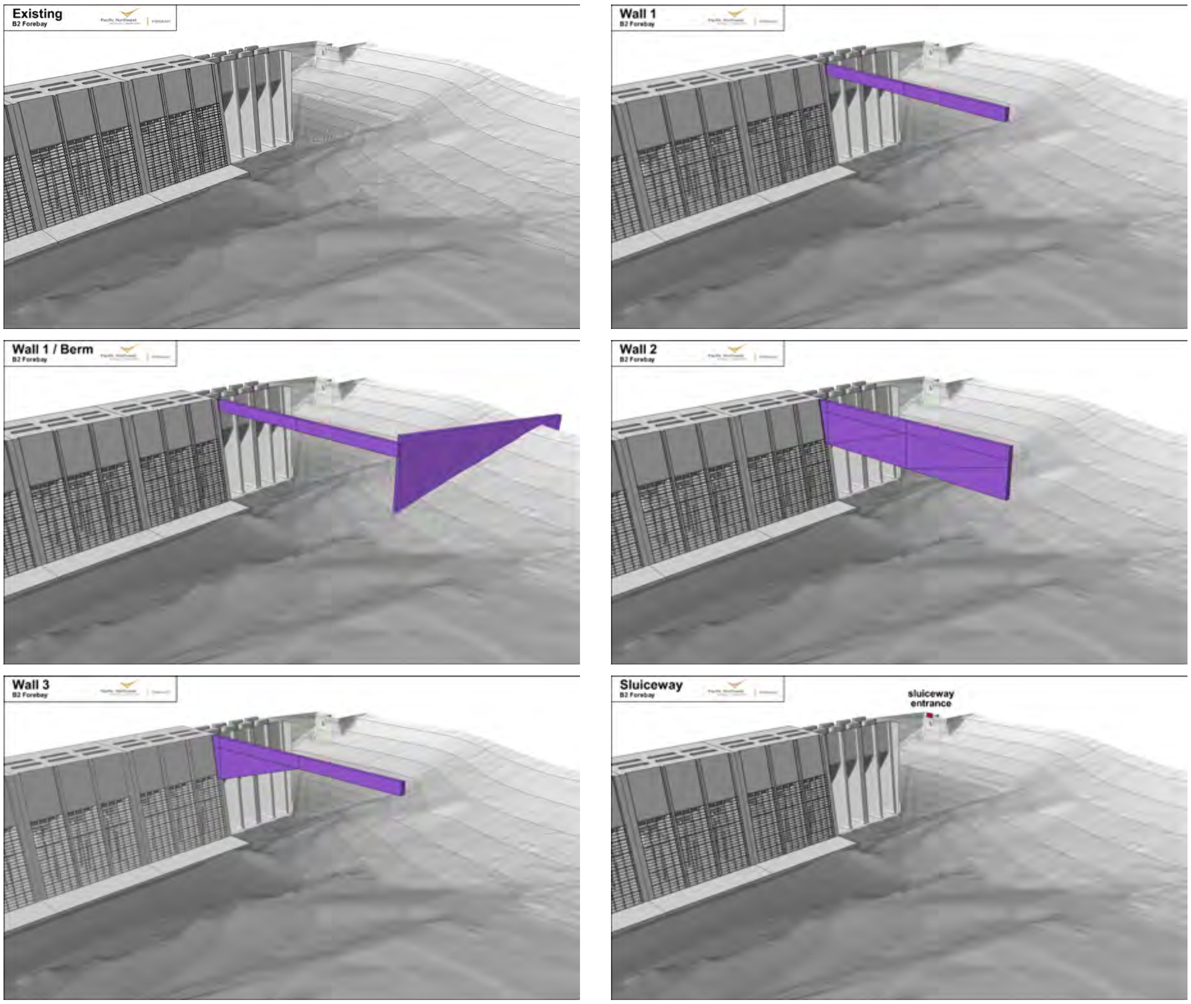


**Figure 2.4.** Detail of the Wall Configurations Tested

## 2.5 Analysis of Results

### 2.5.1 Validation of the model upgrades

The comparisons among the three sets of results (STAR-CD, STAR-CCM+ and ADCP) are established in terms of contours of velocity magnitude, vector plots, and scatter plots, depending on the convenience for each comparison pair. In all cases, modeling results for vector and scatter plots were interpolated at the ADCP measurement locations.

*STAR-CD vs. STAR-CCM+*

- Contours of velocity magnitude at two elevations for river flow case 233 kcfs, as resulting from STAR-CD and STAR-CCM+

- Vector plots of the three approaches (STAR-CD vs. STAR-CCM+ vs. ADCP) at one elevation (elevation 45 ft for river flow 233 kcfs, and elevation 42 ft at river flow 177 kcfs)

- Scatter plots of velocity magnitude for the two river flow cases in table 2.2, with two comparison pairs: (i) STAR-CD vs.STAR-CCM+, and (ii) STAR-CCM+ vs. ADCP

*1st-order vs 2nd-order convection scheme*

- Scatter plots of velocity as obtained from the STAR-CCM+ results with the two convection schemes on river flow scenario 233 kcfs

*Low vs. Environmental turbulence conditions*

- Scatter plots of velocity as obtained from the STAR-CCM+ results with the two inflow turbulence conditions on river flow scenario 233 kcfs

### 2.5.2 Structural Scenarios

Comparison graphics and metrics were produced using Tecplot360$^{TM}$ (Tecplot, Inc.). Simulation results were exported from STAR-CCM+ to Tecplot binary format. Tecplot is a general-purpose scientific plotting application that includes specialized CFD processing capabilities. Specifically, Tecplot can create contour maps and vector-field plots, and generate streamtraces through a velocity field. Results are presented as suites of stream traces with their seed point at a given elevation and either parallel to the face of the dam or parallel to the proposed wall. These stream traces are used to assess the effectiveness of an alternative at reducing the vertical and horizontal recirculation in front of the fish units.

# 3.0 Results and Discussion

The CFD results were to be used to

- Understand the application of the STAR-CCM+ code to the B2 forebay given its many new parameter options relative to STAR-CD,
- Validate the new computational mesh for the B2 forebay, and
- Assess the differences in forebay flow patterns in response to a suite of structural options.

## 3.1 Validation

In this section, the impact of model changes (differencing scheme and inflow turbulence) and the comparison of the STAR-CCM+ and STAR-CD results to field-measured velocities are evaluated. In the latter case, it is important to remember that the models are of different spatial resolutions and that underlying bathymetry has been updated with more recent surveys in the STAR-CCM+ model. The modeling results labeled as STAR-CD were reported in Rakowski et al. (2012a); the ADCP data were those obtained from the work summarized in ENSR (2000).

### 3.1.1 Model Sensitivities

Using the same computational mesh, only a single parameter was varied. First, the convection scheme, second the inlet turbulence. The locations sampled for the ADCP measurements were used for consistency and ease of comparison.

*Convection scheme*

The flow solution was sensitive to the convection scheme used (Table 3.1). A regression of the velocities at the ADCP points of the two STAR-CCM+ models showed the $R^2$ was relatively low (0.84) for a model-to-model comparison on the same computational domain for identical boundary conditions. Two possible reasons are: 1) snapshots of velocity magnitude contours taken every 100 iterations showed that the flow oscillated in the 2nd-order solution, whereas the more dissipative 1st-order solution remained steady after the initial iterations to achieve a steady solution. We expect that the $R^2$ value (of the model to field-measured ADCP data) behaves dynamically as the solution iteration advances.Therefore, we considered the forebay flow solution to be sensitive to the order of the convection scheme.

**Table 3.1.** ADCP Validation Comparison. The number under the model are the **difference** between the ADCP-measured velocity and the simulation velocity grouped by each ensembles of the 8 transect measured (see Figure 3.1).

| | **ADCP** | | **STAR-CD** 1st Order | | **STAR-CCM+** 1st Order | | **STAR-CCM+** 2nd Order | |
|---|---|---|---|---|---|---|---|---|
| | Mean(Uave) m/s | Mean(SD) m/s | Bias m/s | MAE m/s | Bias m/s | MAE m/s | Bias m/s | MAE m/s |
| 1 | 1.316 | 0.589 | 0.362 | 0.458 | 0.418 | 0.495 | 0.293 | 0.386 |
| 2 | 1.251 | 0.645 | 0.249 | 0.284 | 0.319 | 0.332 | 0.208 | 0.266 |
| 3 | 1.136 | 0.558 | 0.136 | 0.257 | 0.169 | 0.257 | 0.161 | 0.326 |
| 4 | 1.803 | 0.361 | 0.176 | 0.185 | 0.231 | 0.231 | 0.179 | 0.179 |
| 5 | 1.405 | 0.247 | 0.12 | 0.148 | 0.159 | 0.177 | 0.136 | 0.165 |
| 6 | 0.09 | 0.104 | 0.045 | 0.049 | 0.093 | 0.093 | 0.075 | 0.111 |
| 7 | 0.975 | 0.233 | - | - | 0.161 | 0.179 | 0.144 | 0.144 |
| 8 | 1.023 | 0.254 | 0.12 | 0.151 | 0.132 | 0.176 | 0.1 | 0.165 |

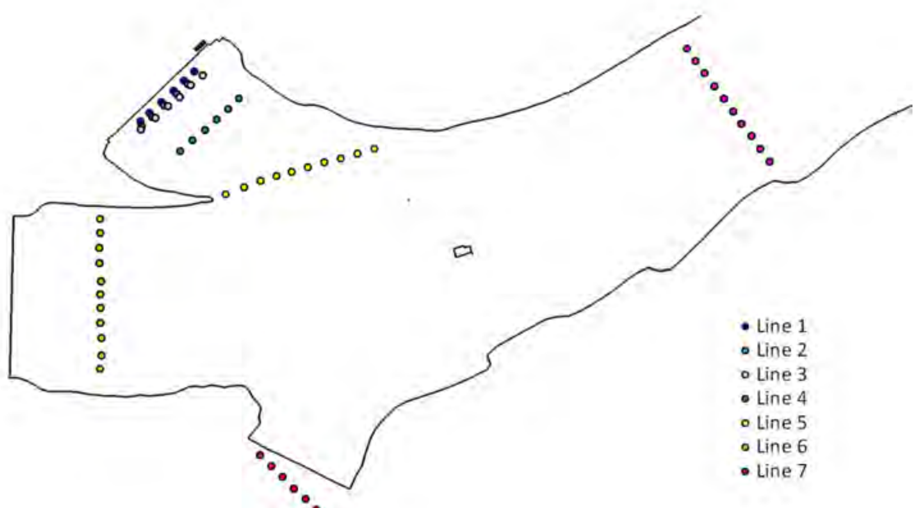


**Figure 3.1.** Location of each of the 8 ADCP transects for the 233 kcfs case (see Table 2.2).

*Inflow turbulence conditions*

The flow solution is relatively insensitive to the boundary turbulence inflow test. Although the difference in turbulence parameter magnitudes is large between the two cases, little effect was observed between the two modeling outcomes as indicated by the high $R^2$ value (>0.926) between the STARCCM+ and STAR-CD models. This test was run with a 2nd-order convection scheme, for which part of the discrepancies can be explained by the changing flow solution of the 2nd-order scheme rather than by the turbulent inflow conditions themselves. The $R^2$ value (comparing STARCCM+ to the ADCP data) (0.80) was still essentially the same as for the STAR-CD, 1st-order, low turbulence solution ($R^2$ = 0.819, reported in Rakowski et al., 2012a).

### 3.1.2 Comparison to ADCP Field-Measured Velocities

Field-measured ADCP forebay velocities were available for the Bonneville forebay. The comparison of the CFD model results and the field-measured data is discussed below and statistics presented in Table 3.1.

Qualitative comparisons of contour plots between the STAR-CD and STAR-CCM+ solutions (Figures 3.2 and 3.3) show that there is little sensitivity to the solver code despite the fact that there was slightly differing bathymetry in the two models (see shape and size of "island" in elevation Z = 35 ft, Figure3.3). However, the 2nd order STAR-CCM+ solution propagates the low velocity zones further downstream of objects. The similarity of results is also illustrated by the vector plots in both river flow scenarios (Figure 3.4). In these comparisons, the largest velocity differences were observed in the vicinity of the powerhouse. The flows in this area at the prototype were very turbulent and transient; these conditions were only partially captured by a steady state solution and are difficult to measure in the field.

Comparisons of ADCP data show that the STAR-CCM+ model remains of the same quality ($R^2$ = 0.787 and 0.673, for the river flow case 233 and 177 kcfs, respectively) as for the STAR-CD solution ($R^2$ = 0.819 and 0.632, reported in Rakowski et al., 2012a). Table 3.1 shows the overall "goodness" of data comparison is best for the second-order model, although the STAR-CD model performed somewhat better than the first-order STAR-CCM+ model. It should be noted that Table 3.1 shows that the mean standard deviation of the field-measured velocity is greater than either bias or MAE of the CFD results.

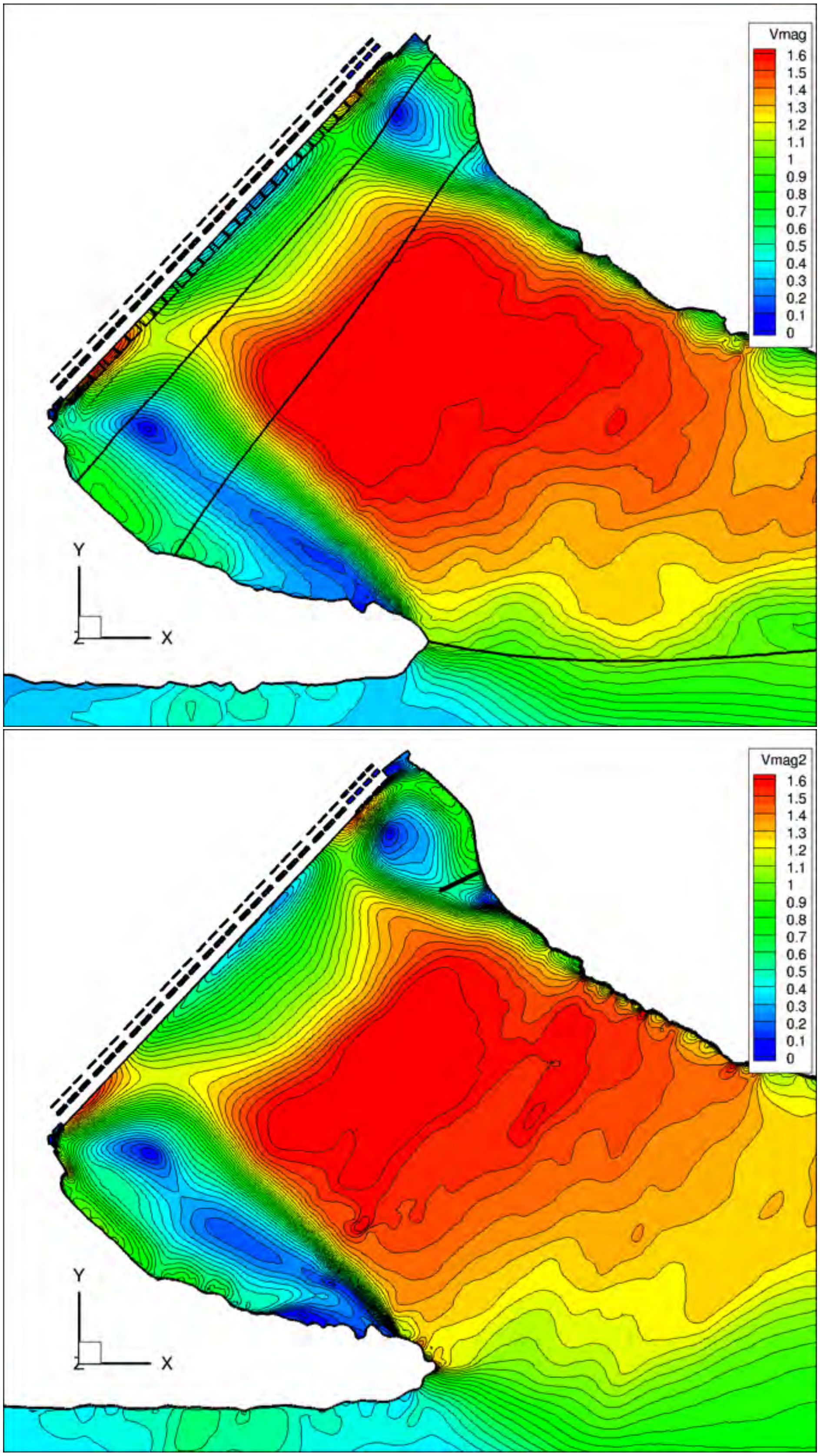


**Figure 3.2.** Contour plots of velocity magnitude at an elevation Z = 55 ft from STAR-CD (top) and STAR-CCM+ (bottom) solver codes for the 233 kcfs ADCP case.

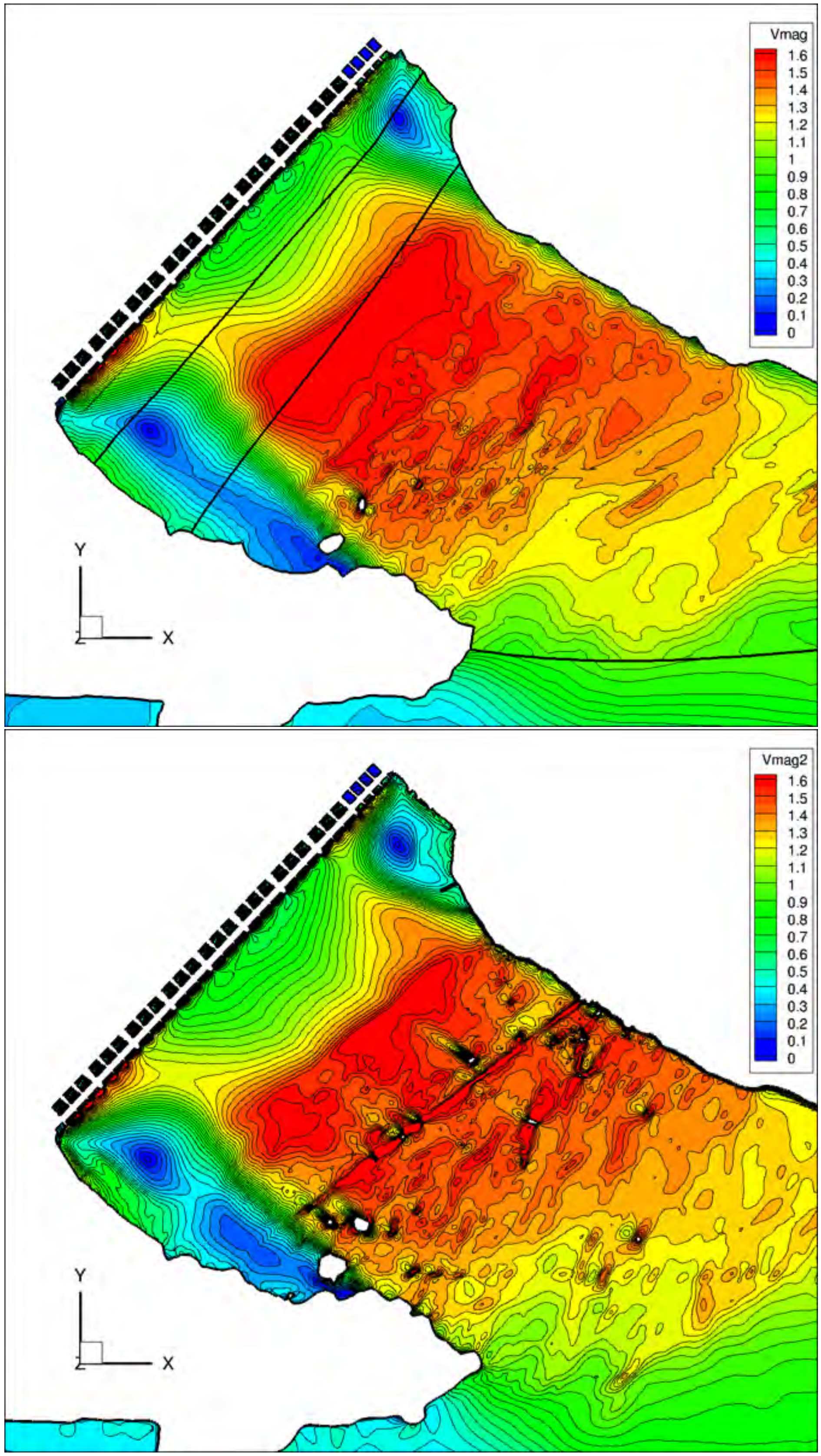


**Figure 3.3.** Contour plots of velocity magnitude at an elevation Z = 35 ft from STAR-CD (top) and STAR-CCM+ (bottom) solver codes for the 233 kcfs ADCP case.

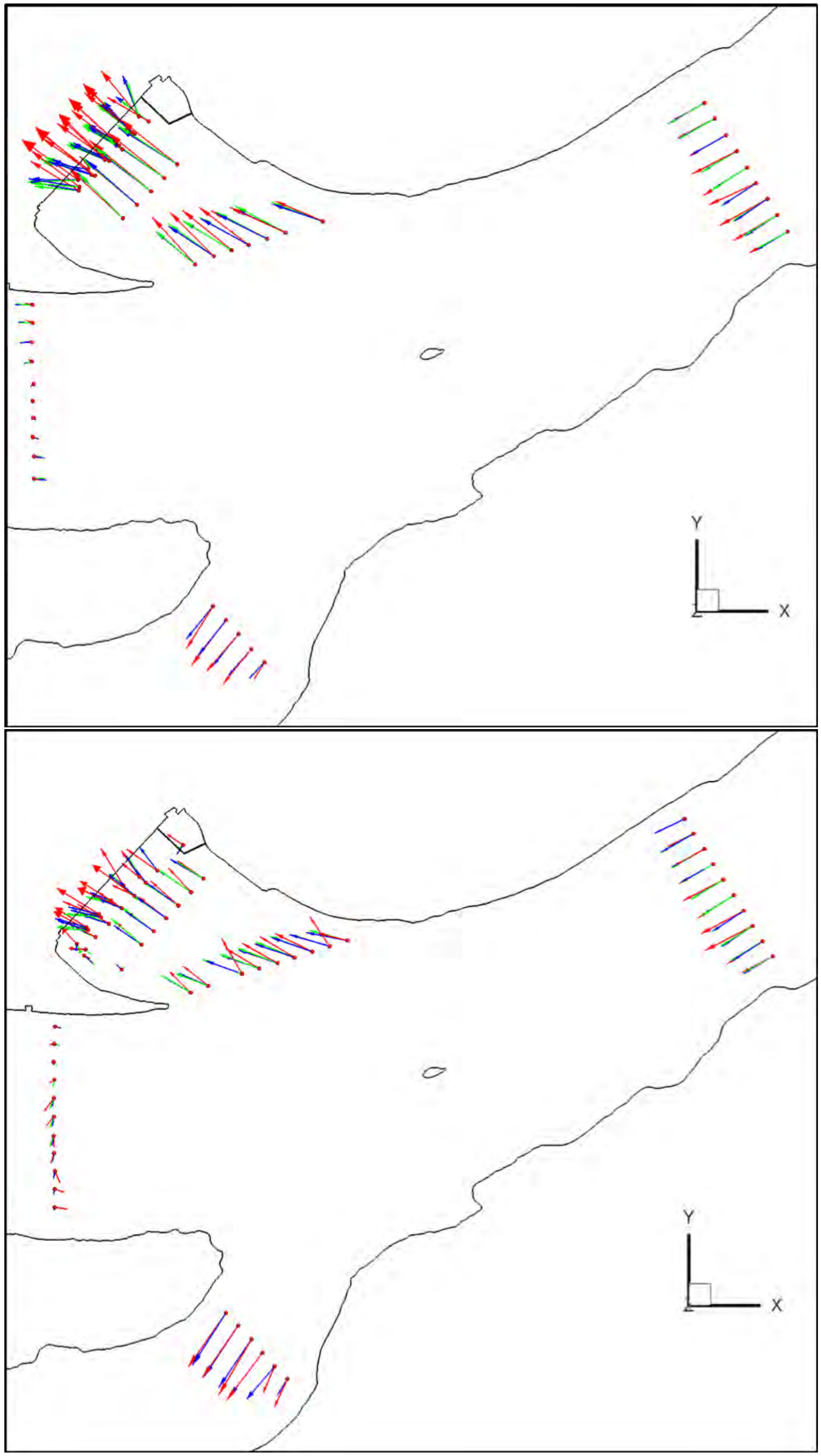


**Figure 3.4.** Comparisons of vector plots of velocity for the river flow 233 kcfs (top) and 177 kcfs (bottom) scenarios, for ADCP measurement locations located at 45 ft and 42 ft elevations, respectively. Red is ADCP data, green is STAR-CD, and blue is STAR-CCM+.

## 3.2 Structural Scenarios

One forebay operational scenario with several wall configurations (Table 2.4) were simulated and the results were analyzed.

The overall forebay flow patterns were compared using streamlines. The seed points were either parallel to the dam face or parallel to the proposed wall location, and seeds released at multiple elevations. The area of concern is just upstream of the fish units and reducing the sources of debris and sediment passing through the fish units. The results are presented with a near-water-surface slice of velocities and streamlines, then graphics of streamlines seeded at a particular elevation and set of location–either along the wall location or parallel to the dam face–are presented.

### 3.2.1 Existing

The clean forebay (Figure 3.5) shows the horizontal recirculation at the surface upstream of the fish units. Floating debris from a large portion of the forebay would tend to move along the face of the powerhouse and be trapped in the Washington shore eddy. The bathymetry in front of the fish units promotes surface recirculation: there is a flow expansion downstream of the adult ladder exit. In addition, there is a more shallow area in the bathymetry just upstream of the fish units, then it is excavated closer to the units with a vertical wall just upstream of the fish units (Figure 3.6). From geometry considerations alone, we expect this varying bathymetry to increase vertical recirculation and, by virtue of decreasing the direct flow into the units by greatly decreasing the depth of flow from directly upstream, to promote horizontal recirculation.

Looking at a more three-dimensional view of the streamtraces near the fish units (Figures 3.7 and 3.8), the streamtraces are, indeed, complex and recirculation occurs both horizontally and vertically, although the streamlines seeded in the upper half of the water column have a more circuitous path to leave the forebay. These results support the observation that much of the floating debris and sediment pass through the fish units. Floating debris recirculates

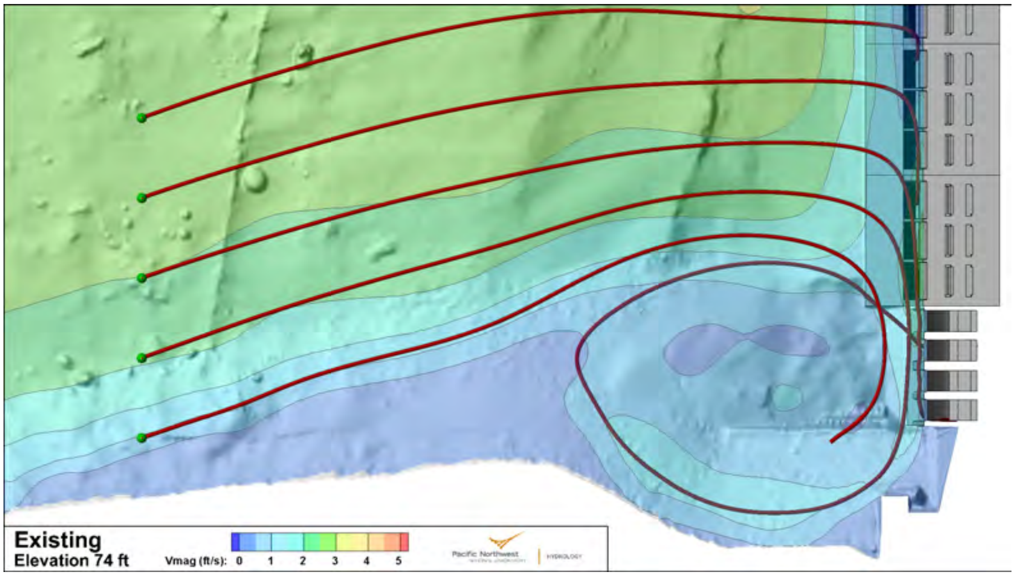


**Figure 3.5.** Clean forebay velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

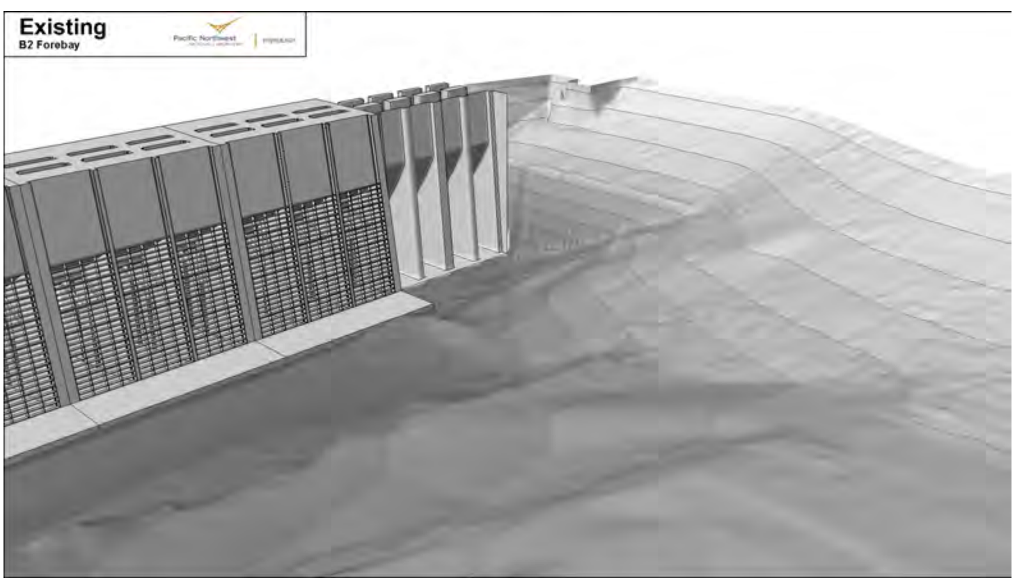


**Figure 3.6.** Oblique view of bathymetry upstream of the fish units.

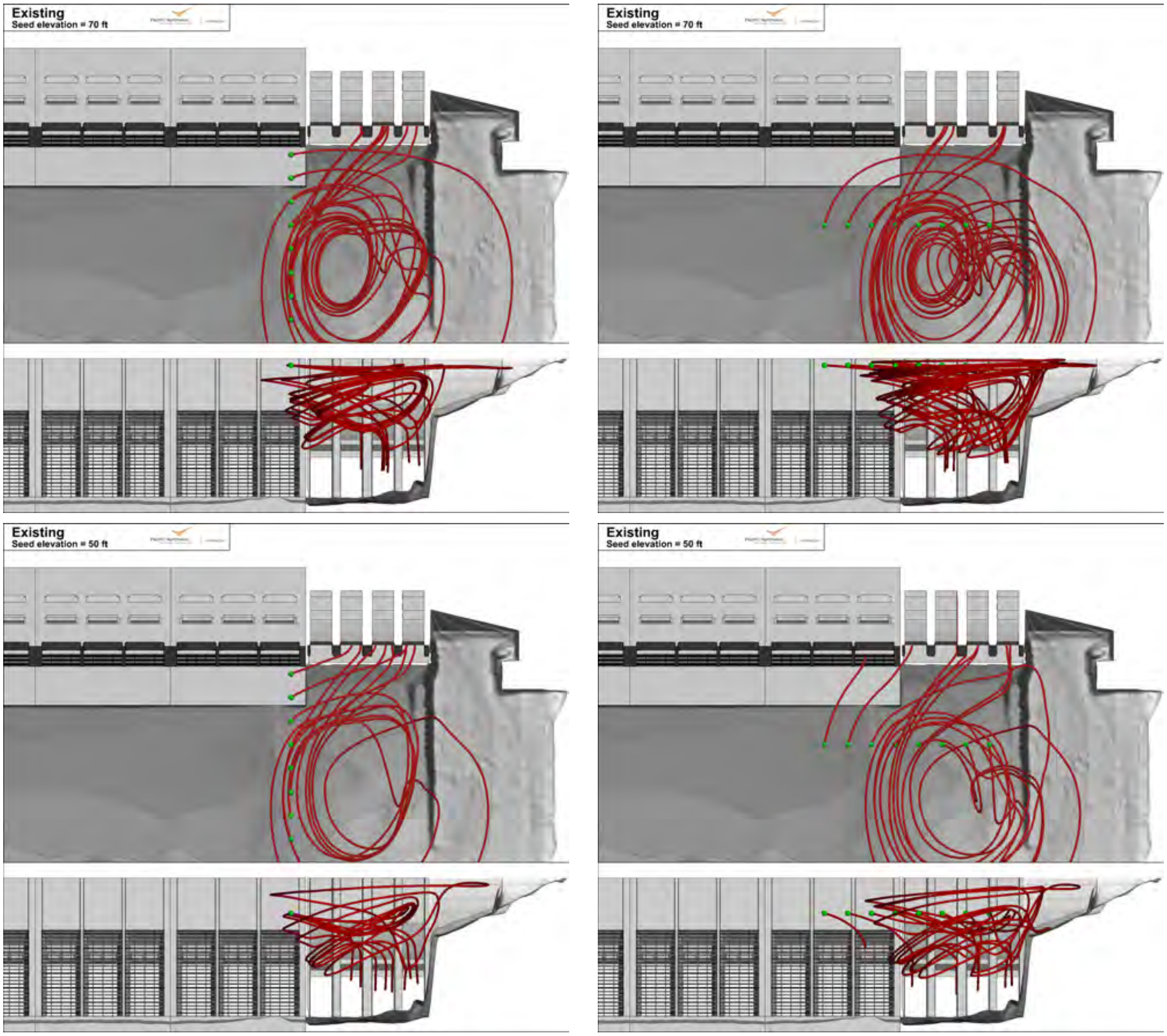


**Figure 3.7.** Clean forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom). These streamlines show the complex 3D nature of the near-dam flow near the Washington shore eddy. Seed points in green. Streamlines show 33 minutes of time.

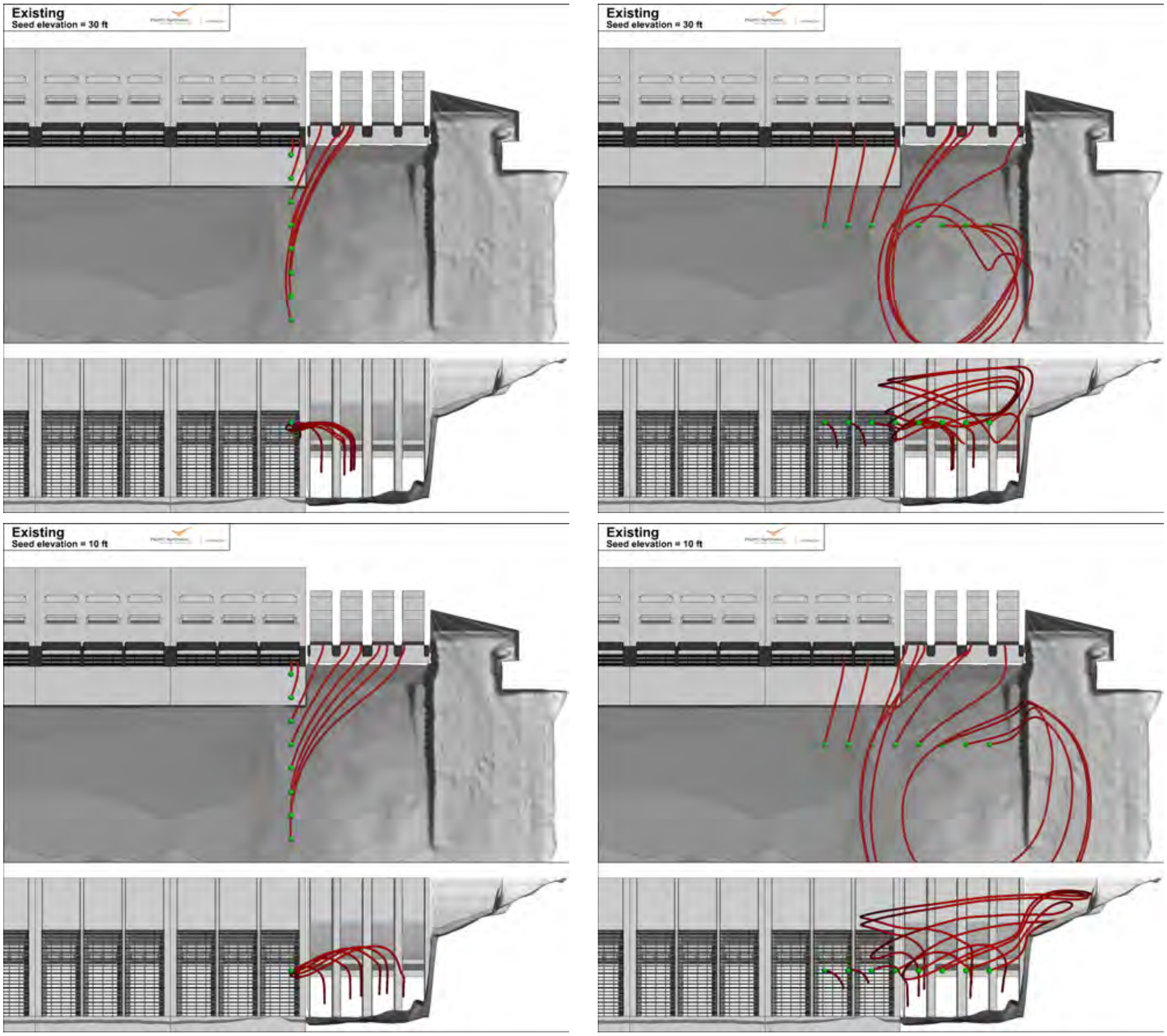


**Figure 3.8.** Clean forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom). These streamlines show the complex 3D nature of the near-dam flow near the Washington shore eddy. Seed points in green. Streamlines show 33 minutes of time.

### 3.2.2 Wall 1

The first concept tested was using a shallow floating wall located perpendicular to the B2 powerhouse between Unit 18 and the Fish Units. The configuration had a gap between the wall and the powerhouse.

As is shown in Figure 3.9, this does not eliminate the Washington shore eddy, however it does limit the lateral extent at the surface. The gap between the powerhouse and the floating wall allows floating debris to follow the powerhouse face and move into the eddy through the gap; thus a reduction in debris quantity into the eddy was not expected for this wall configuration.

Figures 3.10 and 3.11 show that, as before, the lower the seed location, the more direct the route into the fish units.

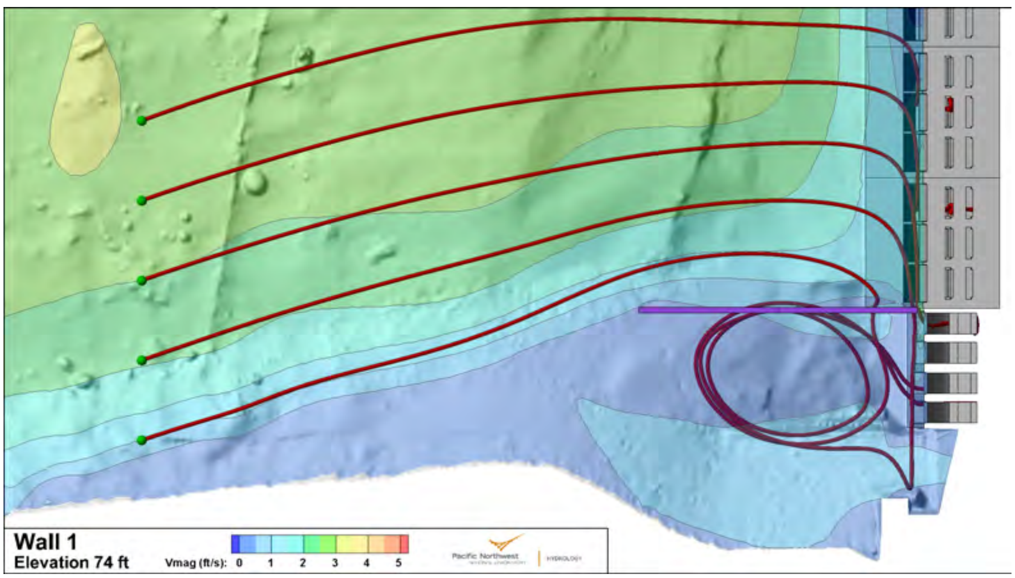


**Figure 3.9.** Wall 1 velocity contours with lines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

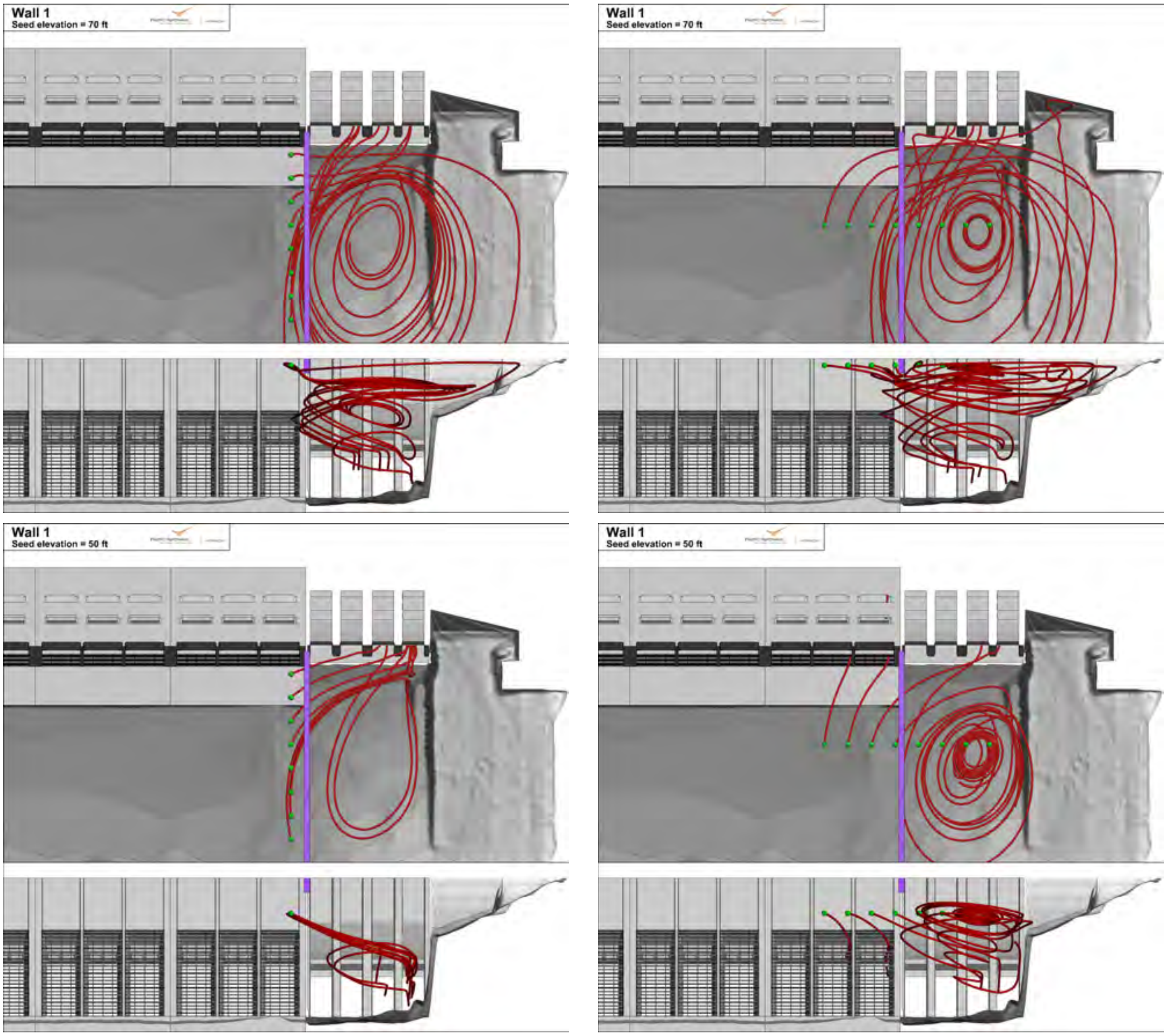


**Figure 3.10.** Wall 1 forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom).


**Figure 3.11.** Wall 1 forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom).

### 3.2.3 Wall 1 Plus Berm

The second concept tested was blocking flow from upstream by adding a berm in the shallow area upstream and connecting it to the shallow floating wall. Given the gap between the floating wall and the powerhouse, floating debris still ends up in the now blocked off area (Figure 3.12) although the upstream extent of the eddy is limited by the berm location. All flow entered the fish units from under the wall (Figures 3.13 and 3.14). This mostly closed off area is now much like a driven cavity with the flow into the fish units resulting in enhanced horizontal recirculation. The resulting flow patterns with the berm included were deemed unacceptable by CENWP.

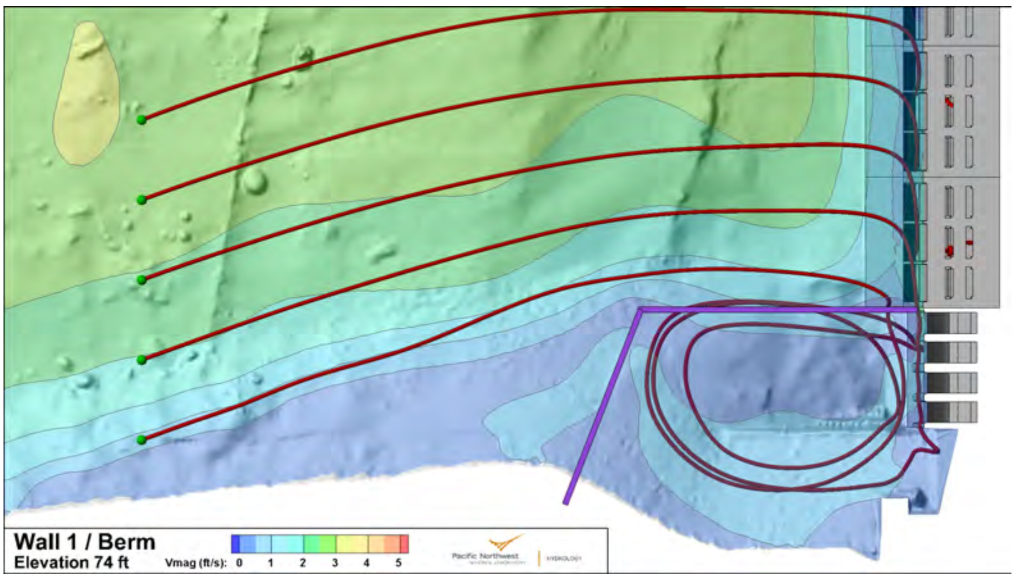


**Figure 3.12.** Wall 1 plus berm velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

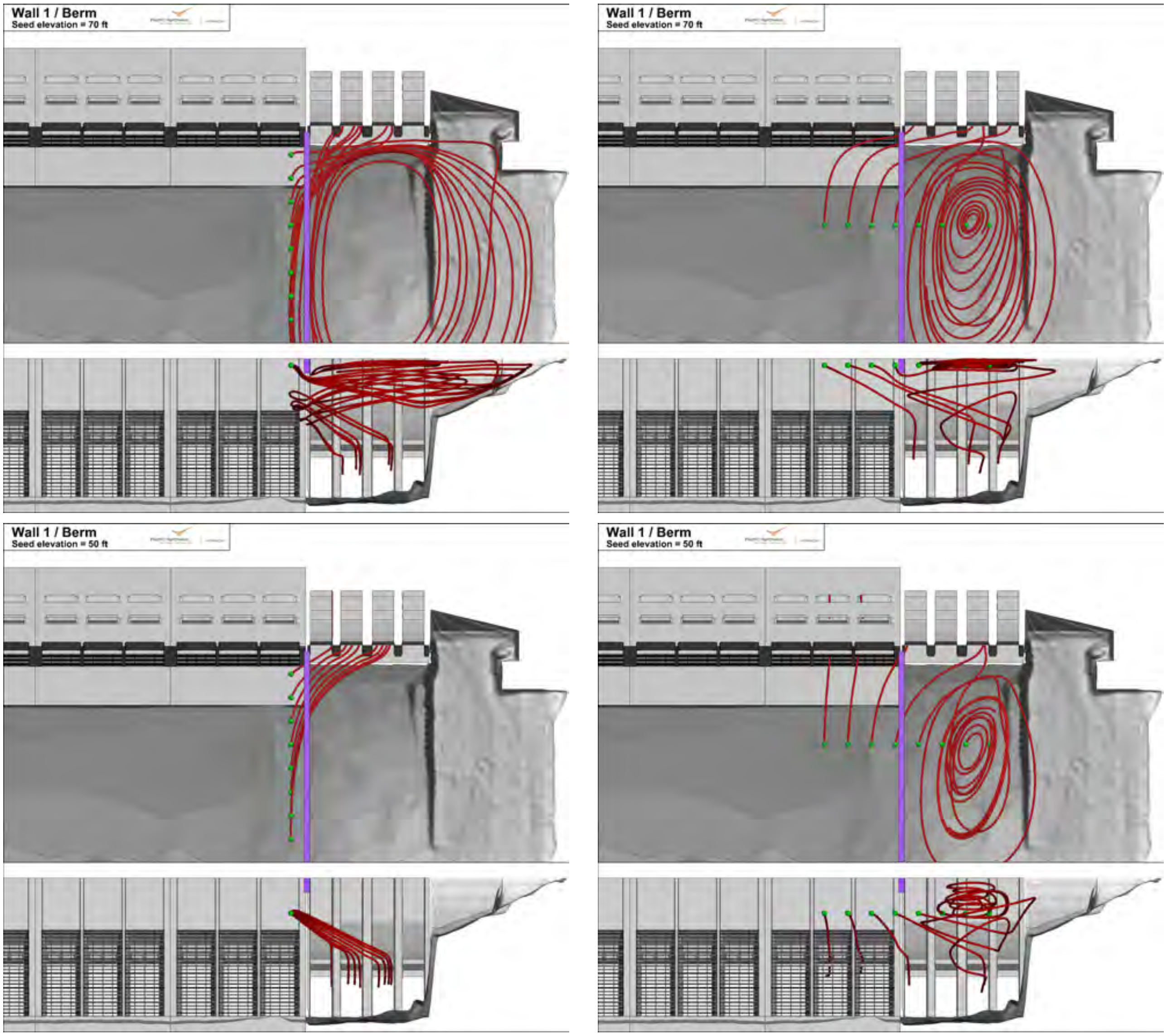


**Figure 3.13.** Wall 1 plus berm forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom).

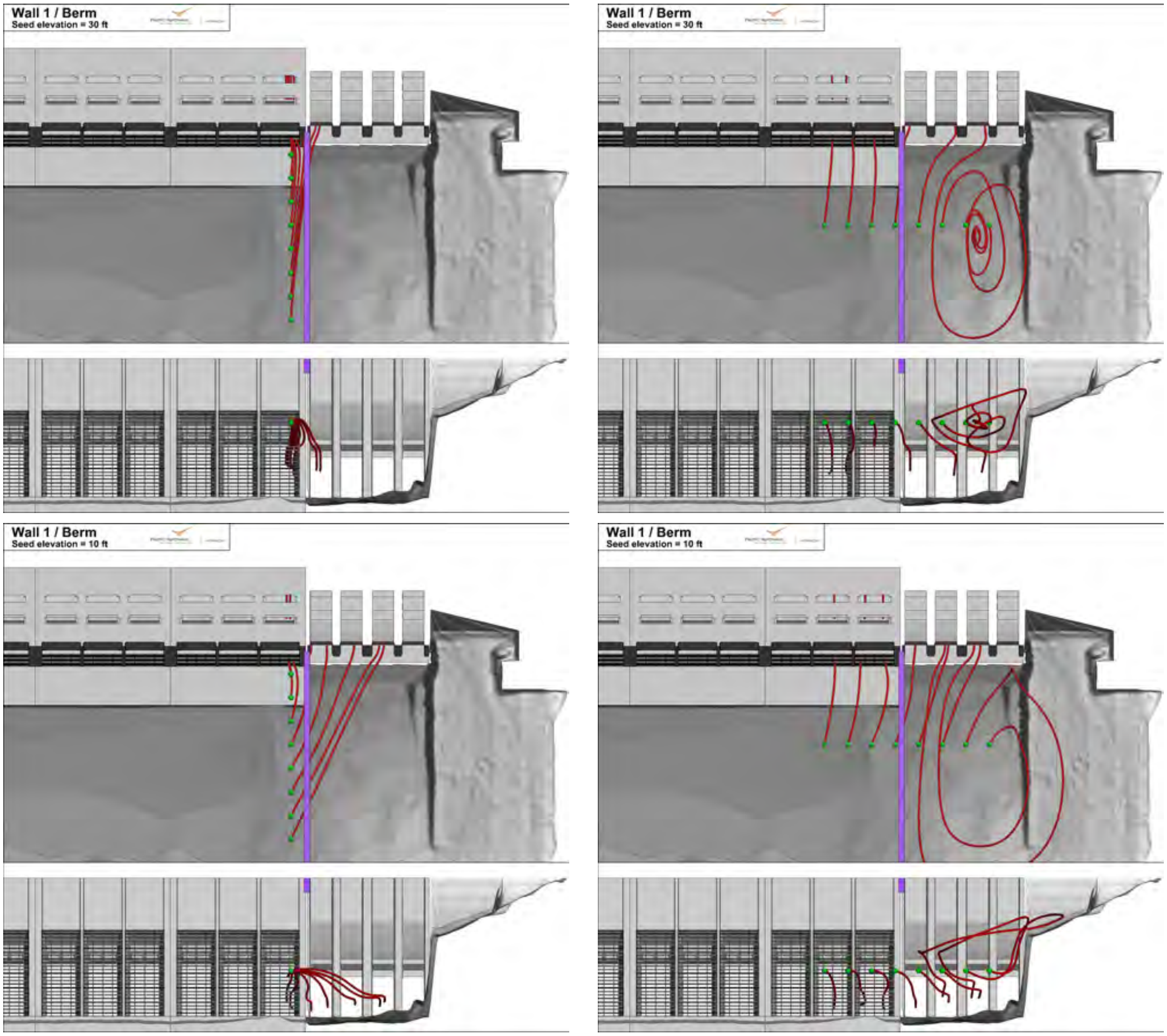


**Figure 3.14.** Wall 1 plus berm forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom).

### 3.2.4 Wall 2

Another concept involved connecting the floating wall to the powerhouse and increasing its draft. The Wall 2 configuration had a much deeper draft than the initial floating wall (Figure 2.3). The deeper draft blocked much of the depth of flow at the upstream end and did change the flow pattern in the eddy. Simulation results (Figures 3.16 and 3.17 show that the flow into the fish units does pass under the wall with an eddy blocking flow into the fish units from the upstream. This wall configuration blocked too much of the flow depth as it increased the lateral flow under the floating wall and into the fish units. However, it would greatly reduce the quantity of floating debris in the eddy although one would expect the debris to accumulate along the wall before sinking and passing through the powerhouse via the fish units.

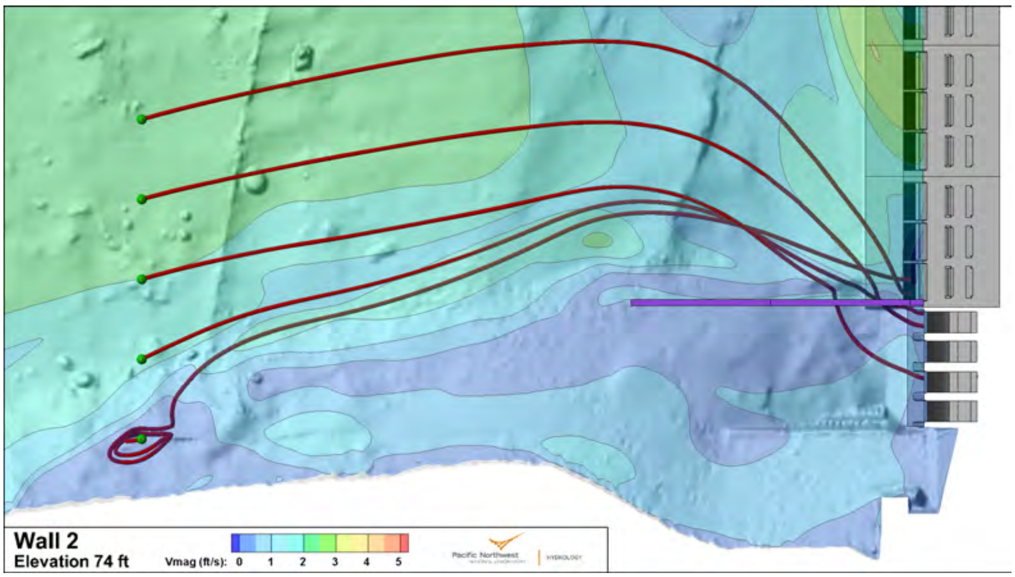


**Figure 3.15.** Wall 2 velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

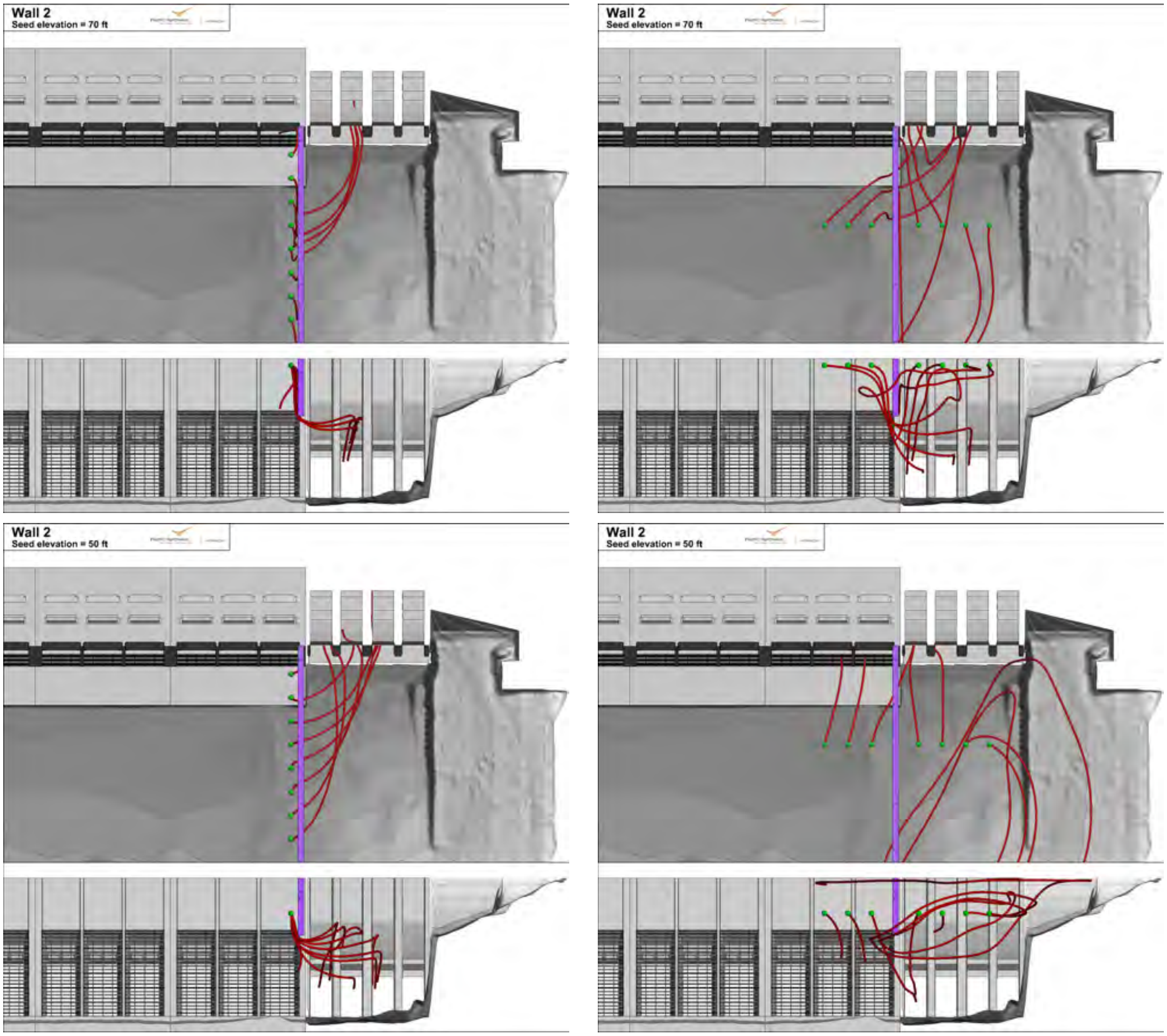


**Figure 3.16.** Wall 2 forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom).

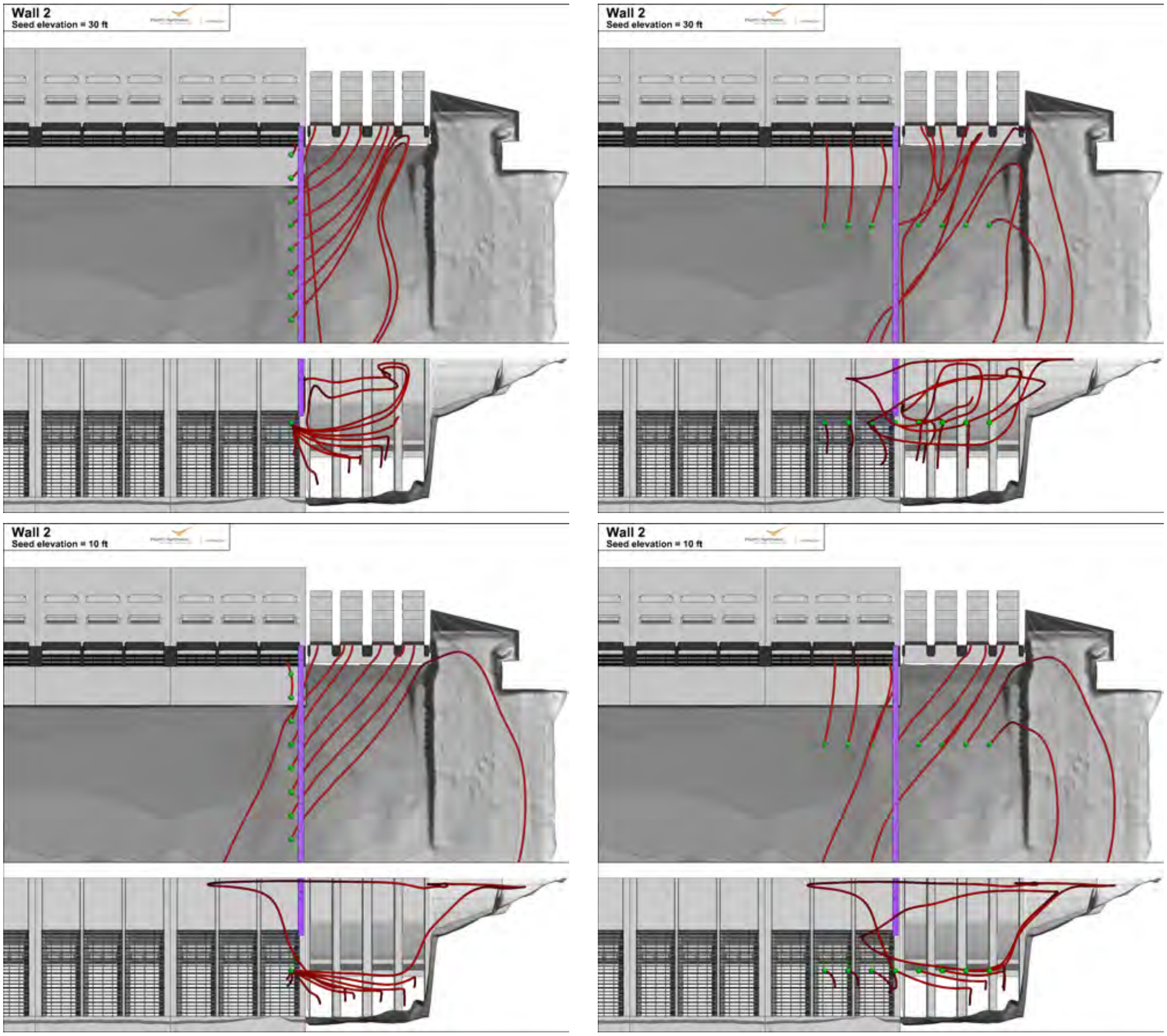


**Figure 3.17.** Wall 2 forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom).

### 3.2.5 Wall 3

The last configuration tested a wall that was shallow draft at the upstream end, then deeper near the powerhouse (Wall 3). The thought was that the near-powerhouse deeper draft would reduce lateral flow across Unit 18 and more of the fish unit water would come from more directly upstream. However, as is shown in Figures 3.15 to 3.20, the vertical recirculation in front of the fish units was increased relative to the Wall 1 and Wall 2 scenarios.

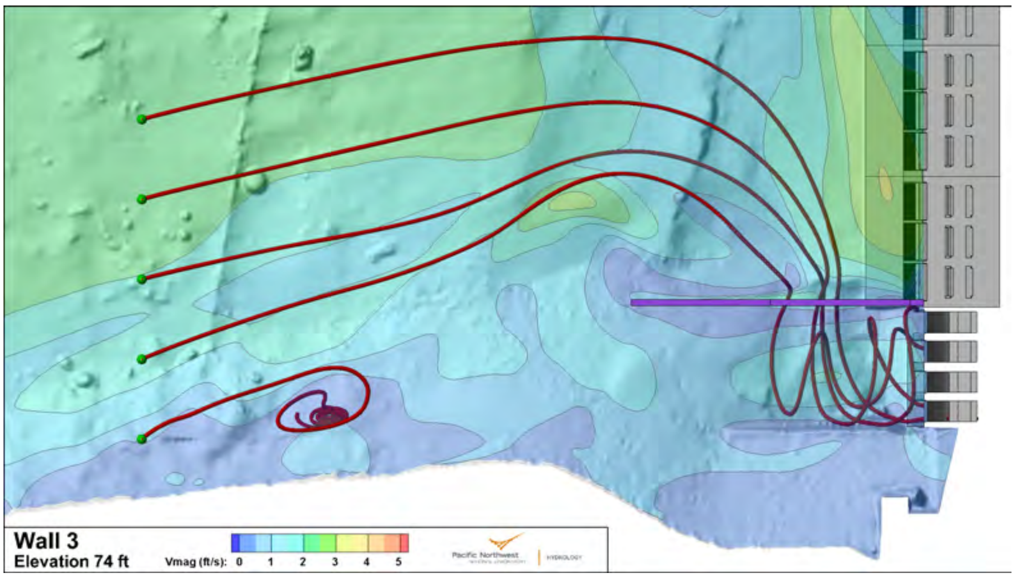


**Figure 3.18.** Wall 3 velocity contours with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

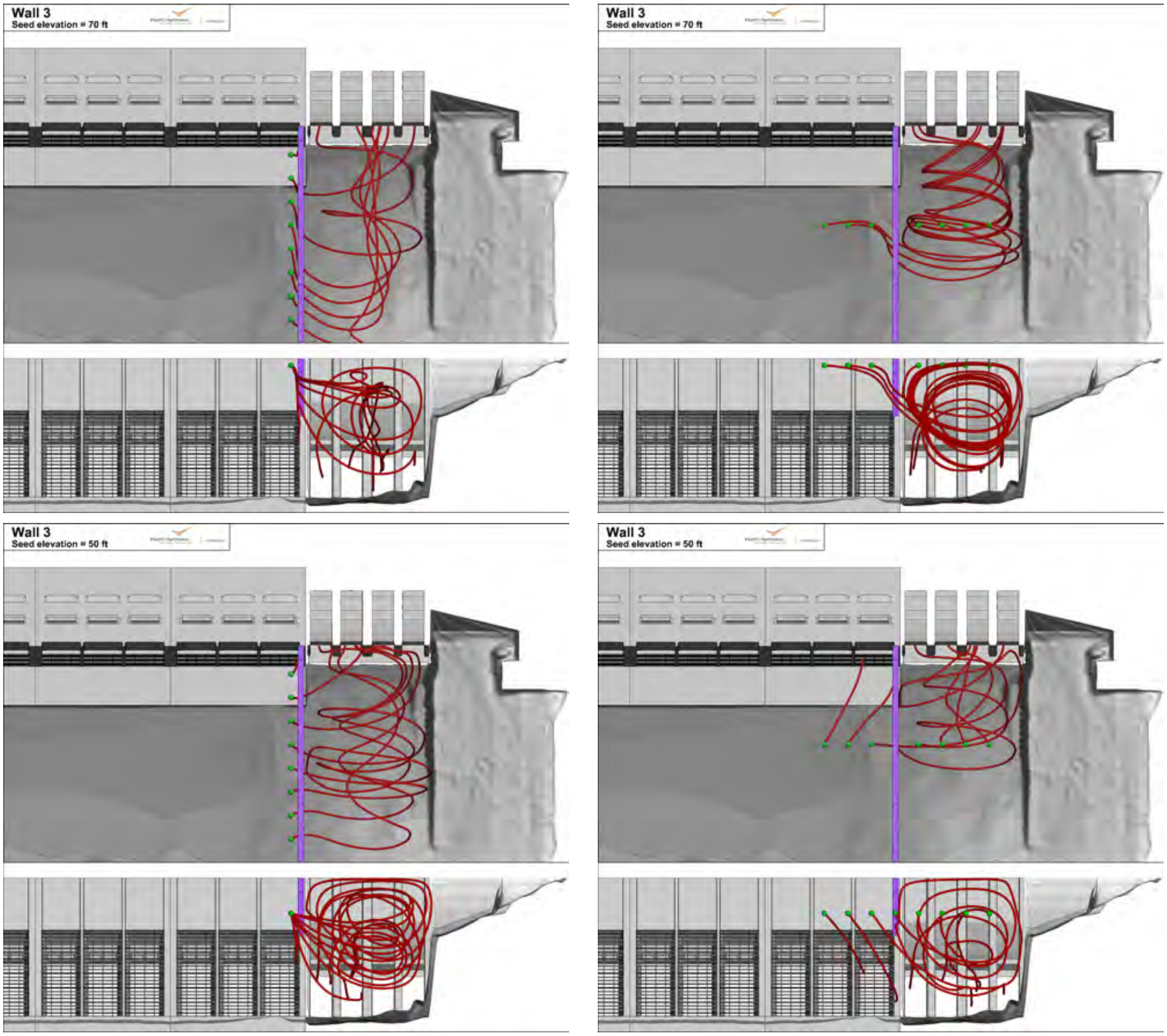


**Figure 3.19.** Wall 3 forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom).

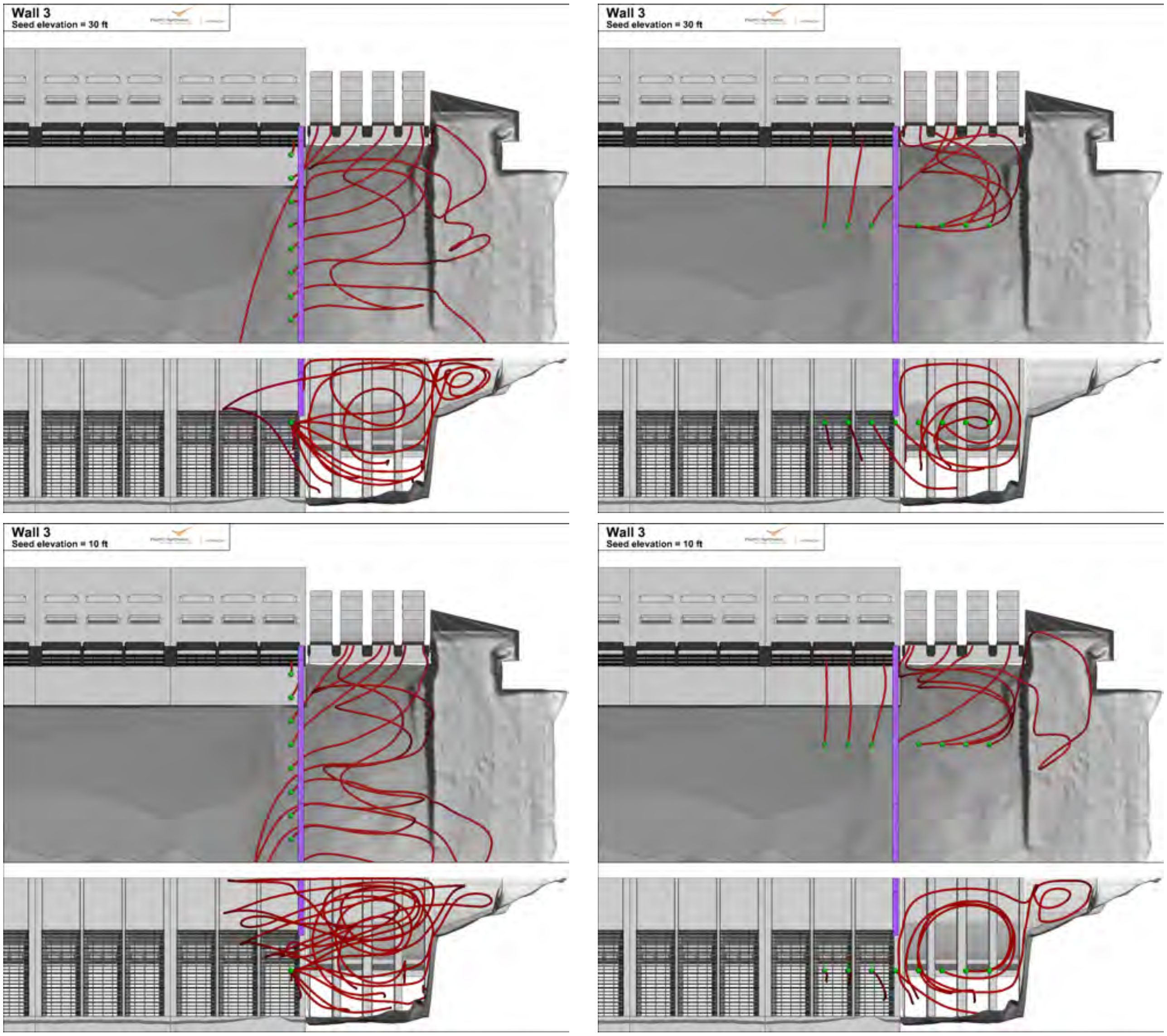


**Figure 3.20.** Wall 3 forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom).

### 3.2.6 Sluiceway

A sluiceway was added to the clean forebay to assess if a relatively low volume sluiceway might be effective at reducing the eddy. Results for this simulation are shown in Figure 3.21. The addition of the sluiceway with a flow of 50 cfs was not effective for reducing the Washington shore eddy nor improving flow conditions into the fish units (Figures 3.22 and 3.23).

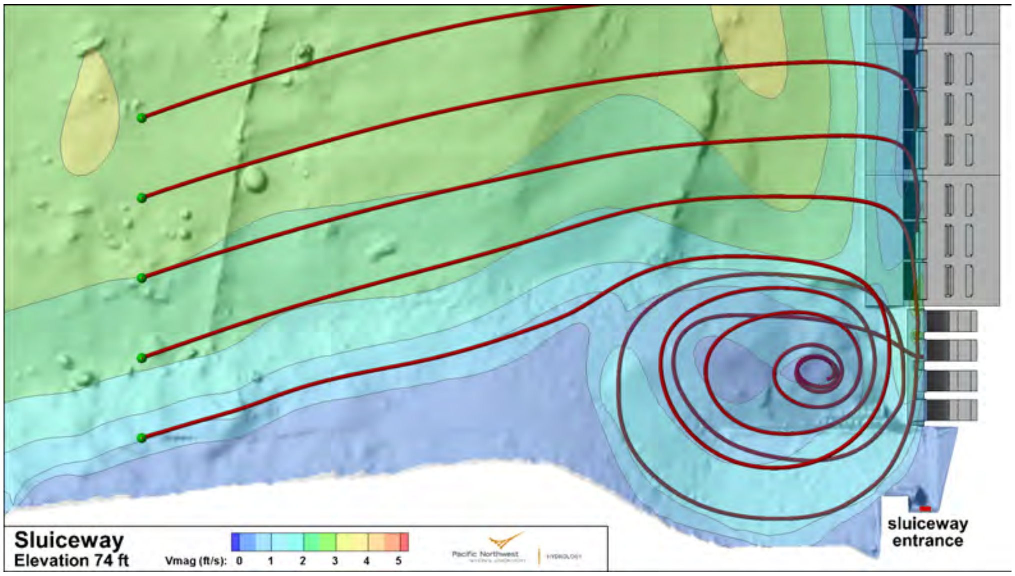


**Figure 3.21.** Velocity contours for an added sluiceway with streamlines seeded at elevation 74 ft, parallel to the B2 powerhouse and upstream of the Washington shore eddy.

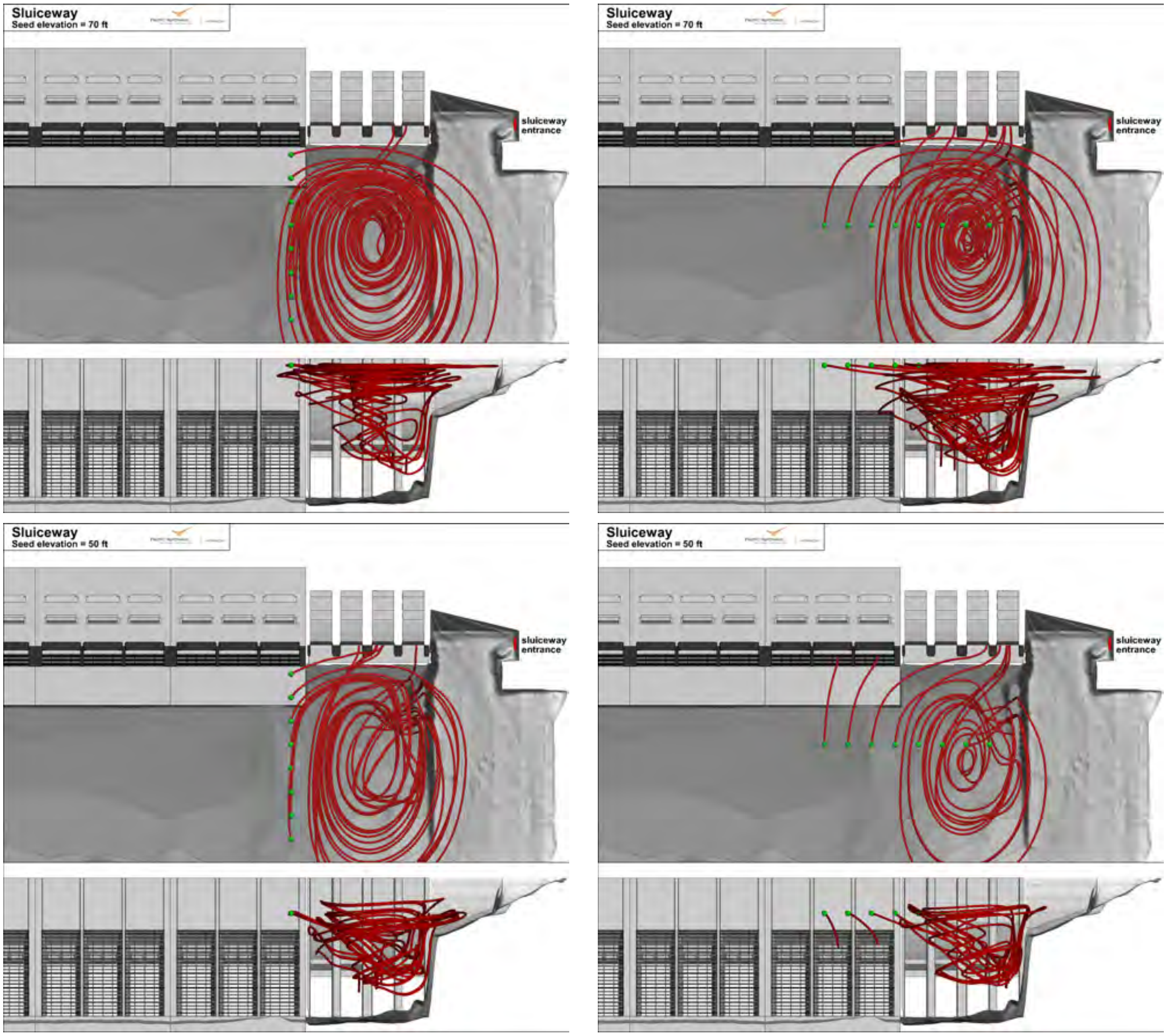


**Figure 3.22.** Wall 2 forebay streamtraces, seeded at elevation 70 ft (top) and 50 ft (bottom).

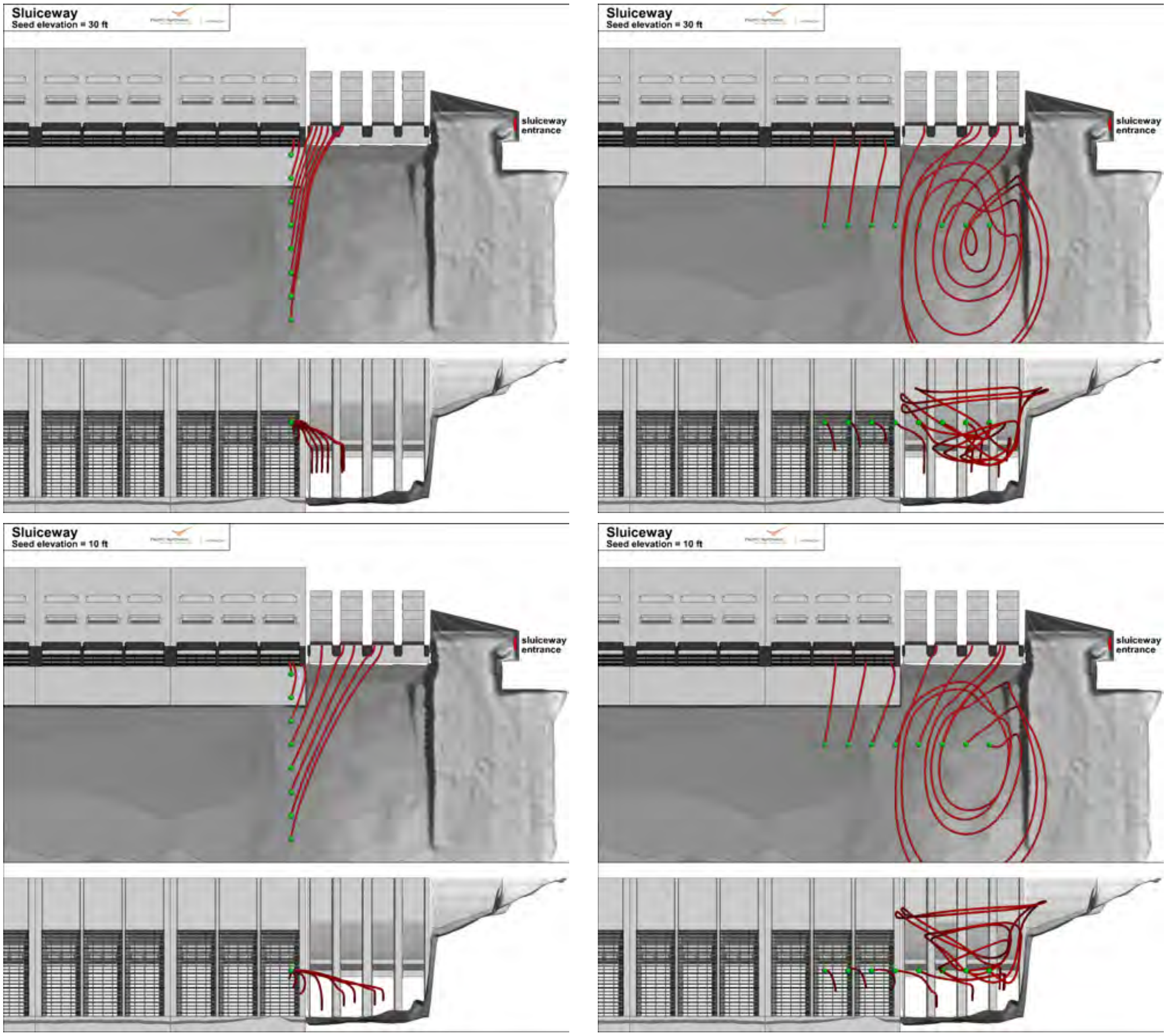


**Figure 3.23.** Sluiceway forebay streamtraces, seeded at elevation 30 ft (top) and 10 ft (bottom).

# 4.0 Conclusions

A new Bonneville forebay model was created for use in STAR-CCM+. This model incorporated the most recent bathymetric surveys and was tested for sensitivity to the order of differencing scheme and inlet boundary turbulence, and validated against field-measured velocity data.

The validated model was used to simulate the impacts of several wall configurations on the velocity field upstream of the fish units of B2. While the addition of the various walls did change the flow patterns, none of the configurations greatly reduced the recirculating flow as desired.

The bathymetry in front of the fish units makes it difficult to reduce or eliminate recirculation without altering the bathymetry through filling and excavation. Future studies could include evaluating these alternatives.

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# APPENDIX H

# BONNEVILLE SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP SYSTEM DDR 2001

US Army Corps
of Engineers
Portland District

Design Documentation Report

# Bonneville Second Powerhouse Auxiliary Water Supply Backup System

## Design Documentation Report

## Columbia River, Washington

***CH2M Hill / Montgomery Watson Joint Venture***

NOVEMBER 2001

Northwest Hydraulic Consultants • CivilTech

# SYLLABUS

This Design Documentation Report (DDR) describes the design, construction, operation and maintenance of the selected scheme to improve fishway operations at the Bonneville Second Powerhouse, in an emergency when a fish unit fails or is taken out of service. This work is performed under Project No. DACW57-97-D-0004, Task Order No. 0023.

This document is preceded by the *Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study* (Alternative Study) dated September 2000 under Project No. DACW57-97-D-0004, Task Order No. 0013, Modification No. 001304. The Ice and Trash Sluiceway has been used as a backup AWS supply, however future modifications to this structure and biological concerns have eliminated this option. The Alternative Study considered a variety of very costly AWS backup supply systems to replace the Ice and Trash Sluiceway backup. However, the Alternative Study concluded that effective backup to the AWS supply was best achieved by making improvements to the existing AWS and developing an operations plan to optimize the AWS when one Fish Unit is out of service. This operations plan defines configurations for: setting flow from the remaining turbine, positioning fishway entrance gates, and closing floating orifice gates and selected diffuser gates depending on the tailwater elevation.

At the end of the Alternative Study, scope was added to include consideration of alternatives developed in the *Bonneville Second Powerhouse Fish Unit Debris Study Reconnaissance Report*, Final, July 20, 2000, which was conducted by the Walla Walla COE. This study described the problems caused by debris buildup on the trashracks and sediment entrainment in the AWS system.

The DDR recommends the following:

AWS Improvements

- Stockpile crucial spare parts for the Fish Units (turbines).
- Block off the lower trashrack panels at the Fish Unit intakes to better control sediment transport into the AWS.
- Replace the existing trashracks and trashrake with new continuous bar trashracks and an automatic traveling gripper rake system.
- Place a log barrier in front of the Fish Unit intakes.
- Install two sets of level transducers across the diffuser grating at the A and B Diffuser Gates in order to monitor clogging.

Operations Plan

- Perform annual soundings immediately upstream of the Fish Unit intakes and dredge during the in-stream work window (December through February if required).
- Outfit the floating orifice gates with aluminum sliding closure plates that can be installed into guides mounted around the orifices. Plates would be installed by raising the floating orifice gates up to the EL 55 deck level.
- Test and verify the recommended operations plan after modifications to the floating orifices have been made.
- Implement the proposed operations plan, in the event of a Fish Unit turbine failure, to modify gate settings, close floating orifices, closes selected gates, and regulate flow at the remaining Fish Unit Turbine.

- Abandon use of the Ice and Trash Sluiceway as a backup to the AWS.

The DDR describes a number of different alternative capital and operational improvements to the AWS. The costs for the improvements considered are listed below:

**Cost Summary**

| Item | Alternative 2 Cost |
|---|---|
| **Floating Orifice Closure** | $181,972 |
| | |
| **Stockpile Crucial Spare Parts** | $129,945 |
| | |
| **Portable Gate Actuator** | $9,605 |
| | |
| **Operations Plan Verification Testing** | $47,850 |
| | |
| **Automatic Traveling Grip Rake** | $1,785,180 |
| | |
| **Blanking off Lower Trashrack Panels** | $132,250 |
| | |
| **Diffuser Grating Monitoring System** | $86,688 |
| | |
| **Total** | $2,373,490 |

The DDR does not recommend a comprehensive schedule for completing the proposed improvements. These improvements are comprised of several independent tasks, which may best be implemented under separate contracts or added to other projects. The DDR identifies critical durations and dates related to each item. This information will allow the USACOE flexibility in implementing the DDR recommendations.

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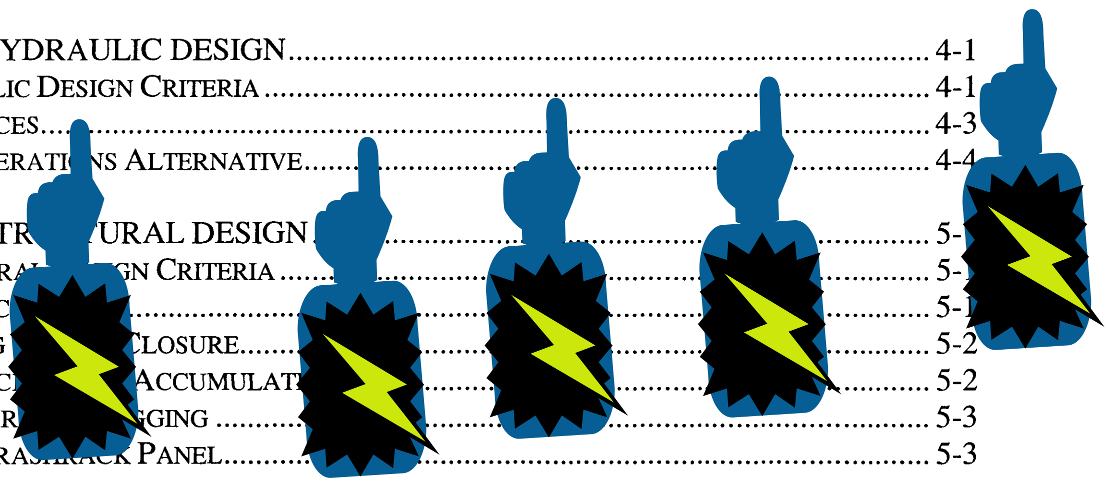

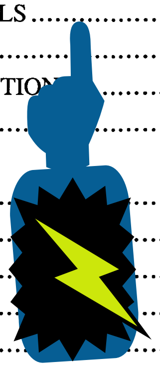
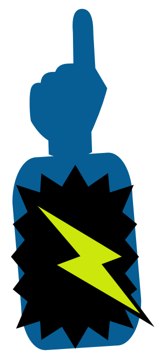

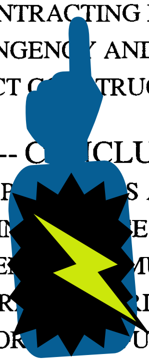
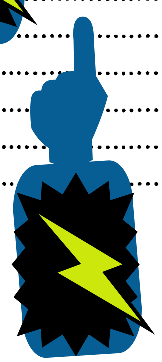

## APPENDICES



## LIST OF TABLES



## LIST OF FIGURES

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## PERTINENT DATA

| Item | Data |
|---|---|
| Dam | |
| Dam Location | Columbia River, Oregon and Washington, River Mile 145.2 |
| Forebay Deck EL | 90 fmsl |
| Tailrace Deck EL | 55 fmsl |
| Maximum Operating Reservoir Level Elevation | 77 fmsl |
| Maximum Pool Elevation | 87.5 fmsl |
| Maximum Tailwater Elevation | 35 fmsl |
| Minimum Tailwater Elevation | 7 ft fmsl |
| | |
| Fishway | |
| Fish Turbines | 2- Escher Wyss Turbines |
| Maximum Flow | 3000 cfs per unit |
| Intake Invert | -22.52 fmsl |
| Trashrack Area | 2530 sf per unit |
| Fishway Main Entrances | 4 – South Downstream Entrance (SDE), South Upstream Entrance (SUE), North Downstream Entrance (NDE), North Upstream Entrance (NUE) |
| Gate Type | Three leaf telescoping weir. |
| Main Entrance Invert EL | - 3 fmsl |
| Main Entrance Width | 12 ft |
| Flow @ Main Entrances | Varies with tailwater. Approximately 1200 cfs per gate. |
| Floating Orifice Gates | 12 total (20 slots) |
| Location | Access from El 55 fmsl tailrace deck |
| Width | 8 ft |
| Length | 42 ft |
| Weight | Approximately 12,000 lbs |
| Orifice Width | 8 gates – 2 ft wide, 4 gates – 4 ft wide |
| Orifice Height | 6 ft |
| Flow Through Orifices | Varies with head difference across the orifice. Approximately 90 cfs per orifice. |

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing Materials |
| ASME | American Society of Mechanical Engineers |
| AWS | Auxiliary Water Supply, American Welding Society |
| B2 | Bonneville Second Powerhouse |
| CENWP | Corps of Engineers Northwest Division Portland District |
| CMAA | Crane Manufactures Association of America |
| cf | Cubic feet |
| cfs | Cubic feet per second |
| DDR | Design Documentation Report |
| EL | Elevation |
| EMT | Electrical Metallic Tubing |
| fmsl | Feet mean sea level |
| fpm | Feet per minute |
| fps | Feet per second |
| FPP | Fish Passage Plan |
| H | High |
| HDC | Hydraulic Design Center, US Corp of Engineers – Portland |
| HP | Horse power |
| ID | Identifier |
| in | Inch |
| IEEE | Institute of Electrical and Electronic Engineers |
| IMC | Intermediate Metal Conduit |
| kW | Kilowatt |
| NEC | National Electrical Code |
| NEMA | National Electrical Manufactures Association |
| NFPA | National Fire Protection Code |
| NDE | North Downstream Entrance |
| NUE | North Upstream Entrance |
| PVC | Poly vinyl chloride |
| PE | Polyethylene |
| lb | Pound |
| lbs | Pounds |
| pcf | Pounds per cubic feet |
| psf | Pounds per square feet |
| psi | Pounds per square inch |
| PRM | Progress Review Meeting |
| RGS | Rigid Galvanized Steel |
| SDE | South Downstream Entrance |
| SUE | South Upstream Entrance |
| sf | Square feet |
| scfm | Standard cubic feet per minute |
| Stn Stl | Stainless Steel |
| kcfs | Thousand cubic feet per second |

| | |
|---|---|
| UHMW | Ultra High Molecular Weight |
| USACE | United States Army Corps of Engineers |
| V | Volt |
| W | Wide |

# SECTION 1 -- INTRODUCTION

## 1.1 Scope and Purpose

a. General. Regional fisheries agencies and tribes have asked the Portland District to address deficiencies in the emergency backup supply to the Auxiliary Water System (AWS) for the fishway at the Bonneville Second Powerhouse (B2). Historically when a Fish Unit fails the Ice and Trash Sluiceway is gated off to force water into the AWS to serve as a backup water supply. Three deficiencies have been identified with this procedure. These deficiencies include:

(1) Inadequate Discharge

(2) Adult Salmonid Fallback and Stranding

(3) Juvenile Salmonid Entrainment into the AWS

Furthermore, future modifications to the Ice and Trash Sluiceway for the Corner Collector Improvements will preclude operating the Sluiceway in an AWS backup mode. The B2 AWS Backup Design Documentation Report (DDR) considers alternatives and recommends specific system modifications to improve the reliability of the existing AWS system and provide an operations plan in the event of a Fish Unit failure.

b. Objectives. The scope of the DDR encompasses several objectives. Some of these objectives are new to this report and some are carried forward from the "Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study", September 2000. These objectives are listed below as they relate to system improvements for increasing the reliability of the AWS and to an operation plan for optimizing the Fishway while a Fish Unit is out of service.

(1) System Improvements

(a) To develop a strategy that prevents juvenile or adult salmonids from entering or being entrained within the auxiliary water system channel upstream of the diffuser grates.

(b) To refine the crucial spare parts list, with the help of Project personnel in order to limit fish unit downtime.

(c) To produce a design to mitigate problems caused by debris entering the AWS.

(d) To investigate methods to decrease sediment accumulation in the AWS.

(e) To investigate the feasibility and cost of monitoring diffuser rack clogging by installing pressure transducers and integrating them into the existing fish unit control and monitoring system.

(2) Operation Plan

(a) To be able to meet NMFS criteria within the fishway, in the event of a fish turbine failure.

(b) To develop a plan for operating the entrance gates, the diffuser gates, and the AWS to minimize criteria violations in the fishway. It is envisioned that this plan will be adopted by the agencies for inclusion in the Fish Passage Plan (FPP).

(c) Design closures at the floating orifice entrances and rehabilitation of existing gates and/or their controls.

## 1.2 AUTHORIZATION

a. This study is authorized under Appropriation 96x3122, Construction General, Columbia River Mitigation. This work is mandated by the 1998 Supplemental Biological Opinion and the 2000 Biological Opinion, Measures Nos. 125 and 127.

## 1.3 PROJECT DESCRIPTION

a. Main Features. The main features studied in this DDR, beginning at the forebay and ending at the tailrace, are as follows (See Plates 1 and 2):

(1) New trashracks, and trashrakes for fish unit intakes located on the north end of B2. The fish units supply the water entering the AWS.

(2) Stockpile spare parts for two fish turbines which supply water to the AWS.

(3) Four New pressure transducers (two pairs) installed at key locations in adult fishway system. (See Plates 14 and 15 )

(4) Floating orifice closure mechanisms for 12 floating orifices (located along the tailwater side of the powerhouse).

(5) Operations plan to optimize fishway conditions during times when only one fish turbine is working.

## 1.4 AGENCY COORDINATION

The NMFS attended the 60% and 90% Progress Review Meetings (PRM) of the DDR. Their input at these meetings was considered and acted upon. Additionally, the ODFW attended the 60% PRM.

## 1.5 PROJECT REFERENCES


a. *Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study*, September 2000.

b. *Bonneville 2$^{nd}$ Powerhouse Fish Unit Debris Study Reconnaissance Report, Final*, July 20, 2000.

c. *Fish Passage Plan*, Corps of Engineers Projects, February 2000.

d. *Bonneville Second Powerhouse Computer Model and Hydraulic Evaluation of the Fishway Facility Adult Bypass System*, October 1998.

e. *Design of Small Dams,* U.S. Bureau of Reclamation.

f. *Fisheries Handbook of Engineering Requirements and Biological Criteria* (1991).

# SECTION 2 -- BACKGROUND

## 2.1 General

a. <u>Previous Studies.</u> Two previous studies/reports, listed in Section 1.5, developed alternatives to address the shortcomings of the AWS, fish unit trashracks, fish unit trashrakes, and diffuser rack blockage. The first, *Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study*, September 2000, addressed the issue of providing a backup supply of water for the fishway if one of the fish turbines were to fail. Historically, should a fish unit fail or be taken out of service for maintenance, the Ice and Trash Chute doubled as the inlet for the backup AWS. By placing stoplogs at the exit, the chute was backwatered to spill water over a weir, down a shaft, and into the south end of the AWS conduit. This weir is positioned along the side of the channel in the upper reach of the chute. However, for compliance with the *2000 Fish Passage Plan* (FPP), this can only occur between September 1 and March 31 to reduce the impact on fish. When the chute is serving as a backup system, adults can fall back into the chute trashrack and become stranded. Juveniles can be impinged on, or entrained through the trashrack, then carried into the chute and the AWS. Furthermore, this backup source can only supply about 2000 cfs as it is presently configured. The chute will form the intake and the outfall for the Corner Collector. At that time the chute will no longer be available for use as backup to the AWS. The corner collector outfall is being studied at this time. The report is titled *Bonneville Second Powerhouse High Flow Outfall Bypass System DDR.*

b. <u>The FPP Outlines Criteria For Fishway Operations</u>. The FPP sets minimum and maximum limits to fishway channel velocities and velocities through the AWS diffusers. Minimum and maximum values are stated for the water surface differentials between the fishway and the tailwater, and between the tailwater elevation and the elevation of the entrance weir crests. The AWS backup system must be flexible and able to respond to varied conditions. Model studies show that criteria specified in the FPP are not met in all cases as the system is currently operated. A compromise must be reached that accommodates physical limitations of the fishway system and the broad range of tailwater elevations encountered at the site.

## 2.2 Fish Unit Down time

a. <u>Reduction of Fish Unit Down Time.</u> Another aspect of improving fish passage at B2 is to develop strategies to reduce the down time of the fish unit turbines. Scheduled maintenance outages are typically 2 to 4 weeks each year, according to maintenance records. However, a breakdown could put a turbine out of commission for an extended period of time. This situation would leave the ladders short on water and violating operating criteria as detailed in the FPP. A failure of Fish Unit 2 resulted in the a loss of service from September 1997 through mid-May 1998 for major overhaul work. One strategy to reduce downtime is to develop a list of spare parts. The *Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study* compiled parts lists based on manufacturer's recommendations and discussion with project personnel. This DDR presents a parts list developed in coordination with the project staff at B2.

## 2.3 TRASHRACK DEBRIS ACCUMULATION

a. <u>General.</u> The second report listed in Section 1.5, *Bonneville 2nd Powerhouse Fish Unit Debris Study Reconnaissance Report*, Final, July 20, 2000, was conducted by the Walla Walla COE. The report began an investigation into debris loading on the fish unit trashracks, and sediment accumulation throughout the fishway. This report presented a number of problem areas and potential solutions. Solutions to these problems are considered further in the DDR phase in order to identify a preferred alternative.

b. <u>Current Method To Clean Trashrack</u>. The trashracks are frequently clogged with debris. At times the head differential across the trashrack exceeds 3-feet. The existing trashrake is inefficient for removing small debris, which becomes lodged between the trashrack bars. The clear space between the bars is 7/8 of an inch. This narrow spacing is required to preclude debris from clogging the 1-inch clear openings in the diffuser gratings. The current method for cleaning the trashracks involves shutting down the Fish Units for approximately 3 hours each night to allow debris to drift away from the fish unit trashracks. The cleaning is implemented when 1.5 to 3-feet of differential is observed across the trashracks. This cleaning method reportedly results in higher maintenance cost and increased risk of emergency shut downs. *Bonneville 2nd Powerhouse Fish Unit Debris Reconnaissance Report, Final,* July 20, 2000 states that thermal cycling, brake wear, and wear due to bearing oil film thickness on start-up are the major causes of the increased risk to the fish units.

## 2.4 SEDIMENT ACCUMULATION IN FISHWAY

a. <u>General.</u> Sediment accumulation within the B2 Adult Fishway Auxiliary Water System has been an ongoing problem. In particular, the flood in 1996 resulted in heavy deposits across the Powerhouse forebay and throughout the Fishway AWS. *The Bonneville 2nd Powerhouse Fish Unit Debris Study Final* - July 20, 2000 describes over 18,000-CY removed from the forebay (7,400-CY upstream of the Fish Units) and 2000 CY of material was removed from the AWS after this event.

b. <u>Sediment Gradation</u>. A sample of the sediment removed from the AWS shows a distribution of: fine gravels, sands, and silt, including fragments of clam-shells. A sieve analysis of this sample is presented by Figure 2-1 Sediment Gradation Curve. This curve indicates that 7 percent of the sample is fine gravel, 4 percent coarse sand, 13-percent medium sand, 54-percent fine sand, and 11-percent silt, and clam shells were also present. The makeup of this sample is indicative of material transported by bedload movement. During full operation of the Second Powerhouse main units, forebay velocities in excess of those recommended to prevent scouring are present. Observations and sampling of material in the AWS was prevented during the 2001 work period due to excessive leakage during dewatering efforts of the North Fishway monoliths. Efforts to sample sediment in the AWS should be made during future maintenance. Further study may be necessary to better ascertain the source and conveyance of sediment accumulations in the AWS.

c. Bathymetry and Soundings. Bathymetry and sounding data of the forebay since 1997 indicate the tendency for sediment to accumulate up to 10-feet above the invert in front of the Fish Unit intakes. Plates 3 through 6, present the original forebay grade after construction, the 1997 post-dredge soundings, the 1998 bathymetry, and the 2000 soundings. Plates 7 through 9 show composite sections A, B, and C for these data. Section A depicts the area of greatest sediment build-up in front of the south Fish Unit 2 intake. Section B is through the south Fish Unit 1 intake (adjacent to the Main Unit 18). This section shows decreased sediment. Section C is through Main Unit 18 and depicts a more gradual forebay invert slope and a clear intake invert. As of March 2000, sediment has built up to an elevation 2 to 12 feet above the invert of the Fish Unit intake (invert elevation: –22.52-fmsl). The steep forebay slope, especially evident in front of the Fish Units, filled in after dredging and buried the lower portion of the Fish Unit trashracks. Table 2-1 - Forebay Sediment Movement presents the volume change in the forebay area adjacent to the Fish Unit intakes. Material upstream of the Fish Units appears to fill in the area dredged out next to the intakes. Volumes are calculated by comparing forebay invert surfaces generated in the "Microstation In-Roads" program from point data obtained by the various surveys. These surfaces are presented on Plates 4 – 6. The extent of the evaluation area is depicted within the dashed lines shown on these plates.

**Table 2-1**
**Forebay Sediment Movement**

| | In-fill, CY | Scour, CY |
|---|---|---|
| 1997 Post Dredge to 1998 | 960 | 530 |
| 1998 to 2000 | 1400 | 790 |

d. Blocking Lower Fish Unit Trashracks. The relatively rapid burying of the lower portion of the Fish Unit trashrack suggests blocking the lower trashrack with blank panels. Existing trashrack panels are 13.5-feet high. Blanking off an entire trashrack section will provide a new intake invert elevation of –9-fmsl. Methods described in the United States Department of Interior Bureau of Reclamation publication titled *Design of Small Dams* were used to estimate headloss through the trashracks. The headloss characteristics of the existing trashrack are shown on Figure 2-2 Existing Trashrack Headloss. Headloss during normal fish turbine flow, 2845-cfs, is low at 0.06 feet of head when the trashrack is relatively clean. Figure 2-3 Proposed Trashrack Headloss depicts the estimated headloss when the lower trashrack panel, (one out of the five of the existing panels are blanked off). If the trashrack is kept reasonably clean, then blanking the lower trashrack panel will not result in excessive headloss. An evaluation by the Hydroelectric Design Center determined that the Fish Units could be operated while blocking off the bottom trashracks without significant loss in turbine performance.

e. Dredging Program. Given the bedload movement from the 1997 post-dredge soundings to the 1998 bathymetry, the invert of the trashracks was buried with up to 10-feet of sediment within a single season. In-water work should only be performed during the December through February timeframe. Therefore, dredging alone does not appear to be a feasible alternative. Dredging of the forebay upstream of the Fish Unit intake will be necessary regardless of the implementation of other improvements. The degree and frequency of the dredging necessary will be dependent on the amount of trashrack, which is blanked off.

f. Internal AWS Sediment Control. Re-suspension of sediment within the AWS has been suggested as a possible alternative to pass sediment through the fishway with air or water jets. Velocities in the AWS Conduit can fall to as low as 0.2 fps and the conduit invert is at –34-fmsl. The lowest fishway invert elevation through which water can discharge to the tailrace is 3 fmsl. This requires that sediment, including coarse sands and fine gravel, be lifted at least 30 vertical feet up through the diffuser chambers and grating. Implementing a system, which would suspend the sediment material in the low velocity AWS conduit and transport it up through the diffusion system and out the fish collection channel fishway entrances is unpractical. Furthermore, if the velocities were high enough to flush the material through the AWS, the diffuser grating would inhibit the flushing of gravel size material.

g. Measuring Fishway Diffuser Grating Clogging. The existing method to determine if the diffuser grating is becoming clogged requires a diver to make direct observations. An automated system would provide a much better means of monitoring and anticipating problems due to clogging of the diffuser grating. The existing level monitoring system can determine the head difference between the AWS conduit and the Fish Collection Channel. Unfortunately, this system is inadequate to determine if clogging of the diffuser grating is occurring. The AWS conduit pressure/level transducer and the collection channel pressure/level transducer are bubbler types. The bubblers are installed in the El. 28 gallery, and send their signals back to the main control board (SA24) located beside the fish turbines. SA24 subtracts the tailwater elevation signal from the collection channel level signal and displays the difference on the front panel. In like manner the water elevation differential between the AWS and the fish collection is calculated and displayed. The air supply to the bubblers does not have enough pressure to overcome the static head generated by a high tailwater. Consequently, both bubblers give incorrect readings when the tailwater is at a high elevation. Furthermore the differential measurements include the loss across the diffuser gates and orifices. The typical differential between the AWS Conduit and the Fish Collection Channel is 1 to 1.5-feet, therefore the loss resulting from clogging of diffuser grating can only be determined indirectly. Small changes of head resulting from diffuser grating clogging would not be nearly as apparent as with a direct measurement method and significant diffuser grating clogging could go unnoticed.

h. Proposed Diffuser Grating Monitoring. Directly measuring the pressure upstream and downstream of the diffuser gratings provides the most reliable and accurate means of determining head differential across the grating. Normal headloss across the diffuser gratings is nearly zero. Therefore, clogging would become apparent with a grating headloss differential of only a few inches. Consequently the direct measurement method is the only alternative considered in this report for monitoring clogging of the diffuser grating.

## 2.5 ALTERNATIVES DESCRIPTION

a. General. A list of the alternatives developed in this DDR is included below with a description of each. The alternatives are separated by improvements to increase AWS reliability and alternatives pertaining to the plan for operating the Fishway with only one Fish Unit in service.

b. System Improvements

(1) Stockpile Crucial Spare Parts. Crucial, frequently used, or long lead time parts for the fish units are recommended to be kept on hand. This will significantly reduce down time for repairs. Recommendations are made for the parts list in Section 9.

(2) Block Lower Portion Of Trashrack. Blocking the lower trashrack panel is proposed to prevent sediment bedload movement into the AWS. This improvement is necessary, because of the rapidity of sediment infill in front of the fish units, and the need to avoid dredging while the fishway is in operation.

(3) Trashrack Debris Accumulation and Diffuser Rack Clogging.

(a) The existing trashrake is shown on Picture H1 in the Appendix H. This rake is ineffective at removing debris and tends to mash it into and through the trashrack. This problem is complicated by the narrow spacing of the trashrack. A clear spacing of 7/8-inch is used. This narrow spacing is required in order to keep the openings through trashrack smaller than the openings through the diffuser gratings. However, the relatively narrow spacing is difficult to clean. An effective cleaning system is critical to preventing the AWS diffuser gratings from clogging.

(b) During the sediment removal effort in 1997 a number of the diffuser gratings were found clogged with debris. As a result of the increased pressure from clogging, badly corroded fasteners failed and a number of grating panels detached from the structural supports. To prevent this problem from reoccurring, use of the existing trashrake has been abandoned. Currently, the trashrack is cleaned by shutting down the Fish Unit Turbines and allowing debris to float away, perhaps into the adjacent Main Unit 18.

(c) Two alternative trashrakes were considered in the 90% DDR; a manual telescoping rake mounted on a gantry, and an automatic monorail supported gripper rake. At the 90% PRM, a decision was made to move forward with the automatic monorail supported gripper rake. The 90%

PRM meeting report is included in Appendix I. Each of these systems utilizes UHMW teeth on the rake head, which partially penetrates the trashrack to lift debris off the bars. The existing bars are only 1.25-inches deep. This bar depth is not adequate to allow the rake teeth to penetrate, because the teeth will hang up on the horizontal members supporting the vertical trashrack bars. The velocity of water within the forebay acting on the proposed rakes is a design concern. A three-dimensional model by CENWP was used to evaluate velocities immediately upstream of the Fish Unit intakes. "Table 2-2, Forebay Velocity at Fish Unit Intakes" presents the design velocities at 3-feet upstream of the Fish Unit trashrack face. The velocities presented are increased by a safety factor of 2.0 from the magnitude generated by the model. The "normal" velocity component is perpendicular to the face of the trashrack and positive in the direction of the powerhouse. The "parallel" velocity component is across the face of the trashrack and positive in a northeasterly direction (away from the Main Unit intakes). See Plate 7 for the location of the points, A through J, in cross section. The location of the velocity in plan are at the respective midpoint of each intake for each fish unit (i.e. 1-South is the southerly intake bay for Fish Unit 1). The resultant velocities are not excessive and will not require special consideration in design of the trashrakes.

**Table 2-2**
**Forebay Velocity at Fish Unit Intakes, fps**

| **Point** | **El.** | **1 –South** | | **1-North** | | **2 –South** | | **2-North** | |
|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Parallel | Normal | Parallel | Normal | Parallel | Normal | Parallel |
| A | 74 | -0.2 | -1.5 | 0.0 | -0.2 | 0.0 | -0.8 | -0.1 | -1.3 |
| B | 70 | 0.2 | 0.5 | 0.2 | 1.0 | 0.1 | 0.0 | -0.1 | -0.8 |
| C | 60 | 0.4 | 2.7 | 0.2 | 1.9 | 0.2 | 1.7 | 0.1 | 0.0 |
| D | 50 | 0.4 | 3.2 | 0.2 | 2.9 | 0.2 | 2.4 | 0.2 | 0.2 |
| E | 40 | 1.4 | 3.6 | 1.1 | 3.6 | 1.1 | 3.4 | 1.2 | 1.6 |
| F | 30 | 1.8 | 3.4 | 1.6 | 3.4 | 1.7 | 3.4 | 1.8 | 2.1 |
| G | 20 | 2.1 | 2.7 | 1.8 | 2.9 | 1.9 | 2.9 | 2.1 | 2.1 |
| H | 10 | 2.4 | 2.3 | 2.1 | 2.5 | 2.2 | 2.4 | 2.2 | 2.2 |
| I | 0 | 2.8 | 2.2 | 2.5 | 2.4 | 2.5 | 2.2 | 1.5 | 1.8 |
| J | -10 | 3.1 | 2.4 | 2.8 | 2.5 | 2.7 | 2.3 | 1.7 | 2.5 |

(d) Both proposed trashrake improvements require a new trashrack. Because of the unusually narrow clear opening required for the trashrack (7/8-inch), the bars must align with bars of the panels. To insure proper trashrake operation, the fabrication of the replacement trashrack should be by the manufacturer of the trashrake cleaner.

(e) Alternative trashrack materials such as fiber reinforced plastics or high density polyethylene have a number advantages over steel such as corrosion resistance, non-icing, lighter weight, and hydraulic efficient profiles. The main disadvantage is strength. Icing is not an issue since the existing trashracks are always submerged at least 25 feet. The lighter weight is no advantage for the existing configuration. The more hydraulically efficient polyethylene bars are offset by the lower strength. The lower strength results in a thicker bar, which in turn cause a significantly greater occluded area of the trashrack. The loss of open area causes higher velocities through the trashrack. With the existing trashrack, the loss of open area defeats the greater hydraulic efficiency of the individual bars. Furthermore, the elliptical bar shape of the composite trashrack will exacerbate clogging with fir cones and drift-wood. Neither proposed cleaning system is compatible with composite trashrack. No further consideration will be given to alternative trashrack materials.

(f) Automatic Traveling Grip Rake. This rake scheme consists of replacing the existing trashracks and trashrake with a monorail mounted traveling gripper rake similar to that manufactured by Brackett Green. See Plates 12 and 13.

(g) Blocking off the Lower Trashrack Panel. In order to decrease sediment movement into the AWS, and reduce dredging frequency, a blank panel can be welded over the bottom section of the fish unit intake trashracks. This modification is proposed regardless of the cleaning system. See Plate 12.

(h) Log Barrier. Large floating logs can accumulate in the forebay adjacent to the Fish Unit intakes. This is particularly true during the higher spring flows when debris loading on the trashracks if heaviest. Although the proposed cleaning system can remove logs, the primary concern is cleaning the smaller material from the submerged trashracks. Removing a potentially large raft of logs from the forebay, before the trashracks could effectively be cleaned, could pose a significant problem. The Project reports that logs have a tendency to accumulate in the area next to the Fish Units. A log barrier would permit either rake to enter the forebay and clean the trashracks without encountering logs. This barrier would consist of a reinforced plate rigidly mounted to the piers between the Fish Unit Intakes. A decision was made at the 90% PRM to move forward without a log barrier. Existing methods of log removal will be employed. A log barrier could be added at a later date if surface debris is a significant problem for removal, handling, and disposal.

(4) Install Pressure Gage in AWS Conduit. Clogging of the diffuser racks is currently difficult to monitor without visual inspection, either by a diver or when the system is taken out of service. Although the existing grating fasteners have been replaced with stainless steel fasteners, the problem of clogging can still present both structural and operational problems. To better monitor potential clogging, pressure transmitters to measure the differential pressure across the diffuser gratings are proposed. The differential will be measured by

a set of two sensors, immediately above and below a given grating. Two locations for each set of transmitters will be used: one at the south end of the Fishway next to the B Diffusers and one at the north end in the junction pool below the fish ladder. Plates 14 and 15 depict this system.

c. Operation Plan

(1) AWS Operations Alternative. This alternative examines methods to improve conditions in the fishway during a fish turbine outage through changes in fishway operations and minor modifications of fishway components. Through the use of the Bonneville Second Powerhouse Fish Ladder Model, recommended settings for the floating orifice gates, the main gates, the diffuser gates, and the fish turbines are presented to allow operators to optimize fishway hydraulics for a range of tailwater elevations.

(2) Floating Orifice Gate Closure Schemes. As a part of implementing the proposed operation plan, the floating orifices need to be closed. There are 12 floating orifices installed on the downstream side of the Fish Collection Channel at Bonneville Second Powerhouse. See Photos H-10 through H-12 in Appendix H. Each floating orifice gate is assembled out of two sections. The upper section consists of a bulkhead type roller gate, 8 ft. wide by 21.75 ft. long with a floatation chamber attached that is 6 ft. deep and 3.8 ft. wide. The floatation chamber allows the gate to rise and fall with the powerhouse tailwater. The upper portion of each gate has a 6-ft. high orifice located 7 ft. below the top of the floatation chamber. Eight of the floating orifices are 2 ft. wide, whereas four are 4 ft. wide. The floatation chamber maintains the top of the orifice approximately 3 ft. below the tailrace water surface and about 4.5 ft. below the water surface in the Fish Collection Channel. The lower portion of the floating orifice gate has no openings, extends 22.25 feet below the upper section. The two sections are bolted together. When the gates are removed from their slots, the gantry crane lifts the upper section above the deck. After the lower section of the gate has been dogged off, the gate sections are unbolted and separated.

(a) Four alternative schemes for closing these orifices were presented in the 60% DDR. They included:

i) Alternative 1 –Slide Gate Mounted to Floating Orifice (Upstream Side) with air driven actuator.

ii) Alternative 2 – Slide Gate Mounted to Floating Orifice (Downstream Side) with air driven actuator.

iii) Alternative 3 –Lower a Bulkhead mounted Stab Plate from Above.

iv) Alternative 4 – Permanent Closure.

(b) The Preferred Alternative at the 60% Level was Alternative 3 – Lower Bulkhead From Above. The clearance between the downstream face of the floating orifices and deck opening was a significant concern during the development of this alternative. It was agreed that measurements be taken at each gate to confirm adequate clearance between the tailrace side of the gate and the concrete opening in the deck at EL 55 before the 90% submittal. *Site Visit Report – Floating Orifice Measurements, C-Diffuser Gates, and Raceways for Level Transmitters in the Transportation Channel at Monolith 1N.* in Appendix J describes this effort. This site visit confirmed the existence of adequate clearance for this alternative.

(c) Alternative 3 modified for the 90% Submittal. As originally conceived, this alternative involved inserting a stab plate into guides on the downstream face of the floating orifice gates by lowering the plates onto the gates with a mechanical lifting device from the EL 55 deck. A field effort was undertaken to verify that the stab plate would fit. During the course of the investigation (see June 7, 2001 field report), a modification to the concept was developed with input from Bonneville Project staff. The modified alternative consists of removable aluminum slide plates, placed by hoisting the floating orifice above the deck with a gantry crane or boom truck, and installing the slide plates at the deck level. Then the floating orifices would be lowered back into position. A line fixed to the top of the top of the slide plate would extend up to the deck and be dogged off. This would allow the slide plate to be pulled without removing the floating orifice gate. Several observations led to this modification. These include the following:

i) A slide plate on the downstream side of the floating orifice gate could be readily installed at deck level.

ii) The riggers expressed concern about sediment fouling gate slots over an extended period of time and inhibiting stab plate installation.

iii) Raising the floating orifices gates to the deck level would allow slots for the slide plates to be cleaned out.

iv) The total length of time to remove all the floating orifices was just over 5 hours. Most of the time involved mobilizing, removing deck slabs, and re-arranging bulkheads. Installing slide plates on the floating orifice gates at deck level would likely take the same length of time as the measurements took. This duration is estimated to be at most 2 hours longer than *Alternative 3 – Lower Bulkhead From Above* described in the 60% DDR.

v) If fouling of the slots occurred (for the slide gates or stab plates), the slots would need to be cleaned out at the deck level with a pressure washer.

vi) Proper seating of the stab plates would be difficult to determine from the deck level.

vii) The floating orifice gates would need to be pulled up to the deck level if improper seating was observed.

viii) Removal of the floating orifice gates did not require the fish units to be shut down. The flow was throttled back during the June 7th field work and the floating orifice gate was readily lifted to the deck level and readily re-installed.

ix) The slide gates would be less than half the size of the stab plates, making them much easier to handle, easier to store, and would be less expensive.

x) No modification to the floatation chamber is anticipated under the new alternative. Aluminum slide plates would be relatively lightweight and would not require adding additional buoyancy to the floating orifice gate floatation chamber. This would also reduce the cost.

xi) A lifting cable on the gates would allow removal of the slide gate without lifting the floating orifice gate to the deck level. Only the deck slabs would be removed; the bulkheads hanging in the adjacent slot would not need to be handled. Two blocks and a weight will prevent slack cable from dangling in the collection channel (see Plate 10). With the modified alternative, the slide gate removal process will take less time than removing the stab plates as envisioned in the 60% DDR.

(3) Diffuser Gates. The diffuser gates control the flow from the AWS into the fish collection channel. Results from the Bonneville Second Powerhouse Fish Ladder Model indicate the operation of the Fishway, with only one Fish Unit, can be improved by closing diffuser gates at the south end of the fishway (B and C diffusers, see Appendix F Figure F-1). This forces more water into the fishway at the north end and increases velocities in the fish collection channel. The ability to effectively operate the gates during an emergency condition has been a concern. To address this concern, the gates were evaluated at the project. The results of this evaluation are presented in the following sections.

(a) Assessment of B Diffuser Gates. The B diffuser gates consist of; two manually actuated 72-inch wide by 72-inch high gates (B1and B2), two motor actuated 72-inch wide by 72-inch high gates (B3 and B4), and four motor actuated 36-inch wide by 72-inch high gates (B5 through B8). Plate 2 depicts the location of these gates. The larger gates use a 1.6-hp motor on the actuator and the smaller gates use a 0.7-hp motor. The proposed operation of the B diffuser gates in the Bonneville Powerhouse 2 Adult Fishway Auxiliary Water System (AWS) will result in higher than normal pressure head across the gates. Potentially 2 to 3 feet of head may develop, whereas the normal range is 1 to 1.5-feet. Limited information was available from the Project and the gate actuator vendor, Limitorque, recommended larger actuator motors. A test was performed to simulate emergency operation conditions while measuring the current in the actuator motors. Only in the extreme case with 3.3 feet of head across the gates did the motor current exceed the motor rating. The excess current only lasted a few seconds as the gate opened from a fully closed position. This excess current was at most 4-percent higher for the larger actuators and 1-percent higher for the smaller actuators. A portable electric motor actuator is recommended to operate the two manual gates (B1and B2). This actuator would also service to operate a gate with a failed actuator.

(b) <u>Assessment of C Diffuser Gates.</u> The C diffuser gates consist of 10 manually actuated 36-inch wide by 60-inch high gates located along the length of the powerhouse. Plate 2 depicts the location of these gates. The gates are positioned by turning an operator nut inside a box mounted flush with the deck on the tailrace side of the powerhouse. The operator turns a hollow shaft, which acts on the threaded portion of a 2-inch diameter gate stem, pulling the stem into the shaft as the gate is raised. The as built drawing (BDP-1-3-2/70) indicates that the design condition for these gates is a 5-foot operating differential. The Project operations staff reports that all the gates are operable by either a hand held actuator (referred to as a "mule") or a drill motor with a operator nut adapter. The proposed portable gate actuator for the B Diffuser Gates could also serve to operate the C diffuser gates.

(c) <u>Rehabilitation Plan</u>. Testing the gates indicated that the existing actuators would perform adequately up to the proposed head conditions. No rehabilitation or upgrades are recommended. No further consideration of this alternative will be given in this DDR.

(4) <u>Main Entrance Gate Controls</u>. The Operational Alternative requires that the NUE gate be closed while the remaining three gates respond automatically to the tailwater elevation. The control capabilities for the main gates were assessed during a site visit. No work on main gate controls will be undertaken in this DDR.

## SECTION 3 -- BIOLOGICAL BASIS

### 3.1 GENERAL

a. This section deals with biological and fish behavior characteristics of the target species, both juvenile and adult. The assumptions stated below deal with seasonality of passage and project operational criteria. In general, the system will be designed to minimize adult and juvenile entrainment. Entrainment is reduced by no longer using the ice and trash chute as a source for auxiliary water.

### 3.2 JUVENILE ENTRAINMENT

a. Ice and Trash Chute. Currently, when a fish unit fails or is taken out of service for maintenance, the Ice and Trash Chute doubles as the inlet for the backup AWS. Water is introduced into the AWS by placing stoplogs at the end of the chute. The water can then spill over a weir, down a shaft, and into the south end of the AWS conduit. The weir is positioned along in the upper reach of the Ice and Trash Chute. When the chute is serving as a backup water supply system, juveniles can be impinged on, or entrained through the trashrack, then carried into the chute and the AWS. This traps the juveniles behind the diffuser gratings leading to the fish collection channel. The design outlined in this DDR eliminates the Ice and Trash Chute as source for backup auxiliary water. This will eliminate the primary entry point for juvenile migrants.

b. Fish Unit Intakes. The intakes to the fish units are protected by trashracks with a clear space of 7/8 inch. Theoretically a juvenile migrant could enter the AWS through the intake and wind up on the wrong side of the diffuser gratings. However, the top of the intake is at elevation 40 fmsl and the bottom of the intake is at elevation –22.5 fmsl. The forebay water surface design range is between 71 and 77 fsml. This intake is considered to be too deep to attract juvenile migrants. Consequently, the intake is considered to be deep intake and does not require fish screen protection.

### 3.3 ADULT PASSAGE PERIOD

a. There are no extended times during the year when adult passage is not an issue. Typically the ladders run all year; however, one fishway ladder may be removed from service at a time during the in-water work period. As defined in the Bonneville Dam section of the FPP, the in-water work period is December 1 through February 28.

b. Shad. Shad normally show up at Bonneville during the later part of May and continue strong through the month of June. Numbers normally drop off significantly by the first two weeks in July. The fish ladders are operated during the shad run with the water over the weirs increased by 0.3 ft (1.3 ft total) to help them move over the weirs and to minimize their holding. However the operation of the main entrances and the collection channels are not changed when the shad are migrating. For construction of the AWS backup facilities it is assumed that the ladders and Juvenile Bypass System (JBS) facilities can be taken out of service during this period. In addition, all work in the water will be scheduled for this period.

## 3.4 ADULT PASSAGE CRITERIA

a. Criteria for Adult Passage Set Forth in the FPP for the B2 Project. The following pertain to the entrances and the powerhouse collection channel:

(1) Head on all entrances should be: 1ft to 2 ft (1.5 ft preferred).

(2) A water velocity of 1.5 fps to 4 fps (2 fps preferred) shall be maintained for the full length of the powerhouse collection channel.

(3) Operate weir crests at elevation 1 ft (fully lowered) for tailwater elevations up to 14 ft. For tailwater elevations greater than 14 ft, operate weir crest 13 ft or greater below tailwater.

(4) Operate all 12 powerhouse floating gate fishway entrances.

b. Floating Orifices. The first three criteria were are considered important for providing favorable hydraulic conditions in the fishway. The numerical model, used to explore various operating scenarios (see Section 4), tracks each of these variables. The DDR recommends that a method to temporarily close the 12 floating orifice gates be installed and operated at times when only one fish turbine is providing water to the AWS. This presents an as yet unquantified risk to upstream migrants by reducing the number of entry points into the fishway, which could delay the upstream migrants. However, it may be the case that closing the floating orifices could be beneficial in reducing adult fallback by preventing fish that enter the south entrances from exiting through the floating orifices along the powerhouse collection channel. Studies detailing the use of the floating orifices have been undertaken. Results have not been published. There is a consensus among the fish agencies, and the COE that the risk to adult fish passage posed by closing the floating orifice gates is acceptable during times of emergency operations.

## SECTION 4 -- HYDRAULIC DESIGN

### 4.1 HYDRAULIC DESIGN CRITERIA

a. General. The hydraulic assumptions state the water levels and flows used as constraints in developing the concept designs for the features at the project. The flows and water levels are divided into two types, maximum design and operating. The maximum design values are those used in designing the structure and assessing the stability and forces acting on it. The operating values are those for which the structure is designed to operate and perform its intended purpose. These can be both minimum and maximum values.

b. Flows. The following are the design flows for which the structures are designed. These flows represent the total river discharge.

(1) Maximum Design Discharge.

(a) 100-year Flood: 700 kcfs

(b) Maximum Inflow: 1,250 kcfs

(2) Operating Discharge.

(a) Maximum for Fish Passage: 515 kcfs (10-Year Flood)

(b) Minimum for Fish Passage: 60 kcfs at each Powerhouse

c. Spill Priority. The Spillway has priority over the powerhouses depending on seasonal juvenile passage requirements.

d. Spill Periods. Spill for fish passage occurs from April through August when 120 kcfs is spilled at night and 75 kcfs is spilled during the day.

e. Powerhouse Operations. The Second Powerhouse operates as a priority over the B1 between March 1st and June 20th. The First Powerhouse has priority over B2 between June 21st through August 31st. Priority shifts back to the Second Powerhouse between September 1st and November 30th. First Powerhouse flows of at least 60 kcfs are maintained to provide favorable tailwater conditions for juvenile out-migration. If the B2 is operated, it must also maintain flows of at least 60 kcfs. The flows at both powerhouses can be reduced below 60 kcfs to minimum unit loading, if needed to achieve the desired spill (FPP Sections 2.2.2 and 2.2.3). Because of higher river flows, more turbines typically run in the spring.

f. Water Levels and Velocities. The following criteria, detailed in the FPP, were used for guidance in developing the auxiliary water supply (AWS) backup alternatives and for the evaluation of the alternatives:

(1) Water surface difference at ladder entrances: 1.0 ft to 2.0 ft, 1.5 ft preferred.

(2) Unsubmerged water depth on fish ladder weir:

(a) 1.0 ± 0.1 ft during the non-shad passage season (August 15 through May 14)

(b) 1.3 ± 0.1 ft during the shad passage season (May 15 through August 15)

(3) Submerged fish ladder and fish-collection-channel transportation velocities: 1.5 to 4.0 fps, 2.0 fps preferred.

(4) Diffuser inflow to fishway, average velocity: 0.26 to 0.50 fps.

(5) Entrance weir depth:

(a) The entrance weir crest shall be fully lowered (crest at 1 fmsl) for tailwater elevations ≤ 14 fmsl.

(b) Operate weir crests 13 ft or greater below tailwater for tailwater elevations >14 fmsl.

(6) Floating orifice operation. Operate all 12 of the proposed floating orifice gates. This criteria could be relaxed for emergency conditions.

(7) Hierarchy of criteria. At the 60% Combined Report Progress Review Meeting (PRM) for the Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study, a hierarchy of criteria was stated by the agencies. The hierarchy is listed in order of decreasing importance:

(a) Entrance velocity (i.e. head across the entrance).

(b) Entrance gate submergence.

(c) Channel velocity.

(d) Diffuser velocity.

g. Headwater and Tailwater Operating Levels. The operating water levels for headwater and tailwater are shown on Table 4-1.

**Table 4-1**
**AWS Design Operating Water Levels**

| | **All Alternatives** fmsl) |
|---|---|
| **Maximum** | |
| *Bonneville 2 Tailwater* | 35 |
| *Bonneville 2 Headwater* | 77 |
| **Minimum** | |
| *Bonneville 2 Tailwater* | 7 |
| *Bonneville 2 Headwater* | 71 |

h. Tailwater Annual Exceedance Curve. Figure 4-1 presents the annual exceedance curve for the tailwater based on a 10-year time period beginning in 1989. The period of record was chosen to encompass the current spill regime. This figure depicts the percent of the time a given tailwater elevation was exceeded during the time period evaluated.

i. Columbia River Combined Probability Flow Profiles. Figure 4-2 depicts the Columbia River Combined Probability Flood Profiles starting approximately 100 miles downstream of the Bonneville Dam. This figure is dated June 1, 1994. The basic data were developed by CENWP, January 17, 1986 and revised by CENPD-PE-WM, November 1987 by G. Holmes.

j. Additional Criteria.

(1) Corner Collector. The proposed Corner Collector project will use the Ice and Trash Chute for a juvenile outfall channel. The alternatives considered for the AWS backup will not compromise operation of the Corner Collector project. Any disturbances of the forebay flow patterns that are concentrating the juvenile migrants in other than the southwest corner of the forebay are prohibited.

## 4.2 References

a. Fisheries Criteria. *2000 Fish Passage Plan*

b. Computer Programs. *Bonneville Second Powerhouse Fishway Numerical Model,* October 1998. Northwest Hydraulic Consultants.

c. Texts.

(1) Brater E.F. and H.W. King, *Handbook of Hydraulics, Sixth Edition.* McGraw-Hill. 1976.

(2) Miller, D.S. *Internal Flow Systems.* BHRA. 1990.

(3) Fisheries Handbook, Milo Bell. U.S. Army Corps of Engineers, North Pacific Division. 1991.

## 4.3 AWS Operations Alternative

a. General. This section provides a discussion of the hydraulic analysis and results required for the development of the operations manual. The operations manual provides procedures for adjusting fish turbines, floating orifice gates, diffuser gates, and main entrance gates when only one turbine is operating. A numerical computer model of the Bonneville Second Powerhouse fishway was used to develop the operational alternatives. Appendix E contains a more detailed discussion of the numerical computer model. The Corps of Engineers report entitled *Bonneville Dam Second Powerhouse – Computer Model and Hydraulic Evaluation of The Fishway Facility Adult Bypass System* (October 1998) provides extensive background on the development of the numerical computer model.

b. Fishway Numerical Hydraulic Computer Model.

(1) The numerical computer model was originally developed by NHC for the Corps of Engineers, Portland District, under contract number DACW 57-96-D-0016. This program was developed as a fishway management tool for project operators to help determine appropriate operating settings for the fishway given limited input data collected for the fishway by project personnel and by automatic recording instruments. Original calibration and verification of the numerical computer model was achieved with field data collected during five site visits. The original numerical computer model was also verified with September 1999 and November 2000 field data. A more detailed discussion of calibration methods and verification results is found in Appendix E.

(2) The numerical computer model computes the following detailed hydraulic characteristic information from user-supplied input data:

- Discharge and channel velocities at selected locations throughout the fishway
- Discharge and velocities through the diffusers
- Entrance weir discharge and head differential over the entrance weirs
- Discharge and velocity of the flow through the submerged floating orifices
- Discharge through Auxiliary Water Supply ('fish') turbines
- Discharge, velocity, and head loss through all segments of the AWS

c. Application of Numerical Computer Model.

(1) The B2 fishway numerical computer model was used for the *Bonneville Second Powerhouse Auxiliary Water System Backup Alternative Study (Sept 2000).* The computer simulations showed that operational changes could be performed

to improve the hydraulic conditions in the fishway during an emergency operating condition, which occurs when just one turbine is running. The operational alternatives consist of manipulating the main entrance weir gates, floating orifice gates, and diffuser gates to optimize hydraulic conditions in the main entrances, the collection channel, and the diffuser gratings.

(2) With only a single turbine operating, the total discharge available to the AWS is significantly decreased (by about 50%), and as a consequence, the head differential over each main entrance gate and over the floating orifice entrances decreases, and the collection channel velocity also decreases. This condition causes these parameters to fall well out of normal operating criteria, jeopardizing the successful passage of adult fish upstream. However, with manipulation of the various flow control systems in the AWS and collection channel, the operational alternative can meet most of the fishway operating criteria.

(3) There are 43 openings between the AWS and the diffusers, which supply the discharge to the fishway. Twenty of the openings are controlled with sluice gates and the others are ungated. The 43 openings are located at numerous points throughout the fishway and on the downstream portion of the fish ladder (see Figure F-1 in Appendix F for locations of fishway features). There are also four main entrance gates, located at the North and South ends of the powerhouse. In addition, there are 12 floating orifice entrances located along the powerhouse collection channel. For the purposes of this discussion, the diffuser gates and entrance gates are categorized as follows:

- NUE and NDE are the North Upstream and North Downstream Main Entrance Gates, respectively.
- A-1 through A-10 diffusers are located at the entrance to the north fish ladder at the north end of the powerhouse in the junction pool area. A-1 through A-4 diffusers were each originally provided with control gates; however, two of the gates have since been removed (A-1 and A-2). Diffusers A-5 through A-10 are not currently provided with control gates.
- B-1 through B-8 diffusers are those located immediately south of the powerhouse portion of the collection channel fishway. All of these diffusers currently are equipped with control gates.
- SDE and SUE are the South Downstream and South Upstream Main Entrance Gates, respectively.
- Powerhouse diffusers C-1 through C-10 (numbered south to north) are those located along the length of the powerhouse collection channel fishway. All of these diffusers currently have functioning gates.
- FO1 through FO20 are the Floating Orifice Entrances, numbered south to north. Twenty openings were constructed for floating orifices; however, only twelve of the openings include floating orifices and the others openings are closed. All twenty of the openings are numbered.
- Ladder Diffusers D-1 through D-15 are located in the fish ladder section of the fishway, and are controlled by overflow weirs. Operational changes

to these diffusers would require major structural modifications because the overflow weirs operate sequentially as the tailwater elevation rises. The total flow contributed to the system through the ladder diffusers is minimal compared to the other diffusers.

(4) The numerical computer model was used to determine the settings for the diffuser gates, floating orifices, and main entrance weir gates necessary to meet the fishway operating criteria. A large number of runs were made for several different categories of flow control system settings. The computer model runs were organized into six Model Run Types:

- Model Run Type 1 – Baseline Case - 2 Turbines – Normal Operation with both fish turbines, all main entrances open, all floating orifice gates open, and all diffusers open.
- Model Run Type 2 – Baseline Case – 1 Turbine – Emergency Operation with one fish turbine, all main entrances open, all floating orifice gates open, and all diffusers open.
- Model Run Type 3 – Main Entrance Gates only – Same as Model Run Type 2, but varying the number of main entrance gates open.
- Model Run Type 4 – Floating Orifice Gates only – Same as Model Run Type 2, but varying the number of floating orifice gates open.
- Model Run Type 5 – Diffusers only – Same as Model Run Type 2, but varying the number of diffuser gates open.
- Model Run Type 6 – Combinations – Same as Model Run Type 2, but combinations of varying number of main entrance gates open, varying number of floating orifice gates open, and varying number of diffuser gates open.

(5) Numerous numerical computer model runs are documented in a previous report entitled *Final Report for Bonneville Second Powerhouse Auxiliary Water Supply System, Backup Alternative Study* dated September 2000. The following nomenclature was developed to organize the numerical computer model runs in those previous reports and is also used in this report. A.X.Y.Z, where 'A' represents the Model Run Type (1, 2, 3, 4, 5, or 6) 'X' is a consecutive number identifying an individual computer model run within a specific Model Run Type 'A.' 'Y' indicates the target head differential across the main entrance gates, and 'Z' indicates the tailwater elevation of the particular model. For example, a model run numbered 3.3.15.8 represents Model Run Type '3' (Main Entrance Gates only), the '3rd' model run of that Type, with target head differential of 1.5 ft, at tailwater elevation 8.0 ft.

(6) The fishway criteria used to assess the success of each numerical computer model simulation are listed in Section 4.1. As discussed in Section 4.1, a hierarchy of the criteria was developed in the previous reports.

d. Selection of Operations Alternatives

(1) Three operational configurations with one turbine operating were selected for further analysis in the *Final Report for Bonneville Second Powerhouse Auxiliary Water Supply System, Backup Alternative Study* dated September 2000. All three included closure of the floating orifices as a necessary modification. These three configurations were selected from the various alternatives studied because they provided the optimum hydraulic conditions in the fishway. In this report, the three operating scenarios are referred to as Configurations 1, 2, and 3.

- Configuration 1 includes the NU-E entrance gate closed, floating orifices closed, some of the B diffusers closed (number of B diffusers closed depends on the tailwater elevation).
- Configuration 2 includes all entrance gates open, floating orifices closed, powerhouse diffuser gates C-1 through C-5 closed, and some of the B diffusers closed.
- Configuration 3 includes all of the entrance gates open, floating orifices closed, most of the B diffusers closed.

e. Numerical Computer Model Verification for Emergency Operating Scenario.

(1) The fishway numerical model was verified with new site data collected on February $28^{th}$, 2001 for the condition where all of the floating orifices were closed. This condition was not previously available during development of the original numerical computer model. The conditions tested in the field correspond to gate, weir, and turbine settings for Configurations 1 and 3 listed above, with a tailwater elevation of approximately 11.5 ft. The results of the numerical computer model verification are included in Appendix F.

(2) The modified numerical computer model with floating orifices closed produced a maximum difference of about 0.40 ft at one location between measured and predicted water surface elevations for this field test during verification. Water surface elevation measurements were taken in the junction pool and upstream of ND-E, SU-E, and SD-E. These water surface elevations were compared with those predicted by the numerical computer model. The difference between the measured and calculated values at the south downstream entrance was higher than the maximum differences determined for previous numerical computer models of the Bonneville Second Powerhouse Fishway and other projects (0.10 to 0.30 ft). However, the data collected for the floating orifice closure test included some uncertainties that may have contributed to the higher maximum difference of 0.40 ft at the south downstream entrance. Appendix F provides a detailed explanation of factors that may have contributed to the higher difference between the predicted and measured water surface elevation.

(3) The accuracy of the model at the extreme high and low tailwater elevations is difficult to estimate; however, we expect approximately the same accuracy as

noted in the verification of the original model throughout the original calibration range. The model was originally calibrated and verified for tailwater elevations ranging from 8.4 ft to 22.7 ft. The maximum difference between predicted and measured values in the original calibration and verification runs was approximately 0.23 ft. The majority of the differences were within 0.10 ft. These differences provide some indication as to the accuracy of the hydraulic model over this range of tailwater elevations. At tailwater elevations greater than 22.7 ft, some of the variables may change. Furthermore, only one verification was done for a closed floating orifice conditions. The combination of closing floating orifices and high tailwater elevations may require additional modifications to the numerical model coefficients. As a result, further verification of the model is recommended before implementation of the operations manual.

(4) Further calibration of the modified computer numerical model by means of adjusting loss coefficients was not considered necessary based on the first set of data for the floating orifice closed condition. With only one exception, the measured and predicted values were within the range of expected differences observed for this and other fishway numerical computer models. The one exception is considered to be a result of the inability to collect the tailrace elevations at all of the entrance staff gauges, which required estimating some of the tailrace elevations from other data that was taken. Additional testing would help clarify this assumption.

(5) Therefore, the numerical computer model was determined adequate to establish an emergency operating protocol; however, further field testing is recommended before the operations manual is adopted in the FPP. The recommendation to close the floating orifices is a recommendation that will remain unaffected with minor adjustments to the numerical computer model. However, some of the recommended diffuser gate settings or the exact elevation of a particular entrance weir could change with adjustments to the model.

f. Future Data Collection.

(1) As discussed, collecting data to verify the numerical computer model for a low, medium, and high tailwater should be done before the emergency operating plans are adopted by the FPP. After the floating orifice closure scheme is constructed, collecting data with the floating orifices closed would be an easier process. Presently, plates have to be welded over the floating orifices for the test, which would make verifying the numerical model at multiple tailwater elevations quite costly and time consuming.

(2) Collecting data for a closed floating orifice condition for one tailwater elevation could be done in one day. Water surface elevations would be collected in several locations to verify that the differences between the predicted and measured elevations are acceptable. Velocity measurements would be taken in

the collection channel. The velocity measurements should be taken at the north end, in the middle, and at the south end of the channel. Velocity measurements in the junction pool area are not necessary and would be difficult to take due to the complicated hydraulic characteristics of the junction pool. Velocity measurements in the north and south channels could be taken, but the velocities in these areas do not appear to be a concern at this point because the predicted velocities are typically well above the minimum criteria in those locations. Even if the numerical computer model predicted values are slightly low or high, the velocities would still meet criteria. Since the floating orifices would be closed and one turbine would be shut-down for the test, coordination with NMFS would be required. The test would be repeated for a low, medium, and high tailwater elevation.

g. Operations Table Development. The numerical computer model was used to predict the hydraulic conditions in the fishway for tailwater elevations ranging from 8.0 ft to 28.0. Tailwater elevations above elevation 28.0 ft were not modeled because these tailwater elevations are well above the original calibration and verification tailwater elevations used to develop the numerical model. Furthermore, Figure 4-1 shows that tailwater elevations above 28.0 ft occur less than 2 percent of the time. Table 4-2 provides a description of the initial computer simulations accomplished in this study, and the location of the output summaries and tables in Appendix F. These computer simulations were done to determine the optimum configuration for each one foot tailwater elevation increment between 8 ft and 28 ft. See Tables F-1 through F-21 for detailed information.

**Table 4-2**
**Alternatives 1, 2, and 3**

| TW (ft) | Turbine Q (cfs) | Floating Orifice Gates Closed | South "B" Diffuser Gates Closed | Power-House "C" Diffuser Gates Closed | Main Entrance Gates Closed | Table ID (See App F) | Figure ID (See App F) |
|---|---|---|---|---|---|---|---|
| **Configuration 1:** | | | | | | | |
| 8 | 2225 | All | B5-8 | None | NU-E | F-1 | F-2 |
| 12 | 3230 | All | B5-8 | None | NU-E | F-5 | F-8 |
| 16 | 3515 | All | B5-8 | None | NU-E | F-9 | F-15 |
| 20 | 3520 | All | B4-8 | None | NU-E | F-13 | F-22 |
| 24 | 3540 | All | B4-8 | None | NU-E | F-17 | F-28 |
| 28 | 3160 | All | B3-8 | None | NU-E | F-21 | F-34 |
| **Configuration 2:** | | | | | | | |
| 8 | 2950 | All | B2-8 | C1-5 | None | F-1 | F-3 |
| 12 | 3230 | All | B2-8 | C1-5 | None | F-5 | F-9 |
| 16 | 3515 | All | B2-8 | C1-5 | None | F-9 | F-16 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 3520 | All | B2-8 | C1-5 | None | F-13 | F-23 |
| 24 | 3540 | All | B2-8 | C1-5 | None | F-17 | F-29 |
| 28 | 3160 | All | B2-8 | C1-5 | None | F-21 | F-35 |
| **Configuration 3:** | | | | | | | |
| 8 | 2950 | All | B2-8 | None | None | F-1 | F-4 |
| 12 | 3230 | All | B2-8 | None | None | F-5 | F-10 |
| 16 | 3515 | All | B2-8 | None | None | F-9 | F-17 |
| 20 | 3520 | All | All | None | None | F-13 | F-24 |
| 24 | 3540 | All | All | None | None | F-17 | F-30 |
| 28 | 3160 | All | All | None | None | F-21 | F-36 |

Note: The first letter of the Table ID and Figure ID corresponds to the appendix.

h. Operational settings for the computer simulations were designed to minimize the number and complexity of gate, weir, and floating orifice changes with varying tailwater elevation. This is expected to minimize project staff effort expended to meet the requirements established in this operations manual. As Table 4-2 shows, Configuration 1 requires three different south diffuser gate settings depending on the tailwater elevation. Configuration 2 requires the same south diffuser gate settings for the entire tailwater elevation range. Configuration 3 requires only one change in the diffuser gate settings in the middle of the tailwater elevation range. The tables and figures located in Appendix F provide the hydraulic conditions for each of the Configuration shown in Table 4-2.

i. One configuration was selected for each tailwater elevation shown in Table 4-2 by comparing the criteria to the predicted hydraulic conditions in the fishway. In some cases, the optimum configuration for an intermediate tailwater elevation was obvious because it fell within a range where the higher and lower tailwater elevation had the same optimum configuration. In other cases, the tailwater elevation fell into a range where the higher and lower tailwater elevations each had different optimum configuration. In this case, computer simulations were required to verify which configuration provided the optimum hydraulic conditions. Table 4-3 provides one recommended configuration for all tailwater elevations between 8.0 ft and 28.0 ft. An effort was made to minimize the closure of B-1 and B-2 because these gates are manually operated and take a considerable amount of time to open and close.

j. The recommended configurations provide predicted hydraulic conditions in the fishway that most closely meet the fishway criteria. The entrance head criteria was given the highest priority, as discussed in Section 4.1. All of the recommended configurations meet the entrance head criteria. The submergence criteria of 13.0 ft are nearly met at the higher tailwater elevations. Although submergence criteria are not met at lower tailwater elevations (10.0 to 17.0 ft), the entrance head drop criteria are met, which is consistent with the criteria priority established by the resource agencies.

k. The channel velocities met criteria in all of the recommended configurations, with the exception of the junction pool area. The channel velocity criteria are very difficult to meet in the junction pool area due to the complexity of the flow characteristics under any operating scenario. At the downstream end of the fish ladder (upstream end of junction pool), the total flow in the system is small. Farther downstream in the junction pool, the diffusers supply more water to the channel, which increases velocities. The diffuser velocity criteria were not met in any of the computer simulations and were given the lowest priority. Some of the diffuser velocities exceed 0.5 fps under existing conditions with two turbines. Diffuser velocities shown as 0 fps indicate that the diffuser is closed. In some cases, powerhouse diffuser velocities are greater than zero even though the diffusers are closed. This is due to the configuration of the diffuser chambers and the associated flow paths, which can cause reverse flow through diffusers in some cases.

l. The selected configurations for all tailwater elevations between 8.0 ft and 28.0 ft are shown in Tables 4-3 and 4-4. As shown in Table 4-3, only Configurations 1 and 2 are included in the Operations Plan. Configuration 3 results did not meet criteria as well as the other configurations. Table 4-3 includes the operations table with the appropriate diffuser gate and turbine settings. Table 4-4 provides a summary of the hydraulic conditions associated with the selected configuration for each tailwater elevation. The results of all of the computer simulations are included in Appendix F. Studying all of the configurations for the intermediate tailwater elevations was not required because the results for tailwater elevations 8, 12, 16, 24, and 28 indicated which configurations would provide the optimum results.

m. As discussed previously, an attempt was made to optimize the fishway criteria in the following order: 1) Entrance velocity (head drop across entrance weir) 2) Entrance gate submergence 3) Channel velocities 4) Diffuser velocities. Tables F-1 through F-21 in Appendix F show the minimum and maximum channel velocities. Figures F-1 through F-36 show where the channel velocities are out of criteria for each scenario examined.

**Table 4-3**
**Operations Table**

| TW (ft) | Turbine MW | Turbine Q (cfs) | Floating Orifice Gates Closed | South "B" Diffuser Gates Closed | Power-House Diffuser Gates Closed | Main Entrance Gates Closed | Table ID | Figure ID |
|---|---|---|---|---|---|---|---|---|
| 8 | 13.90 | 2950 | all | B2-8 | C1-5 | None | F-1 | F-3 |
| 9 | 13.95 | 3010 | all | B3-8 | C1-5 | None | F-2 | F-5 |
| 10 | 14.05 | 3090 | all | B3-8 | C1-5 | None | F-3 | F-6 |
| 11 | 14.15 | 3165 | all | B3-8 | C1-5 | None | F-4 | F-7 |
| 12 | 14.20 | 3230 | all | B3-8 | C1-5 | None | F-5a | F-11 |
| 13 | 14.40 | 3340 | all | B3-8 | C1-5 | None | F-6 | F-12 |
| 14 | 14.40 | 3400 | all | B3-8 | C1-5 | None | F-7 | F-13 |
| 15 | 14.60 | 3520 | all | B3-8 | C1-5 | None | F-8 | F-14 |
| 16 | 14.30 | 3515 | all | B3-8 | C1-5 | None | F-9a | F-18 |
| 17 | 14.20 | 3560 | all | B3-8 | C1-5 | None | F-10 | F-19 |

| TW (ft) | Turbine MW | Turbine Q (cfs) | Floating Orifice Gates Closed | South "B" Diffuser Gates Closed | Power-House Diffuser Gates Closed | Main Entrance Gates Closed | Table ID | Figure ID |
|---|---|---|---|---|---|---|---|---|
| 18 | 14.00 | 3575 | all | B5-8 | None | NU-E | F-11 | F-20 |
| 19 | 13.60 | 3535 | all | B5-8 | None | NU-E | F-12 | F-21 |
| 20 | 13.30 | 3520 | all | B4-8 | None | NU-E | F-13 | F-22 |
| 21 | 13.00 | 3510 | all | B4-8 | None | NU-E | F-14 | F-25 |
| 22 | 12.70 | 3505 | all | B4-8 | None | NU-E | F-15 | F-26 |
| 23 | 12.40 | 3505 | all | B4-8 | None | NU-E | F-16 | F-27 |
| 24 | 12.20 | 3535 | all | B4-8 | None | NU-E | F-17 | F-28 |
| 25 | 11.60 | 3535 | all | B4-8 | None | NU-E | F-18 | F-31 |
| 26 | 11.10 | 3365 | All | B4-8 | None | NU-E | F-19 | F-32 |
| 27 | 10.60 | 3285 | All | B4-8 | None | NU-E | F-20 | F-33 |
| 28 | 10.00 | 3160 | All | B3-8 | None | NU-E | F-21 | F-34 |

## Table 4-4
## Recommended Alternative Summary Table

| | Normal Operating Scenario | Emergency Operating Scenario | | | | |
|---|---|---|---|---|---|---|
| **Tailwater Elev. (ft)** | **Summary of hydraulic conditions under normal operations** (two turbines operating) | **Selected Alternative** | **Summary of Hydraulic Conditions with Emergency Operating Alternative** (one turbine operating) | **Floating Orifices Closed** | **Entrance Weir Gates Closed** | **Diffuser Gates Closed** |
| **8** | • Entrance head drop meets criteria<br>• Low channel velocities along short section at south end of powerhouse and in junction pool<br>• Some diffuser velocities exceed 0.5 fps | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 1.00 ft meets criteria<br>• Collection channel velocities meet criteria along most of powerhouse. Channel velocities are low at junction pool and high along the north channel<br>• Approximately 28.5 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8 |
| **9** | | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 1.00 ft meets criteria<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8 |
| **10** | | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 2.00 ft (criteria required weir Elev. 1.00 ft)<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8 |
| **11** | | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 2.50 ft (criteria required weir Elev. 1.00 ft)<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8 |

| | Normal Operating Scenario | Emergency Operating Scenario | | | | |
|---|---|---|---|---|---|---|
| **Tailwater Elev. (ft)** | **Summary of hydraulic conditions under normal operations** (two turbines operating) | **Selected Alternative** | **Summary of Hydraulic Conditions with Emergency Operating Alternative** (one turbine operating) | **Floating Orifices Closed** | **Entrance Weir Gates Closed** | **Diffuser Gates Closed** |
| **12** | | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 3.40 ft (criteria required Weir Elev. 1.00 ft)<br>• Channel velocities meet criteria except in junction pool and in short section of Unit 8<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |
| **13** | | Alternative 2 | • Entrance head drop meets criteria<br>• Entrance Weir Crest Elev. 4.00 ft (criteria required Weir Elev. 1.00 ft)<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |
| **14** | Note: Submergence requirements change at tailwater elevation 14.0 ft. 13.0 ft of submergence is required for tailwater elevations greater than 14.0 ft. | Alternative 2 | • Entrance head drop meets criteria<br>• Submergence is 9.5 ft instead of 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |
| **15** | | Alternative 2 | • Entrance head drop meets criteria<br>• Submergence is 10.0 ft instead of 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |
| **16** | • Entrance head drop meets criteria<br>• Submergence criteria is met<br>• Low channel velocities along short section of powerhouse and in junction pool<br>• Some diffuser velocities exceed 0.5 fps | Alternative 2 | • Entrance head drop meets criteria<br>• Submergence is 10 ft instead of 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 22 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |

| | Normal Operating Scenario | Emergency Operating Scenario | | | | |
|---|---|---|---|---|---|---|
| **Tailwater Elev. (ft)** | **Summary of hydraulic conditions under normal operations** (two turbines operating) | **Selected Alternative** | **Summary of Hydraulic Conditions with Emergency Operating Alternative** (one turbine operating) | **Floating Orifices Closed** | **Entrance Weir Gates Closed** | **Diffuser Gates Closed** |
| **17** | | Alternative 2 | • Entrance head drop meets criteria<br>• Submergence is 10.0 ft instead of 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 20 percent of the diffuser velocities exceed 0.5 fps | All | None | B3 thru B8<br>C1 thru C5 |
| **18** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 25 percent of diffuser velocities exceed 0.5 fps | All | NU-E | B5 thru B8 |
| **19** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 13.0 ft<br>• Channel velocities meet criteria except in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B5 thru B8 |
| **20** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 11.80 to 12.50 ft<br>• Channel velocities low in junction pool<br>• Approximately 25 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **21** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 25 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |

| | Normal Operating Scenario | Emergency Operating Scenario | | | | |
|---|---|---|---|---|---|---|
| **Tailwater Elev. (ft)** | **Summary of hydraulic conditions under normal operations** (two turbines operating) | **Selected Alternative** | **Summary of Hydraulic Conditions with Emergency Operating Alternative** (one turbine operating) | **Floating Orifices Closed** | **Entrance Weir Gates Closed** | **Diffuser Gates Closed** |
| **22** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 23 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **23** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 19 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **24** | • Entrance head drop meets criteria<br>• Submergence criteria is met<br>• Low channel velocities along Unit 11 section of channel and in junction pool<br>• Some diffuser velocities exceed 0.5 fps | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 19 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **25** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 17 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **26** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 17 percent of the diffuser velocities exceed 0.5 fps | All | NU-E | B4 thru B8 |
| **27** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 15 percent of the diffuser vellocities exceed 0.5 fps | All | NU-E | B4 thru B8 |

| | Normal Operating Scenario | Emergency Operating Scenario | | | | |
|---|---|---|---|---|---|---|
| **Tailwater Elev. (ft)** | **Summary of hydraulic conditions under normal operations** (two turbines operating) | **Selected Alternative** | **Summary of Hydraulic Conditions with Emergency Operating Alternative** (one turbine operating) | **Floating Orifices Closed** | **Entrance Weir Gates Closed** | **Diffuser Gates Closed** |
| **28** | | Alternative 1 | • Entrance head drop meets criteria<br>• Submergence is 12.80 ft<br>• Channel velocities low in junction pool<br>• Approximately 15 percent of the diffuser velocities exceed 0.5 fps | All | NUE | B3 thru B8 |

n. Since it may be difficult for project personnel to change from Configuration 1 to 2 between tailwater elevations 17.0 ft and 18.0 ft, a sensitivity analysis was done to determine the hydraulic conditions that would result if the configuration is not changed at the selected break point. Additional computer simulations were done to provide the hydraulic characteristics associated with both Configurations 1 and 2 for tailwater elevations between 15.0 ft and 20.0 ft. Sensitivity Analysis Table located in Appendix G provides the results associated with both Configurations 1 and 2 for this tailwater elevation range. The results of these additional computer simulations show that the powerhouse collection channel velocities would meet criteria with either configuration for this range of tailwater elevations. The only difference would be that the entrance head drops meet criteria more closely in the recommended configuration for each tailwater elevation. As discussed previously, the entrance head criteria were given the highest priority when selecting the optimum configuration for each tailwater elevation. Outside of the 15.0 ft to 20.0 ft range, operating at configurations other than the most selected configuration is not recommended because the recommended configuration does provide significantly better results at some tailwater elevations.

# SECTION 5 -- STRUCTURAL DESIGN

## 5.1 STRUCTURAL DESIGN CRITERIA

a. Structural Materials

(1) Structural steel: ASTM A36

(2) Steel plates: ASTM A242

(3) Welds: AWS Structural Welding Code-steel, AWS D1.1

(4) Aluminum Plate: ASTM B209 (Alloy 5083)

(5) Stainless Steel: ASTM A316

b. Design Loads

| | | |
|---|---|---|
| (1) | General Structural Safety Factor used for Steel and Aluminum Design: | 1.7 |
| (2) | (2) Hydrostatic Head across Floating Orifice Gate Closures, ft: | 2 |
| | This load was determined by nhc using the fishway numerical model. Additionally, the FPP specifies that the maximum head across the fishway main entrance gates not exceed 2 feet. | |
| (3) | Hydrostatic Head across Fish Unit Trashrack, ft: | 20.0 |
| (4) | Soil Load acting on Blank Fish Unit Panel, pcf: | 130 |
| (5) | Maximum Deflection across Floating Orifice Gate Closures, in: | 0.25 |

c. Densities

(1) Concrete- 150 pcf.

(2) Steel- 490 pcf.

(3) Water- 62.4 pcf.

(4) Aluminum – 165 pcf.

## 5.2 REFERENCES

a. Engineer References:

(1) American Society of Steel Construction, Ninth Edition

(2) EM 1110-2-2105, Design of Hydraulic Steel Structures, updated 5/31/94

(3) Specifications for Aluminum Structures – Allowable Stress Design

b. Referenced Reports and Literature:

(1) Custom Molded UHMW-PE Specifications

## 5.3 FLOATING ORIFICE CLOSURE

a. Slide Plate Mounted to Floating Orifice

(1) In the development of a closure scheme for the floating orifice openings, many alternatives were investigated. These alternatives are briefly described in the background section of this DDR. The recommended closure system (see Plate 10) consists of:

(a) Channel guides welded to the face of each floating orifice.

(b) A closure plate inserted into the guides.

(c) Plate is inserted when the floating orifice (FO) is raised to deck level.

(d) A tag line from the gate to the deck level to allow removal without lifting the FO.

(2) The closure plates will be fabricated from aluminum so they will be light and easy to handle. The small plates (8 total) will be 0.25 by 26 by 76-inches and weigh approximately 50-lbs. The large plates (4 total) will be 0.625 by 50 by 76-inches and weigh approximately 230-lbs. The installation operation will be done at eye level so there will be positive confirmation that the plate is inserted properly. The existing deck gantry crane will be used to raise the floating orifices and to lift the deck cover slabs. The weight added to the floating orifice is minimal, and no modification is required to the flotation tank. A tag line will be attached to each closure plate so it can be easily removed without raising the floating orifice gate.

## 5.4 TRASHRACK DEBRIS ACCUMULATION

a. Load Capacity of Existing Trashracks. The trashrack consists of two structural elements, the bar grating and the supporting member. The bar grating is the critical element. Spacing of the bars must match the teeth of the trashrake in order for the rake to penetrate the trashrack for proper cleaning. If the trashrack were clogged with debris, it has a maximum capacity of 1,250 psf (20 feet of differential head) based on the bar grating capacity. The capacity is based on the normal allowable working stress, which is approximately half of the ultimate load.

## 5.5 DIFFUSER RACK CLOGGING

a. Diffuser Grating Configuration. The diffuser rack assembly consists of three structural elements. They are the bar grating, the bar grating attachment bolts and the supporting beams. See Plate 11 for typical framing details. If the diffuser rack were to become plugged with debris the hydraulic force would increase to the point where a structural failure would occur. Each element in the diffuser rack system has a different failure load.

b. Diffuser Grating Fasteners. The gratings are fastened with stainless steel 2 ¼" x 3/8" button head bolts with a 1.5" x 4" flat bar retainer on top (4 per grating panel). This 308 stainless steel is stronger than the mild steel bolts previously used. The button head bolt was used strictly for "fish friendly" purposes. This was to eliminate the protrusion and any sharp edges that may exist with a hexagon bolt. The bar grating attachment bolts have a capacity of 600 psf (9.6 feet of differential head).

c. Bar Grating Capacity. The bar grating panel capacity is indeterminate. However, engineering judgment indicates that the grating panels can withstand far greater differential head than the support beams to which they are attached.

d. Support Beam Capacity. The support beams have a capacity of 130 psf (2.2 feet of differential head). The capacity as stated is based on the allowable working stress. The actual failure load would be approximately two times the working stress level. The support beams are considered the weak link should the diffuser gratings fail due to clogging.

## 5.6 BLANK TRASHRACK PANEL

a. Blank Panel Modification to Existing Trashracks. The lower panel of each trashrack intake is proposed to be blanked off to effectively raise the invert of the Fish Unit intake from elevation –22-fmsl, 13.5-feet to elevation –9-fmsl. This will allow for a reasonable level of bedload to build up next to the intake without the material entering the AWS. The panels will be blanked off by welding a 0.375-inch thick plate onto the existing trashrack bars. This plate will be welded around the perimeter in addition to 2-inch long fillet welds at each bar at midspan between the horizontal supports, and at every tenth bar in front of each horizontal support. This modification will allow the old trashracks to safely withstand both soil loading up to the top of the blank trashrack and a 20-foot hydraulic differential load.

## SECTION 6 -- MECHANICAL DESIGN

### 6.1 MECHANICAL DESIGN CRITERIA

a. Floating Orifice Closure – Slide Gate

(1) Design Head (across gate): 2 feet

(2) Nominal Gate Sizes:

(a) 24 inch W x 72 inch H

(b) 48 inch W x 72 inch H

b. Diffuser gates

(1) Maximum Head (across gate): 3 feet

c. Trashrack Debris Accumulation

(1) Trashrack Design Differential Head: 20 feet

(2) Trashrack Panels per Intake: 4 @ 19.854 feet W x 13.417 feet H

(3) Trashrack Clear Opening: 0.875 inches

(4) Trashrack Inclination: 8°

(5) Rake Width: 6 feet

(6) Maximum Debris Load: 1,000 lbs

(7) Cleaning Cycle Time: 90 minutes

### 6.2 REFERENCES

a. Engineer References.

(1) EM 1110-2-4205 Hydroelectric Power plant Mechanical Design, Change 1, 31 Jul 1996

(2) EM 385-1-1 Safety and Health Requirements Manual, 03 Sep 1996

(3) ER 1110-2-8159 Life Cycle Design and Performance, 31 Oct 1997

(4) ASTM American Society for Testing Materials

(5) ASME — American Society for Mechanical Engineers

(6) AWS — American Welding Society

(7) NEMA — National Electrical Manufacturer's Association

(8) CMAA — Crane Manufactures Association of America

(9) IEEE — Institute of Electrical and Electronic Engineers

(10) NEC — National Electric Code 1999 Edition Engineers

b. Texts.

(1) Handbook of Hydraulics, Ernest F. Brater, Horace William King, 6th Edition

c. Referenced Reports and Literature.

(1) Memorandum for Record: Data Report, Bonneville 2nd Powerhouse Fish Unit Debris Study, CEERD-HR-F (1110-2-1403b), 1 Aug 2000

(2) Bonneville 2nd Powerhouse Fish Unit Debris Study Reconnaissance Report, Final – 20 Jul 2000

d. Memorandums.

(1) *Montgomery Watson Site Visit Report: Diffuser B Gate Testing, January 3, 2001.*

(2) *Montgomery Watson Site Visit Report: Floating Orifice Measurements and Information gathering on existing raceways, and C Diffuser Gates, June 7, 2001.*

(3) *Montgomery Watson: B2 AWS DDR – Floating Orifice Gates, June 20, 2001*

## 6.3 Floating Orifice Closure Scheme.

a. This scheme consists of removable aluminum sliding closure plates, placed by hoisting the floating orifices gates up to the deck level and sliding nominally 6-feet tall slide plates into guides mounted on the downstream face of the floating orifice gates. The small slide gates (2-foot wide and weighing 50-lbs) could be installed by hand, whereas the larger slide gates (4-foot wide and weighing 230-lbs) will require the use of a small utility crane such as a boom truck. The floating orifices would then be lowered back into position. A tagline fixed to the top of the slide plate would extend up to just below the deck. This would allow the slide plate to be pulled without removing the floating orifice gate. Two blocks and a 10-pound weight are included on the tagline to prevent the slack cable from dangling in the collection channel during high tailwater conditions. This configuration is depicted in Section A on Plate 10.

The length of each tagline cable is approximately 68-feet. The weight will hang at about elevation 52-fmsl during the minimum tailwater condition of 7-fmsl. At the maximum tailwater condition of 35-fmsl the weight would hang at elevation 38-fmsl. The total installation time is estimated at 5 to 7-hours. Removal of the slide gates is estimated at about 4-hours. The slide gates are depicted on Plate 10. The development of this alternative is described in the Memo titled, *B2 AWS DDR – Floating Orifice Gates, June 20, 2001* and included in Appendix I.

b. When the slide gates are not in use they will be stored in a rack. This rack is depicted on Plate 11. The rack is fabricated from 2-inch and 4-inch tube steel, flat bar and steel plate. The rack will be hot dipped galvanized after fabrication and include boxes on each side for storing the tagline assemblies. The rack includes lifting lugs on the top and fork lift slots on the bottom to facilitate transport. The total weight of the rack is approximately 1300-pounds empty and 2800-pounds filled. Slots will be lined with ¼-inch thick UHMW panels to prevent corrosion between the plates and the rack.

### 6.4 Diffuser Gates

a. Assessment from Site Visit. The B diffuser gates consist of two manually actuated 72-inch wide by 72-inch high gates (B1and B2), two motor actuated 72-inch wide by 72-inch high gates (B3 and B4), and four motor actuated 36-inch wide by 72-inch high gates (B5 through B8). The larger gates use a 1.6-hp motor on the actuator and the smaller gates use a 0.7-hp motor. The proposed operation of the B diffuser gates in the Bonneville Powerhouse 2 Adult Fishway Auxiliary Water System (AWS) will result in higher than normal pressure head across the gates. Potentially 2 to 3-feet of head may develop, whereas the normal range is 1 to 1.5-feet across the diffuser gates. Limited information was available from the Project and the gate actuator vendor, Limitorque, recommended upgraded actuator motors to accommodate the potential heads during emergency fishway operation. A test was performed to simulate emergency operating conditions while measuring the load on the actuator motors. Only in the extreme case with 3.8-feet of head across the gates did the motor current exceed the motor rating. The excess current only lasted a few seconds as the gate opened from a fully closed position. This excess current was at most 4-percent higher for the larger actuators (72" x 72" gates) and 1-percent higher for the smaller actuators (36" x 72" gates). Detailed test results are presented in the Site Visit Memorandum titled *Diffuser B Gate Testing*, January 3, 2000. This memorandum is included in Appendix J. A portable gate actuator is proposed to operate the two manually actuated gates.

b. Assessment of C Diffuser Gates. The C diffuser gates consist of 10 manually actuated 36-inch wide by 60-inch high gates located along the length of the powerhouse. Plate 2 depicts the location of these gates. The gates are positioned by turning an operator nut inside a box mounted flush with the deck on the tailrace side of the powerhouse. The operator turns a hollow shaft, which acts on the threaded portion of a 2-inch diameter gate stem, pulling the stem into the shaft as the gate is raised. The as-built drawing (BDP-1-3-2/70) indicates that the design condition for these gates is a 5-foot operating differential. The Project operations staff reports that all the gates are operable by either a hand held actuator (referred to as a "mule") or a drill motor with a operator nut adapter. The proposed portable gate actuator for the B Diffuser Gates could also serve to operate the C diffuser gates.

c. Rehabilitation Plan. Testing the gates indicate that the existing actuators will perform adequately up to the proposed head conditions. If greater head conditions are required, then the "Limitorque" actuator motors and torque spring assemblies will need to be upgraded.

## 6.5 Main Gate Controls

a. No mechanical issues are associated with improvements to the fishway main entrance gate controls.

## 6.6 Sediment Accumulation

a. No mechanical issues are associated with improvements required for sediment accumulation.

## 6.7 TRASHRACK DEBRIS ACCUMULATION

a. Automatic Gripper Rake

(1) This rake uses a monorail mounted gripper rake to clean debris from the trashrack. The monorail extends across the length of the Fish Unit intakes, along the Erection Bay, to a post mounted on the deck of the Fingerling Evaluation monolith. A bin or truck will be located at the north end of the monorail for debris. Plate 12 depicts a section view of the improvements and Plate 13 a plan view. Typical debris accumulations include small driftwood, pine cones, weeds, grasses, and occasionally larger branches, sunken logs are a possibility but not common.

(2) Typically, the cleaner will operate automatically by positioning the gripper rake above a trashrack. The cleaner can be operated manually or automatically. The rake is lowered, while hanging free, down to a wedged shaped transition at the top of the trashrack (approximately 40-feet below the deck). This transition section will have guide bars, spaced approximately 3-feet on center to engage the rake teeth and guide them into the trashrack. The rake will partially penetrate the trashrack as it descends cleaning the trashrack. At the bottom the gripper rake closes and the inside rake moves away from the rack. The rake is then drawn back up the rack on rollers to the monorail. A detail of the rake, both descending and ascending the trashrack is depicted on Plate 13. Once in the top position, the rake travels to the north end of the monorail and empties the debris into a bin. The rake is then re-positioned and the process repeated.

The maximum debris load is 1,100-lbs (an "Ultra Duty" model is available with a 6,600-lb capacity). The maximum raking speed is 60-fpm vertically and 100-fpm horizontally along the monorail. Minimum estimated cycle time for both fish unit racks is 90-minutes (excluding offsite disposal). The frequency of cleaning will vary seasonally with the debris load in river. During spring runoff, a cycle of one to two times a day may be required. During the rest of the year a cycle of at least once a week should be practiced to prevent debris from packing into the bars. Actual frequency will need to be determined in the field based on the amount of debris removed.

(3) The standard actuator for opening and closing the gripper is hydraulic. Concerns were raised at the 90% PRM with the potential of hydraulic leaks, which may affect fish. To avoid this possibility, a pneumatic actuated system is proposed. This system will require five cylinders in lieu of the single hydraulic cylinder. This is required because the system will operate at approximately 125 psi of pressure instead of 1300 psi. The same size hose will be used (nominal 0.75 inch), to avoid an excessively large hose reel. This size air hose will result in a gripper opening and closing time of about 20-seconds as opposed to 6-seconds. This in turn lengthens the total cleaning cycle time from 80 minutes to 90 minutes. A cost increase of $12,000 is associated with this change and is included in the updated cost estimate.

(4) The UHMW teeth will be cast in approximately 12-inch long sections with a cross section depicted by the detail on Plate 13. Each tooth will be 0.625-inches wide at the face of the trashrack (in the descending/engaged position) and 0.25-inches wide at the trailing edge (the edge furthest into the trashrack). This configuration insures that the teeth will drop into the 0.875-inch wide space, rather than "ride down" the 0.375-inch wide face of the trashrack bars.

(5) A stainless steel plate perforated with 7/8-inch diameter holes will line the inside of both gripper jaws to enhance the retention of debris cleaned from the trashrack. In addition, the tips of each jaw will mate together to effectively enclose the debris. The ends must remain open to allow for removal of debris, which is longer than the rake. Furthermore, the rake can be adjusted to extend slightly beyond the invert of the trashrack and remove sediment deposited at the Fish Unit intake. By carefully examining the debris, the Project can be warned of possible sediment movement into the AWS.

(6) This system requires a trashrack with deeper bars than the existing racks (currently 1.25-inches deep) in order for the UHMW teeth to partially penetrate the trashrack to avoid the structural support backing bars. The tight, 7/8-inch clear spacing also dictates UHMW plastic teeth to reduce friction, wear, and allow for ready replacement. New trashrack panels will be continuous for each intake with an epoxy protective coating. This will require four 13.5-feet panels for a total height of 53-foot at each entrance, with the lower trashrack panels (13.5-feet) are blocked off. This configuration results in a new trashrack invert of –9-fmsl. Trashrack panels will be self-aligning with tapered pins as they are

placed in the trashrack slots. A wedge shaped transition section will mate with the top of the trashrack to direct the free hanging rake onto the trashrack.

## 6.8 Diffuser Rack Clogging

a. No mechanical issues are associated with improvements required for sediment accumulation.

# SECTION 7 -- ELECTRICAL DESIGN

## 7.1 ELECTRICAL DESIGN CRITERIA

a. General

(1) Provide control of new equipment via local control panels.

(2) Provide remote indication of system status, and remote control by connecting the new equipment to the existing control and telemetry systems

(3) Provide features that allow the system to be inspected and maintained easily by project personnel.

(4) The existing grounding system from the North Substation will be used for accommodating the new equipment installation.

(5) Minimize interruptions to electrical systems resulting from construction.

(6) Minimize interruptions to control systems resulting from construction.

b. Power Distribution Equipment

(1) Seismic Zone 3 rated.

(2) The 480 VAC feeder to each load shall be designed for less than 3 percent voltage drop.

(3) Enclosures:

(a) Outdoor, corrosive, and wet areas - NEMA-4X, stainless steel or aluminum.

(b) Indoor - NEMA 12, painted steel.

(4) Local Control Panels and Controls

(a) Outdoor, corrosive, and wet areas - NEMA-4X, stainless steel or aluminum.

(b) Indoor - NEMA 12, painted steel.

c. Electric Motors

(1) Non-submersible motors will be in locations that are easily accessible for operation and maintenance.

(2) Motors less than 0.25 kW (1/3 HP) will be 110 volts, one phase, unless otherwise specified.

(3) Motors 0.25 kW (1/3 HP) and larger will be 460 volts, three phase, unless otherwise specified.

(4) Motors will be totally enclosed fan cooled (TEFC). All motors will be "premium efficiency" and rated for 1.15 service factor, class F insulation without exceeding class B temperature rise.

(5) Motors will be started with NEMA rated across the line starters combination motor starters with overload protection and 120 V control transformers, unless otherwise specified.

(6) Individual power factor correction capacitors for each motor will not be used.

d. Motor Safety Switches

(1) Motor safety/disconnect switches will not be used if possible. Safety switches are not required by code if the controller circuit breaker/disconnect can be individually locked open and is in sight of the motor controller (starter). Switches if used will be the heavy duty corrosion resistant type.

e. Raceway

(1) Exposed conduit - All exposed conduit will be rigid galvanized steel (RGS) except as noted.

(a) Encased conduit will be Schedule 40 PVC.

(b) Encased conduit will be 27mm (1") minimum size.

(c) Flexible conduit will be liquid-tight with integral ground.

(d) Exposed conduit will be 21mm (3/4") minimum size.

(e) Exposed conduit that contain only grounding conductors will be schedule 80 PVC.

(2) All conduit concealed, buried, or encased in concrete will be Schedule 40 PVC.

(3) Encased conduit will be one-inch minimum size and will have an outer diameter not exceeding 1/3 of the concrete slab thickness. Where conduit emerges from concrete encasement, a PVC coated RGS elbow will be utilized for transition from the concrete.

(4) All conduit systems will be installed with full length copper grounding conductors, sized in accordance with NEC Article 250.

(5) Wire fills will not exceed the allowable per Appendix C10 of the '99 NEC. This table is for Schedule 40 PVC and is designated as the basis for conduit cross sectional area for all wiring on the project since it has the smallest available cross section for all the types of conduit.

(6) Intermediate metal conduit (IMC) or electrical metallic tubing (EMT) will not be permitted.

(7) Fittings will be malleable iron or gray-iron with zinc plating for galvanized conduit, and PVC for PVC conduit.

f. Wire and Cable

(1) Low Voltage Power and Lighting Cable:

(a) All wire rated for 600 volts in duct or conduit for all power and lighting circuits will be Class B Type XHHW cross-linked polyethylene insulation conforming to UL 44.

(b) All conductors will be stranded copper. Aluminum or non-stranded wire will not be permitted.

(c) Wire size for power circuits will not be smaller than No. 12 AWG. Control wiring will not be smaller than No. 14 AWG.

(d) Flexible power and control cables for submersible motors shall be armored.

(2) Instrumentation Cable:

(a) Instrumentation cable shall be rated 600 volts.

(b) Individual conductors shall be No 16 AWG.

(c) Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 AWG stranded tined copper drain wire, and a PVC outer jacket.

(3) Wire and Cable Identification:

(a) All cables will have an identifying marker at each end.

(b) All individual conductors, including those that are part of cables, will have a identifying marker at each end.

(c) Markers on all new wires will be black indelible computer printed text on white backgrounds of either the heat shrink type or self-laminating wrap-around type.

(d) Markers inside vendor furnished panels will be black indelible computer printed text on white backgrounds of the standard type furnished by the manufacturer.

g. Grounding

(1) Grounding system will conform to applicable requirements of National Electrical Code Article 250 and local codes. The ground system will be connected to the existing dam grounding system at the Second Powerhouse.

(2) Materials:

(a) Grounding loop conductors will be bare annealed copper conductors suitable for direct burial. Conductors will be #4/0 unless sized otherwise on Contract Drawings.

(b) Ground rods will be 21mm (3/4") diameter and 3m (10') long unless sized otherwise on Contract Drawings.

(c) Exposed conduit that contain only grounding conductors will be schedule 80 PVC.

(3) Installation:

(a) All raceways will include a stranded bare copper grounding conductor.

(b) Connection to ground electrodes and ground conductors will be exothermic welded where concealed and will be bolted pressure types where exposed.

(c) Copper bonding jumpers will be used to obtain a continuous metallic ground across non-conductive structural.

(4) Shield Grounding:

(a) Shielded power cable shall have its shield grounded at each termination in a manner recommended by the cable manufacturer.

(b) Shielded instrumentation cable shall be grounded at one end only ; this shall typically be at the "receiving" end of the signal carried by the cable.

h. Instrumentation

(1) Water level transducers will not project into the flow stream to avoid injuring fish and being damaged by debris. Ultrasonic level transducers with automatic air temperature compensation or pressure sensor types shall be used. Accuracy shall allow the facility to operate as required.

(2) Instrumentation for packaged equipment will be vendor furnished.

## 7.2 REFERENCES.

a. The electrical design will conform to the following U.S. Corp of Engineers and industry codes and standards.

b. <u>Engineer References.</u>

| | | |
|---|---|---|
| (1) | EM 385-1-1 | US Army Corps of Engineers (USACE), Safety and Health Requirements Manual, Sept., 1996 |
| (2) | ANSI C2-1997 | American National Standard Institute, National Electrical Safety Code (NESC), 1997 Edition |
| (3) | NFPA 70 | National Fire Protection Association, National Electrical Code (NEC), 1999 Edition |
| (4) | NFPA-101-HB85 | Life Safety Code |
| (5) | TM 5-811-1 | Departments of the Army and the Air Force, Electrical Power Supply and Distribution, 12 Sept 84 |
| (6) | TM 5-811-2 | Departments of the Army and the Air Force, Electrical Design, Interior Electrical System, 01 Sept 83 |

## 7.3 FLOATING ORIFICE CLOSURE SCHEMES

a. No electrical issues are associated with these alternatives.

## 7.4 DIFFUSER GATES

a. Testing of the gates indicate that the existing actuators will perform adequately up to the proposed head conditions. If greater head conditions are required, then the "Limitorque" actuator motors will need to be upgraded along with motors starter heaters, trip adjustments, or possibly the motor starter feeding the actuator.

## 7.5 MAIN GATE CONTROLS

a. The main gates for the fishway entrances, NUE, NDE, SUE, and SDE each have open/close/automatic control capability. This allows the gates to operate independent of each other; therefore, no additional improvements are necessary to accommodate emergency operation.

## 7.6 Sediment Accumulation

a. No electrical issues are associated with this section.

## 7.7 Trashrack Debris Accumulation

a. Automatic Gripper Rake.

(1) The "Bracket Green" automatic gripper rake cleaner uses a combination of a 5.5-hp motor for the hoist, two 0.5-hp motors for the traversing the monorail, and a 2-hp compressor for the gripper rake. This system requires a 40-amp, 480-volt, 3-phase power service.

(2) This service can be provided from an existing electrical panel located at deck level (90-fmsl) in a new building on the Fingerling Evaluation monolith. The new raceway would extend from the panel, out along the top of the forebay wall to a new junction box as shown on Plate 13. This raceway would consist of a 1.0-inch diameter RGS conduit.

(3) Power is distributed to the gripper rake trolley by a festooned cable running along the monorail. A control panel would be provided at the north end of the monorail next to the power junction box.

(4) A cleaning cycle can be initiated either manually, by remote input, on a timer, or by a preset water level differential across the trashrack. The differential signal will require new sensors upstream and downstream of the trashrack. A sonic level transmitter will be mounted on the outside of a monorail support column to measure the forebay level. The downstream side of the trashrack will be monitored by a loop powered pressure transducer, mounted in the visitors gallery at about elevation 61 with a pressure tap core-drilled through the wall to the intake gate slot, avoiding the three air induction pipes embedded in the wall. The intake gate slot will act as a stilling well to provide a more stable level reading. The difference between the two signals will provide the differential used for control.

## 7.8 Diffuser Rack Clogging

a. Diffuser Grating Monitoring System.

(1) The diffuser grating monitoring system consists of two sets of level transducers installed immediately above and below selected diffuser gratings located at the south end of the Fishway adjacent to the B Diffuser gates and at the north end in the junction pool below the fish ladder. These transducers are submersible 2-wire strain gauge devices, which generate a 4 to 20-mA current proportional to a range of 40-feet of water. The transducers require 12 to 30-VDC excitation voltage. This power for the transmitters is supplied by a new power supply

located in panel SA24 (located at elevation 5.0 in the Erection Bay). Power for the VO Module is supplied via the communication wiring from a new separate power supply module, which also passes along the communication-signal to the protocol converter module. The accuracy of the transducers will be 0.1-percent allowing 0.04-feet of resolution. Differential pressure across the diffuser grating in excess of 0.2-feet indicates clogging. Two feet of differential is the maximum allowed for safe loading. Plate 14 depicts the layout and details of the monitoring system. Plate 15 depicts a schematic of this system.

(2) Each level sensor is lowered through a 2-inch, schedule 80, PVC conduit mounted flush to the wall of the fish collection channel. Conduits and wiring for the sensors are terminated in a control panel located at approximately elevation 50.

(3) Each control panel encloses an analog input I/O module, which converts the current output from the level transducer to a digital signal. The module and level transmitters are powered over the communication wiring. Design is based on a "MTL I/O95" series input and communication module. Modules are looped together with a 2-wire communications "Transnet" cable. This cable terminates at the I/O Block and Power Supply module located in panel SA24. An "MTL" protocol converter is used to interface between the "MTL" power supply module and the existing "G.E. Fanuc" programmable logic controller with the Modbus protocol.

(4) The existing "G.E. Fanuc" programmable logic control currently interfaces with other AWS level control signals. This controller will be modified to include an upgraded CPU to allow the required serial communications, an analog output module, and a communications module. The upgraded controller will accept the new water levels at the diffuser grating, calculate differentials across the diffuser gratings, and output both collection channel level and grating pressure differential at each of the two locations.

(5) The digital displays of the levels and pressure differential will be added to the existing panel door with the existing AWS hydraulic information. Direct display of the collection channel level at each end of the powerhouse is a secondary benefit.

# SECTION 8 -- CONSTRUCTION

## 8.1 Floating Orifice Closure

a. Slide Plate Mounted to Floating Orifice.

(1) This alternative requires modification of the 12 existing floating orifice panels. The panels can be placed in 20 slots along the tailrace of the powerhouse. Plate 2 shows the location of the active slots. Slots FO-3, FO-4, FO-6, FO-8, FO-13, FO-15, FO-17, and FO-19 are inactive. Prior to modifying the floating orifice gates, 14-weeks should be allowed for fabricating slide plates, guides, and appurtenances. Existing bulkheads allow taking up to two floating orifices out of service at a time. The existing lifting device allows for pulling and installing bulkheads and orifices from the deck. The proposed modifications will require a week to perform. Therefore, the sequencing will involve exchanging two floating orifices with bulkheads, performing the modifications, re-installing the modified floating orifices and removing the bulkheads, then moving to the next set. This sequence will need to be repeated 6 times to modify all the floating orifices. This work will need to be performed during the in-water work period from December through February when the Fish Units can be shut down. With the bulkheads currently available the entire process will take about 6 to 8 weeks. This duration may conflict with other scheduled in-water work. If this is the case, then additional bulkheads will be required to allow work on more than 2 floating orifices at a time. If time constraints become an issue, it may be desirable to shut the fishway down during construction to allow work to proceed on all the floating orifice gates at once. The FPP requires that at least one fish ladder remain in operation at all times. A shut down of the Bonneville Second Powerhouse fish ladder would require coordination with Bonneville First Powerhouse to ensure that the requirements outlined in the FPP are met.

(2) The work to be performed on the floating orifices includes the following:

(a) Fabricate or purchase aluminum slide plates, slide plate guides and seals, tag lines, and other misc. parts.

(b) Exchange the floating orifice with the bulkheads.

(c) Weld slide plate guides around orifice.

(d) Pressure test panels for air-tightness and epoxy coat damaged areas, allow for paint cure time.

(e) Mount slide plate to orifice panel.

(f) Test slide plate assembly.

## 8.2 Diffuser Gates

a. Replace operating wheels on diffuser gates B1 and B2 with an operating wheel that has a nut in the center for operation with the portable actuator. Allow 6 week lead time for materials.

## 8.3 Main Gate Controls

a. The existing main gate controls perform adequately during normal and anticipated emergency conditions. Therefore, no modifications are necessary.

## 8.4 Sediment Accumulation

a. Construction to manage sediment accumulation requires both dredging and blocking the lower portion of the Fish Unit trashrack. The majority of this work will be performed during the in-water work period. A 3 week lead time should be allowed for steel panel fabrication in addition to procurement and submittal review. The following activities will be required:

(1) Weld plate onto the upstream face of the two spare trashrack panels and coat with epoxy paint. Allow one week for the coating to cure.

(2) During the in-stream work period with the Fish Units shut down, the forebay area upstream of the Fish Unit intakes will be dredged to free the lower trashrack panels and clear this area of debris and excess sediment.

(3) Remove the existing trashrack panels.

(4) Weld plate onto the upstream face of two of the previously installed trashrack panels and coat with epoxy paint. Allow one week for the coating to cure.

(5) Install the four blank panels in the bottom of the trashrack slots.

(6) Surplus old trashrack panels.

## 8.5 TRASHRACK DEBRIS ACCUMULATION

a. Construction to manage sediment accumulation requires both dredging and blocking the lower portion of the Fish Unit trashrack. The majority of this work will be performed during the in-water work period. A 3 week lead time should be allowed for steel panel fabrication in addition to procurement and submittal review. The following activities will be required:

b. Automatic Gripper Rake.

(1) Installation of an automatic gripper rake cleaning system will require fabrication, electrical improvements, deck modifications, and a new trashrack system. The majority of this work will be performed during the in-water work period. A total lead time of 34 weeks should be budgeted for submittals and fabrication. The following activities will be required:

(a) Fabricate the automatic gripper rake, and new trashrack.

(b) Extend the new power service from the panelboard in the building on the Fish Evaluation Facility to a new Junction Box.

(c) Cut slots into the Erection Bay forebay wall to allow mounting of the monorail supports.

(d) Mount trashrake support monorail on the Erection Bay deck.

(e) After the sediment accumulation improvements are in place, install the new trashracks with the existing gantry crane.

(f) Mount the automatic gripper rake on the monorail and connect electrical power cable.

(g) Test and calibrate rake system.

## 8.6 DIFFUSER RACK CLOGGING.

a. Diffuser Grating Monitoring System.

(1) A majority of this work will need to be performed during the in-water work period while the Fishway is out of service. Work on this alternative includes the following:

(a) Acquire the conduit, wire, level transmitters, transmitter panels, G.E. Funac PLC modules, and other material. Typical lead times are 6 weeks.

(b) Re-program PLC to include logic for level transmitter communications; analog level outputs to digital displays, and digital outputs for high diffuser grating alarm lights.

(c) Install the level transmitter panels and associated conduit to the existing power house control wire cable-trays.

(d) Install control wiring from the Fish Unit control panel SA24 to each of the transmitter panels at Diffuser Gate B2 and Diffuser Gate A (located next to the junction pool).

(e) During the in-water work period, install the two upper and lower level transmitter conduits. (The transmitter panels will need to be temporarily removed.)

(f) Upgrade the existing G.E. Funac PLC in control panel SA4 with a new 10 slot module rack, a new CPU, a communication module, and an analog output module, and a digital output module. Install "MTL" modules. Install digital displays for fish collection channel level and diffuser grating differential on the SA4 door. Install the diffuser grating alarm lights. Complete panel SA4 wiring of improvements.

(g) After all level transmitter conduits have been installed and the fishway re-filled with water; install the level transmitters and complete wiring.

(2) Test and calibrate diffuser grating monitoring system.

## 8.7 PROJECT SCHEDULE.

a. No explicit schedule is proposed for the improvements. The various items are relatively simple improvements, which tend to be independent of each other. This approach will allow the most flexibility in implementing the improvements.

SECTION 9 -- STOCKPILE CRUCIAL GENERATOR AND TURBINE PARTS

## 9.1 GENERAL

a. Identification of Parts for List. The list of parts to be stockpiled was identified by determining the failure mechanisms of the past and parts needed to repair common failures; identifying long lead time items (more than 30 days to acquire); and identifying parts, though locally available, that could be out of stock at a particular time. The costs of the parts and the likelihood that a part will be needed will influence the decision to buy and stock long lead time and locally available parts.

b. Inventory. Project staff completed an inventory of existing spare parts. The available parts were compared with the recommended spare parts lists assembled by turbine manufacturers. Project staff, including maintenance foremen, then compiled a list of crucial parts they feel should be assembled in order to expedite the process of turbine repair in event of a fish unit outage. Table 9-1 provides a list of the crucial parts.

**Table 9-1**
**Crucial Spare Parts List**

| Description | Unit | Quantity |
|---|---|---|
| Metric Poly Pac Seals | Ea | 3 |
| Twin-Pump External Oil Cooling System | Ea | 2 |
| Governor Blade and Gate Distributing Valve Bushing and Plunger Assembly | Ea | 2 |
| Governor Actuator Screw Pump | Ea | 1 |
| Rotor Pole Keys | Set | 2 |
| Commutation rings | Set | 1 |
| XJ Breaker for Fish Units (refurbished) | Set | 1 |
| Auto Voltage Regulator | Set | 1 |
| Exciter Breakers | Set | 1 |

c. Long Lead Time Parts. One long lead time spare part was identified: the Thrust Bearing Oil Coolers. The Thrust Bearing Oil Coolers can be replaced by an external pump cooling system. A twin pump, external oil cooler would provide reliability and redundancy to the cooling system.

d. 3-D Cam Controller. In a previous draft of this report, the 3D Cam Controller (controlling the wicket gate and blade angle) was identified as a crucial part in need of replacement. The existing 3D Cam Controller is old in cyber-years, and spare parts were thought to not be available. However, by spring of 2002, the 3D Cam Controllers at the First Powerhouse will be replaced with new units. The old 3D Cam Controllers contain identical parts as the fish unit 3-D Cam Controllers. It is the opinion of the Project staff that the old 3D Cam Controllers could serve as an adequate supply of spare parts for the existing 3D Cam Controllers at the fish units. The Project staff does not recommend the purchase of new ones. A back up system is in place. In the event of a 3D Cam Controller breakdown, an existing mechanical system could be used. The existence of a mechanical backup, and the existence of a large supply of spare parts, have removed the 3D Cam Controller from the crucial spare parts list.

e. Storage Area. Discussions with Project personnel indicate that the "+41" storage area or a drier piping gallery could be made available to accommodate the storage needs for the spare parts. If properly stored, the shelf life of many of the items on the spare parts list is not limited. Poly Pac Seals however deteriorate over time; a schedule for their replacement should be developed.

# SECTION 10 -- OPERATIONS AND MAINTENANCE

## 10.1 Floating Orifice Closure Schemes

a. Slide Plate Mounted to Floating Orifice.

(1) Maintenance would be accomplished at the time of the slide plate installation. The guides would be cleared of any fouling with a pressure washer.

## 10.2 Diffuser Gates

a. No changes in gate operations are anticipated when both fish turbines are in operation. For emergency operations when one turbine is out of service, refer to Appendix G – Operations Manual.

b. Except for the diffuser gates B1 and B2, the gates will be opened and closed by existing methods. An operating nut will be installed on gates B1 and B2 that will enable these gates to be actuated by an electric portable operator.

c. No change in diffuser gate maintenance procedures are anticipated.

## 10.3 Main Entrance Gate Controls

a. No changes are recommend to the current operation and maintenance of the existing Main Entrance Gate Control system.

## 10.4 Dredging

a. An annual sediment monitoring program should be implemented. Dredging could then be scheduled during the in-water work period to clear sediment accumulation immediately upstream of the Fish Unit intakes. By blocking of the lower trashrack panel, a higher forebay invert elevation of –9.0-fmsl is acceptable. Anticipated annual dredging under this configuration is 200 to 400-cubic yards. Dredge material is typically barged downstream of the project and emptied into a deep portion of the channel.

## 10.5 Trashrack Debris Accumulation

a. Automatic Gripper Rake

(1) This trashrack cleaning system has separate electric motors for monorail travel, raising and lowering the gripper rake, and to drive a compressed air system for actuating the gripper rake. The system positions the rake above a section of trashrack and lowers the gripper rake down the trashrack to clean off debris.

The UHMW teeth on the rake partially penetrate the vertical trashrack bars to clean out debris. When the rake reaches the bottom, the teeth close together, and the rake is drawn back to the monorail on a roller. Debris is emptied into a bin (or truck) at the north end of the monorail and the rake is re-positioned. The process is completely automated and can be initiated by a timer, water level differential across the trashrack, or manually. The debris bin or truck will need to be emptied periodically. Woody debris and vegetation collected from trashrack cleaning is usually burned, when permitted, on the project site. Trash and rubbish are disposed offsite.

(2) Routine quarterly maintenance and inspection will be required for the hydraulic system, the trolley drive, the rake hoist, and wear of the trashrake head. Annual inspection of the trashrack, by divers, should be performed to insure that the system is cleaning properly. The entire system should be operated at least weekly to insure that the trashracks do not build up debris, which may be difficult to remove if left for longer periods of time.

(3) Large floating logs can accumulate in the forebay adjacent to the fish unit intakes. The proposed trashrack cleaner is capable of removing the logs. However, the primary purpose of the trashrack cleaner is to remove smaller debris that clogs the trashrack below the surface. Existing methods of removing a log buildup in the corner of the forebay should be continued in order to keep the surface area clear. This will allow trashrack cleaning to occur in a regular and timely manner.

### 10.6 Diffuser Rack Clogging

a. The differential pressure at each of the two monitoring locations (B Gates and A Gates) will be digitally displayed on the SA24 panel along with the existing operating parameters. Routine observations of the differential levels should be made at least on a weekly basis and more frequently during periods of high flow. Differential pressure greater than 2-feet is excessive, however 0.4-feet is indicative of clogging. Typically, the differential across the grating will be less than 0.01-feet. At the first indication of clogging, an inspection by divers should be initiated at both the diffuser grating and the trashrack.

b. Little maintenance is required for the system. However, quarterly inspections of the transducer performance should be performed. This will involve raising the transducer within the conduit a predetermined distance (approximately 2 feet) and comparing the change on the digital readout to insure proper operation. Clogging in the conduit may occur and require cleaning by snaking and flushing. A clogged or flattened vent tube in the transducer cable will require replacing the transducer.

# SECTION 11 -- COST ESTIMATES

## 11.1 PROJECT DESCRIPTION

a. The B2 powerhouse at the Bonneville Project is located on the north side of the Columbia River at Mile 146 about 40 miles east of Portland, Oregon. The AWS supplies water to the adult fishway through diffuser chambers over a range of tailwater elevations. The focus of the B2 AWS Backup Alternative Study is to recommend system modifications to resolve deficiencies in the AWS backup water supply. Seven items are considered in this report. The major features of each item are discussed in detail in Section 2 of this report. Costs were developed for the following:

(1) Floating Orifice Closure

(2) Stockpile Crucial Turbine and Generator Parts

(3) Portable Gate Actuator

(4) Operations Plan Verification Testing

(5) Automatic Traveling Grip Rake and New Trashrack

(6) Blanking Off Lower Trashracks

(7) Diffuser Grating Monitoring System

b. This section summarizes the cost of each remedial alternative group and explains some of the major design features of each option within each group. Finally, in-water work periods, assumptions, and wage rates are discussed. See Appendix D for the MCACES Cost Summary Table for the estimate.

## 11.2 SUMMARY OF COSTS

a. Table 11-1 presents the costs in tabular form. The total project price is $2,373,490.

**Table 11-1**
**Cost Summary**

| Item | Cost |
|---|---|
| **Floating Orifice Closure** | $181,972 |
| | |
| **Stockpile Crucial Spare Parts** | $129,945 |
| | |
| **Portable Gate Actuator** | $9,605 |
| | |
| **Operations Plan Verification Testing** | $47,850 |
| | |
| **Trashrack Cleaning Schemes** | |
| Automatic Traveling Grip Rake and Trashrack | $1,785,180 |
| | |
| **Blanking off Lower Trashrack Panels** | $132,250 |
| | |
| **Diffuser Grating Monitoring System** | $86,688 |
| | |
| **Total** | $2,373,490 |

b. Project Description. A brief description of the work to be done in order to implement each alternative is provided below.

(1) Floating orifice closure. This alternative consists of 8 – 24 x 72-inch, low head (2-foot) aluminum slide plates and 4 – 48 x 72-inch, low head (2-foot) aluminum slide plates mounted on the upstream (collection channel side) of the floating orifice. To install the slide plates, the gates will be lifted to the deck at EL 55 and placed by hand with or without the assistance of a boom truck. A tag line attached to the plate will allow the slide plate to be removed without lifting the floating orifice gate to the deck level.

(2) Stockpile crucial spare parts. This scheme consists of buying spare turbine and generator parts for use immediately after a fish unit turbine goes off-line. Project personnel have reviewed inventory and accessed the likelihood of parts failures.

(3) Trashrack debris accumulation and diffuser rack clogging. The trashrack cost is based on steel weight for a trashrack similar to the existing racks, but with a deeper (2-inch) bar. Only 4 of the 5 panels will be replaced since the lower panels will be blanked off and re-used.

(4) Operations plan verification testing. Further testing to verify operation plan recommendations.

(5) Automatic Traveling Grip Rake and New Trashracks: This consists of replacing the existing trashracks and trashrake with a monorail mounted traveling gripper rake similar to the system manufactured by Brackett Green. Dredging will be required upstream of the intake. The existing trashracks will be removed, and the new trashrack and monorail type cleaner will be installed. Power will be extended to a junction box at the north end of the Fish Unit intake.

(6) Blanking Off Lower Trashrack Panels: This involves welding a blank panel onto the face of the bottom existing trashrack panel, thereby shortening the total trashrack length of each trashrack section.

(7) Monitor diffuser rack clogging. This item provides two sets of level transmitters, one at the A diffuser gates, adjacent to the North Upstream Entrance and one at the B Diffuser Gates adjacent to the South Upstream Entrance. Two transmitters are included at each location, upstream and downstream of the diffuser grating. Each level transmitter will connect to a local digital transmitter to communicate over a pair of communication wires with a central panel. Annunciation of the levels and alarms will be incorporated into the programmable logic controller in the SA24 panel.

## 11.3 BASIS OF THE ESTIMATE

a. The basis of the estimate is the *Final Submittal, Bonneville Second AWS Backup Design Documentation Report* and drawings submitted October 2001 (under Contract No. DACW57-97-D-0004, Task Order Case No. 0023).

## 11.4 CONSTRUCTION SCHEDULE

a. Anticipated construction work would take place between September 2003 and February 2004. Restrictions on in-water work apply between March and November of each year.

b. No overtime is anticipated during construction, but some double shifts may be necessary during in-water work periods.

c. The project will be accomplished using one construction acquisition plan.

## 11.5 SUBCONTRACTING PLAN

a. Not applicable.

## 11.6 CONTINGENCY AND ESCALATION

a. Each estimate includes a 20% contingency and 8% escalation. The escalation factor is based on the midpoint of construction for the project of October 2003. The indices for escalation were based on the Tri-Service Military Construction Program (CMP) Index for FY97 through 04 Program, dated January 1998. The construction project was expected to take one year to construct and require one in-water work period from December to February of 2003-2004.

## 11.7 PROJECT CONSTRUCTION

a. Project site access will be by an existing paved road to the B2 site and by barge on the Columbia River.

b. Construction Methodology: Construction of the different alternatives will require civil, structural, mechanical and electrical work to be performed in a sequenced and coordinated fashion.

c. Unusual Conditions: Cold winter weather when in-water work is allowed, high winds and rough water are conditions that make working on, and adjacent to the Columbia River and B2 difficult.

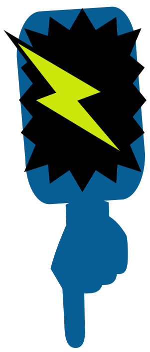
d. Equipment/Labor Availability and Distance Traveled: Construction equipment will be mobilized and demobilized by the general construction firm securing the contract. It is anticipated that the firm will be from the Oregon/Washington area.

e. Labor was assumed to be available without restriction considering the close proximity to the Portland area.

## SECTION 12 -- CONCLUSIONS AND RECOMMENDATIONS

### 12.1 AWS OPERATIONS ALTERNATIVE

a. <u>Emergency Operations Manual.</u> The instruction in the emergency operations manual should be implemented when a fish turbine goes off line. Verification of the recommended emergency fishway settings should be undertaken at low, medium, and high tailwaters, before adopting the operations plan into the FPP.



### FLOATING ORIFICE CLOSURE SCHEMES.

a. <u>Aluminum Sliding Orifice Closure</u>. Attaching a slide plate to the tailrace side of the floating orifice gates is the recommendation of this DDR. This concept is simple and cost effective. Installation can occur in one night shift. Installation can be accomplished by lifting the floating orifice gate to deck level and sliding the plates into the guides. This method allows visual inspection of the gate guides. If the guides are fouled, they can be pressure washed to ensure proper seating. Removing the plates can be accomplished by using a portable crane to pull up a tag line secured to the slide plate, while the floating orifice gates remain in position. Plates will be stored and transported in a steel rack.

### 12.3 SEDIMENT ACCUMULATION.

a. <u>Block Lower Portion of Trashrack.</u> Because of the rapid infilling of sediment in front of the Fish Units, a dredging program by itself would be insufficient. The sediment buildup that occurred between 1997 and 1998 demonstrates that the existing trashrack invert will be partially buried within a single season. Dredging should not occur during the operation of the AWS. Therefore, the frequency of dredging required would be once per year. Consequently, the sediment accumulation, alternative of blocking the lower portion of trashrack is the only feasible alternative.

### 12.4 TRASHRACK DEBRIS ACCUMULATION.

a. <u>Trashrack Cleaner.</u> Installation of the automatic traveling grip rake is recommended. The existing trash rack should be replaced with a trash rack designed by the same manufacturer that builds the trashrake. Pneumatic actuation of the gripper is recommended to avoid contamination of the fishway with hydraulic fluid.

### 12.5 MONITORING DIFFUSER RACK CLOGGING.

a. <u>Recommendation.</u> Installing a diffuser grating differential pressure monitoring system is recommended.

### 12.6 STOCKPILING CRUCIAL SPARE PARTS.

a. <u>Recommendation.</u> Proceed with the purchase and stockpiling of the spare parts listed in Section 9.

# APPENDIX A

# LIST OF REVISIONS

# APPENDIX B

# TECHNICAL REVIEW DOCUMENTS

# 11/05/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [x] CONCEPT [ ] FINAL [ ] PLANS & SPECS [ ] PRELIMINARY | **Bonneville 2 AWS Backup System** 90% DDR ITR Review | | 8/30/01 |

| REVIEWER | | | ACTION TAKEN ON COMMENT |
|---|---|---|---|
| [X] CH2M/MW JV [ ] AIR FORCE [ ] ARMY | NAME: Pete Wiedemann; PHONE NUMBER: 425-453-5005 ext. 5085 | [ ] ARCHITECT [ ] LAND ARCHITECT [ ] CIVIL [ ] SANITARY [X] MECHANICAL [ ] ELECTRICAL [ ] STRUCTURAL [ ] Technical Review Team | |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Page i Operations Plan, second bullet | For added clarity consider changing "aluminum slide plates" to "aluminum sliding closure plates." | | C | |
| 2. | Para 1.4 | No "Agency Coordination" text has been provided. | | Noted | |
| 3. | Para 6.3 a. | See Comment No. 1 | | C | |
| 4. | Para 6.5 | It is not clear what the main gates are. Should this be Fishway Main Entrance Gates? | | C | |
| 5. | Para 6.7.a.(2) | First sentence is unclear. Is the cleaner manually or automatically operated? | | C – the cleaner can be operated either manually or automatically. This will be clarified. | |
| 6. | Para 6.7.b.(4) | It is unclear as to how a toothed rake will be able to lift sediment. | | This issue will be addressed with the manufacturer. | |
| 7. | Para 8.1 a. (1) | In the fourth line, clarify what the "additional bulkheads" are. | | C – " additional" has been changed to existing. | |
| 8. | Paras 9.1 b.,c, & d | These three paragraphs are confusing. Para b. talks about crucial spare parts, but it's not clear if any of these parts are in the current inventory. Table 9-1 title should state "Crucial Spare Parts List". How do paragraphs. c and d. relate to the above? The two items discussed here are not listed in the table, but sound "crucial." | | The word "cooling" has been added to paragraph c.<br><br>Paragraph d explains that the project staff no longer requests a new 3D Cam Controller. | |

# 11/05/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| [ ] DESIGN MEMO | [x] CONCEPT | [ ] FINAL | **Bonneville 2 AWS Backup System** | | |
| [ ] PLANS & SPECS | [ ] PRELIMINARY | | **90% DDR ITR Review** | | 8/30/01 |

| REVIEWER | | | |
|---|---|---|---|
| [X] CH2M/MW JV | NAME: **Pete Wiedemann** | [ ] ARCHITECT | [X] MECHANICAL |
| [ ] AIR FORCE | | [ ] LAND ARCHITECT | [ ] ELECTRICAL |
| [ ] ARMY | PHONE NUMBER: **425-453-5005 ext. 5085** | [ ] CIVIL | [ ] STRUCTURAL |
| [ ] | | [ ] SANITARY | [ ] Technical Review Team |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 9. | Para 12.2 a (2) (i) | Since the potential release of hydraulic fluid into the fishway exists with both alternatives, should it be mentioned at all? This disadvantage can't be used to compare the two alternatives.. | | It was included to be sure it was discussed. With the decision to adopt Alt2, the gripper type rake, the issue becomes moot. | |

# REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*



| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [x] DESIGN MEMO; [x] CONCEPT; [ ] FINAL; [ ] PLANS & SPECS; [ ] PRELIMINARY; 90% | Bonneville Second Powerhouse<br>Auxiliary Water Supply Backup System | Bonneville second Powerhouse | 9/14/01 |

**REVIEWER**

| | | |
|---|---|---|
| [x] NWP-OP-B<br>[ ] AIR FORCE<br>[ ] ARMY | NAME Thomas P. Delaney<br>PHONE NUMBER 216-623-6003 | [ ] ARCHITECT [ ] LAND ARCHITECT [ ] CIVIL [ ] SANITARY<br>[ ] MECHANICAL [ ] ELECTRICAL [x] STRUCTURAL [ ] |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Para 5.1.b.1 | Is the general structural safety factor used for aluminum and steel design? | | Yes, this will be clarified in the text. | |
| 2. | Para 5.5.a | What is the thickness of the bar grating for the diffuser rack? | | C – Bearing bars are 3/16" x 1¼" – Details will be included on Plate 11. | |
| 3. | Plate 10 | In the detail callout in section B the aluminum closure plate is called out as UHMW. | | C | |
| 4. | Plate 10 | In section B, won't the UHMW in the guides eventually begin to bind against the closure plate? | | Lifting lags will be spread out further to insure an even vertical pull. | |
| 5. | Plate 10 | Why is the tack line for the new closure plate shown at an angle as it goes up to the deck at elevation 55? | | The position of the tag line tie off point is arbitrary. It could be hung anywhere in the slot. | |
| 6. | Plate 10 | In detail 1, a 3/8" steel eye bolt seems kind of small. | | The eye bolt only needs to support the weight of the cable and clearance is limited. | |
| 7. | | | | | |
| 8. | | | | | |
| 9. | | | | | |

# 11/05/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [ ] CONCEPT [ ] FINAL<br>[ ] PLANS & SPECS [ ] PRELIMINARY [x] DDR | Bonneville Second Powerhouse AWS Backup System<br>90% Review | Bonneville Second Powerhouse | 9/19/00 |

**REVIEWER**

| | | |
|---|---|---|
| NHC | NAME Richard Regan<br>PHONE NUMBER 206-241-6000<br>360-437-5153 | [x] Hydraulic [ ] MECHANICAL<br>[ ] LAND ARCHITECT [ ] ELECTRICAL<br>[ ] CIVIL [ ] STRUCTURAL<br>[ ] SANITARY [ ] Technical Review Team |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Cover | The cover page should credit Northwest Hydraulic Consultants Inc. along with CH2M Hill / Montgomery Watson as a large portion of the work was accomplished by **nhc** | | C – Cover will include nhc. | |
| 2. | Figure 2.2 | Is the title to this table incorrect? Should it be " …with Existing Trashrack" ? | | C | |
| 3. | Para. 2.4 f | Should include a discussion that even if the sediments could be suspended and flushed there is the issue of the diffuser grating that would block gravel size material. | | C | |
| 4. | Para. 2.4 g | Check the values for head loss between the AWS and the Collection Channel. 1 to 1.5 ft seems excessive. | | Field measurements and numerical modeling indicate 1.0 to 1.5 ft is a reasonable range. | |
| 5. | Table 2.2 | This shows two 2-North columns, shouldn't one be 2-South? | | C | |
| 6. | Para 2.5 b (4) | The last sentence describes two sensors one upstream and the other downstream of a grate. Suggest that above and below in place of upstream and downstream. | | C | |
| 7. | Para 2.5 c (4) | Should specify which main gate will be closed. | | C | |
| 8. | Para.3.1 | This study does not address juvenile entrainment, should the report include some discussion on this issue. | | C – A discussion of the juvenile entrainment issue will be added to Section 3-2. | |
| 9. | Table 3.2 | Juvenile swimming speeds are listed here but are not used or discussed in the report. What purpose do the table serve? | | C - Juvenile swimming speeds were included when screened intakes were being considered. The table will be removed. | |

# 11/05/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| DESIGN MEMO | CONCEPT | FINAL | Bonneville Second Powerhouse AWS Backup System | Bonneville Second Powerhouse | 9/19/00 |
| PLANS & SPECS | PRELIMINARY | X DDR | 90% Review | | |

| REVIEWER | | | |
|---|---|---|---|
| NHC | NAME: Richard Regan | X Hydraulic | MECHANICAL |
| | | LAND ARCHITECT | ELECTRICAL |
| | PHONE NUMBER: 206-241-6000<br>360-437-5153 | CIVIL | STRUCTURAL |
| | | SANITARY | Technical Review Team |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 10. | Para 4.1 b (2) | Make clear that the operating discharge is total river discharge | | C | |
| 11. | Para 4.1 f (2)b | Dates given for Shad passage are also dates given in table 3-1 for all the other species. Suggest eliminating the dates. | | Shad are not included in the table. This data is included in response to ITR comments. | |
| 12. | Para. 4.3 e(4) | Suggest that the recommendation be made to add staff gages and repair and or extend the existing ones. | | This is an operations and maintenance item decision. Project biologists should make this recommendation. | |
| 13. | Para. 4.3 i | I don't understand how the selection was made from patterns shown on the table 4-2? This needs to be explained in more detail. | | Text will be modified to clarify this statement. | |
| 14. | Para. 5.3 a (2) | Is the removal of the plate accomplished with the Fishway in operation? If so has the load on the slide plate been determined and the lifting line been sized for this load? | | The load is identified in 5.1b. Its source will be identified in same location. The lifting line and connection between the plate and the line will be specified during P&S. | |
| 15. | Para 6.3 a | If both plates are the same height (6-ft) that the weight of the 2-ft wide one should be ½ of the 4 ft wide one, | | The plates vary in thickness. See Plate 10, Section B. | |
| 16. | Para 8.1 a (1) | With the fishway out of operation why do bulkheads have to be placed when a floating orifice is removed? Seems like as many orifices as needed can be removed at one time to accomplish the work in the allowed December through February time period. | | Discussion is added to address this point. | |
| 17. | Para 10.2 a | The word "in" appears to be missing in the first sentence. | | C | |
| 18. | Para 10.4 a | Should include an annual sediment monitoring program and only dredge when necessary. | | C | |

# 11/05/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [ ] CONCEPT [ ] FINAL<br>[ ] PLANS & SPECS [ ] PRELIMINARY [x] DDR | Bonneville Second Powerhouse AWS Backup System<br>90% Review | Bonneville Second Powerhouse | 9/19/00 |

| REVIEWER | | |
|---|---|---|
| NHC | NAME: Richard Regan<br>PHONE NUMBER: 206-241-6000<br>360-437-5153 | [X] Hydraulic [ ] MECHANICAL<br>[ ] LAND ARCHITECT [ ] ELECTRICAL<br>[ ] CIVIL [ ] STRUCTURAL<br>[ ] SANITARY [ ] Technical Review Team |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 19. | Plate 10 | Detail 2 shows a top seal. Question the need for the seal. A design with a minimum gap would be acceptable. | | If a top seal is not included in the design, a UHMW strip should be included to separate dissimilar metals. This issue can be settled during plans and specs. | |

# 11/05/01REVIEW COMMENTS



*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [x] CONCEPT [ ] FINAL<br>[ ] PLANS & SPECS [ ] PRELIMINARY [ ] | **Bonneville 2 AWS Backup Alternatives Study**<br>**90% DDR ITR Review** | | 5/9/01 |

**REVIEWER**

| | | | |
|---|---|---|---|
| [X] CH2M/MW JV<br>[ ] AIR FORCE<br>[ ] ARMY | NAME: **Al Giorgi**<br>PHONE NUMBER: **425-883-8295** | [ ] ARCHITECT<br>[ ] LAND ARCHITECT<br>[ ] CIVIL<br>[ ] SANITARY | [ ] MECHANICAL<br>[ ] ELECTRICAL<br>[ ] STRUCTURAL<br>[X] BIOLOGICAL |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1 | | General- The 90% appropriately treated matters identified at the 60% submittal. No new issues were apparent in this version. | | Noted | ----- |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

# REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

PAGE OF

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| X DESIGN MEMO; CONCEPT; FINAL; PLANS & SPECS; PRELIMINARY; X 90% | Bonneville Second Powerhouse<br>Auxiliary Water Supply Backup System | Bonneville second Powerhouse | 8/22/2001 |

**REVIEWER**

X NWP-OP-B; AIR FORCE; ARMY

NAME Patrick Hunter

PHONE NUMBER 541/374-4573

ARCHITECT; LAND ARCHITECT; CIVIL; SANITARY; X MECHANICAL; ELECTRICAL; STRUCTURAL

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Para. 2.4 d. | Who is the Hydraulic Design Center and how did they determine the Fish Units could be operated with the lower trashrack blocked? Was this a physical model test or a computer model test? Was there a decrease in efficiency? Were there limits on flow? | | C. Hydroelectric Design Center. Brian Moentenich compared the physical features and dimensions of the B2 to some units that had been modeled physically at WES. From these comparisons he concluded that there would not be a measurable effect on the turbine performance, assuming that the trashracks were kept clean. He stated that trash would probably accumulate more quickly and reccomended that more frequent monitoring of head loss across the trash racks be done. | |
| 2. | Para 2.5(3) (c) | Says positive normal is in the direction of the powerhouse. This is unclear. Is it the same as the direction of the water flow? | | Yes, this will be clarified. | |
| 3. | Para 2.5(3)(d) | Do the trashrake manufacturers normally make trashracks also? | | Yes, this will be clarified. | |
| 4. | Para 2.5(3)(e) | Were calculations actually made to determine that alternative materials have to be so large that the velocities are unacceptable? | | We did not calculate but used experience.An alternate material was installed at Naches. We have a sample and it is big. In order to get the same strength or resistance to bending, the clear space is much smaller as a ratio to the bar width than it is with a steel bar. The intake width is already set, leaving less area available to flow as it is taken up by the bar width. | |
| 5. | Para 2.5(3)(e) | Why does an elliptical shape exacerbate clogging? | | The clear space between two elliptical bars standing side by side forms the shape of a funnel. It is widest at the upstream edge and narrowest in the middle. This profile will tend to orient trash as it encounters the outer edge of the bars and then wedge the debris into the narrowest section of the rack, whereas a rectangular section tends to retain bebris on the face of the trashrack. | |
| 6. | Para 2.5(3)(e) | Why is neither proposed trashrake compatible with an alternative material trashracks? The rakes are made of alternative materials. | | The HDPE trashracks have a much lower strength than steel and require a deeper section with support bars through the middle in addition to the back supports. This configuration would interfere with the penetrating teeth of the rake. | |

# REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

PAGE OF

| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| X DESIGN MEMO | CONCEPT | FINAL | Bonneville Second Powerhouse | Bonneville second Powerhouse | 8/22/2001 |
| PLANS & SPECS | PRELIMINARY | X 90% | Auxiliary Water Supply Backup System | | |

**REVIEWER**

| | | | |
|---|---|---|---|
| X NWP-OP-B | NAME Patrick Hunter | ARCHITECT | X MECHANICAL |
| AIR FORCE | | LAND ARCHITECT | ELECTRICAL |
| ARMY | PHONE NUMBER 541/374-4573 | CIVIL | STRUCTURAL |
| | | SANITARY | |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 7. | Plate 13 | The parking location for Alt 1 blocks the roadway and prevents parking for at least 3 vehicles. Can the machine be parked slightly south in line with the retaining wall if required? | | Yes | |
| 8. | Para 6.7a(4) and b( 5) | It isn't clear if there are four single trashracks, 53 foot lengtheach or four 13.5 foot trashracks in each slot. It would be difficult to handle a 53 foot long trashrack. | | C - There are four 13.5-foot sections installed in each of four slots. Will clarify text. | |
| 9. | | | | | |

# REVIEW COMMENTS



| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| [ ] DESIGN MEMO | [ ] CONCEPT | [ ] FINAL | Bonneville 2nd Powerhouse AWS Backup DDR, 90% | Bonneville Dam, OR/WA | 8/16/01 |
| [ ] PLANS & SPECS | [ ] PRELIMINARY | [X] 90% DDR | | | |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| [ ] CENWP-EC-DX | NAME Pat Jones | [ ] ARCHITECT | [ ] MECHANICAL | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
| [ ] AIR FORCE | | [ ] LAND ARCHITECT | [ ] ELECTRICAL | (A = Comment accepted) | (C = Correction made. List drawing or paragraph number where correction made) | |
| [ ] ARMY | PHONE NUMBER X4790 | [ ] CIVIL | [ ] STRUCTURAL | (If not accepted explain) | (If not corrected, explain) | (Initials) |
| [ ] | | [ ] SANITARY | [x] COST | | | |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
|---|---|---|---|---|---|
| 1. | General | Suggest that Ed Zurawski of Montgomery-Watson check the next submittal of the estimate. | A | Agreed. | |
| 2. | General | Please submit an electronic copy of the MCACES estimate to me. e-mail: patrick.t.jones@usace.army.mil | A | The electronic copy will be sent today. | |
| 3. | MCACES Summary Sheets | There are several blanks on these sheets. Can you fill them in? | A | To reduce confusion, the summary totals of the various alternatives were covered to be blank. | |
| 4. | Detail page 1 | Looks like only 400 labor hours are included in this item. Note states it should include 500 hours of labor. | A | The estimate detail will be changed to reflect 500 labor hours to match the note. | |
| 5. | Detail page 4 | I can't find the referenced "attached spreadsheet." | A | The Seattle office will forward, as estimate backup, the spreadsheet detailing the costs for the spare parts. | |
| 6. | | | | | |
| 7. | | | | | |
| 8. | | | | | |
| 9. | | | | | |
| 10. | | | | | |

# REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*



| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| X DESIGN MEMO; PLANS & SPECS; CONCEPT; PRELIMINARY; FINAL; X 90% | Auxiliary Water Supply Backup System | Bonneville Second Powerhouse | 8/29/00 |

**REVIEWER**

| | | | |
|---|---|---|---|
| X CENWP-EC-DE; AIR FORCE; ARMY | NAME Duncan Kwong, duncan.kwong@usace.army.mil; PHONE NUMBER (503)808-4920 | ARCHITECT; LAND ARCHITECT; CIVIL; SANITARY | MECHANICAL; X ELECTRICAL; STRUCTURAL; HYDRAULIC |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Para 7.7.a(3) | Please do not use any pole-mounted cable reel assemblies or any other pole mounted devices. | | C – The alternative proposing this supply has been dropped. | |
| 2. | Para 7.8.a(1) | Identify where is the 24 VDC power supply for the transducers coming from and where the 120VAC supply for the power supply is coming from. | | C – Power supply will be separate from the MTL module and located in panel SA24. | |
| 3. | Para 8.5.a(b) | The panel in the Fish Evaluation Facility is limited to 200A and when the two air compressors and air dryer are running there may not be sufficient power for a 50 hp motor. | | C – This alternative has been dropped from the report. | |
| 4. | Para 8.5.a(f) & (g) | Please do not use any pole mounted devices. | | See note 1 | |
| 5. | Para 10.6 | Identify where will the power for these transducers be coming from. | | See note 2 | |
| 6. | | | | | |
| 7. | | | | | |
| 8. | | | | | |
| 9. | | | | | |
| 10. | | | | | |

# REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

PAGE OF

| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE 9/6/01 |
|---|---|---|---|---|---|
| X DESIGN MEMO | CONCEPT | FINAL | Bonneville 2nd Powerhouse Auxiliary Water Supply Backup System DDR – 90% Submittal | | |
| PLANS & SPECS | PRELIMINARY | 90% | | | |

| REVIEWER | | | |
|---|---|---|---|
| NWP-EC-D_______ | NAME David Illias | ARCHITECT | MECHANICAL |
| AIR FORCE | | LAND ARCHITECT | ELECTRICAL |
| ARMY | PHONE NUMBER X4901 | CIVIL | STRUCTURAL |
| | | SANITARY | |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | ACTION TAKEN ON COMMENT: REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | Par. 1.2 | The delivery order is not the proper authorization. Isn't it a particular BIOP measure. | | C – This study is authorized under Appropriation 96x3122, Construction General, Columbia River Mitigation. This work is mandated by the 1998 Supplemental Biological Opinion and the 2000 Biological Opinion, Measures Nos. 125 and 127. | |
| 2. | Par. 2.1 | Isn't the corner collector outfall being studied at the present time. Reference to that study should be included in the text along with any other related study. | | C – Will site report. | |
| 3. | Par. 2.1.a | Citing that the 1996 flood event represent an extreme condition. Need to provide a more typical annual accumulation. | | Quantitative information regarding typical accumulation is not available. Attempts to evaluate accumulations during the preparation of this report have been hampered by excessive leakage in the AWS during maintenance. This also has disrupted annual maintenance during the in water work period. Recommendations will be made to measure and record any sediment accumulation on an annual basis. | |
| 4. | Par. 10.4 | Is there a dredge material disposal site. Note where the dredge materials are disposed. | | C – Discussion of dredge material disposal will be included. | |
| 5. | Par 10.5.b | Is a debris truck required for this alternative. If so then it should be included in the cost estimate. | | Existing equipment is anticipated to be used for debris disposal. | |
| 6. | Par. 11.2 | The alternative cost comparison should be based on annual costs and not just first costs. The annual cost should include labor required to operate alternative one | | It was agreed at the 90% PRM to proceed with the gripper type trash rake for reasons other than cost. | |
| 7. | General | The report should describe the type, size and estimated quantity of debris. The log boom (large debris barrier) will need to be removable in order to remove any large sinker logs. Also will the project crane be able to remove debris outside the barrier. Suggest try not constructing the barrier and see how it works without one. | | C. It was agreed at the 90% PRM to not include the log barrier. A discussion regarding floating debris will be included in Section 10.5. | |
| 8. | Plate 10 | Suggest providing a plan to determine the location of the orifice closure in relation to the fishway channel. | | C – A plan view is included on Plate 10. | |
| 9. | | | | | |
| 10. | | | | | |
| 11. | | | | | |

# REVIEW COMMENTS



| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| X DESIGN MEMO | CONCEPT | FINAL | Bonneville Second Powerhouse | Bonneville Second Powerhouse | 8-31-01 |
| PLANS & SPECS | PRELIMINARY | % | Aux. Water Supply Backup System, DDR | | |

**REVIEWER**

| | | | |
|---|---|---|---|
| X CENWP-EC-DM | NAME Dwayne Weston | ARCHITECT | X MECHANICAL |
| AIR FORCE | | LAND ARCHITECT | ELECTRICAL |
| ARMY | PHONE NUMBER | CIVIL | STRUCTURAL |
| | 503-808-4928 | SANITARY | |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number where correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1. | 6.3-a | Please describe in the text a range of design head for slide gates. | | The design head is reported in the criteria section. The gates are floating. The head remains constant throughout the design tailwater range. | |
| 2. | 6.4 b | Last sentence in paragraph b makes reference to "proposed portable actuator for B diffuser", I do not see the proposed actuator listed in the section discussing B gates (section a) | | C | |
| 3. | 6.7 General | Both alternatives show a log barrier. Describe in text how will this be cleaned? | | It was decided at the 90% PRM to delete the log barrier. | |
| 4. | 6.7 General | Describe in text types of debris common to this intake. | | C | |
| 5. | 6.7-a and b | Please state range of estimated time between cleaning cycles. | | C – discussion will be added. | |
| 6. | 6.7-b(5) | Depth of new trash rack is not specified for this system. | | C – This will be added. Note it is stated in Section 5 (–9fmsl) | |
| 7. | 6.7 General | Please discuss some of the operational advantages and disadvantages to each system. Please make a recommendation of best type of system. | | It was decided at the 90% PRM to move forward with the gripper type trash rake. | |
| 8. | | | | | |
| 9. | | | | | |

To: "Dennis Dorratcague (E-mail)" <dennis.dorratcague@mw.com>, "Peter Barton (E-mail)" <Peter.T.Barton@us.mw.com>
cc:

Subject: FW: 90% Comments

fyi

-----Original Message-----
**From:** **Dasso, Joseph M NWP**
**Sent:** Wednesday, August 29, 2001 11:24 AM
**To:** Maurseth, Jerome A NWP
**Subject:** 90% Comments

Jerry,
About the only comment I have is the following:

I don't see the need for a construction schedule in this DDR. I don't have any idea exactly how, in what order, when, and who will pay for, implementing each of the recommendations. So having a schedule is kind of silly. What I think will actually happen is we will present the finished report (recommendations) to FDDRWG and that body will help us establish priorities. Then you and I will budget and schedule accordingly.

Mark

**Response:**
**Schedule will be deleted from report. Long lead time items will be identified.**

# 11/07/01REVIEW COMMENTS



*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| DESIGN MEMO / PLANS & SPECS / X CONCEPT / PRELIMINARY / FINAL | **Bonneville 2 AWS Backup Alternatives Study** 60% DDR ITR Review | | 5/22/01 |

| REVIEWER | | | |
|---|---|---|---|
| X CH2M/MW JV / AIR FORCE / ARMY | NAME: See Item No. 1<br>PHONE NUMBER: 425-453-5000 (Wiedemann) | ARCHITECT / LAND ARCHITECT / CIVIL / SANITARY | MECHANICAL / ELECTRICAL / STRUCTURAL / Technical Review Team |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1 | ----------------- | The reviewers are indicated by their initials as follows:<br>PFW – Pete Wiedemann Mechanical Review<br>RR – Dick Regan Hydraulics Review<br>TD – Tom Delaney Structural Review | | | ----------- |
| 2-PFW | General | Scope of study is confusing. The title on the cover implies only a backup (new?) system to the AWS is being studied. However, para 1.1.a states that a backup (emergency) system already exists. In addition, the first para. of the syllabus states the study covers O&M considerations with the existing system. | | Para 1.1.a lists deficiencies with the existing backup system. The syllabus states that the design, construction and the O &M costs will considered for any alternative being evaluated. | |
| 3-PFW | Cover | The Montgomery Watson name should be replaced with the CH2M HILL M-W joint venture name. | | C | |
| 4-PFW | Syllabus, page i | Next to the last bullet: At the end of the sentence add – "(Alternative 4 of the Trashrack Cleaning Systems)". | | C | |
| 5-PFW | Table of Contents, page v | Only Appendix D has been provided. | | Did not reproduce all the appendicies for the mechanical reviewer. | |
| 6-PFW | Para 1.3.a.(3) | The rest of the document mentions only 3 transducers. | | C – There are three pairs of transducers. Two transducers are installed at three locations. | |
| 7-PFW | Para 1.4 | No "Agency Coordination" text has been provided. | | Noted | |
| 8-PFW | Paras 2.5.c.(1) & (2) | Reference in both paragraphs is to a "trailer mounted compressor, generator and tank." Shouldn't this be: "trailer mounted compressor, air receiver, and diesel engine drive"? | | C | |
| 9-PFW | Paras 6.1.a.(1)(b), (2)(b),&(3)(b) | The 0.2 friction factor for the UHMW seals seems low for design purposes. In addition, the seals will need a higher "break-out" force to initially get the gate moving. This needs to be factored into the sizing of the operators. | | The gates are very low head (2-feet) without wedging devices, therefore 0.2 should be an appropriate coefficient of | |

# 11/07/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|
| DESIGN MEMO | x CONCEPT / FINAL | Bonneville 2 AWS Backup Alternatives Study | | 5/22/01 |
| PLANS & SPECS | PRELIMINARY | 60% DDR ITR Review | | |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| X CH2M/MW JV | NAME: See Item No. 1 | ARCHITECT | MECHANICAL | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
| AIR FORCE | | LAND ARCHITECT | ELECTRICAL | (A = Comment accepted) | (C = Correction made. List drawing or paragraph number whwere correction made) | |
| ARMY | PHONE NUMBER: 425-453-5000 (Wiedemann) | CIVIL | STRUCTURAL | (If not accepted explain) | (If not corrected, explain) | (Initials) |
| | | SANITARY | Technical Review Team | | | |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
|---|---|---|---|---|---|
| | | | | friction. The hydraulic load factor of 2.0 accounts for unseating. | |
| 10-PFW | Paras 6.1.c.(1)(f) &(2)(f) | The stated max. debris load is different for the two rakes. Is this because the two rakes have different rated capacities? If the telescoping rake has a larger capacity shouldn't this be listed as an advantage in Chapter 12? Also, the "design log" at Bonn 2 powerhouse s 2' in diameter, 40 feet long, and weighs 8000 lbs. There's some chance this could become a "sinker" and have to be fished out from the bottom. Do we have a problem here with either trashrake, or will some other crane be used? | | C: The stated debris load pertains to the rated capacity. Alt. 1 has a higher capacity and this will be included as an advantage. Extraordinary debris, such as logs, will need to be handled by the gantry crane. This will be clarified in the text. | |
| 11-PFW | Para 6.5 | Not clear what the Main Gates are. Should this be Main Entrance Gates? | | C | |
| 12-PFW | Paras 6.7(a)(4) & (b)(4) | Both paragraphs should state how much deeper the trash rack bars need to be. | | C: The bar depth is 2-inches minimum and will be clarified in the text. | |
| 13-PFW | Para 8.1.a | For consistency with the rest of the document, the heading should read: "Alternative 1 – Slide Gate Mounted to Floating Orifice (Upstream Side). | | C | |
| 14-PFW | Para 8.1.a.(1) | In the fifth sentence clarify what the "additional bulkheads" are. | | C | |
| 15-PFW | Para 8.1.b | For consistency with the rest of the document, the heading should read: "Alternative 2 – Slide Gate Mounted to Floating Orifice (Downstream Side). | | C | |
| 16-PFW | Para 9.1.e | In the first sentence, state the table numbers for the "previous tables." | | C – Section is revised. | |

# 11/07/01REVIEW COMMENTS

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| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| DESIGN MEMO; X CONCEPT; FINAL; PLANS & SPECS; PRELIMINARY | **Bonneville 2 AWS Backup Alternatives Study** **60% DDR ITR Review** | | **5/22/01** |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| X CH2M/MW JV; AIR FORCE; ARMY | NAME: **See Item No. 1** PHONE NUMBER: **425-453-5000 (Wiedemann)** | ARCHITECT; LAND ARCHITECT; CIVIL; SANITARY | MECHANICAL; ELECTRICAL; STRUCTURAL; Technical Review Team | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
|---|---|---|---|---|---|
| 17-PFW | Para 9.1.e | Since Table 9-2 doesn't state that these are additional spare parts to purchase, it is not clear whether these parts are on hand, are to be purchased, or a combination of both. | | C – Section is revised, Table 9-2 is deleted. | |
| 18-PFW | Para 10.1.(a) | For consistency with the rest of the document, the heading should read: "Alternative 1 – Slide Gate Mounted to Floating Orifice (Upstream Side). | | C | |
| 19-PFW | Para 10.1.(b) | For consistency with the rest of the document, the heading should read: "Alternative 2 – Slide Gate Mounted to Floating Orifice (Downstream Side). | | C | |
| 20-PFW | Para 12.2.a.(1)(c) | State why this alternative is more reliable than Alternative 2. | | C | |
| 21-PFW | Paras 12.4a.(2)(f) & (b)(2)(a) | Since debris has to be disposed of with either raking options, why is it a disadvantage to both? | | This was included to highlight the disposal requirements. Currently the cleaning method does not remove debris from the flow-stream, rather debris passes through the Main Units. | |
| 22-PFW | Plate 2 | Too many superfluous callouts; the studied features do not stand out. A larger scale, just showing the dam, might also be helpful. | | C – Callouts removed. Dam is shown in figures included in Appendix F. | |
| 23-PFW | Plate 11 | Is the UHMW seal assembly, in Section B, similar to what is required for Alternative 1? If so, so state. | | The gate seal will depend on the manufacturer's standard for a low seating head / no unseating head fabricated gate. The frame and seals for these gates differ from the Section B detail. Note; clearance is not an issue on Alternative 1. | |
| 24-PFW | Plate 12 | Drawing is very difficult to follow. The text (para 2.5 c.(3)) states that this alternative consists only of a "stab plate" and "detachable lifting mechanism" However, different terminology is used on the drawing, and it is not clear from view-to-view what is the stab plate and what is the lifting mechanism. In | | C | |

# 11/07/01REVIEW COMMENTS

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**DESIGN DOCUMENT TYPE**

DESIGN MEMO | x CONCEPT | FINAL
PLANS & SPECS | PRELIMINARY

PROJECT **Bonneville 2 AWS Backup Alternatives Study**

**60% DDR ITR Review**

LOCATION

DATE **5/22/01**

**REVIEWER**

X CH2M/MW JV
AIR FORCE
ARMY

NAME **See Item No. 1**

PHONE NUMBER **425-453-5000 (Wiedemann)**

ARCHITECT | MECHANICAL
LAND ARCHITECT | ELECTRICAL
CIVIL | STRUCTURAL
SANITARY | Technical Review Team

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| | | addition, if Section B/11 is the section shown on Plate 11, then Plate 11 should refer back to Plate 12. | | | |
| 25-PFW | Plate 13 | Alternate 2 Section: "Sheave" is misspelled and "STN STL" should be added to the abbreviation list. | | C | |
| 26-PFW | Plate 14 | It might be helpful to call out the debris bin on the Detail Section. | | C | |
| 27-PFW | Plate 15 | In the Detail Section: the clearance between the gripper and monorail knee brace may not be sufficient for the monorail to travel with gangly debris. | | This may be a problem at the center support, but only with large limbs or logs, other debris will be broken or swept downward. This configuration has a minimum of 8-inches of clearance between the gripper and support column. | |
| 1-RR | Page vii | Flow through orifices stated that flow varies with tailwater, this is not the case the flow varies with head difference across the orifice. Also states that there are 12 orifices whereas other portions of the report states that there are 20, which is correct? | | C: Clarification made to text. There are 20 floating orifice openings, however, only 12 of those actually have operating floating orifices. The rest are closed with permanent bulkheads. | |
| 2-RR | Numerous pages | The report discusses model studies to analyze conditions within the fishway system. The term model should be qualified throughout the report as a numerical computer model. | | C | |

# 11/07/01REVIEW COMMENTS

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| DESIGN DOCUMENT TYPE | | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|---|
| DESIGN MEMO | X CONCEPT | FINAL | Bonneville 2 AWS Backup Alternatives Study<br>60% DDR ITR Review | | 5/22/01 |
| PLANS & SPECS | PRELIMINARY | | | | |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| X CH2M/MW JV<br>AIR FORCE<br>ARMY | NAME: See Item No. 1<br>PHONE NUMBER: 425-453-5000 (Wiedemann) | ARCHITECT<br>LAND ARCHITECT<br>CIVIL<br>SANITARY | MECHANICAL<br>ELECTRICAL<br>STRUCTURAL<br>Technical Review Team | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
|---|---|---|---|---|---|
| 3-RR | Sect. 2.4 | Investigations should be accomplished to determine the source of the sediments, the % of material carried in suspension and as bed load, and the gradation of the material that is entering the AWS. If the majority of the material is suspended the design presented to keep material out of the AWS will not work. This material might be the remains of the upstream cofferdam and if so the remnants most likely are moving as bed load a dredging of this area in a manner that would provide a trap might stop the material transport into the units. However if as suspected the majority of the sediments are carried in suspension the only solution is a scheduled AWS sediment removal operation. | | Further investigation may be worthwhile, however the proposed solution of blocking off the lower portion of the trashrack is at least a good first step. Given that the Fish Unit intakes have been buried at least twice it is likely that bedload movement is a significant contributor to the sediment build up within the AWS. | |
| 4-RR | Sect 4.1 j (1) | Don't understand this statement. Needs to be clarified. | | C- deleted | |
| 5-RR | Figure 2.2 and 2.3 | What is the basis for the data points shown on these two graphs? This basis should be explained in the text. | | C | |
| 6-RR | Sect 4.1 j (1) | What does this paragraph mean? Clarification is required. | | C | |
| 7-RR | Sect 4.2 b | Provide credit to NHC for this report | | C | |
| 8-RR | Sect 4.2 c (3) | Give credit to the author (Milo Bell) for this text. | | C | |
| 9-RR | Sect 4.3 b (2) | Is the entrance weir submergence 's' given value? here it states that it is computed. This should be checked and corrected as required. | | C: Clarification made to text. The tailwater elevation is given; however, the weir elevation can be adjusted in the model. | |

# 11/07/01REVIEW COMMENTS

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| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [x] CONCEPT [ ] FINAL<br>[ ] PLANS & SPECS [ ] PRELIMINARY | Bonneville 2 AWS Backup Alternatives Study<br>60% DDR ITR Review | | 5/22/01 |

| REVIEWER | | | |
|---|---|---|---|
| [x] CH2M/MW JV<br>[ ] AIR FORCE<br>[ ] ARMY | NAME: See Item No. 1<br>PHONE NUMBER: 425-453-5000 (Wiedemann) | [ ] ARCHITECT<br>[ ] LAND ARCHITECT<br>[ ] CIVIL<br>[ ] SANITARY | [ ] MECHANICAL<br>[ ] ELECTRICAL<br>[ ] STRUCTURAL<br>[ ] Technical Review Team |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | ACTION TAKEN ON COMMENT: REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 10-RR | Sect 4.3 c (2) | Should state in percent how much the AWS discharge is reduced with one turbine operation | | C | |
| 11-RR | Sect 4.3 c (3) | The words "lowest portion of the fish ladder" should be "lower portion of the fish ladder". ALSO this section discusses 20 floating orifices, this should be changed to 12. This same cmt. pertaining to orifices is applicable to the 6th bullet item in this Section. | | C | |
| 12-RR | Sect 4.3 c (3) | Third bullet item change the word "supplied" to "equipped" | | C | |
| 13-RR | Sect 4.3 c (3) | Fifth bullet item. The statement that not all diffusers have functioning gates is confusing. Does this mean that all diffusers have gates and some do not work or does it mean that some diffusers do not have gates. This should be clarified. | | The condition of the powerhouse diffuser gates will be checked in June 2001. According to project staff, all gates are functioning and all openings have gates. | |
| 14-RR | Sect 4.3 c (3) | Seventh bullet item. Why weren't operational changes to the Ladder diffusers considered. Should explain. By reducing discharge through these diffusers, it would provide water to areas that might need it more. | . | The ladder diffusers are controlled by weir valves. A structural modification would be required to change the operation of these diffusers. The amount of discharge through these diffusers is small compared to the B diffusers. | |
| 15-RR | Sect 4.3 c (5) | Provide reference to the previous reports that you discuss | | C | |
| 16-RR | Sect 4.3 e | See comment 1F. This paragraph needs to be rewritten to qualify the expected accuracy of the model and not give the impression that the model that the model will provide adequate data to establish emergency operation. | | Testing the operational changes at a low, medium, and high tailwater will be recommended in the 90% report. | |

# 11/07/01REVIEW COMMENTS

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| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| DESIGN MEMO / PLANS & SPECS / X CONCEPT / PRELIMINARY / FINAL | **Bonneville 2 AWS Backup Alternatives Study**<br>**60% DDR ITR Review** | | **5/22/01** |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| X CH2M/MW JV<br>AIR FORCE<br>ARMY | NAME **See Item No. 1**<br>PHONE NUMBER **425-453-5000 (Wiedemann)** | ARCHITECT<br>LAND ARCHITECT<br>CIVIL<br>SANITARY | MECHANICAL<br>ELECTRICAL<br>STRUCTURAL<br>Technical Review Team | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
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| 17-RR | Sect 4.3 j | This paragraph should provide more information pertaining to diffuser criteria not being met. Discussion on whether the criteria was exceeded the max or below the min., and how much is needed. | | C | |
| 1F-RR | Appendix F | The reconfigured model (no orifice flow and one turbine off) was somewhat verified for against the data taken for field test 1. The computed data did not compare to well with the observed, up to 0.4 ft off. Then this same model configuration is used to predict conditions with the tailwater 3 ft lower and 16.5 ft higher. A detail explanation must be presented in this appendix discussing expected accuracy at these extremes and the need for more field data especially at higher tailwater elevations. | | Testing the fishway for a floating orifice condition requires a significant amount of project staff time and must be done during the winter maintenance period. As a result of some unforeseen complications during data collection for this particular test, the 0.4 ft difference was considered to be an outlier. Testing at other tailwater elevations will be recommended in the 90 percent report. | |
| 1. TD | General | The floating orifices should be shown somewhere in the plates. I did not see them in the information I have. | | Will add to Plate 2. | |
| 2. TD | Section 5-1 | There should be references in the text to each plate where an alternative is shown. | | Will add reference. | |
| 3. TD | Page 5-1 | Add references to any Corps Engineering Manuals used. | | Will add reference. | |
| 4. TD | Page 5-4 | Since there is nothing shown with respect to the structure of the trash rack or the diffuser rack, it is impossible to verify the information in paragraphs 5.4, 5.5, and 5.6. The structure for these racks should be shown somewhere. | | Will add Plate 18 to show details. | |
| 5. TD | Plates General | There are places where the existing structure is shown screened and some where it is not shown screened. The plates should be consistent when showing existing structure. | | Will make consistent. | |

# 11/07/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | | PROJECT | LOCATION | DATE |
|---|---|---|---|---|
| DESIGN MEMO / PLANS & SPECS | X CONCEPT / PRELIMINARY / FINAL | **Bonneville 2 AWS Backup Alternatives Study** 60% DDR ITR Review | | 5/22/01 |

| REVIEWER | | | | ACTION TAKEN ON COMMENT | | |
|---|---|---|---|---|---|---|
| X CH2M/MW JV / AIR FORCE / ARMY | NAME: See Item No. 1 / PHONE NUMBER: 425-453-5000 (Wiedemann) | ARCHITECT / LAND ARCHITECT / CIVIL / SANITARY | MECHANICAL / ELECTRICAL / STRUCTURAL / Technical Review Team | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE | DESIGN OFFICE | BACK CHECK BY |
|---|---|---|---|---|---|
| 6. TD | Plate14 | In the Erection Bay Section-The callout for the proposed solid plate should be coordinated with the text. The text calls this plate a blank plate. | | C | |
| | | | | | |
| | | | | | |

# 07/30/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*



| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [x] CONCEPT [ ] FINAL<br>[ ] PLANS & SPECS [ ] PRELIMINARY [ ] | Bonneville 2 AWS Backup Alternatives Study<br>60% DDR ITR Review | | 5/9/01 |

| REVIEWER | | | |
|---|---|---|---|
| [x] CH2M/MW JV<br>[ ] AIR FORCE<br>[ ] ARMY | NAME: Al Giorgi<br>PHONE NUMBER: 425-883-8295 | [ ] ARCHITECT<br>[ ] LAND ARCHITECT<br>[ ] CIVIL<br>[ ] SANITARY | [ ] MECHANICAL<br>[ ] ELECTRICAL<br>[ ] STRUCTURAL<br>[x] BIOLOGICAL |

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| 1 | 1.1.b | I suggest two additional biological objectives be considered for inclusion:<br>1. Develop a strategy that prevents juvenile or adult salmonids from entering and being entrained within the auxiliary water system channel below the diffuser grates.<br>2. Be able to maintain NMFS criteria within the fishway, in the event of a fish turbine failure. | | C. Text added. | ----- |
| 2 | Section 3 | Somewhere in this section it would be instructive to discuss the effects or risks to the adult salmonids that is associated with either the permanent or temporary closure of the orifices along the face of the dam. Investigators at the University of Idaho have evaluated effects of orifice closure at Bonneville. But to my knowledge the results have not yet been published. That information should be considered in the decision making process. | | Requests for the results of the Uof I study on the effects of closing the floating orifices have been made on several occasions. The decision to permanently close the floating orifices can not be made without the results of the U of I study. Text will be added that states that there is a risk to the upstream migrants caused by reducing the number of entry points to the B2 fishway, however, this risk is unquantified. It may be that the orifice closure is a benefit to fish passage by reducing adult fallback along the powerhouse collection channel. | |
| 3 | Table 3-1 | Consider adding shad to this table, since they are such a dominant using the fishway and certain operating conditions are maintained to accommodate shad. | | Will consult with COE biologists. | |
| 4 | 3.5.a | It may be helpful to state those adult criteria that are important in dictating strategies considered in the DDR For example the 1.5-4.0 fps water velocity criteria that the modeling effort focused on. | | C. Text added. The charts in Appendix F provide a graphical method to visualize the extent that the channel velocities would be out of criteria. Entrance velocity, entrance gate submergence, channel velocity and diffuser velocity were all tracked and reported in the numerical modeling effort. Using the | |

# 07/30/01REVIEW COMMENTS

*(For use of this form, see NPD Suppl 1, ER 1110-1-12.)*

| DESIGN DOCUMENT TYPE | PROJECT | LOCATION | DATE |
|---|---|---|---|
| [ ] DESIGN MEMO [X] CONCEPT [ ] FINAL [ ] PLANS & SPECS [ ] PRELIMINARY | **Bonneville 2 AWS Backup Alternatives Study** **60% DDR ITR Review** | | 5/9/01 |

**REVIEWER**

| | | |
|---|---|---|
| [X] CH2M/MW JV [ ] AIR FORCE [ ] ARMY | NAME: Al Giorgi PHONE NUMBER: 425-883-8295 | [ ] ARCHITECT [ ] LAND ARCHITECT [ ] CIVIL [ ] SANITARY [ ] MECHANICAL [ ] ELECTRICAL [ ] STRUCTURAL [X] BIOLOGICAL |

**ACTION TAKEN ON COMMENT**

| ITEM NO. | DRAWING SHEET SPEC PARA | COMMENTS | REVIEW CONFERENCE (A = Comment accepted) (If not accepted explain) | DESIGN OFFICE (C = Correction made. List drawing or paragraph number whwere correction made) (If not corrected, explain) | BACK CHECK BY (Initials) |
|---|---|---|---|---|---|
| | | | | hierarchy of criteria as stated by the agencies, all attempts were made to maintain the entrance velocity and submergence (at the expense of channel velocity and diffuser velocity). Channel velocity was difficult to maintain, and diffuser velocity criteria were sacrificed to help meet them. | |
| 5 | 3.4 | The subheading for this section does not appear appropriate, since the juvenile passage period is never described in this subsection. | | C. Text changed | |
| 6 | 4.1.j | Is the 2-h changeover requirement still in effect? I was under the impression this was relaxed. | | C. deleted. | |
| 7 | 4.1.e | Is the first sentence accurate? The latest version of the fish passage plan for Bonneville indicates that powerhouse priority varies from 1 March – 30 November (Table Bon-5 in the FPP). That table suggests that initially B2 has priority, and then it switches to B1 21 June – 31 August, then back to B2 priority. | | C. Text added. | |
| 8 | 4.1.c | Is this an accurate characterization? If the previous comment is correct, then this one may need recasting. | | C. Text deleted. | |
| 9 | 13.2.a | It may be appropriate to describe the risks associated with the recommended alternative at this point in the report. Refer to comment 2 above | | C. Text added. | |
| 10 | Appendix F | Figures in this section have legends for 1.5 and 4.0 fps, but the significance of these values is not indicated anywhere. Perhaps a global caption that identifies these as the range bounding acceptable water velocity within the fishway (@ NMFS criteria). | | C | |

**Comments on B2 AWS DDR 60% submittal: Response to comments are in *italics.***

-----Original Message-----
**From:** **Dasso, Joseph M NWP**
**Sent:** Friday, April 13, 2001 1:45 PM
**To:** Maurseth, Jerome A NWP
**Subject:** B2 AWS Meeting

Jerry,
I won't be able to make the meeting. I have another one scheduled at the same time for the Bradford Island Landfill. It looks like MW is on track anyway. The only comments I have are:

Does it make sense to go on designing motorized gates for the orifice openings. Perhaps, as we talked the other day, they could verify whether the openings can be blocked at all tailwater elevations. If so, we could cost that option out instead of proceeding with the motors, etc.

> *No decision has been made concerning permanent blockage of the orifice gates. At the 60% PRM, it was decided to develop a non-motorized solution. This solution would lower a bulkhead (stab plate) from above.*

On page 2-3, they have a forebay sediment table. It shows infill and scour from '97 to '98 and from '98 to 2000. I would like to know where they got their data. I don't believe it is correct.

> *Montgomery Watson received three data sets from CENWP as hard copies and as electronic copies. Rex O. Duus NWP supplied the electronic data. These data sets are:*
>
> - *1997 Soundings. Point data referencing depths from elevation 70 <cl-144-145.dgn>.*
> - *1998 Bathemetry. Measured direct elevations. <part of bonneville base file supplied by CENWP>*
> - *March 2000 Soundings. Point data referencing depths from elevation 70 <cl-144-mark.dgn>.*
>
> *The process used to interpret the data was as follows: The data were converted to elevation points. An evaluation area was defined as a space 100 feet from the face of the powerhouse and 120 feet from the face of the retaining wall, into the forebay (as denoted on Plates 3, 4, 5, and 6). Contours were generated in Intergraph from the points within the evaluation area. The contours were refined by hand and some extrapolation of the data was required immediately adjacent to the face of the powerhouse on the March 2000 survey data. (these contours are designated as dashed lines shown on Plate 6 in the DDR). The infill and scour quantities were calculated using "inroads" add-on software with Intergraph. Quantities were also checked by hand using the average end area method.*
>
> *Discrepancies between our conclusions and other reports or data should be clarified in order to proceed with the 90% submittal.*

Can't think of anything else. If everyone accepts the idea of blocking the lower section of the intakes, then I could presumable get Dwayne started on a trashrake/trashrack contract.

Mark

**Pat Hunter Comments to Bonneville Powerhouse Auxiliary Water Supply Backup System 60% Report:**

**Page i**. Should some discussion of the FU/AWS Debris Problem be included in this explanation of the report?

*Detailed explanations are available in the body of the report. It is our intent to keep the syllabus brief.*

**Page 2-5 Alt 2.** Will this type of gate drop if debris gets in the guide? (Since this is not a recommended alternative, it should not become a problem).

*We agree that debris could be a problem, though at this location, the water flowing from the orifices has passed through a trashrack and diffuser gratings. We are unaware of eddy patterns that would collect debris on the tailrace side and overwhelm the orifice flow. But a stick hanging up in the guide slot could stop the gate.*

**General**. Should some type of collection channel velocity measurement system be included to verify the water velocities are within criteria during operation?

*Velocity is an important parameter however, providing velocity measuring devices are not in the scope of this contract.*

**Section 9,** The Project will try to have information on the spare parts in stock and a recommendation on what spare parts would be stocked by May 7, 2001.

*Noted.*

# APPENDIX C

# AGENCY COORDINATION

# APPENDIX D

# COST ESTIMATE

BONNEVILLE SECOND POWERHOUSE

AWS BACKUP DESIGN DOCUMENT REPT
CONSTRUCTION COST ESTIMATE
100%

Designed By: MWH
Estimated By: J LOUCKS

Prepared By: J LOUCKS

Preparation Date: 09/13/01
Effective Date of Pricing: 09/13/01

Sales Tax: 0.00%

| | QUANTY UOM | CONTRACT | CONTINGN | ESCALATN | OWN FURN | SIOH | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | 140,135 | 28,027 | 13,810 | 0 | 0 | 181,972 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | 100,070 | 20,014 | 9,861 | 0 | 0 | 129,945 | |
| B-25 OPERATIONS ALTERNATIVE | | 36,849 | 7,370 | 3,631 | 0 | 0 | 47,850 | |
| B-27 PORTABLE POWER OPERATOR | | 7,397 | 1,479 | 729 | 0 | 0 | 9,605 | |
| B-30 TRASHRACK CLEANING SYSTEM | | 1,476,598 | 295,320 | 145,513 | 0 | 0 | 1,917,430 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | 66,757 | 13,351 | 6,579 | 0 | 0 | 86,688 | |
| TOTAL B2 AWS BACKUP FACILITIES | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |

| | QUANTY UOM | CONTRACT | CONTINGN | ESCALATN | OWN FURN | SIOH | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | | | | | | | |
| B-1003 MANUAL DOWNSTREAM SLIDE GATE | | 140,135 | 28,027 | 13,810 | 0 | 0 | 181,972 | |
| TOTAL FLOATING ORIFICE CLOSURE | | 140,135 | 28,027 | 13,810 | 0 | 0 | 181,972 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | | | | | | | |
| B-2001 FISH UNIT SPARE PARTS LIST | | 100,070 | 20,014 | 9,861 | 0 | 0 | 129,945 | |
| TOTAL STOCKPILE CRUCIAL SPARE PARTS | | 100,070 | 20,014 | 9,861 | 0 | 0 | 129,945 | |
| B-25 OPERATIONS ALTERNATIVE | | | | | | | | |
| B-2520 TESTING PROGRAM | | 36,849 | 7,370 | 3,631 | 0 | 0 | 47,850 | |
| TOTAL OPERATIONS ALTERNATIVE | | 36,849 | 7,370 | 3,631 | 0 | 0 | 47,850 | |
| B-27 PORTABLE POWER OPERATOR | | | | | | | | |
| B-2710 PROVIDE PORTABLE POWER OPERATOR | | 7,397 | 1,479 | 729 | 0 | 0 | 9,605 | |
| TOTAL PORTABLE POWER OPERATOR | | 7,397 | 1,479 | 729 | 0 | 0 | 9,605 | |
| B-30 TRASHRACK CLEANING SYSTEM | | | | | | | | |
| B-3002 AUTOMATIC TRAVEL GRIP RAKE | | 1,374,753 | 274,951 | 135,477 | 0 | 0 | 1,785,180 | |
| B-3003 BLKG OFF LOWER PNL | | 101,845 | 20,369 | 10,036 | 0 | 0 | 132,250 | |
| TOTAL TRASHRACK CLEANING SYSTEM | | 1,476,598 | 295,320 | 145,513 | 0 | 0 | 1,917,430 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | | | | | | | |
| B-4001 INSTALL LEVEL TRANSDUCERS | | 66,757 | 13,351 | 6,579 | 0 | 0 | 86,688 | |
| TOTAL MONITOR DIFFUSER RACK CLOGGING | | 66,757 | 13,351 | 6,579 | 0 | 0 | 86,688 | |
| TOTAL B2 AWS BACKUP FACILITIES | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |

| | QUANTY UOM | DIRECT | FIELD OH | HOME OFC | PROFIT | BOND | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | 365,561 | |
| SUBTOTAL | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | 2,373,490 | |

| | QUANTY UOM | DIRECT | FIELD OH | HOME OFC | PROFIT | BOND | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | 108,669 | 10,867 | 5,977 | 12,551 | 2,071 | 140,135 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | 77,600 | 7,760 | 4,268 | 8,963 | 1,479 | 100,070 | |
| B-25 OPERATIONS ALTERNATIVE | | 28,575 | 2,858 | 1,572 | 3,300 | 545 | 36,849 | |
| B-27 PORTABLE POWER OPERATOR | | 5,736 | 574 | 315 | 663 | 109 | 7,397 | |
| B-30 TRASHRACK CLEANING SYSTEM | | 1,145,042 | 114,504 | 62,977 | 132,252 | 21,822 | 1,476,598 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | 51,768 | 5,177 | 2,847 | 5,979 | 987 | 66,757 | |
| TOTAL B2 AWS BACKUP FACILITIES | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | 365,561 | |
| SUBTOTAL | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | 2,373,490 | |

| | QUANTY UOM | DIRECT | FIELD OH | HOME OFC | PROFIT | BOND | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | | | | | | | |
| B-1003 MANUAL DOWNSTREAM SLIDE GATE | | 108,669 | 10,867 | 5,977 | 12,551 | 2,071 | 140,135 | |
| TOTAL FLOATING ORIFICE CLOSURE | | 108,669 | 10,867 | 5,977 | 12,551 | 2,071 | 140,135 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | | | | | | | |
| B-2001 FISH UNIT SPARE PARTS LIST | | 77,600 | 7,760 | 4,268 | 8,963 | 1,479 | 100,070 | |
| TOTAL STOCKPILE CRUCIAL SPARE PARTS | | 77,600 | 7,760 | 4,268 | 8,963 | 1,479 | 100,070 | |
| B-25 OPERATIONS ALTERNATIVE | | | | | | | | |
| B-2520 TESTING PROGRAM | | 28,575 | 2,858 | 1,572 | 3,300 | 545 | 36,849 | |
| TOTAL OPERATIONS ALTERNATIVE | | 28,575 | 2,858 | 1,572 | 3,300 | 545 | 36,849 | |
| B-27 PORTABLE POWER OPERATOR | | | | | | | | |
| B-2710 PROVIDE PORTABLE POWER OPERATOR | | 5,736 | 574 | 315 | 663 | 109 | 7,397 | |
| TOTAL PORTABLE POWER OPERATOR | | 5,736 | 574 | 315 | 663 | 109 | 7,397 | |
| B-30 TRASHRACK CLEANING SYSTEM | | | | | | | | |
| B-3002 AUTOMATIC TRAVEL GRIP RAKE | | 1,066,066 | 106,607 | 58,634 | 123,131 | 20,317 | 1,374,753 | |
| B-3003 BLKG OFF LOWER PNL | | 78,976 | 7,898 | 4,344 | 9,122 | 1,505 | 101,845 | |
| TOTAL TRASHRACK CLEANING SYSTEM | | 1,145,042 | 114,504 | 62,977 | 132,252 | 21,822 | 1,476,598 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | | | | | | | |
| B-4001 INSTALL LEVEL TRANSDUCERS | | 51,768 | 5,177 | 2,847 | 5,979 | 987 | 66,757 | |
| TOTAL MONITOR DIFFUSER RACK CLOGGING | | 51,768 | 5,177 | 2,847 | 5,979 | 987 | 66,757 | |
| TOTAL B2 AWS BACKUP FACILITIES | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,417,390 | 141,739 | 77,956 | 163,709 | 27,012 | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | 365,561 | |

| | QUANTY UOM | DIRECT | FIELD OH | HOME OFC | PROFIT | BOND | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| SUBTOTAL | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | 2,373,490 | |

| | QUANTY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| FIELD OVERHEADS - 10% | | | | | | | | 141,739 | |
| SUBTOTAL | | | | | | | | 1,559,129 | |
| PRIME'S HOME OFFICE RECOVERY - 7.5% | | | | | | | | 77,956 | |
| SUBTOTAL | | | | | | | | 1,637,086 | |
| PRIME CONTRACTOR'S PROFIT - 10% | | | | | | | | 163,709 | |
| SUBTOTAL | | | | | | | | 1,800,794 | |
| PRIME CONTRACTOR'S BOND - 1.5% | | | | | | | | 27,012 | |
| TOTAL INCL INDIRECTS | | | | | | | | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | | 365,561 | |
| SUBTOTAL | | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | | 2,373,490 | |

| | QUANTY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | | 572 | 30,881 | 6,988 | 48,200 | 22,600 | 108,669 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | | 0 | 0 | 0 | 77,600 | 0 | 77,600 | |
| B-25 OPERATIONS ALTERNATIVE | | | 0 | 0 | 0 | 0 | 28,575 | 28,575 | |
| B-27 PORTABLE POWER OPERATOR | | | 0 | 100 | 100 | 5,200 | 336 | 5,736 | |
| B-30 TRASHRACK CLEANING SYSTEM | | | 1,500 | 78,834 | 26,800 | 881,109 | 158,300 | 1,145,042 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | | 350 | 18,601 | 6,917 | 23,250 | 3,000 | 51,768 | |
| TOTAL B2 AWS BACKUP FACILITIES | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| FIELD OVERHEADS - 10% | | | | | | | | 141,739 | |
| SUBTOTAL | | | | | | | | 1,559,129 | |
| PRIME'S HOME OFFICE RECOVERY - 7.5% | | | | | | | | 77,956 | |
| SUBTOTAL | | | | | | | | 1,637,086 | |
| PRIME CONTRACTOR'S PROFIT - 10% | | | | | | | | 163,709 | |
| SUBTOTAL | | | | | | | | 1,800,794 | |
| PRIME CONTRACTOR'S BOND - 1.5% | | | | | | | | 27,012 | |
| TOTAL INCL INDIRECTS | | | | | | | | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | | 365,561 | |
| SUBTOTAL | | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | | 2,373,490 | |

| | QUANTY UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | | | | | | | |
| B-10 FLOATING ORIFICE CLOSURE | | | | | | | | |
| B-1003 MANUAL DOWNSTREAM SLIDE GATE | | 572 | 30,881 | 6,988 | 48,200 | 22,600 | 108,669 | |
| TOTAL FLOATING ORIFICE CLOSURE | | 572 | 30,881 | 6,988 | 48,200 | 22,600 | 108,669 | |
| B-20 STOCKPILE CRUCIAL SPARE PARTS | | | | | | | | |
| B-2001 FISH UNIT SPARE PARTS LIST | | 0 | 0 | 0 | 77,600 | 0 | 77,600 | |
| TOTAL STOCKPILE CRUCIAL SPARE PARTS | | 0 | 0 | 0 | 77,600 | 0 | 77,600 | |
| B-25 OPERATIONS ALTERNATIVE | | | | | | | | |
| B-2520 TESTING PROGRAM | | 0 | 0 | 0 | 0 | 28,575 | 28,575 | |
| TOTAL OPERATIONS ALTERNATIVE | | 0 | 0 | 0 | 0 | 28,575 | 28,575 | |
| B-27 PORTABLE POWER OPERATOR | | | | | | | | |
| B-2710 PROVIDE PORTABLE POWER OPERATOR | | 0 | 100 | 100 | 5,200 | 336 | 5,736 | |
| TOTAL PORTABLE POWER OPERATOR | | 0 | 100 | 100 | 5,200 | 336 | 5,736 | |
| B-30 TRASHRACK CLEANING SYSTEM | | | | | | | | |
| B-3002 AUTOMATIC TRAVEL GRIP RAKE | | 1,140 | 60,496 | 22,020 | 842,250 | 141,300 | 1,066,066 | |
| B-3003 BLKG OFF LOWER PNL | | 360 | 18,338 | 4,780 | 38,859 | 17,000 | 78,976 | |
| TOTAL TRASHRACK CLEANING SYSTEM | | 1,500 | 78,834 | 26,800 | 881,109 | 158,300 | 1,145,042 | |
| B-40 MONITOR DIFFUSER RACK CLOGGING | | | | | | | | |
| B-4001 INSTALL LEVEL TRANSDUCERS | | 350 | 18,601 | 6,917 | 23,250 | 3,000 | 51,768 | |
| TOTAL MONITOR DIFFUSER RACK CLOGGING | | 350 | 18,601 | 6,917 | 23,250 | 3,000 | 51,768 | |
| TOTAL B2 AWS BACKUP FACILITIES | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| FIELD OVERHEADS - 10% | | | | | | | 141,739 | |

| | QUANTY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| SUBTOTAL | | | | | | | | 1,559,129 | |
| PRIME'S HOME OFFICE RECOVERY - 7.5% | | | | | | | | 77,956 | |
| SUBTOTAL | | | | | | | | 1,637,086 | |
| PRIME CONTRACTOR'S PROFIT - 10% | | | | | | | | 163,709 | |
| SUBTOTAL | | | | | | | | 1,800,794 | |
| PRIME CONTRACTOR'S BOND - 1.5% | | | | | | | | 27,012 | |
| TOTAL INCL INDIRECTS | | | | | | | | 1,827,806 | |
| CONTINGENCY - 20% | | | | | | | | 365,561 | |
| SUBTOTAL | | | | | | | | 2,193,367 | |
| ESCALATION - 8% | | | | | | | | 180,123 | |
| TOTAL INCL OWNER COSTS | | | | | | | | 2,373,490 | |

| SRC | LABOR ID | DESCRIPTION | BASE | OVERTM | TXS/INS | FRNG | TRVL | RATE | UOM | UPDATE | **** TOTAL **** DEFAULT | HOURS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL | X-ELECTRN | Outside Electrician | 27.30 | 0.0% | 46.5% | 10.47 | 0.00 | 50.46 | HR | 09/17/99 | 22.78 | 240 |
| MIL | X-EQOPRLT | Outside Equip. Oper Light | 23.27 | 0.0% | 46.5% | 8.20 | 0.00 | 42.29 | HR | 09/17/99 | 17.05 | 350 |
| MIL | X-LABORER | Outside Laborer (Semi-Skilled) | 22.10 | 0.0% | 46.5% | 6.36 | 0.00 | 38.74 | HR | 09/22/99 | 11.84 | 772 |
| MIL | X-PLUMBER | Outside Plumber | 27.80 | 0.0% | 46.5% | 9.60 | 0.00 | 50.33 | HR | 09/22/99 | 18.66 | 350 |
| MIL | X-STRSTEEL | Outside Steel Worker | 24.22 | 0.0% | 46.5% | 10.35 | 0.00 | 45.83 | HR | 09/17/99 | 18.82 | 660 |

** EQUIPMENT BACKUP **

| SRC | ID.NO. | EQUIPMENT DESCRIPTION | DEPR | FCCM | FUEL | FOG | TR WR | TR REP | EQ REP | TOTAL RATE | ** TOTAL ** HOURS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MAP | C75GV011 | CRANE,HYD,S/P,RT,4WD,30T/80'BOOM | 18.15 | 4.84 | 6.46 | 2.42 | 3.44 | 0.61 | 21.88 | 57.80 HR | 105 |
| GEN | T40Z6950 | FLATBED, 8' (2.4 M) X 9' (2.7 M) | 0.26 | 0.04 | | | | | 0.24 | 0.54 HR | 440 |
| MIL | T45XX011 | TRLR,LOWBOY, 25T, 2 AXLE | 1.61 | 0.46 | | 0.40 | 0.58 | 0.10 | 1.51 | 4.67 HR | 440 |
| GEN | T50Z7320 | TRUCK, PICKUP, 8,800 (3992 KG) | 2.08 | 0.35 | 2.67 | 0.94 | 0.23 | 0.04 | 2.39 | 8.69 HR | 750 |
| MAP | W30MG099 | WATER TANK, PORTABLE, 500 GAL | 0.23 | 0.06 | | | 0.07 | 0.01 | 0.24 | 0.61 HR | 520 |
| MIL | W35XX003 | WELDER, 300 AMP, W/1 AXLE TRLR | 0.76 | 0.16 | 1.70 | 0.51 | 0.04 | 0.01 | 1.04 | 4.21 HR | 560 |
| GEN | XMEZ8760 | COMPRESSOR, 115 V, AIR, PORTABLE | 0.19 | 0.02 | 0.04 | 0.27 | 0.02 | | 0.21 | 0.75 HR | 400 |
| GEN | XMEZ9180 | TOOL VAN | 2.90 | 0.93 | 9.89 | 3.06 | 0.48 | 0.07 | 2.63 | 19.96 HR | 480 |
| GEN | XMEZ9200 | POWERLINE, CABLE REEL-CARRIER | 1.38 | 0.30 | | 1.00 | 0.10 | 0.02 | 1.50 | 4.30 HR | 360 |
| GEN | XMEZ9480 | TORCH, OXYGEN/ACETYLENE | 0.23 | 0.02 | | 1.50 | | | 0.25 | 2.00 HR | 360 |

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No errors detected...

* * * END OF ERROR REPORT * * *

SUMMARY REPORTS SUMMARY PAGE



DETAILED ESTIMATE DETAIL PAGE



BACKUP REPORTS BACKUP PAGE



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B-10. FLOATING ORIFICE CLOSURE QUANTY UOM CREW ID OUTPUT MANHRS LABOR EQUIPMNT MATERIAL OTHER TOTAL COST UNIT

B. B2 AWS BACKUP FACILITIES
B-10. FLOATING ORIFICE CLOSURE

B-1003. MANUAL DOWNSTREAM SLIDE GATE

Note: This alternative consists of 8-24"x169" low-head plates and 4-48"x172" low-head (2-foot) plates, which will slide over the downstream (tailrace side) of the floating orifice. Each plate will be placed by lowering it onto the floating orifice from above. When not in use, plates will be kept in a specially fabricated rack for storage and transport.

Prod: 3-4 weeks or 500 hrs.

B-100301. GENL CONDITIONS/OVERHEADS

Note: Item provides an allowance for misc. costs including permitting, mobilization, and special equipment fabrication etc..

| | | QUANTY UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USR AA <I | > ALLOWANCE | | | | 0.00 | 3000.00 | 1500.00 | 1500.00 | 1500.00 | 7500.00 | |
| | | 1.00 LS | | 0.00 | 0 | 3,000 | 1,500 | 1,500 | 1,500 | 7,500 | 7500.00 |
| | TOTAL GENL CONDITIONS/OVERHEADS | | | | 0 | 3,000 | 1,500 | 1,500 | 1,500 | 7,500 | |

B-100302. FABRICATE/INSTALL SLIDE GATES

Note: Item includes the following activities:

a) Fabricate or pruchase the slide plate holder assembly, the floatation chamber extensions, the slide plate and guides, cable retrival system and rack fabrication other misc. parts.
b) Exchange the floating orifice with the bulkhead.
c) Disassemble the upper and lower orifice panels.
d) Weld a new floatation chamber extension onto the existing upper orifice panel.
e) Weld the threaded slide gate guides onto the upper orifice panel.
f) Pressure test panels for air-tightness and epoxy coat.
g) Re-install modified floating orifice gate assembly.
h) Test slide gate actuation.

Labor: 3 Men @ 3 weeks x 10 hrs/day = 450 hrs; Say 500 hrs..

| | | QUANTY UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL AA < | > OUTSIDE EQUIP. OPER LIGHT | | | | 1.00 | 42.29 | 0.00 | 0.00 | 0.00 | 42.29 | |
| | | 100.00 HR | X-EQOPRLT | 1.00 | 100 | 4,229 | 0 | 0 | 0 | 4,229 | 42.29 |
| MIL AA < | > OUTSIDE LABORER (SEMI-SKILLED) | | | | 1.00 | 38.74 | 0.00 | 0.00 | 0.00 | 38.74 | |
| | | 272.00 HR | X-LABORER | 1.00 | 272 | 10,536 | 0 | 0 | 0 | 10,536 | 38.74 |
| MIL AA < | > OUTSIDE PLUMBER | | | | 1.00 | 50.33 | 0.00 | 0.00 | 0.00 | 50.33 | |
| | | 100.00 HR | X-PLUMBER | 1.00 | 100 | 5,033 | 0 | 0 | 0 | 5,033 | 50.33 |

| B-10. FLOATING ORIFICE CLOSURE | | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL AA < | > OUTSIDE STEEL WORKER | | | | | 1.00 | 45.83 | 0.00 | 0.00 | 0.00 | 45.83 | |
| | | 100.00 | HR | X-STRSTEEL | 1.00 | 100 | 4,583 | 0 | 0 | 0 | 4,583 | 45.83 |
| L GEN AA < | > FLATBED, 8' (2.4 M) X 9' (2.7 M) | | | | | 0.00 | 0.00 | 0.54 | 0.00 | 0.00 | 0.54 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 120.00 | HR | T40Z6950 | 1.00 | 0 | 0 | 65 | 0 | 0 | 65 | 0.54 |
| MIL AA < | > TRLR,LOWBOY, 25T, 2 AXLE | | | | | 0.00 | 0.00 | 4.67 | 0.00 | 0.00 | 4.67 | |
| | (ADD TOWING TRUCK) | 120.00 | HR | T45XX011 | 1.00 | 0 | 0 | 560 | 0 | 0 | 560 | 4.67 |
| GEN AA < | > TRUCK, PICKUP, 8,800 (3992 KG) | | | | | 0.00 | 0.00 | 8.69 | 0.00 | 0.00 | 8.69 | |
| | GVW 4X4, 3/4 TON | 120.00 | HR | T50Z7320 | 1.00 | 0 | 0 | 1,043 | 0 | 0 | 1,043 | 8.69 |
| GEN AA < | > TORCH, OXYGEN/ACETYLENE | | | | | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 2.00 | |
| | (W/ TANKS & HOSES) | 120.00 | HR | XMEZ9480 | 1.00 | 0 | 0 | 240 | 0 | 0 | 240 | 2.00 |
| GEN AA < | > POWERLINE, CABLE REEL-CARRIER | | | | | 0.00 | 0.00 | 4.30 | 0.00 | 0.00 | 4.30 | |
| | (W/ DBL AXLE TRAILER) | 120.00 | HR | XMEZ9200 | 1.00 | 0 | 0 | 516 | 0 | 0 | 516 | 4.30 |
| L GEN AA < | > TOOL VAN | | | | | 0.00 | 0.00 | 19.96 | 0.00 | 0.00 | 19.96 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 120.00 | HR | XMEZ9180 | 1.00 | 0 | 0 | 2,395 | 0 | 0 | 2,395 | 19.96 |
| GEN AA < | > COMPRESSOR, 115 V, AIR, PORTABLE | | | | | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.75 | |
| | | 120.00 | HR | XMEZ8760 | 1.00 | 0 | 0 | 90 | 0 | 0 | 90 | 0.75 |
| MIL AA < | > WELDER, 300 AMP, W/1 AXLE TRLR | | | | | 0.00 | 0.00 | 4.21 | 0.00 | 0.00 | 4.21 | |
| | | 120.00 | HR | W35XX003 | 1.00 | 0 | 0 | 506 | 0 | 0 | 506 | 4.21 |
| MAP AA < | > WATER TANK, PORTABLE, 500 GAL | | | | | 0.00 | 0.00 | 0.61 | 0.00 | 0.00 | 0.61 | |
| | POLYETHYLENE, W/14' UTILITY TRLR | 120.00 | HR | W30MG099 | 1.00 | 0 | 0 | 73 | 0 | 0 | 73 | 0.61 |
| USR AA <I | > FAB/PURCHASE 48"X84" LH SLD GAT | | | | | 0.00 | 0.00 | 0.00 | 3600.00 | 0.00 | 3600.00 | |
| | | 4.00 | EA | | 0.00 | 0 | 0 | 0 | 14,400 | 0 | 14,400 | 3600.00 |
| USR AA <I | > FAB/PURCHASE 24"X84" LH SLD GAT | | | | | 0.00 | 0.00 | 0.00 | 2250.00 | 0.00 | 2250.00 | |
| | | 8.00 | EA | | 0.00 | 0 | 0 | 0 | 18,000 | 0 | 18,000 | 2250.00 |
| USR AA <I | > RIGGERS & CRANE | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 2000.00 | 2000.00 | |
| | | 2.00 | WKS | | 0.00 | 0 | 0 | 0 | 0 | 4,000 | 4,000 | 2000.00 |
| USR AA <I | > PROTECTIVE COATINGS | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 300.00 | 300.00 | |
| | | 12.00 | EA | | 0.00 | 0 | 0 | 0 | 0 | 3,600 | 3,600 | 300.00 |
| USR AA <I | > CUSTOM GATE GUIDES W/ UHMW SEATS | | | | | 0.00 | 0.00 | 0.00 | 900.00 | 0.00 | 900.00 | |
| | | 12.00 | EA | | 0.00 | 0 | 0 | 0 | 10,800 | 0 | 10,800 | 900.00 |
| USR AA <I | > FIELD WELDING (SUB) | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 200.00 | 200.00 | |
| | | 12.00 | EA | | 0.00 | 0 | 0 | 0 | 0 | 2,400 | 2,400 | 200.00 |
| USR AA <I | > J SEAL/GASKETT ALLOWANCE | | | | | 0.00 | 3500.00 | 0.00 | 3500.00 | 0.00 | 7000.00 | |
| | (Approx. 300-400 LF) | 1.00 | LS | | 0.00 | 0 | 3,500 | 0 | 3,500 | 0 | 7,000 | 7000.00 |

| B-10. FLOATING ORIFICE CLOSURE | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| USR AA <I > STORAGE/TRANSPORT RACK | | | 0.00 | 0.00 | 0.00 | 0.00 | 3.00 | 3.00 | |
| | 1300.00 LB | 0.00 | 0 | 0 | 0 | 0 | 3,900 | 3,900 | 3.00 |
| USR AA <I > RETRIVAL CABLE SYSTEM | | | 0.00 | 0.00 | 0.00 | 0.00 | 600.00 | 600.00 | |
| | 12.00 EA | 0.00 | 0 | 0 | 0 | 0 | 7,200 | 7,200 | 600.00 |
| TOTAL FABRICATE/INSTALL SLIDE GATES | | | 572 | 27,881 | 5,488 | 46,700 | 21,100 | 101,169 | |
| TOTAL MANUAL DOWNSTREAM SLIDE GATE | | | 572 | 30,881 | 6,988 | 48,200 | 22,600 | 108,669 | |
| TOTAL FLOATING ORIFICE CLOSURE | | | 572 | 30,881 | 6,988 | 48,200 | 22,600 | 108,669 | |

| B-20. STOCKPILE CRUCIAL SPARE PARTS | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|

B-20. STOCKPILE CRUCIAL SPARE PARTS

B-2001. FISH UNIT SPARE PARTS LIST

Note: This scheme consists of buying spare turbine and generator parts for use immediately after a fish unit goes off-line. Project personnel have been reviewing inventory and accessing the likelihood pf parts failures. A preliminary list of parts with a cost of approximately $77,000 has been assembled to date. These do not include the suggested manufactures spare parts list, or the cost of spare parts for the 3-D CAM. These costs were assembled during the Bonneville Secon Powerhouse Auxiliary Water System Backup Alternative Study, Sept. 2000.

| | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USR AA <I > ALLOWANCE | | | | | 0.00 | 0.00 | 0.00 | 77600.00 | 0.00 | 77600.00 | |
| (See attached speadsheet) | 1.00 | LS | | 0.00 | 0 | 0 | 0 | 77,600 | 0 | 77,600 | 77600 |
| TOTAL FISH UNIT SPARE PARTS LIST | | | | | 0 | 0 | 0 | 77,600 | 0 | 77,600 | |
| TOTAL STOCKPILE CRUCIAL SPARE PARTS | | | | | 0 | 0 | 0 | 77,600 | 0 | 77,600 | |

| B-25. OPERATIONS ALTERNATIVE | QUANTY UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| B-25. OPERATIONS ALTERNATIVE | | | | | | | | | | |
| Note: This alternative provides support for the operational aspects of the system after structural modifications have been completed. This scope includes a three step testing process to document design changes. In addition, costs for a powered actuator are detailed to facilitate operating manual sluice gates. | | | | | | | | | | |
| B-2520. TESTING PROGRAM | | | | | | | | | | |
| USR AA <I > NORTHWEST HYDROLOGY/TEST | | | | 0.00 | 0.00 | 0.00 | 0.00 | 9525.00 | 9525.00 | |
| | 3.00 EA | | 0.00 | 0 | 0 | 0 | 0 | 28,575 | 28,575 | 9525.00 |
| TOTAL TESTING PROGRAM | | | | 0 | 0 | 0 | 0 | 28,575 | 28,575 | |
| TOTAL OPERATIONS ALTERNATIVE | | | | 0 | 0 | 0 | 0 | 28,575 | 28,575 | |

| B-27. PORTABLE POWER OPERATOR | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| B-27. PORTABLE POWER OPERATOR | | | | | | | | | |
| B-2710. PROVIDE PORTABLE POWER OPERATOR | | | | | | | | | |
| USR AA <I > WACHS P/2 POW-R-DRIVE OPERATOR | | | 0.00 | 0.00 | 0.00 | 4800.00 | 336.00 | 5136.00 | |
| | 1.00 LS | 0.00 | 0 | 0 | 0 | 4,800 | 336 | 5,136 | 5136.00 |
| USR AA <I > OPERATING NUT - MODIFY HAND WHL | | | 0.00 | 50.00 | 50.00 | 200.00 | 0.00 | 300.00 | |
| | 2.00 EA | 0.00 | 0 | 100 | 100 | 400 | 0 | 600 | 300.00 |
| TOTAL PROVIDE PORTABLE POWER OPERATOR | | | 0 | 100 | 100 | 5,200 | 336 | 5,736 | |
| TOTAL PORTABLE POWER OPERATOR | | | 0 | 100 | 100 | 5,200 | 336 | 5,736 | |

| B-30. TRASHRACK CLEANING SYSTEM | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|

## B-30. TRASHRACK CLEANING SYSTEM

### B-3002. AUTOMATIC TRAVEL GRIP RAKE

Note: This alternative consists of replacing the existing trashracks and trash rake with a monorail traveling gripper rake equal to system manufactured by Brackett Green. Dredging will be required upstream of the intake. The existing trashracks will be removed. The new trashrack and monorail type cleaner will be installed. Power will be extended to a junction box at the north end of the Fish Unit intake.

#### B-300201. GENL CONDITIONS/OVERHEADS

Note: Item provides an allowance for misc. costs including permitting, mobilization, and special equipment fabrication etc..

| | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| USR AA <I > ALLOWANCE | | | 0.00 | 10000.00 | 5000.00 | 5000.00 | 5000.00 | 25000.00 | |
| | 1.00 LS | 0.00 | 0 | 10,000 | 5,000 | 5,000 | 5,000 | 25,000 | 25000 |
| TOTAL GENL CONDITIONS/OVERHEADS | | | 0 | 10,000 | 5,000 | 5,000 | 5,000 | 25,000 | |

#### B-300202. INSTALL AUTOMATIC TRVL GRIP RAKE

Note: Item includes the following activities:

a) Fabricate the automatic gripper rake and new trash rack.
b) Extend the new power service from the paneloard in the bldg on the Fish Evaluation Facility to a new junction box.
c) Cut Slots into the Erection bay forebay to extend the existing "forebay side" gantry rail and add a new middle gantry rail along the length or the Erection bay.
d) Mount trash rake support monorail on the Erection Bay deck.
e) After sediment accumulation improvements are in place, install the new trashracks with the existing service crane.
f) Starting at elevation 44-fmsl, install UHMW plastic panels on the forebay side face of the Erection Bay.
g) Mount the automatic gripper rake on the monorail and connect electrical power cable.

Labor: 4 Men @ 5 weeks x 10 hrs/day = 1000 hrs

| | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| MIL AA < > OUTSIDE EQUIP. OPER LIGHT | | | 1.00 | 42.29 | 0.00 | 0.00 | 0.00 | 42.29 | |
| | 200.00 HR X-EQOPRLT | 1.00 | 200 | 8,458 | 0 | 0 | 0 | 8,458 | 42.29 |
| MIL AA < > OUTSIDE LABORER (SEMI-SKILLED) | | | 1.00 | 38.74 | 0.00 | 0.00 | 0.00 | 38.74 | |
| | 300.00 HR X-LABORER | 1.00 | 300 | 11,621 | 0 | 0 | 0 | 11,621 | 38.74 |
| MIL AA < > OUTSIDE PLUMBER | | | 1.00 | 50.33 | 0.00 | 0.00 | 0.00 | 50.33 | |
| | 200.00 HR X-PLUMBER | 1.00 | 200 | 10,065 | 0 | 0 | 0 | 10,065 | 50.33 |

| B-30. TRASHRACK CLEANING SYSTEM | | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL AA < | > OUTSIDE STEEL WORKER | | | | | 1.00 | 45.83 | 0.00 | 0.00 | 0.00 | 45.83 | |
| | | 400.00 | HR | X-STRSTEEL | 1.00 | 400 | 18,333 | 0 | 0 | 0 | 18,333 | 45.83 |
| MIL AA < | > OUTSIDE ELECTRICIAN | | | | | 1.00 | 50.46 | 0.00 | 0.00 | 0.00 | 50.46 | |
| | | 40.00 | HR | X-ELECTRN | 1.00 | 40 | 2,019 | 0 | 0 | 0 | 2,019 | 50.46 |
| L GEN AA < | > FLATBED, 8' (2.4 M) X 9' (2.7 M) | | | | | 0.00 | 0.00 | 0.54 | 0.00 | 0.00 | 0.54 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 240.00 | HR | T40Z6950 | 1.00 | 0 | 0 | 130 | 0 | 0 | 130 | 0.54 |
| MIL AA < | > TRLR,LOWBOY, 25T, 2 AXLE | | | | | 0.00 | 0.00 | 4.67 | 0.00 | 0.00 | 4.67 | |
| | (ADD TOWING TRUCK) | 240.00 | HR | T45XX011 | 1.00 | 0 | 0 | 1,121 | 0 | 0 | 1,121 | 4.67 |
| GEN AA < | > TRUCK, PICKUP, 8,800 (3992 KG) | | | | | 0.00 | 0.00 | 8.69 | 0.00 | 0.00 | 8.69 | |
| | GVW 4X4, 3/4 TON | 240.00 | HR | T50Z7320 | 1.00 | 0 | 0 | 2,086 | 0 | 0 | 2,086 | 8.69 |
| MAP AA < | > WATER TANK, PORTABLE, 500 GAL | | | | | 0.00 | 0.00 | 0.61 | 0.00 | 0.00 | 0.61 | |
| | POLYETHYLENE, W/14' UTILITY TRLR | 240.00 | HR | W30MG099 | 1.00 | 0 | 0 | 146 | 0 | 0 | 146 | 0.61 |
| MIL AA < | > WELDER, 300 AMP, W/1 AXLE TRLR | | | | | 0.00 | 0.00 | 4.21 | 0.00 | 0.00 | 4.21 | |
| | | 240.00 | HR | W35XX003 | 1.00 | 0 | 0 | 1,012 | 0 | 0 | 1,012 | 4.21 |
| GEN AA < | > COMPRESSOR, 115 V, AIR, PORTABLE | | | | | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.75 | |
| | | 200.00 | HR | XMEZ8760 | 1.00 | 0 | 0 | 150 | 0 | 0 | 150 | 0.75 |
| L GEN AA < | > TOOL VAN | | | | | 0.00 | 0.00 | 19.96 | 0.00 | 0.00 | 19.96 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 200.00 | HR | XMEZ9180 | 1.00 | 0 | 0 | 3,992 | 0 | 0 | 3,992 | 19.96 |
| GEN AA < | > POWERLINE, CABLE REEL-CARRIER | | | | | 0.00 | 0.00 | 4.30 | 0.00 | 0.00 | 4.30 | |
| | (W/ DBL AXLE TRAILER) | 200.00 | HR | XMEZ9200 | 1.00 | 0 | 0 | 860 | 0 | 0 | 860 | 4.30 |
| GEN AA < | > TORCH, OXYGEN/ACETYLENE | | | | | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 2.00 | |
| | (W/ TANKS & HOSES) | 200.00 | HR | XMEZ9480 | 1.00 | 0 | 0 | 400 | 0 | 0 | 400 | 2.00 |
| MAP AA < | > CRANE,HYD,S/P,RT,4WD,30T/80'BOOM | | | | | 0.00 | 0.00 | 57.80 | 0.00 | 0.00 | 57.80 | |
| | | 80.00 | HR | C75GV011 | 1.00 | 0 | 0 | 4,624 | 0 | 0 | 4,624 | 57.80 |
| USR AA <I | > FAB/PURCHASE NEW TRASHRACK B2 FU | | | | | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 2.00 | |
| | | 274000 | LB | | 0.00 | 0 | 0 | 0 | 548,000 | 0 | 548,000 | 2.00 |
| USR AA <I | > PAINTING/COATING TRASHRACKS | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 3.00 | 3.00 | |
| | | 30000 | SF | | 0.00 | 0 | 0 | 0 | 0 | 90,000 | 90,000 | 3.00 |
| USR AA <I | > UNIT SHUTDOWN | | | | | 0.00 | 0.00 | 500.00 | 250.00 | 250.00 | 1000.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 500 | 250 | 250 | 1,000 | 1000.00 |
| USR AA <I | > REMOVE EXIST TRASHRACK | | | | | 0.00 | 0.00 | 500.00 | 500.00 | 0.00 | 1000.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 500 | 500 | 0 | 1,000 | 1000.00 |
| USR AA <I | > PURCHASE NEW MONORAIL AUTO TR | | | | | 0.00 | 0.00 | 0.00 | 280000.00 | 50.00 | 280050.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 0 | 280,000 | 50 | 280,050 | 280050 |

| B-30. TRASHRACK CLEANING SYSTEM | | QUANTY UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USR AA <I | > CONCRETE SIDEWALL DEMO (4 EA) | | | | 0.00 | 0.00 | 1000.00 | 1000.00 | 0.00 | 2000.00 | |
| | | 1.00 LS | | 0.00 | 0 | 0 | 1,000 | 1,000 | 0 | 2,000 | 2000.00 |
| USR AA <I | > CONCRETE REPAIR (4 EA) | | | | 0.00 | 0.00 | 500.00 | 2500.00 | 0.00 | 3000.00 | |
| | | 1.00 LS | | 0.00 | 0 | 0 | 500 | 2,500 | 0 | 3,000 | 3000.00 |
| USR AA <I | > ELECTRICAL CONDUIT/MATLS | | | | 0.00 | 0.00 | 0.00 | 2000.00 | 0.00 | 2000.00 | |
| | | 1.00 LS | | 0.00 | 0 | 0 | 0 | 2,000 | 0 | 2,000 | 2000.00 |
| USR AA <I | > DREDGING AT UPSTREAM SECTION | | | | 0.00 | 0.00 | 0.00 | 0.00 | 34.00 | 34.00 | |
| | | 1000.00 CY | | 0.00 | 0 | 0 | 0 | 0 | 34,000 | 34,000 | 34.00 |
| USR AA <I | > MONORAIL INSTALLTION W/ FASTNERS | | | | 0.00 | 0.00 | 0.00 | 3000.00 | 0.00 | 3000.00 | |
| | | 1.00 LS | | 0.00 | 0 | 0 | 0 | 3,000 | 0 | 3,000 | 3000.00 |
| USR AA <I | > PNUMATIC ACTUATOR ADDER | | | | 0.00 | 0.00 | 0.00 | 0.00 | 12000.00 | 12000.00 | |
| | | 1.00 LS | | 0.00 | 0 | 0 | 0 | 0 | 12,000 | 12,000 | 12000 |
| | TOTAL INSTALL AUTOMATIC TRVL GRIP RAKE | | | | 1,140 | 50,496 | 17,020 | 837,250 | 136,300 | 1,041,066 | |
| | TOTAL AUTOMATIC TRAVEL GRIP RAKE | | | | 1,140 | 60,496 | 22,020 | 842,250 | 141,300 | 1,066,066 | |

B-3003. BLKG OFF LOWER PNL

Note: This alternative is a cost adjustment to the Trashrack. This involves welding a blank panel onto the face of the bottom existing trashrack and shortening the total trashrack length of each trashrack section. This variation applies to both alternatives trash rakes.

B-300301. GENL CONDITIONS/OVERHEADS

Note: Item provides an allowance for misc. costs including permitting, mobilization, and special equipment fabrication etc..

| | | QUANTY UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USR AA <I | > ALLOWANCE | | | | 0.00 | 2500.00 | 1000.00 | 1000.00 | 1000.00 | 5500.00 | |
| | | 1.00 LS | | 0.00 | 0 | 2,500 | 1,000 | 1,000 | 1,000 | 5,500 | 5500.00 |
| | TOTAL GENL CONDITIONS/OVERHEADS | | | | 0 | 2,500 | 1,000 | 1,000 | 1,000 | 5,500 | |

B-300302. ADJUST TRASHRACK PANEL

Note: Item includes the following activities:

a) Weld new blank panel onto the face of the bottom of the existing trashrack.

Labor: 4 Men @ 1 weeks x 10 hrs/day = 200 hrs

| B-30. TRASHRACK CLEANING SYSTEM | | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL AA < | > OUTSIDE EQUIP. OPER LIGHT | | | | | 1.00 | 42.29 | 0.00 | 0.00 | 0.00 | 42.29 | |
| | | 50.00 | HR | X-EQOPRLT | 1.00 | 50 | 2,115 | 0 | 0 | 0 | 2,115 | 42.29 |
| MIL AA < | > OUTSIDE LABORER (SEMI-SKILLED) | | | | | 1.00 | 38.74 | 0.00 | 0.00 | 0.00 | 38.74 | |
| | | 100.00 | HR | X-LABORER | 1.00 | 100 | 3,874 | 0 | 0 | 0 | 3,874 | 38.74 |
| MIL AA < | > OUTSIDE PLUMBER | | | | | 1.00 | 50.33 | 0.00 | 0.00 | 0.00 | 50.33 | |
| | | 50.00 | HR | X-PLUMBER | 1.00 | 50 | 2,516 | 0 | 0 | 0 | 2,516 | 50.33 |
| MIL AA < | > OUTSIDE STEEL WORKER | | | | | 1.00 | 45.83 | 0.00 | 0.00 | 0.00 | 45.83 | |
| | | 160.00 | HR | X-STRSTEEL | 1.00 | 160 | 7,333 | 0 | 0 | 0 | 7,333 | 45.83 |
| GEN AA < | > FLATBED, 8' (2.4 M) X 9' (2.7 M) | | | | | 0.00 | 0.00 | 0.54 | 0.00 | 0.00 | 0.54 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 40.00 | HR | T40Z6950 | 1.00 | 0 | 0 | 22 | 0 | 0 | 22 | 0.54 |
| MIL AA < | > TRLR,LOWBOY, 25T, 2 AXLE | | | | | 0.00 | 0.00 | 4.67 | 0.00 | 0.00 | 4.67 | |
| | (ADD TOWING TRUCK) | 40.00 | HR | T45XX011 | 1.00 | 0 | 0 | 187 | 0 | 0 | 187 | 4.67 |
| GEN AA < | > TRUCK, PICKUP, 8,800 (3992 KG) | | | | | 0.00 | 0.00 | 8.69 | 0.00 | 0.00 | 8.69 | |
| | GVW 4X4, 3/4 TON | 40.00 | HR | T50Z7320 | 1.00 | 0 | 0 | 348 | 0 | 0 | 348 | 8.69 |
| MAP AA < | > WATER TANK, PORTABLE, 500 GAL | | | | | 0.00 | 0.00 | 0.61 | 0.00 | 0.00 | 0.61 | |
| | POLYETHYLENE, W/14' UTILITY TRLR | 40.00 | HR | W30MG099 | 1.00 | 0 | 0 | 24 | 0 | 0 | 24 | 0.61 |
| MIL AA < | > WELDER, 300 AMP, W/1 AXLE TRLR | | | | | 0.00 | 0.00 | 4.21 | 0.00 | 0.00 | 4.21 | |
| | | 160.00 | HR | W35XX003 | 1.00 | 0 | 0 | 674 | 0 | 0 | 674 | 4.21 |
| GEN AA < | > COMPRESSOR, 115 V, AIR, PORTABLE | | | | | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.75 | |
| | | 40.00 | HR | XMEZ8760 | 1.00 | 0 | 0 | 30 | 0 | 0 | 30 | 0.75 |
| L GEN AA < | > TOOL VAN | | | | | 0.00 | 0.00 | 19.96 | 0.00 | 0.00 | 19.96 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 40.00 | HR | XMEZ9180 | 1.00 | 0 | 0 | 798 | 0 | 0 | 798 | 19.96 |
| GEN AA < | > POWERLINE, CABLE REEL-CARRIER | | | | | 0.00 | 0.00 | 4.30 | 0.00 | 0.00 | 4.30 | |
| | (W/ DBL AXLE TRAILER) | 40.00 | HR | XMEZ9200 | 1.00 | 0 | 0 | 172 | 0 | 0 | 172 | 4.30 |
| GEN AA < | > TORCH, OXYGEN/ACETYLENE | | | | | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 2.00 | |
| | (W/ TANKS & HOSES) | 40.00 | HR | XMEZ9480 | 1.00 | 0 | 0 | 80 | 0 | 0 | 80 | 2.00 |
| MAP AA < | > CRANE,HYD,S/P,RT,4WD,30T/80'BOOM | | | | | 0.00 | 0.00 | 57.80 | 0.00 | 0.00 | 57.80 | |
| | | 25.00 | HR | C75GV011 | 1.00 | 0 | 0 | 1,445 | 0 | 0 | 1,445 | 57.80 |
| USR AA <I | > 0.38"X13.5H X 19.5W STEEL PLATS | | | | | 0.00 | 0.00 | 0.00 | 2.35 | 0.00 | 2.35 | |
| | | 16110 | LB | | 0.00 | 0 | 0 | 0 | 37,859 | 0 | 37,859 | 2.35 |
| USR AA <I | > COATING (BLASTING 3 COAT EXPOXY) | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 | 5.00 | |
| | | 3200.00 | SF | | 0.00 | 0 | 0 | 0 | 0 | 16,000 | 16,000 | 5.00 |
| | TOTAL ADJUST TRASHRACK PANEL | | | | | 360 | 15,838 | 3,780 | 37,859 | 16,000 | 73,476 | |

| B-30. TRASHRACK CLEANING SYSTEM | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL BLKG OFF LOWER PNL | | | | | 360 | 18,338 | 4,780 | 38,859 | 17,000 | 78,976 | |
| TOTAL TRASHRACK CLEANING SYSTEM | | | | | 1,500 | 78,834 | 26,800 | 881,109 | 158,300 | 1,145,042 | |

| B-40. MONITOR DIFFUSER RACK CLOGGING | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|

B-40. MONITOR DIFFUSER RACK CLOGGING

B-4001. INSTALL LEVEL TRANSDUCERS

Note: This item provides level tansducers at three locations just upstream and downstream of the diffuser grating. These locations include the North Junction Pool and Diffuser Gate B@ adjacent to the North Upstream entrance. Two transducers are included at each location with a digital transmitter communicating over a pair of communication wires back to a central control panel.

B-400101. GENL CONDITIONS/OVERHEADS

Note: Item provides an allowance for misc. costs including permitting, mobilization, and special equipment fabrication etc..

| | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| USR AA <I > ALLOWANCE | | | 0.00 | 2500.00 | 1000.00 | 1000.00 | 1000.00 | 5500.00 | |
| | 1.00 LS | 0.00 | 0 | 2,500 | 1,000 | 1,000 | 1,000 | 5,500 | 5500.00 |
| TOTAL GENL CONDITIONS/OVERHEADS | | | 0 | 2,500 | 1,000 | 1,000 | 1,000 | 5,500 | |

B-400102. REPROGRAM PLC/INSTALL TRANSDUCER

Note: Item includes the following activities:

a) Acquire the conduit, wire, level transmitters, transmitter panels, GE Funac, PLC modules and other materials.
b) Re-program PLC to include logic for level transmitter communications; analog level outputs to digital displays, and digital outputs for high diffuser grating alarm lights.
c) Install the level transmitter panels and associated conduit to the existing power house control wire cable trays.
d) Install power and control wiring form the Fish Unit control panel SA4 to each of the transmitter panels at the North Junction Pool and at Diffuser Gate B2.
e) During the water work period, install the two upper and lower level transmitters conduits.
f) Upgrade the existing GE Funac PLC in control panel SA4 with a new 10 slot module rack, a new CPU, a communication modulem and an alalog output module, and a digital output module. Install the diffuser grating alarm lights. Complete panel SA4 wiring of improvements.
g) Install the level transmitters and complete wiring.
h) Test and calibarate diffuser grating monitoring system.

Labor: 3 Men @ 2.5 weeks x 10 hrs/day = 350 hrs

| | QUANTY UOM CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| USR AA < > OUTSIDE EQUIP. OPER LIGHT | | | 1.00 | 42.69 | 0.00 | 0.00 | 0.00 | 42.69 | |
| | 50.00 HR | 0.00 | 50 | 2,135 | 0 | 0 | 0 | 2,135 | 42.69 |

| B-40. MONITOR DIFFUSER RACK CLOGGING | | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIL AA < | > OUTSIDE LABORER (SEMI-SKILLED) | | | | | 1.00 | 38.74 | 0.00 | 0.00 | 0.00 | 38.74 | |
| | | 100.00 | HR | X-LABORER | 1.00 | 100 | 3,874 | 0 | 0 | 0 | 3,874 | 38.74 |
| MIL AA < | > OUTSIDE ELECTRICIAN | | | | | 1.00 | 50.46 | 0.00 | 0.00 | 0.00 | 50.46 | |
| | | 200.00 | HR | X-ELECTRN | 1.00 | 200 | 10,093 | 0 | 0 | 0 | 10,093 | 50.46 |
| L GEN AA < | > FLATBED, 8' (2.4 M) X 9' (2.7 M) | | | | | 0.00 | 0.00 | 0.54 | 0.00 | 0.00 | 0.54 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 40.00 | HR | T40Z6950 | 1.00 | 0 | 0 | 22 | 0 | 0 | 22 | 0.54 |
| MIL AA < | > TRLR,LOWBOY, 25T, 2 AXLE | | | | | 0.00 | 0.00 | 4.67 | 0.00 | 0.00 | 4.67 | |
| | (ADD TOWING TRUCK) | 40.00 | HR | T45XX011 | 1.00 | 0 | 0 | 187 | 0 | 0 | 187 | 4.67 |
| GEN AA < | > TRUCK, PICKUP, 8,800 (3992 KG) | | | | | 0.00 | 0.00 | 8.69 | 0.00 | 0.00 | 8.69 | |
| | GVW 4X4, 3/4 TON | 350.00 | HR | T50Z7320 | 1.00 | 0 | 0 | 3,041 | 0 | 0 | 3,041 | 8.69 |
| L MAP AA < | > WATER TANK, PORTABLE, 500 GAL | | | | | 0.00 | 0.00 | 0.61 | 0.00 | 0.00 | 0.61 | |
| | POLYETHYLENE, W/14' UTILITY TRLR | 120.00 | HR | W30MG099 | 1.00 | 0 | 0 | 73 | 0 | 0 | 73 | 0.61 |
| L MIL AA < | > WELDER, 300 AMP, W/1 AXLE TRLR | | | | | 0.00 | 0.00 | 4.21 | 0.00 | 0.00 | 4.21 | |
| | | 40.00 | HR | W35XX003 | 1.00 | 0 | 0 | 169 | 0 | 0 | 169 | 4.21 |
| L GEN AA < | > COMPRESSOR, 115 V, AIR, PORTABLE | | | | | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.75 | |
| | | 40.00 | HR | XMEZ8760 | 1.00 | 0 | 0 | 30 | 0 | 0 | 30 | 0.75 |
| L GEN AA < | > TOOL VAN | | | | | 0.00 | 0.00 | 19.96 | 0.00 | 0.00 | 19.96 | |
| | (ADD 20,000 - 25,000 GVW TRK) | 120.00 | HR | XMEZ9180 | 1.00 | 0 | 0 | 2,395 | 0 | 0 | 2,395 | 19.96 |
| USR AA <I | > MISC MATLS (GROUT/PVC/ANCHORS) | | | | | 0.00 | 0.00 | 0.00 | 1500.00 | 0.00 | 1500.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 0 | 1,500 | 0 | 1,500 | 1500.00 |
| USR AA <I | > PURCHASE SUBMESIBLE LEVEL TRANS | | | | | 0.00 | 0.00 | 0.00 | 1400.00 | 0.00 | 1400.00 | |
| | | 4.00 | EA | | 0.00 | 0 | 0 | 0 | 5,600 | 0 | 5,600 | 1400.00 |
| USR AA <I | > LOCAL CONTROL PANELS | | | | | 0.00 | 0.00 | 0.00 | 2500.00 | 0.00 | 2500.00 | |
| | | 2.00 | EA | | 0.00 | 0 | 0 | 0 | 5,000 | 0 | 5,000 | 2500.00 |
| USR AA <I | > MISC ELEC MATLS (CODUIT/WIRE) | | | | | 0.00 | 0.00 | 0.00 | 1200.00 | 0.00 | 1200.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 0 | 1,200 | 0 | 1,200 | 1200.00 |
| USR AA <I | > MODIFY EXIST PANEL | | | | | 0.00 | 0.00 | 0.00 | 8000.00 | 2000.00 | 10000.00 | |
| | | 1.00 | LS | | 0.00 | 0 | 0 | 0 | 8,000 | 2,000 | 10,000 | 10000 |
| USR AA <I | > 10" X 2'-0" CORE DRILLED HOLES | | | | | 0.00 | 0.00 | 0.00 | 325.00 | 0.00 | 325.00 | |
| | | 2.00 | EA | | 0.00 | 0 | 0 | 0 | 650 | 0 | 650 | 325.00 |
| USR AA <I | > 2" X 3'-0" CORE DRILLED HOLES | | | | | 0.00 | 0.00 | 0.00 | 300.00 | 0.00 | 300.00 | |
| | | 1.00 | EA | | 0.00 | 0 | 0 | 0 | 300 | 0 | 300 | 300.00 |
| | TOTAL REPROGRAM PLC/INSTALL TRANSDUCER | | | | | 350 | 16,101 | 5,917 | 22,250 | 2,000 | 46,268 | |

| B-40. MONITOR DIFFUSER RACK CLOGGING | QUANTY | UOM | CREW ID | OUTPUT | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL INSTALL LEVEL TRANSDUCERS | | | | | 350 | 18,601 | 6,917 | 23,250 | 3,000 | 51,768 | |
| TOTAL MONITOR DIFFUSER RACK CLOGGING | | | | | 350 | 18,601 | 6,917 | 23,250 | 3,000 | 51,768 | |
| TOTAL B2 AWS BACKUP FACILITIES | | | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | | | | 2,422 | 128,416 | 40,805 | 1,035,359 | 212,811 | 1,417,390 | |

| | QUANTY UOM | CONTRACT | CONTINGN | ESCALATN | OWN FURN | SIOH | TOTAL COST | UNIT |
|---|---|---|---|---|---|---|---|---|
| B B2 AWS BACKUP FACILITIES | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |
| TOTAL BONNEVILLE SECOND POWERHOUSE | | 1,827,806 | 365,561 | 180,123 | 0 | 0 | 2,373,490 | |

**Trent T Gathright <trent@bgusa.com> on 09/25/2001 04:00:14 PM**

To: Frank Postlewaite <Frank.E.Postlewaite@us.mw.com>
cc:

Subject: Bonneville Dam, Brackett Bosker Questions, Our Ref. P00-115

Mr. Postlewaite,

Per our on going discussions regarding the Brackett Bosker and the questions relating to pneumatics vs. hydraulics, we are pleased to confirm the following:

1. Yes, pneumatics are a viable option that we can utilize in lieu of hydraulics. It will require 4 - 5 pneumatic cylinders to maintain the same gripper debris retaining capabilities.

2. We do not enough failure data on the life of the cylinder seals and/or the number of cycles/strokes to quantify a definitive life. While some applications have lasted for more than 20 years, some may developed a slight problem in 12 to 15 years but the failures are so far in between that we could say the cylinders have a better than 20 year life expectancy in fresh water. Since we have agreed to pursue pneumatics, this question is now essentially nullified.

3. As also discussed, we do not have enough failure data to quantify hydraulic fluid consumption as is with no. 2, this is now also nullified.

4. We trust you have reviewed the photos previously sent showing the perforated plate. if you require more, please advise and I will see what we can round up.

5. We are not that concerned with protection of the hoses considering they will be operating on new bar screens. Since we would design & build the new bar screens, and since they will be 7/8" bar openings, we will increase the number of supports, which will aid in preventing damage to the hose while deeply submerged. The only real flags of trouble for us are high velocity projects ( above 4 ft/sec) combined with operating on existing bar screens with horizontal spacer supports that terminate from section to section. Since this projects includes neither of these, we are not concerned with hose damage.

6. We also confirm a budget price add on for the pneumatics of $ 12,000.00 USD.

Regarding the "open" competition of the specifications, as we discussed, we recommend including numerous qualification statements such as:

Only qualified manufacturers will be considered having a minimum of XXX installations in the US operating for a minimum of XXX years.

You can also include very definitive statements such as : Designs utilizing hydraulics or mechanical means to close and retain debris shall absolutely not be considered due to the sensitive of the project requirements.

If you read our the spec on our CD shown under "Municipal- for Raw Water Intakes", you will find a number of these already included.

PLEASE LET ME KNOW WHAT ELSE YOU REQUIRE BUT I WILL BE OUT ON WEDNESDAY (POSSIBLE THURSDAY AS WELL AS I HAVE JURY DUTY AND I HAVE THE DISTINCT HONOR OF FULFILLING MY CIVIC DUTY, ALBEIT BAD TIMING).

Brackett Green USA, Inc.
1335 Regents Park Dr., Suite 140
Houston, TX 77058

Trent T. Gathright
Marketing Manager

Tel: 281-480-7955
Fax: 281-480-8225
Mob: 832-489-7956

Email: trent@bgusa.com
Web: www.bgusa.com

URGENT

BRACKETT GREEN USA, INC.
ADVANCED WATER SCREENING TECHNOLOGY

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PH: (281) 480-7955 – FAX: (281) 480-8225
*E-Mail: main@bgusa.com ··· Web Site: www.bgusa.com*

# TELEFAX COMMUNICATION

| | | | |
|---|---|---|---|
| TO: | Montgomery Watson | DATE: | January 9, 2001 |
| Attn: | Mr. Frank Postlewaite | FAX NO: | 1-425-881-8937 |
| CC: | Scott & Associates | | |
| Attn: | Mr. Gary M. Scott | FAX NO: | 1-510-536-1885 |
| FROM: | Trent T. Gathright | NO. OF PAGES: | Twelve (12) |

**SUBJECT: BUDGET PROPOSAL REQUEST**

**EQUIPMENT RECOMMENDED:** Brackett Bosker® Raking Machine
**BG-USA FILE REFERENCE NUMBER:** P00-115

Dear Mr. Postlewaite,

We, Brackett Green USA, Inc., are pleased to provide the following Budget Proposal based on the above customer reference information and the following conditions/considerations: (normally ex-works)

## I. EQUIPMENT INCLUDED IN BUDGET PRICE BY (X)

| | | | |
|---|---|---|---|
| X | Heavy Duty Brackett Bosker® Raking Machine; Option for Bar screens | X | Factory Coating |
| X | Controls | X | Factory Testing |
| X | Anchor Bolts | X | Shipment Loading |
| X | O & M Manuals | | Freight to Site |
| X | Warranty | | Field Service |

## II. ITEMS NORMALLY SUPPLIED BY OTHERS

Unloading at Site / Field Touch-up
Installation / Erection / Mounting
Civil Works / Grouting / Anchor Installation
Conduit / Wiring / Cables & Glands
Access Ladders / Handrails / Flooring
Site Protection / Storage
State, Federal, Local Taxes or Use Taxes

## III. TYPICAL DELIVERY AND SHIPMENT

### A. DELIVERY

The Equipment can be typical delivered in 28-30 weeks based on:

| | | WEEKS |
|---|---|---|
| A. | General Drawings for Review | 8 - 10 |
| B. | Review by Client/User | 4 - 6 |
| C. | Details, Fabrication Shipment | 16 - 18 |
| | TOTAL | 28 - 30 |

### B. OVERALL SIZE / WEIGHT

| | | |
|---|---|---|
| A. | Approximate Size | Bar screen: 19'-6" W x 67'-0" L Each<br>Bosker – See attached Drawing |
| B. | Approximate Weight | Bar screen: 160,000#<br>Bosker: 25,000 # |

## IV. VALIDITY AND PAYMENT

### A. VALIDITY

This Budget Proposal should be considered as valid for approximately three (3) months based on normal industry circumstances. After such time, please check with us for changes such as material/labor rates continued validity.

### B. NORMAL PAYMENT TERMS

The budget prices are based on our normal payment terms, which are as follows:

10% - Of the contract value on submission of equipment/foundation drawings.

30% - Of the contract value at a point 3/5ths of the contract period when major raw materials will have been received from our Suppliers.

60% - Of the contract value on deliver to agreed point or as made ready for delivery if delayed by Purchaser.

## V. NORMAL TERMS AND CONDITIONS

The following budget price(s) are based on our standard general conditions of tender available on request.

## VI. BUDGET PRICES

A. One (1) Heavy Duty Brackett Bosker® Raking Machine with Trolley & Gripper, Monorail, Support Columns, Automatic Control System, Ultrasonic Differential Level Controller, per the attached specifications and drawing.

Total Budget Price: $ 280, 000.00 USD

( Two Hundred Eighty Thousand Dollars)

*Optional Pricing*

B. Four (4) each, Bar screens, designed for Raking by a Heavy Duty Brackett Bosker® Raking Machine. Each Bar screen will be 19'-6" wide X 67'-0" High, per the attached specification.

Carbon Steel Option:

Total Budget Price: $ 662, 500.00 USD

( Six Hundred Sixty-Two Thousand Five Hundred Dollars)

Stainless Steel Option:

Total Budget Price: $ 1,150, 000.00 USD

( One Million One Hundred Fifty Thousand Dollars)

C. Field Service

Our Field Service Technicians are available for $900.00 USD/Day plus all travel, living and per diem at cost. (Please refer to table I to determine if Field Service has been included).

## VII. INFORMATION ATTACHED

| | | |
|---|---|---|
| X | Typical Specification Reference | Brackett Bosker® Raking Machine; Automatic Controls with Differential Level Control; Bar screens |
| X | Outline Drawing Reference | General Arrangement Drawing |
| X | Brochure Reference | Brackett Bosker Raking Machine Under separate cover) |

If you have any further questions, please contact your local sales representative, Mr. Gary Scott of Scott & Associates, at 1-510-536-1884, or the undersigned directly at 281-480-7955.

Best Regards,
Brackett Green USA, Inc.

Trent T. Gathright
Marketing Manager

CC: Brackett Green USA, Inc. – Mr. W. Ford Wall - Listed

# SPECIFICATION

# FOR

# BRACKETT BOSKER®

# RAKING MACHINE

# HEAVY DUTY DESIGN FOR CURVED TRACK

## I. GENERAL DESCRIPTION

### A. CONCEPT

The Brackett Bosker® Raking Machine will be designed and arranged to remove debris from a Bar Screen, transport it to and discharge into the appropriate debris container (by others) or discharge area.

### B. DESCRIPTION

The Brackett Bosker® Raking Machine will primarily consist of an overhead monorail type track, a traversing trolley and a gripper unit. The trolley will travel along the overhead track until the desired Bar Screen has been reached. The gripper unit may then be lowered to engage and penetrate the Bar Screen for debris removal to just above invert elevation. The gripper may then be closed, raised and debris transported to the appropriate dumping site.

The overhead track will be fabricated from two (2) channel sections continuously welded together with an intermediate top plate to protect the traversing motors and wheels from inclement weather. This provides the track for the traversing drives and support wheels fitted to the top of the trolley. The track will be supported at various points by support columns of hollow steel tubing flanged at the bottom for direct fastening to the civil work deck.

The trolley unit will contain the two (2) traversing gear motors, hoisting shaft and hydraulic power pack. The trolley will be traversed by gear motors mounted on top of the trolley and will include rubber-rimmed wheels, fitted directly to the gearbox output shaft to run inside the track. The hoisting gear will consist of two spirally grooved rope drums mounted on a common shaft within the trolley to raise and lower the gripper. The hoist shaft will be driven by a geared motor unit. The hydraulic power pack provides for the operation of the two hydraulic cylinders which open/close the gripper. Fluid power is transferred to cylinders through high strength hydraulic hoses which are wound on two (2) spring tensioned drums operating in sequence with hoisting drums. Electrical power to the trolley unit is supplied by a trailing cable which contains both power and control leads supported on cable wagons inside the track.

The gripper head will be supported by the hoist shaft via wire ropes and will consist of a series of special teeth designed to engage with the Bar Screen and are opened/closed by two (2) hydraulic cylinders. The gripper head will be prevented from swaying by specially designed swing restrictors.

### C. SITE DATA

| | |
|---|---|
| Site | Bonneville PH2 – Fish Turbine |
| Liquid Being Screened | Columbia River Water |
| Number of Screens Serviced | Four (4) |
| Deck Level | 90.0' |
| Top of Barscreen Level | 44.0' |

## C. SITE DATA - Continued

| | |
|---|---|
| Invert Level | -21.92' |
| Channel Width | 19.5' |
| Channel Depth | 111.92' |
| Screen Inclination | 10° |

## D. TECHNICAL DATA

| | |
|---|---|
| Number of Cleaners | One (1) |
| Gripper Width | 7'-2" |
| Maximum Debris Load | 1,100 Lbs |
| Weight of Trolley | 2,200 Lbs |
| Weight of Gripper | Max. 2,750 Lbs |
| Length of Straight Track | 140.5' |
| Curve Track Radius | 12'. |
| Raking Speed (up/down) | 60 Fpm |
| Traversing Speed (left/right) | 100 Fpm |
| Gripper open/close time | 6 Sec |
| Hoist Motor Size | 5.5 Hp |
| Traversing Motor Size (Two Each) | 1/2 Hp x 2 |
| Hydraulic Motor Size | 2 Hp |
| Motor Speeds | 1800 Rpm |
| Motor Enclosure | TEFC/IP55 |
| Hydraulic Operating Pressure | 1300 Psi |

# II. SPECIFICATION

## A. MATERIALS OF CONSTRUCTION

| | |
|---|---|
| Gripper | Galvanized Steel |
| Hoist Cables | Stainless Steel, Gr. 316 |
| Trolley/Hoist Parts | Mild Carbon Steel |
| Trolley Enclosure | Carbon Steel w/ Stainless Steel Doors |
| Track | Mild Carbon Steel |
| Columns | Mild Carbon Steel |
| Track/Columns Fasteners | Zinc Plated |
| Foundation Fasteners | By Others |

## B. ACCESSORIES

The following items will be supplied:

- First Filling of Lubricants.

## C. PROTECTION

All equipment not manufactured in corrosion resistant materials, or otherwise protected, will be protected as follows:

- All mild steel structural parts will be hot dip galvanized in accordance with ASTM A-123.
- Bought in items such as motors, gearboxes, etc... will be supplied in the manufactures' standard finish, suitable for the application.

## D. CONTROLS

See separate specification.

Options for manual controlled, automatic/timed controlled and differential level controlled.

## BRACKETT BOSKER® RAKING MACHINE

## SPECIFICATION

## FOR AUTOMATIC CONTROLS

### A. STANDARD

Enclosure: NEMA 4

Enclosure Mounted Components

Pushbuttons: NEMA Type 4/4x Non-illuminated

1. Lamp Test
2. Reset For
3. Start Auto Sequence
4. Emergency Stop (Twist to reset)

Pilot Lights: NEMA Type 4/4x

1. Emergency Stop Activated
2. Trolley Motor Fault/Overload
3. Hoist Motor Fault/Overload
4. Hydraulic Pump Motor Fault/Overload
5. Low Hydraulic Fluid Level
6. Running

Switches

1. Manual/Off/Automatic: 3 Position NEMA Type 4/4x
2. Flange Mounted Disconnect

Elapsed Time Meters: NEMA 4

1. Trolley Motor
2. Hoist Motor

Internal Control Components

Programmable Logic Controller:

1. Chassis
2. Power Supply
3. Digital Input Modules
4. Digital Output Modules
5. Processor

Periodic Time Clock: Fifteen (15) minute multiple intervals

Control Power Transformer with mounted fuse block.



[illegible]

Motor Starters with overload protection.

1. Trolley Motor
2. Hydraulic Pump Motor
3. Hoist Motor

## B. OPTIONS

1. Separately fused thermostatically controlled anti-condensation heater.
2. Differential Level Detectors for automatic start.
3. Multiple cleaning zone selection switches.
4. Output signals of customers request.
5. Remote plug-in pendant station and receptacle for local manual controls. NEMA Type environmental ratings 1, 2, 3, 4, 4x or 13.
6. Trolley mounted floodlights for night operation.
7. Programming for multiple well widths and inverts.
8. Processor Programming Software Kit

## C. SAFETY FEATURES

1. Solid State Motor Overload Relays with Automatic/Manual Resets. These relays have field selectable trip class 10, 15, 20 or 30 and provide jam and ground fault protection.
2. Secondary fail-safe, limit switch to prevent trolley overtravel as a back up to the primary proximity switch.
3. Secondary fail safe, limit switch in addition to the primary proximity switch, to detect a slack rope condition which indicates an obstruction in the grippers path.
4. Trolley Mounted Visual and Audible Alarms activated by the start signal, to warn personnel near by of automatic equipment.

The Brackett Bosker® removes debris form a bar screen, section by section. Each section width is equal to the width of the gripper. The removal of debris will be automatically controlled.

The automatic cleaning cycle is initiated in one of the three ways:

1. An operator depresses the AUTO START pushbutton located on the front of the control panel.

or

2. The periodic time clock located in the control panel.

or

3. The differential level controls.

One the start signal is given, a time delay is begun and an audible and a visible alarm is activated.

After the time delay, the trolley, with gripper is the open position, moves along the monorail toward the first section of the cleaning zone. When the trolley reaches the first section, a proximity sensor sends a signal for the trolley to stop. As soon as the trolley stops, a time delay is initiated, then the gripper is lowered to engage the bar screen. As the gripper lowered, the debris is forced to the bottom of the bar screen.

Once the gripper has made its complete descent to the bottom limit, the hydraulic cylinders will close the gripper jaws, securing the debris for removal. Now the hoist motor rewinds the wire rope, lifting the gripper and load safely toward the trolley as the gripper enters the swing restrictor plates on the trolley, the upper hoist proximity switch is actuated and the hoist motor is stopped. Next the trolley motor is started and the trolley is moved to the designated dump area.

When the loaded Brackett Bosker® reaches the dumpsite a proximity sensor sends a signal for the trolley to stop. Once stationary, the cylinders release the jaws of the gripper allowing the debris to fall into the dump area.

The Bosker® will repeat this cycle until each section of the cleaning zone is cleared. Finally the trolley will return to the designated park position.

REF: P00-115

# SPECIFICATION

# FOR

# BAR SCREENS

## I. GENERAL DESCRIPTION

The bar screen (Trash Rack) will be designed to be a raked by a Raking Machine. The trash racks will extend from bottom of the channel to an elevation of 44.0'.

The bar screen will be of all welded and bolted construction, manufactured with rectangular section bars attached to built-in steel section supports beams spanning the width of the channel.

## II. SPECIFICATIONS

### A. SITE DATA

| | |
|---|---|
| Site | Bonneville PH2 – Fish Turbine |
| Liquid Being Screened | Columbia River Water |
| Deck Level | 90.0' |
| Top of Barscreen | 44.0' |
| Channel Base Level | -21.92' |
| Channel Depth | 111.92' |
| Channel Width | 19.5' |

### B. SCREEN DATA

| | |
|---|---|
| Number of Screens | Four (4) |
| Screen Width | 19.5' |
| Screen Height | 67.0' |
| Number of Screen Sections | Nine (9) sections per Screen |
| Bar Size | 3/8" x 1-1/2" |
| Bar Spacing | 7/8" |
| Angle of Installation | 10° |

### D. MATERIAL OF CONSTRUCTION

| | Carbon Steel Option | Stainless Option |
|---|---|---|
| Screen Bars | Carbon Steel, A-36 | Stainless Steel, Gr 316 |
| Support Beams | Carbon Steel, A-36 | Stainless Steel, Gr 316 |
| Transition Plate | Carbon Steel, A-36 | Stainless Steel, Gr 316 |
| Fasteners | Zinc Plated | Stainless Steel, Gr 316 |

### E. PROTECTION

See protection specification for protection.



1-16-201 2:11PM FROM BRACKETT GREEN USA 281 480 8225 P.10

## New B2 FU Trashrack Weights

| | Quantity | Component Dim. in inches | | | Volume cubic inches | Weight lbs 0.2833 | Surface Area, sf |
|---|---|---|---|---|---|---|---|
| | | Thickness | Width | Length | | | |
| Trashrack Bars | 181 | 0.375 | 2 | 161 | 21856 | 6192 | 961 |
| Horizontal Supports | 5 | 0.375 | 15 | 234 | 6581 | 1864 | 250 |
| | 10 | 2 | 4 | 234 | 18720 | 5303 | 195 |
| Vertical Supports | 5 | 0.375 | 15 | 161 | 4528 | 1283 | 172 |
| | 10 | 0.375 | 4 | 161 | 2415 | 684 | 98 |
| Top Lifts | 2 | 2.25 | 7.5 | 20 | 675 | 191 | 5 |
| Side Plates | 4 | 0.5 | 4 | 161 | 1288 | 365 | 40 |
| | 2 | 0.375 | 19 | 161 | 2294 | 650 | 87 |
| | 2 | 0.375 | 15 | 161 | 1811 | 513 | 69 |
| | 4 | 3.5 | 1.5 | 6 | 126 | 36 | 2 |
| | 2 | 0.5 | 4 | 36 | 144 | 41 | 5 |
| Total Weight per Assembly, lbs | | | | | | 17,122 | |
| Total Number of Assemblies | | | | | | 16 | |
| Total Weight, lbs | | | | | | 273,956 | |
| Total Surface Area, per Assembly | | | | | | | 1883 |
| Total Surface Area, sf | | | | | | | 30,129 |
| Fabrication Cost, $/lb | | | | | $2.00 | | |
| Total Fabrication Cost | | | | | | $547,912 | |
| Coating Cost, $/sf | | | | | $3.00 | | |
| Total Coating Cost | | | | | | $90,387 | |
| Total Cost | | | | | | **$638,300** | |

WACHS

THE WACHS COMPANIES

PIPE MACHINERY & SERVICE SINCE 1883

# FACSIMILE

**DATE:** **July 12, 2001**

**COMPANY:** **Montgomery Watson**

**ATTENTION:** **Mr. Frank Postlewaite**

**NUMBER OF PAGES: 4 (Includes this Page)**

**From:** **WACHS COMPANIES**
100 Shepard Street
Wheeling, IL 60090

**Bret O'Brien - Application Engineer**
**Direct Phone:** 847-484-2651
**Fax:** 847-520-1147
**Website:** www.wachsco.com

Frank,

Please find attached the quotation that you requested.

Should you have any questions or need any additional information, please feel free to contact me directly at 847-484-2651.

Sincerely,

Bret O'Brien
Application Engineer

# THE WACHS COMPANIES

PIPE MACHINERY & SERVICE SINCE 1883

QUOTATION

TO: Mr. Frank Postlewaite
Montgomery Watson
2375 130th Ave. North East
Suite 200
Bellevue, WA 98005

DATE: July 12, 2001
OUR QUOTATION NO.: BO0107121203
PAYMENT TERMS: Net 30 Days
SHIPPING TERMS: FOB Wheeling
VALID THROUGH: September 10, 2001

Shown below is the quotation you requested:

| ITEM | QTY | PART NO | DESCRIPTION | PRICE | LINE TOTAL |
|---|---|---|---|---|---|
| 1 | 1 | 11-000-02 | Wachs 110 Volt Electric Powered P/2 Pow-R-Drive Portable Reversible Valve Operator, complete with 110 Volt Electric Drive, LCD Revolution Counter w/push button reset, Torque Arm Extension, Steel Storage Case and Manual. | $4.250.00 | $4,250.00 |
| 2 | 1 | 05-402-00 | Valve Key, 8 foot long with 2" Ductile Iron Socket and Stop Collar. | $186.84 | $186.84 |
| | | | | **Sub Total :** | **$4,436.84** |
| | | | | **Shipping & Handling** | **$275.00** |
| | | | | **Quote Total :** | **$4,711.84** |

We will pre-pay and add the shipping charges to your invoice or ship via collect using your preferred carrier.

Should you have any questions or would like to place an order, please feel free to contact me at 847-484-2651 or Gary Althide 916-719-6529.

Sincerely,

Bret O'Brien

By: Bret O'Brien
Application Engineer

**WACHS**

# POW-R-DRIVE II

## [illegible]LE, LOW COST, HAND HELD VALVE TURNING MACHINE...

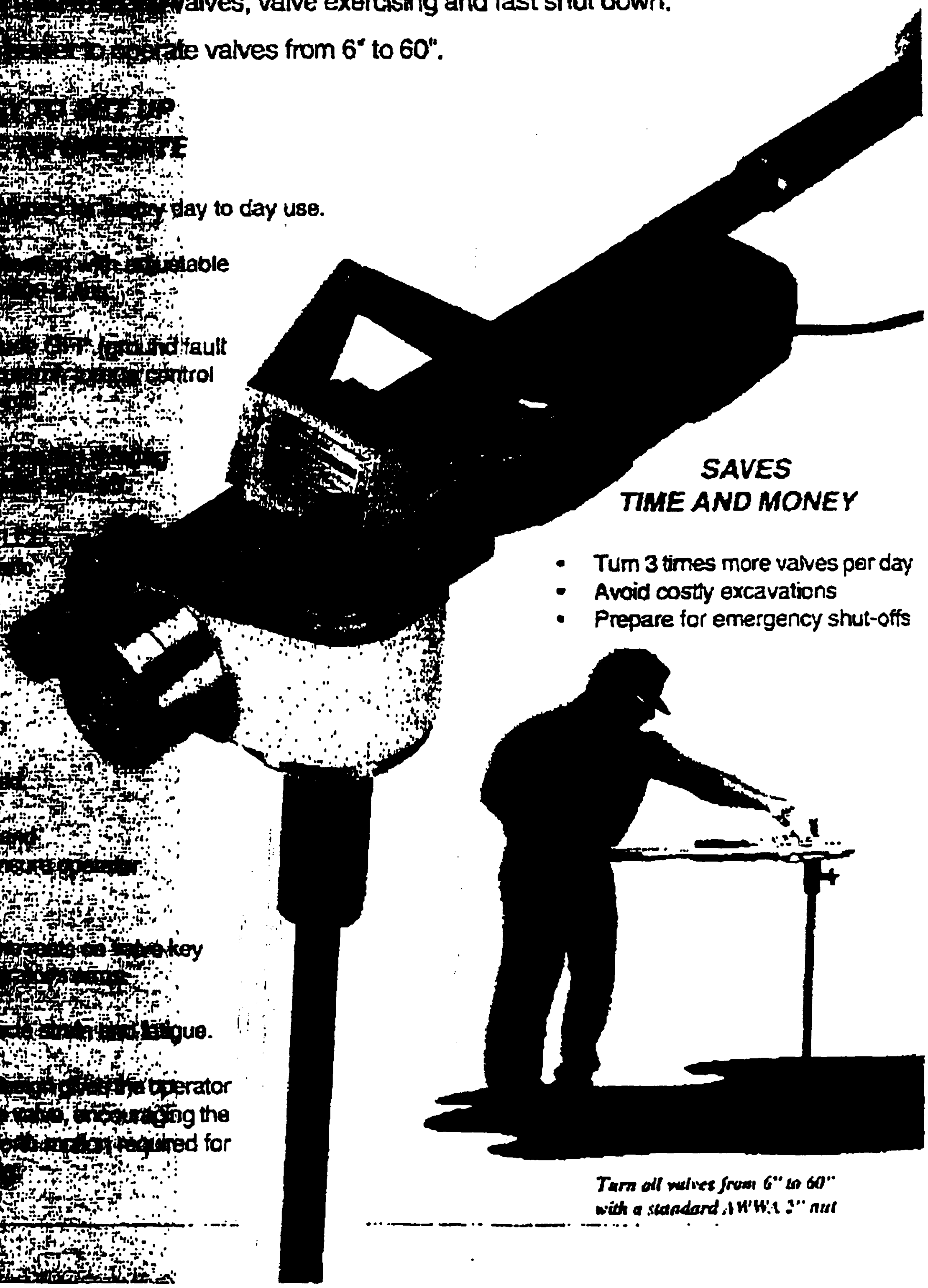
[illegible]eased productivity, operator safety and valve protection.

[illegible]valves, valve exercising and fast shut down.

[illegible]e valves from 6" to 60".

[illegible]

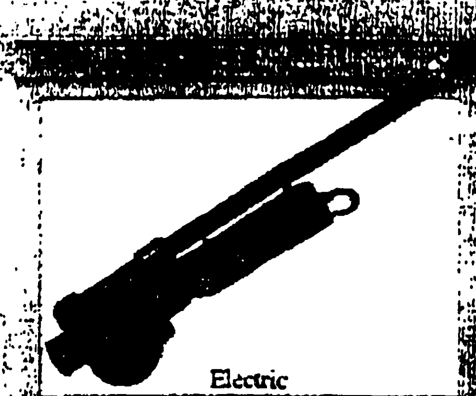
- [illegible] day to day use.
- [illegible]able [illegible]
- [illegible] fault [illegible]control [illegible]
- [illegible]
- [illegible] operator.
- Easy one man setup [illegible]
- [illegible]
- [illegible]key [illegible]
- [illegible]gue.
- [illegible] operator [illegible]ging the [illegible]red for [illegible]

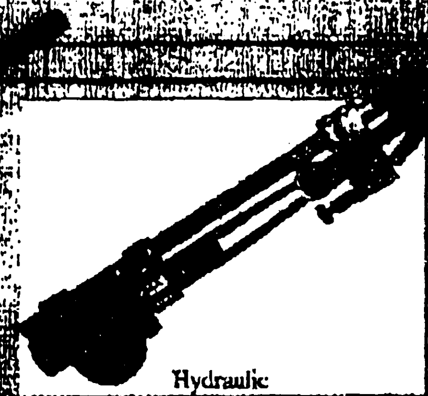


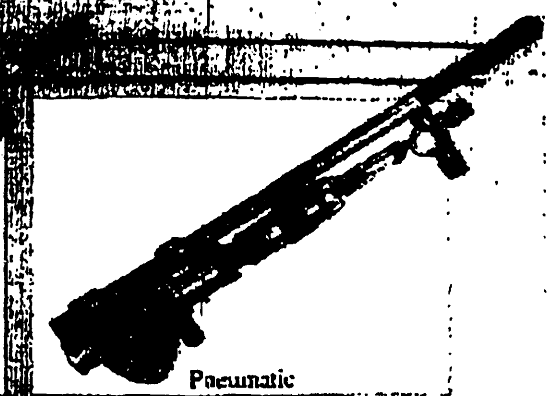
### SAVES TIME AND MONEY

- Turn 3 times more valves per day
- Avoid costly excavations
- Prepare for emergency shut-offs

*Turn all valves from 6" to 60" with a standard AWWA 2" nut*




## SPECIFICATIONS

**Capacity:** Operates all gate valves 6" to 60" (15.3 to 152.4 cm) and other equipment requiring mechanized turning.

**Drive:**
- Sealed lightweight aluminum gearbox
- Two stage reduction
- Planetary primary
- Bronze/Steel secondary (120:1 reduction)

**Power Requirements:**

| Electric | Hydraulic | Pneumatic |
|---|---|---|
| 110 V AC/220 V AC (15 AMP OR 3300 WATT) | 8 gpm @ 1800 psi | 70 cfm @ 90 psi |

**Peak Torque:** 800 ft./lbs. (1084 N-m)

**Motor Controls:**

**Electric:**
- 2 speed gearbox (Low RPM/High Torque) (High RPM/Low Torque).
- Overload Reset Button.
- On/off, forward/reverse and neutral.
- GFI (ground fault interrupter) with test and reset.

**Hydraulic:**
- Adjustable torque setting valve from 0 to 800 ft./lbs. with torque indicator gauge.
- Reversing valve, spring loaded self centering automatic stop after release.

**Pneumatic:**
- Reversible pneumatic motor with spring loaded on/off lever.
- Automatic stop after release.

**Revolution Counter:** Built in digital counter display. Push button reset counts in 1/10 revolution increments, forward and reverse automatically.

**Torque Gauges:** Hydraulic: 0 to 800 ft./lbs. Glycerine filled.
Pneumatic: 0 to 800 ft./lbs.

**Finish:** Enamel paint, Nickel plated handles and accessories.

**Valve Key Size:** 1" square solid (2.54 cm).

**Socket:** 2" square. AWWA standard (5 cm).

**Dimensions:**

| | Length | Width | Height |
|---|---|---|---|
| Pow-R-Drive II | 39-3/4" (101 cm) | 7-3/4" (20 cm) | 7" (18 cm) |
| Storage Case | 40-1/2" (103 cm) | 10-1/4" (26 cm) | 8-1/2" (22 cm) |

**Weight:**

| Electric | Hydraulic | Pneumatic |
|---|---|---|
| 32 lbs. (15 kg) | 36 lbs. (16 kg.) | 37 lbs. (17 kg.) |

## Torque Performance Charts

### Electric 110 Volts

| TORQUE FT./LBS. | RPM *High Speed Low Torque Setting | AMPS | RPM Low Speed High Torque Setting | AMPS |
|---|---|---|---|---|
| 100 | 12.5 | 8.8 | | |
| * 175 | 9 | 10 | 5.5 | 8 |
| 300 | 4.3 | 15 | 4.7 | 9.5 |
| 375 ** | 4.0 | 20 | 4.2 | 11 |
| 500 | 2 | 25 | 3.5 | 13.2 |
| 600 | | | 2.5 | 15.5 |
| 700 | | | 1.5 | 17.8 |
| 800 | | | .5 | 20 |

* Factory rated continuous load high speed/low torque
** Factory rated continuous load low speed/high torque

### Electric 220 Volts

| TORQUE FT./LBS. | RPM *High Speed Low Torque Setting | AMPS | RPM Low Speed High Torque Setting | AMPS |
|---|---|---|---|---|
| 100 | 10.2 | 3.1 | | |
| * 175 | 9.9 | 4.4 | 5.2 | 3.2 |
| 300 | 7.4 | 6.1 | 4.8 | 3.5 |
| 375 ** | 5 | 7.6 | 4.6 | 4.5 |
| 500 | 2 | 10 | 3.6 | 5.5 |
| 600 | | | 2.8 | 6.2 |
| 700 | | | 1.5 | 7.5 |
| 800 | | | 5 | 10 |

* Factory rated continuous load high speed/low torque
** Factory rated continuous load low speed/high torque

### Hydraulic

Based on 8 gpm @ 1800 psi

| FT/LBS | RPM |
|---|---|
| 100 | 12 |
| 200 | 12 |
| 300 | 12 |
| 400 | 12 |
| * 500 | 12 |
| 600 | 12 |
| 700 | 12 |
| 800 | 11 |

* Factory rated continuous load

### Pneumatic

Based on 90 psi @ 70 cfm

| FT/LBS | RPM |
|---|---|
| 100 | 13 |
| 200 | 11 |
| 300 | 7 |
| 400 | 5 |
| * 500 | 4 |
| 600 | 3 |
| 700 | 2 |
| 800 | 1 |

* Factory rated continuous load

**Standard Accessories:**
- Torque Arm Extension for two man operation.

**Optional Accessories:**
- 8' Valve Key (244 cm)
- 2" Square AWWA Socket
- 15/16 Drive Socket
- 4' Valve Key (122 cm)
- Stop Collar.

CE

LIT-72 Rev'd 12/97 5000

WACHS

**MONTGOMERY WATSON**

# Telephone Discussion Notes

**Subject:** B2 AWS Diffuser Grating Monitoring

**Discussion:**

Costs and availability of MTL Components

| | | |
|---|---|---|
| A/I Module for analog input (4-20 mA) | $1158 each | 3 weeks |
| To Modbus (Protocol Converter) | $2120 each | 6 weeks |
| Power Supply PS-01 | $2085 | 3 weeks |

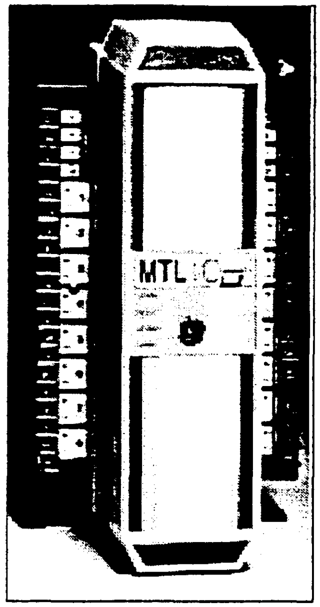
- Power supply powers the communicators and the level transmitters
- A/I talks to the Modbus converter thru the PS-01

| Montgomery Watson Party | Other Party |
|---|---|
| Project Name: BO 23 | Company Name: MTL |
| Project No. ______ Billable? Yes, No | Address: ______ |
| Employee Name: Frank Postlewaite | Phone No. 603-926-0090/703-361-0111 |
| Date: 7/17 Time: 11:05 AM | Person Name: Sales & Tech Support |

Call placed by: MW _____, Other Party _____

GO-60 (10/84)

# MTL I/O95™
## *System Overview*




The MTL I/O95 system consists of 3 key elements:

System Software

MTL I/O95 software provides the drivers to directly interface to your Windows application programming package. The system software utilizes a PC interface card with dual ported memory to manage TransNet communications. I/O data is automatically updated independent of the host computer and is readily accessible by the host PC. The interface card performs data validation and maintains system status information. The interface card also controls the transmission of data between the PC and the I/O modules.

I/O Modules and Termination bases

The I/O modules acquire and process I/O data from the field mounted sensors and actuators. The modules continually self-check for errors and faults. All field wiring connects directly to the module bases. The I/O modules plug into the termination bases, allowing the modules to be "hot swapped" without removing power or field wiring.

Module Power Supplies

The module power supplies provide power to the TransNet communications network over the same wires used for the communications network.

These elements define a cost-effective I/O solution, resulting in a measurement and control system that can be truly distributed throughout your plant.

Network Communications

The system network operates up to one mile from the host computer, allowing the modules to be placed right next to the process they are to monitor and control. The distributed architecture of MTL I/O95 eliminates the need to run sensor wires to a central host system, saving you significant time and money in the installation process.

Modules Built for the Plant Floor

The modules are designed to be installed directly in harsh industrial applications. The modules provide input to output isolation of 1500V rms, protecting the module and the system from transients. The modules operate over 0 to 60 degrees C and can withstand up to 95% relative humidity, assuring reliable performance in your application. The modules are calibrated at both 25 and 50 degrees C. Each analog module incorporates an internal sensor to measure ambient temperature and compensate for temperature effects during operation, resulting in accuracy of 0.1% over temperature.

| | |
|---|---|
| Analog I/O Modules | |
| Modularity | 8 or 16 channels each |
| Input Types | 4-20mA, TCs, RTDs, strain gage, mV, V, LVDT |
| Output Types | 0-20mA, 4-20mA |
| Isolation | 1500 Vrms Input to Output, Input to Power, and Channel to Channel |
| Accuracy | ± 0.1%, ± 0.05% & ± 0.02% of span over temperature |
| Common Mode Rejection | 160dB Transient Protection Meets C37.90.1 Surge Withstand Test - 3000V peak |
| Input Resistance | > 500 M Ohms |
| Discrete I/O Modules | |
| Modularity | 16 or 32 channels each |
| Type | AC and DC Inputs and Outputs From 90 Vac to 260 Vac & 5 Vdc to 125 Vdc |
| Isolation | 1500 Vrms Input to Output, Input to Power |
| Transient Protection | Meets C37.90.1 Surge Withstand Test - 3000V peak |
| Counters | Up to 450 Hz, optional on Discrete Input Module |
| High Speed Counter | Up to 200 Khz for Frequency, Up / Down Counting & Quadrature |
| Host Computer Interfaces Supported | IBM AT Computer Interface & VME Backplane Interface |
| System CPU | Dual Processors manage host computer interface and control and check communications |
| RAM | 64K dual port RAM |
| Required Card Slots for PC | 1/2 size PC/AT slot (Upto to 10 Cards per PC) |
| Required Card Slots for Backplane VME Computer | 6U Style Card, Single Slots |
| I/O Capacity per interface card | 1920 Analog I/O / 3840 Digital I/O |
| Communications | |
| Throughput | 320 analog in 30 msec, 640 digital in 12 msec |
| Wire | Twinaxial cable |
| Distance | Up to 1 mile from Host (without repeaters), Fiber Optic Extenders Available |
| Error Checking | CRC-16 format verification, watch dog timer |
| Redundant Communications | Optional Redundant Communications Interface Adapter |
| Software Interfaces | Compatible with many popular MMI / HMI software packages some listed below: |

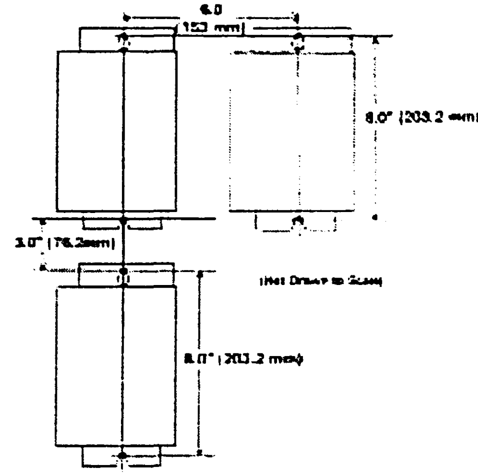
| | |
|---|---|
| Intellution FIX & FIX Dynamics | Intellution Paradym |
| NemaSoft Paragon | Soft PLC |
| Iconics Genesis | Steeplechase Software VLC |
| Wonderware InTouch | Citect |
| DDE & DDE32 Applications | C Tool Kit with DLL's (for Win 3.1, 95 & NT) |
| Lab View | GE Cimplicity |
| *OPC applications (Preliminary) | |

| | |
|---|---|
| Environmental | |
| Temperature, Rated Performance | 0 to +60 Deg C |
| Temperature, Operating | -20 to +60 Deg C |
| Temperature, Storage | -40 to +85 Deg C |
| Humidity | 0 to 95% RH noncondensing |
| Power Requirements | 18 to 35 Vdc |
| Analog Modules Consumption | 12.5 W for input modules, 20.0 W for output modules |
| Discrete Modules | 3 W for input modules, 4 W for output modules |
| Standards FM | FM Class I, Div II, Groups A,B,C & D hazardous locations |
| CE | CE Marked, EMC Directive (1995), LVD |
| Physical Module Weight | 2.2 lbs. (1.0 kg) |
| Module Bases | (Refer to selection table on page 10 for appropriate base) |
| Base Dimensions | 8.6 in. (218mm) L x 5.1 in. (129.5mm) W x 1.6 in (40.6mm) H |
| Assembly Dimensions | 9.5 in. (241mm) L x 5.1 in. (129.5mm) W x 4.25 in (108mm) H |

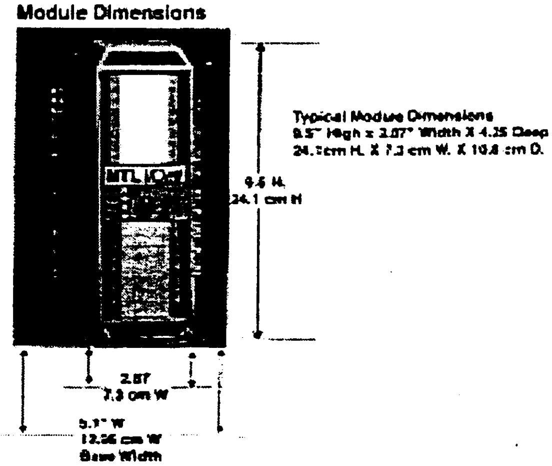
# *Selection and Configuration*

MTL I/O95 is designed specifically for PC based monitoring and control applications in harsh industrial environments. For those applications that may be exposed to hazardous gases. MTL I/O95 is approved for use in Class 1, Division 2, Groups A, B, C, and D environments.

One of the first things to consider is where you are going to install your I/O. With MTL I/O95 , you can install the modules as close to the process as you desire. The industrially hardened modules are built to withstand harsh plant floor environments. This distributed mounting of the I/O modules can save you considerable money in wiring when installing your system. since all field wiring is terminated at the module and you will only need to bring the communications wiring back to your computer.




Module Dimensions




## Analog Input Modules

There are some options in the selection of analog input modules, that give you the ability to optimize the modules for your requirements. MTL I/O95 input modules are available with full 3 port isolation as well as with input to output isolation only. Refer to the Selection Table on pages 10 - 11 for specific model numbers.

## Input to Output Isolation

Only You can consider the modules with input to output isolation only if your environment is not electrically noisy and will not be susceptible to ground loops caused by noise and interference. These products will provide good, cost-effective performance in those environments that are not electrically harsh and will not experience channel to channel interference.

## Full 3 Port Isolation

If you have electrically noisy environments or are not sure about the environment, you should choose the 3 port isolated products. These products provide isolation from input to output, input to power and channel to channel, and will eliminate the effects of ground loops and provide superior performance in the harshest of industrial environments.

## Analog Output Modules

Analog output modules are available to provide a 4-20 mA current output. These products are 3 port isolated and provide isolation from input to output, input to power and channel to channel.MTL I/O95 is a good choice for your data acquisition and control applications. The system's integrated nature assures a quick system startup.

MTL I/O95 offers a simple approach to the selection and configuration of your system. The system's open architecture and clear definition of module and base options allow the first time user to quickly and simply become familiar with the product

### Discrete Input Modules

Discrete Inputs are available to address AC or DC Inputs. Counters are optionally available for the discrete inputs. These products are 3 port isolated and provide isolation from input to output, input to power and channel to channel.

### Discrete Output Modules

Discrete Outputs are available to address AC or DC Output requirements. A monitoring option is available to provide system feedback on all discrete outputs. These products are 3 port isolated and provide isolation from input to output, input to power and channel to channel.

## A Sample MTL I/O95 Application

The following steps should be followed as you prepare to purchase and/or configure the MTL I/O95 system components for your particular application:

Determine the types and quantity of I/O modules required at each location.

Select the interface and software to be used.

Choose the driver package which is appropriate for your computer hardware and software.

Calculate power supply requirements.

Now, we will apply these steps in the selection and configuration of a sample I/O application. Let's assume that this is a two location field application with the following conditions:

The first remote location contains fifteen thermocouples. The second remote field location contains thirteen 4 - 20mA inputs, six analog outputs, forty 24 Vdc digital inputs, and twelve 24 Vdc digital outputs.

The host computer is a PC, running Intellution's *FIX 32 for Windows NT.*

### Determining I/O Types and Quantities

Our first step is to determine the types and quantity of I/O that are necessary.

At the first field location, one AIU-16 module and its TE07-M base will fully accommodate the thirteen thermocouples.

At the second location, an AIH-16 and TE08-M will collect the 13 high level analog inputs, and an AOC-08 and TE03-M will provide the six analog outputs.

The forty digital inputs will be collected by a DI24D-32 and TE01-M, and a DI24D-16 with a TE02-M, and a DO24D-16 and TEF09-5M will provide the 12 digital outputs.

### Choosing an Interface and Software

Next, we will select the interface and software. The FIX-HOSTWIN 32 package includes both the PC master card and driver software for use with *Intellution FIX 32.*

### Defining I/O Power Requirements

Finally, we should determine power requirements.

Based on the power supply chart on page eleven, our application would require a total of 64 watts. With this requirement, we would then order one PS-170 power supply and the PSC-24 power adapter.

### Sample System - Final Configuration

We now have a complete distributed I/O system, with the following products in its configuration:

| Model | Qty. | Description |
|---|---|---|
| AIU-16 | 1 | Universal Input Module |
| TE07-M | 1 | Universal Input Base |
| AIH-16 | 1 | High Level Input Module |
| TE08-M | 1 | High Level Input Base |
| AOC-08 | 1 | Isolated Current Output Module |
| TE03-M | 1 | Isolated Current Output Base |
| DI24D-32 | 1 | Discrete 24 Vdc Input Module |
| TE02-M | 1 | Discrete Input Base |
| DO24D | 1 | Discrete Output Module |
| TEF09-5M | 1 | Discrete Output Base |
| FIX-HOSTWIN32 | 1 | FIX Driver with PC card |
| PS-170 | 1 | 170 Watt Power Supply |
| PSC-24 | 1 | 24 Volt, 170 Watt Power Adapter |

MTL I/O95 Selection Table

| Analog Inputs | Input Type | Channels | Module | Base | Page #: |
|---|---|---|---|---|---|
| Universal | Type J,K,T,E,R,S,B,C,N | 16 | AIU-16 | TE07-M | 10 |
| | mV, volts and 4-20mA | 8 | AIU-08 | TE07-M | 10 |
| Universal High- | " " | 16 | AIU-16-EP & -EP2 | TE07-M | 10 |
| Accuracy Models | " " | 8 | AIU-08-EP & -EP2 | TE07-M | 10 |
| RTD | 100 Ohm Pt, 120 Ohm Ni | 16 | AIR-16 | TE06-M | 12 |
| " | " " | 8 | AIR-08 | TE06-M | 12 |
| RTD High- | 100 Ohm Pt, 120 Ohm Ni | 16 | AIR-16-EP2 | TE06-M | 12 |
| Accuracy Models | " " | 8 | AIR-08-EP2 | TE06-M | 12 |
| RTD | 10 Ohm Copper | 16 | AICR-16 | TE06-M | 12 |
| | | 8 | AICR-08 | TE06-M | 12 |
| High Level | 4-20mA, +/-5V, 1-5 V | 16 | AIH-16 | TE08-M | 14 |
| | | 8 | AIH-08 | TE08-M | 14 |
| Strain Gage | 350-1000 Ohm bridge | 16 | AIS-16 | TE12-M | 16 |
| | | 8 | AIS-08 | TE12-M | 16 |

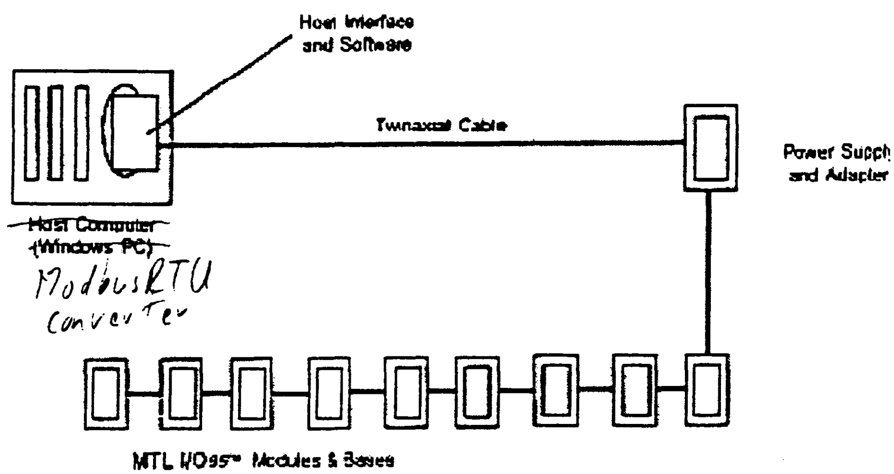
| Analog Outputs | Input Type | Channels | Module | Base | Page #: |
|---|---|---|---|---|---|
| Current | 0-20,4-20mA Output | 16 | AOC-16 | TE03-M | 18 |
| | | 8 | AOC-08 | TE03-M | 18 |

| Discrete Inputs | Input Type | Channels | Module | Base | Page #: |
|---|---|---|---|---|---|
| Standard Inputs | 5VDC | 32 | DI05D-32 | TE01-M | 22 |
| | | 16 | DI05D-16 | TE02-M | 22 |
| | 24VDC | 32 | DI24D-32 | TE01-M | 22 |
| | | 16 | DI24D-16 | TE02-M | 22 |
| | 48VDC | 32 | DI48D-32 | TE01-M | 22 |
| | | 16 | DI48D-16 | TE02-M | 22 |
| | 125VDC | 32 | DI125D-32 | TE01-M | 22 |
| | | 8 | DI125D-16 | TE02-M | 22 |
| | 115VAC | 32 | DI115A-32 | TE01-M | 22 |
| | | 16 | DI115A-16 | TE02-M | 22 |
| | 230VAC | 32 | DI230A-32 | TE01-M | 22 |
| | | 16 | DI230A-16 | TE02-M | 22 |
| **Discrete Inputs with Counters (first 4 channels up to 400 Hz)** | | | | | |
| Counters | 5VDC | 32 | DI05D-32-C | TE01-M | 22 |
| | | 16 | DI05D-16-C | TE02-M | 22 |
| (400Hz) | 24VDC | 32 | DI24D-32-C | TE01-M | 22 |
| | | 16 | DI24D-16-C | TE02-M | 22 |
| | 48VDC | 32 | DI48D-32-C | TE01-M | 22 |
| | | 16 | DI48D-16-C | TE02-M | 22 |
| | 125VDC | 32 | DI125D-32-C | TE01-M | 22 |
| | | 16 | DI125D-16-C | TE02-M | 22 |

| Discrete Inputs | Input Type | Channels | Module | Base | Page #: |
|---|---|---|---|---|---|
| High Speed Counters All Channels (200Khz) | 24VDC | 16 | DI24D-16-HC | TE01-HC-M | 20 |
| | | 8 | DI24D-08-HC | TE01-HC-M | 20 |

| Discrete Outputs | Output Type | Channels | Module | Base | Page #: |
|---|---|---|---|---|---|
| | 2-50 Vdc, Pulsed Output | 16 | DO24D-16PO | TEF09-5M | 24 |
| | 4-130 Vdc, Pulsed Output | 16 | DO125D-16PO | TEF09-5M | 24 |
| | 20-230 Vac, Pulsed Output | 16 | DO230A-16PO | TEF09-5M | 24 |
| | 48 Vdc, H Drive Output | 16 | DO48HD-16 | TE11-M | 24 |
| | 0-50 Vdc | 16 | DO24D-16 | TEF09-5M | 24 |
| | 0-50 Vdc, monitored | 16 | DO24D-16M | TEF09-5M | 24 |
| | 0-125 Vdc | 16 | DO125D-16 | TEF09-5M | 24 |
| | 0-125 Vdc, monitored | 16 | DO125D-16M | TEF09-5M | 24 |
| | 0-230 Vac | 16 | DO230A-16 | TEF09-5M | 24 |
| | 0-230 Vac, monitored | 16 | DO230A-16M | TEF09-5M | 24 |

## Sample MTL I/O95 System Layout




## Power Supply Requirements

| Module Type | Channels | Watts |
|---|---|---|
| Analog Inputs | 8 | 10 |
| Analog Inputs | 16 | 17 |
| Analog Outputs | 8 | 17 |
| Analog Outputs | 16 | 25 |
| Discrete Inputs | All Models | 4 |
| Discrete Outputs | All Models | 5 |
| High Speed Counters | All Models | 7 |

# Analog Inputs: High Level Modules

For applications that interface to +/- 5V dc, 1 - 5V and/or 4 - 20 mA in harsh industrial environments, select the High Level Input Modules, AIH-08 and AIH-16. For -10 to +10 volt VDC select the AIH-08-10V or AIH-16-10V.

### Module Description

These flexible modules are configurable on a channel by channel basis, allowing the user to select unique input types and ranges for each channel. The modules are designed to be installed directly in harsh industrial applications. The modules feature 3 port isolation of 1500 V rms, protecting the module and the system from transients and eliminating the errors caused by ground loops in the system. The modules are calibrated at both 25 and 50 deg C. Each module incorporates an internal sensor to measure ambient temperature and compensate for temperature effects during operation, resulting in accuracy of 0.1% over temperature.

Each module continuously transmits the present value of the input channels. They can be configured to maintain and report the peak (highest value) and valley (lowest value) of any channel since the last reset. The user can also configure a software filter for each input channel. The modules feature internal diagnostics that are presented via status lights on the module front. These lights indicate detection of an open circuit, communications status or module diagnostics status. Modules are offered in 16 and 8 channel versions to allow you to choose the right size for your needs.

### Termination Bases

Each module requires a model TE08-M Termination Base. Remember to order one base for each module. The termination bases can be either DIN-Rail mounted or can be surface mounted directly on a wall or in a cabinet. All system wiring connects directly to the TE08- M base, which can be wired separately before the modules are installed to speed system installation. The universal modules plug directly into the TE08-M and can be easily removed without disturbing field wiring to allow easy access to the field screw terminals. Since the modules incorporate a low power design, they can also be "hot swapped" allowing units to be switched while the entire system is still under power, assuring ongoing system operation during simple maintenance activities.


### External Power Connections

For applications where several high level inputs are powered from a common user power supply, the TE08-AM Termination Base is available to allow you to jumper (selectable) power to adjacent channels, simplifying the overall wiring installation. If the inputs are sharing a common power supply in this configuration, they are not isolated channel to channel.

### Selecting a High Level Analog Module

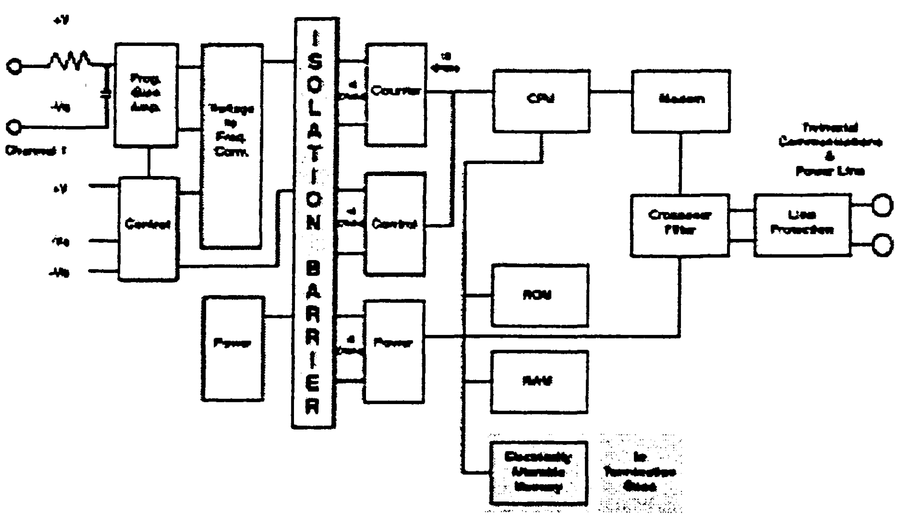
For 8 channel applications, choose the AIH-08, and for 16 channel applications, choose the AIH-16. Both modules are capable of interfacing with the following input types and ranges:

| Input Type | Range |
|---|---|
| Voltage | +/- 5V, 1 - 5 V |
| Current | 0 - 20 mA |
| ~~AIH-08-10V~~ | -10 to +10 VDC |
| ~~AIH-16-10V~~ | 0-20 mA |
| Module Base (requires 250 Ohm external shunt resistors for 4-20 mA inputs Order our part number RS-250-8) | TE08-M |
| Module Base, with External Power Connections (Also includes internal 250 Ohm 4-20 ma shunt resistors) | TE08-AM |

## High Level Input Module Specifications

| | | |
|---|---|---|
| | AIH-08<br>AIH-16 | AIH-08-10V<br>AIH-16-10V |
| Modularity 8 or 16 channels each | 8 or 16 channels each | |
| Input Types 4-20mA,1-5V, +/-5V | 0-10V dc | |
| Isolation 1500 V rms Input to Output, Input to Power & Channel to Channel | | |
| Accuracy +/- 0.1% of span over temperature | | |
| Conversion Rate | 16 readings every 21.8 msec | |
| Common Mode | Rejection 160dB | |
| Transient Protection | Meets C37.90.1 Surge Withstand Test - 3000V peak | |
| Input Resistance | > 500 M Ohms | |
| User Configurable Parameters | Module address | |
| Host computer configuration | Input filter per channel | |
| available on a single channel basis | High and low value per channel | |
| Module Diagnostics | | |
| Power Up Diagnostics | Internal voltage within range, CPU diagnostics<br>All RAM Memory, ROM and EAROM checksum | |
| Run Time Diagnostics | Watchdog timer, Auto zero, Temperature Compensation | |
| System Throughput | 320 analog in 30 msec, 640 digital in 12 msec | |
| Distance | Up to 1 mile from Host (without repeaters) | |
| Environmental | | |
| Temperature, Rated Performance | 0 to 60 Deg C | |
| Temperature, Operating | -20 to 60 Deg C | |
| Temperature, Storage | -40 Deg C to 85 Deg C | |
| Humidity | 0 to 95% RH noncondensing | |
| Power Requirements | 18 to 35 VDC; 12.5 W for AIH-16, 7W for AIH-08 | |
| Standards | | |
| FM | FM Class I, Div II, Groups A, B, C and D hazardous locations | |
| CE | CE Marked, EMC Directive (1995), LVD | |
| Module Base | TE08-M | |
| Module Base, with external power connections | TE08-AM | |

## Analog Input Signal Conditioning Block Diagram



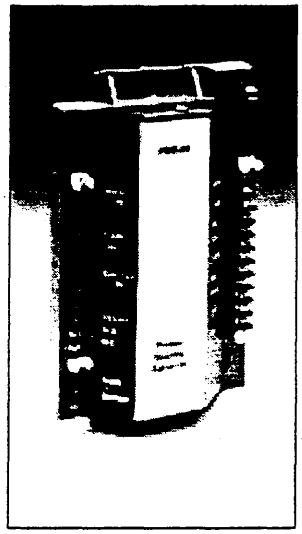
# Power Supply for MTL I/O95

MTL I/O95 requires 18 to 35 Vdc of power to operate. The product line uniquely provides power over the same two wires used for communications, which reduces the number of wires which have to be connected to the system and run back to the host computer. The result is an efficient installation of remotely mounted I/O modules, significantly reducing the time and cost of starting up your system.

**PS-01 Description** Two power options are provided. For smaller applications, the PS-01 power supply can be used to convert 115 Vac 60 Hz or 230 Vac 50Hz power to provide 20W of DC power for the I/O modules, which regulate and isolate the power within the modules. The PS-01 is used with a TE04-M Termination Base, which is used to provide both power and communications on the two wire TransNet communications network. Refer to the power supply requirements table on page 11 to determine the power needed for your application.

**PSC-24 & PSC-24-3 Description** For larger applications, the PSC-24 Central Power Supply Adapters allows the use of any commercial power supply that delivers between 18 and 35Vdc to supply power to the modules. The PSC-24 places the power on the TransNet communications system, which provides both power and communications to the MTL I/O95 modules. The PSC-24 will deliver up to 6 Amps at the appropriate voltages. For special saftey requirements a PSC-24-3 can be ordered. This will deliver up to 3 Amps at the appropriate voltages.
When using larger quantities of modules, the PSC-24 can reduce the number of power supplies needed to deliver DC power to the system.The PSC-24 also has provisions for backup power supply connections. This power supply will activate when the main supply input is 1.5 Vdc less than the backup supply voltage. The backup power supply is activated instantly and is glitch-free so that power is not lost and remains constantly supplied to the network.

**PS-170 Description** The model PS-170 power supply is offered to provide up to 170 W of system power. It can be used in conjunction with the PSC-24 Central Power Adapter to provide power to the MTL I/O95 system.



In applications above 170 W, two PS-170's can be used with two PSC-24 Adapters to distribute power to the network. Refer to the power requirements table on page 11 to determine the power necessary for your application.

Note: Models PS01, PSC-24, PSC-24-3 and PS170 are FM approved for use in Class I, DIV 2, Groups A, B, C and D hazardous locations.

## Power Supply Specifications

| Feature | PS-01 | PS-170 |
|---|---|---|
| Input Power | 100-130 Vac, 60 Hz<br>180-260 Vac, 50 Hz | 100-130 Vac, 60 Hz<br>180-260 Vac, 50 Hz |
| Output Volts | 28Vdc | 28Vdc |
| Operating Range | 18 to 35 Vdc | 19.6-30.8V |
| Maximum Output Ratings | 20 W @ 60 C | 173W @ 50 C 120W @ 60 C |
| Current Limit | NA | 7.0-7.3A |
| Overvoltage Protection Range | NA | 32-35V |
| Environmental | | |
| Operating Temperature | 0 to 60 Deg C | 0 to 71 Deg C |
| Storage Temperature | -40 to +85 Deg C | -20 to +75 Deg C |
| Humidity | 0 to 95% RH, noncondensing | up to 95% RH, noncondensing |
| Dimensions | 9.5" x 5.1" x 4.25"<br>(242 x 130 x 108 mm) | 8.7" x 4.3" x 3.9"<br>(220 x 110 x 100 mm) |
| Weight | 3.2 lbs, 1.45 Kg | 3.96 lbs, 1.8 Kg |
| Module Bases | TE04-M | N/A |
| Standards | FM C I, Div II, Groups A, B, C and D hazardous locations | Same as PS-01<br>CE Marked |

## PSC-24 & PSC-24-3 Power Supply Adapter Specifications

| | |
|---|---|
| Main Power Supply Input | 18-35 Vdc, unregulated |
| Backup Power Supply Input | 18-35 Vdc, unregulated |
| Activation | Activates when main power is 1.5V below backup supply voltage<br>Glitch free transfer maintains power on the network at all times |
| Current Capacity (PSC-24) | 6 Amps |
| Fuse Rating | 6 Amps Max. on either main or backup power supply |
| Current Capacity (PSC-24-3) | 3 Amps |
| Fuse Rating | 3 Amps Max. on either main or backup power supply |
| Relay Connections | Activates when main power supply fails |
| Noise | Less than 10mV rms noise in 1.0 to 2.5 MHz communications band |
| LED Indicators | Main LED - Voltage is present at main power input<br>Backup LED - Voltage is present at backup power input<br>"Fuse Blown" LED - PSC-24 Fuse has blown, no voltage power terminals |
| Standards | |
| FM | FM Class I, Div II, Groups A, B, C and D hazardous locations |
| CE | CE Marked, EMC Directive (1995), LVD |

# MTL I/O95™ Accessories

The MTL I/O95 system comes with a complete range of accessories and additional products for network redundancy,relays, fiber optic extension, base programming, and interface cabling.

**Modbus Interface Converter** The model MODBUS95 converts TransNet communications protocol to Modbus RTU protocol. Connections are made via RS232 or RS422/485. Communication Speeds supported up to 115.2Kbaud.
The MODBUS95 supports the following functions:

| | |
|---|---|
| Read Output Status (01) | ReadInput Status (02) |
| Read Output Registers (03) | Read Input Registers (04) |
| Force Single Coil (05) | Preset Single Register (06) |
| Force Multiple Coils (15) | Preset Multiple Registers (16) |

Other features include:
Status Information about the System & Modules. (Health)
Readback Information from Digital & Analog Outputs.
A mapping utility is included with the Interface to document system information & set Communication Speed and Node Address. For more detailed information contact MTL.

**Redundant Network Selector** The RNS-01 is a useful accessory in TransNet communications. It has three common uses including use as a Power Supply Adapter.

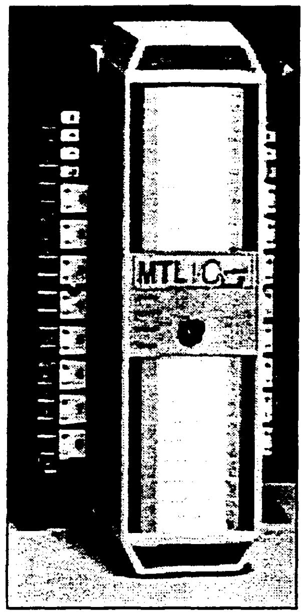
In the first, the RNS-01 has two inputs to a single TransNet connection and can be used to provide redundancy in some applications. Contact MTL applications engineering for further information.

In the second, the RNS-01 is used as a network splitter, allowing the user to tap (T) into the network at that point.

In the third, the RNS-01 is used as a repeater for applications where the TransNet communication length is beyond one mile.

**Bus Switching Device** The BSD-01 is a relay that can be used to switch between two communications networks. It can be used with redundant host computers to select the desired communications link.

**Fiber Optic Converter** The CI-FIBER is a fiber optic converter that may be used to extend the TransNet communications network beyond one mile, or can provide noise immunity in very noisy environments. Two specific CI-FIBER converters are needed to insert a fiber optic link within the TransNet network.




**Base Programmers** The BP-01 base programmer is an optional product which most commonly used to address a network of system bases before the modules are installed and the system is online.
The BP-03 base programmer is an optional product which is used to clear the base earom and reset the address to default.

**Interface Cables and Options**

| | |
|---|---|
| CAI-01 | 150 Ohm Interface cable, 10 ft. length. |
| CAI-01-T | 150 Ohm Interface cable with integral 150 Ohm terminating resistor, 10 ft. length. |
| CAI-02 | Interface cable with phone jack on one end and DB9 on the other end, used with External Configuration option. |
| CA150-XXX* | 150 Ohm Twinax TransNet cable available in 100,250,500,1000 foot lengths |
| CA100P-1000 | 100 Ohm Plenum Rated TransNet cable in 1000 foot legnths (200 Deg. C Rated) |
| RS-50-2 | 50 Ohm Termination Resistors (Pack of 2) |
| RS-75-2 | 75 Ohm Termination Resistors (Pack of 2) |
| RS-100-2 | 100 Ohm Termination Resistors (Pack of 2) |
| RS-125-2 | 125 Ohm Termination Resistors (Pack of 2) |
| RS-150-2 | 150 Ohm Termination Resistors (Pack of 2) |
| CRS-XX* | DB9M to DB9F termination adapter available in 50,75,100,125,150 Ohm versions |
| * note: | Substitute the XX for the value |

# APPENDIX E

# HYDRAULIC MODEL DESCRIPTION

# Appendix E
## Description of Bonneville Second Powerhouse Fish Ladder Model

### 1.0 PURPOSE

This work was undertaken to develop a numerical computer model of Bonneville Dam Second Powerhouse, Adult Fish Facility. This model provides a tool by which the hydraulic characteristics resulting from the present mode, and any reasonably expected future mode of operation can be determined over a wide range of tailwater elevations, and these characteristics compared to present-day fishway hydraulic criteria. The numerical model also provides a means to identify measures that could be taken to maximize compliance with these criteria.

### 2.0 BACKGROUND INFORMATION

This work has been accomplished by Northwest Hydraulic Consultants (**nhc**) under contract to the Corps of Engineers, Portland District, as part of the Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems program and was authorized by contract number DACW 57-96-D-0016, Task Order Number 0002. The bypass of adult anadromous fish from the tailrace of a dam to the forebay with a minimum of delay is critical in order that they continue their migration to the spawning channels. Well-defined criteria have been established for operating these bypass facilities (fishways) in the most efficient manner. Compliance with the criteria is essential for optimal operation of the fishways. The goal of this program is to identify measures that will maximize compliance with the hydraulic criteria. Accomplishing this goal requires the development of computer operated numerical simulation models which will provide accurate information concerning the flow characteristics throughout the fishway facility. The flow characteristics of particular concern are: ladder weir and orifice head, discharge and velocity; transportation channel average velocity, discharge and depth; fishway entrance head, depth, velocity, and discharge; diffuser velocity and discharge; and orifice entrance characteristics.

### 3.0 INTRODUCTION

The second powerhouse fishway was constructed to facilitate the bypass of adult anadromous fish. The design of these facilities was based on the best fishway hydraulic criteria that existed at the time of design and construction. Fishway Design criteria have been developed over the years based on continued experience with upstream fish passage facilities. Compliance with current fishway hydraulic criteria is essential to optimal operation of the fishway. The evaluation of the fishway system described in this appendix was undertaken to determine the hydraulic characteristics resulting from the present mode of operation, compare these characteristics to present-day fishway hydraulic criteria, and identify measures that could be taken to maximize compliance with these criteria.

The second powerhouse fishway facility includes two entrances on the south side of the powerhouse, a fish collection channel along the downstream face of the powerhouse, two entrances on the north side of the powerhouse, and a ladder extending from the north end of the powerhouse to the forebay. Water supplied to the fishway facility originates from two sources: the fishladder exit on the upstream face of the dam and from two turbines that are connected to conduits and diffusers referred to as the Auxiliary Water Supply System (AWS). A computer model of the second powerhouse fishway facility was developed based on a detailed analysis of the AWS routing, the fishway entrances, powerhouse collection channel, and the fishladder. The model does not include the control or exit section features located at the upstream end of the fishladder.

Measured prototype data obtained during five site visits were required to calibrate and verify the model. These prototype data were collected in a manner that provided information for steady state flow conditions at a variety of tailwater elevations. The fishway facility was cleaned of accumulated debris between the third and fourth site visit. A site visit was made during the cleaning operation, and it was apparent that a substantial amount of sediment and debris had accumulated in the AWS and fish ladder. This debris and sediment was suspected to be in sufficient quantities as to affect the hydraulic performance of the fishway. Therefore, the fourth and fifth site visits were taken to obtain data after the sediment was removed. The first and fifth site visits were taken during low tailwater elevations. The second and fourth site visits were taken during high tailwater elevations. The third site visit represents a mid tailwater elevation.

The fishway computer model presented in this appendix incorporates user-friendly interactive screens that enables a user who is familiar with the fish facility operation to run a simulation with only a few input parameters. Thus, the day-to-day operation can be monitored and a more complete operation guide can be developed. The computer model output provides a detailed description of the hydraulic characteristics of the operation of the fishway facility by calculating the discharge, average velocity, depth, and water surface elevations at defined ungaged locations, many of which are inaccessible for direct prototype measurements. The model also provides the hydraulic characteristics of the flow conditions at the fishway entrances, at diffusers, and within the AWS itself.

## 4.0 REFERENCES

The following references were used:


1. Army Corps of Engineers, Fisheries Handbook of Engineering Requirements and Biological Criteria, 1991.

2. Miller, D.S., Internal Flow Systems, BHRA, 1978.

3. Army Corps of Engineers, Hydraulic Design Criteria, Waterways Experiment Station.

4. Army Corps of Engineers, "Fishladders for John Day Dam Columbia River, Oregon and Washington." TR No. 103-1, Dec 1968.

5. Army Corps of Engineers, Fish Passage Plan for 1992, Corps of Engineers Projects, March 1992.

6. Rossman, Lewis, Hydraulic and Water Quality Simulator for Water Distribution Networks "EPANET", U.S. Environmental Protection Agency, RREL.

7. Army Corps of Engineers, Fish Ladders for Lower Monumental Dam Snake River, Washington, Technical Report 109-1 Corps of Engineers, Division Hydraulic Laboratory, Bonneville OR, Dec. 1973.

8. Army Corps of Engineers, As-built drawings of the Bonneville Second Powerhouse fishway facility.

9. Handbook of Hydraulics, Seventh Edition, King and Brater, et al, McGraw-Hill, 1963.

10. Army Corps of Engineers, "Hydraulic Data for Adult Bypass Fishways, Bonneville Second Powerhouse - December 1995," Summit Technology Inc.

11. Engineering Hydraulics, Rouse, 1950

## 5.0 SITE VISITS

Five site visits were made to collect real-time data for use in the development of the computer model (see Reference 10).

The first site visit occurred on 31 August 1994. The tailwater elevation was relatively low; elevation 8.36 ft MSL. The data was collected from 1440 to 1540 hrs every 10 minutes and averaged to provide a steady state description of the flow in the fishway. In addition to the data recorded for the active components of the fishway facility, the static components were provided by Corps of Engineers personnel. These included the number of operating pumps, diffuser gate settings and gage calibration data.

Analysis of the first site visit data indicated that less time and more frequent readings would result in a similar description of the hydraulic characteristics. A time of 30 minutes and 15 minutes with readings every 5 minutes was selected for the second and third data collections, respectively.

The second site visit was delayed until a high tailwater elevation was available. This visit was made on 20 June 1995 when the tailwater was 22.71 ft MSL. The data was collected from 1345 to 1415 hrs every 5 minutes and averaged.

The third site visit was made on 22 Aug 1995 at a tailwater elevation of 13.67 ft MSL. The data was collected from 1535 to 1555 hrs every 5 minutes and averaged.

The first three visits provided the range of tailwater elevations necessary for computer model calibration; however, the fishway was cleaned in December 1997 and significant amounts of sediment were removed from the AWS and other sections of the fishway. Therefore, two more site visits were made to obtain data that would represent the conditions after the AWS was cleaned.

Site visit 4 was made on 30 June 1998 at a tailwater elevation of 20.9 ft MSL. Site visit 5 was made on 3 September 1998 at a tailwater elevation of 12.5 ft MSL. During site visit 4, data was taken from 14:00 to 14:15 every 5 minutes and averaged. During site visit 5, data was taken from 14:35 to 14:45 every 5 minutes and averaged.

Model calibration was completed based on site visits 2 and 5 data, which represent a low and high tailwater elevation, respectively. Model verification was completed based on site visit 3 representing a mid-range tailwater elevation. The model was also verified using site visits 1 and 2.

# 6.0 NUMERICAL MODEL DEVELOPMENT

## 6.1 General

Two separate computer programs were developed for hydraulic analysis of the Bonneville Second Powerhouse fishway facilities. These computer programs are linked to run as one program called **BONNE2**. The program simulates:

a) The pumps and the AWS system closed conduit flow, and

b) The open channel flow portion of the fish ladder downstream from the control section, the transportation channel, and the fishway entrances.

The model does not simulate the control and exit section of the upstream end of the fish ladder.

The hydraulic characteristics of the AWS system are simulated using the pipe network simulation program (**nhcnet**) which is based on the EPA program EPANET and modified by **nhc** to allow rectangular conduits and internal weirs. The open channel flow characteristics of the fish ladder, transportation channels, and fishway entrances are simulated using a **nhc** developed site-specific fishway analysis program (**nhcbonn2**). Hydraulic analysis of the fishway system involves a trial and error solution using both **nhcnet** and **nhcbonn2** to achieve a solution. To facilitate the computer application, the two programs have been linked by a third computer program (**fishstep**) which enables sequential operation of these two programs. The linking program converts the output from **nhcnet** to input to **nhcbonn2**, runs **fishnet**, checks the results against the input to **nhcnet** to determine if a solution has been achieved and, if a solution has not been achieved resets input to **nhcnet**, then reruns both **nhcnet** and **nhcbonn2**. This procedure is repeated until a solution is achieved. See Figure 1 for the flow chart of the Program Logic that details the procedure that this numerical model incorporates.

Three user interface screens are provided by the program **fishinp.** These screens include a menu to allow easy point and click modification to and input of the variable parameters used to run the programs. The four combined programs that analyze Bonneville Second Powerhouse fishway facility are run via a DOS Batch file termed **BONNE2.BAT**. These four programs compute a steady flow simulation of the hydraulic characteristics of the fishway facility.

## 6.2 AWS System Numerical Model

The FISHWAY sub-program **nhcnet** input describes the AWS system by a series of nodes representing specific conduit sizes, branches, gates, internal weirs, and inflow (turbines) and outflow locations (diffusers). Between successive nodes the conduit is described by height, width (or diameter), actual roughness, length, and the summation of shape loss coefficients associated with that portion of the conduit. The shape loss coefficient, k, defines the hydraulic head loss, $h_L$, of features such as bends, expansions, contractions, valves, branches of dividing and combining flow, etc. as function of the velocity head, $h_L=k(V^2/2g)$. The completed Bonneville Second Powerhouse Fish Facility **nhcnet** model involves 270 conduits, 55 fixed grade nodes (FGNS), 280 junctions, 2 turbines feeding water to the system, and 16 valves that control flow to the diffusers. The FGNS are located at the water surface elevation at the gatewells of the turbine draft tubes and at the water surface directly above the fishway floor-diffuser locations. Figure 2 depicts a schematic of the AWS system that defines all the interior nodes, pipes, and FGNS used in the **nhcnet** input. The friction loss within the AWS is computed based on an actual roughness height of e = 0.004 ft by the Darcy Weisbach Equation:

$$H_{Lf} := f \cdot \frac{L}{D} \cdot \frac{V^2}{2 \cdot g}$$

Where:

$$f := 0.25 \cdot \left( \log \left( \frac{e}{3.7 \cdot D} + \frac{5.74}{R_N^{0.9}} \right) \right)^{-2}$$

Where:

| | | |
|---|---|---|
| $f$ | = | friction factor |
| $R_N$ | = | Reynolds Number |
| $e$ | = | actual roughness height (ft) |
| $D$ | = | hydraulic diameter |
| $L$ | = | conduit length |
| $H_{Lf}$ | = | head loss from friction |
| $V$ | = | velocity |

The shape loss coefficients were allocated based on data presented in References 2, 3, and 9. Modifications to the specific coefficients were required at various locations in order to represent the unusual geometric conditions involved in the AWS system. These modifications were based on engineering judgment. The **nhcnet** program input includes: FGNS water surface elevations at each diffuser, and FGNS water surface elevation at the gatewells of the turbine draft tubes. The **nhcnet** program computes the total discharge into the system, the discharge in each pipe, and the discharge from each diffuser. The outflow discharge at each diffuser FGNS is transferred to **nhcbonn2**, the fishway analysis program, by **fishstep**, for computing the open channel hydraulic characteristics of the fishway system, including the water surface elevations at each diffuser. **Fishstep** then compares the water surface elevation at each diffuser to that used by **nhcnet** to compute the diffuser discharge.

If the assumed and computed elevations balance is within 0.02 ft or the discharge does not change by more the 0.1 cfs, the simulation is completed; if not, iterations continue until a solution is obtained within these limits.

## 6.3 BONNE2 Numerical Model

The BONNE2 sub-program **nhcbonne2** computes the discharge, water surface elevations, average velocities and head differentials that occur in the fish ladder, transportation and collection channels, and at the fishway entrances. The computations of the hydraulic characteristics are based on the geometric shape and associated hydraulic head losses that occur throughout the open channel portion of the fishway. The input to **nhcbonne2** is the outflow discharge from each operating diffuser (computed by **nhcnet**), the tailwater elevation at the two main entrances, the entrance gate settings, and the depth of flow over the most upstream fish ladder weir.

The **nhcbonne2** describes the open channel portions of the fish facility by continuity, energy, and Manning's friction loss equations. The hydraulic characteristics of the transportation channel are computed at selected intervals by standard step backwater methods using loss coefficient values selected as a result of the model calibration.

The open channel portion of the fishway facility is described in **nhcbonn2** by the following equations:

continuity equation:

$$Q := V \cdot A$$

energy equation:

$$Z_1 + d_1 + \frac{\alpha \cdot V_1^2}{2 \cdot g} := Z_2 + d_2 + \frac{\alpha \cdot V_2^2}{2 \cdot g} + H_L$$

Manning's equation:

$$H_{Lf} := \left( \frac{Q \cdot n}{1.49 \cdot A \cdot R^{\frac{2}{3}}} \right)^2 \cdot L$$

The variables in the equations described above are defined as:

$Q$ = channel discharge (cfs)
$V$ = average channel velocity (fps)
$A$ = area of water in channel section (ft^2)
$H_{Lf}$ = head loss resulting from friction (ft)
$Z$ = elevation above datum (ft)

g = gravitational constant (ft/s^2)
d = depth of water in channel section (ft)
L = Length of conduit (ft)
R = hydraulic radius (ft)
n = transportation channel loss coefficient (not necessarily equivalent to the expected Manning's friction coefficient)
$H_L$ = Total headloss, friction and shape loss

The weirs and orifices involved in the fishladder portion of the facility are described by the following equations:

unsubmerged weir (6.3.1)

$$Q_w := C_w \cdot L \cdot h_1 \cdot (2 \cdot g \cdot h_w)^{0.5}$$

submerged weir (6.3.2)

$$Q_w := C_w \cdot C_V \cdot L \cdot h_1 \cdot (2 \cdot g \cdot h_w)^{0.5}$$

orifice: (6.3.3)

$$Q_o := C_o \cdot A \cdot (2 \cdot g \cdot h_o)^{0.5}$$

The main entrance weirs to the fishway facility are described by the following equation:

$$Q_e := 5.35 \cdot C_V \cdot C_R \cdot \left(h_1^{1.5}\right) \cdot L \cdot \left(1 - C_L\right) \quad (6.3.4)$$

The discharge coefficient $C_R$, for the main entrance submerged weirs was empirically derived based on Rehbock's weir equation, (Reference 11):

$$K_r := \frac{h_1}{P}$$

when $K_r$ is equal to or less than 2.5: (6.3.5)

$$C_R := 0.611 + 0.08 \cdot K_r$$

when $K_r$ is greater than 2.5: (6.3.6)

$$C_R := 0.6 + \frac{0.5275}{K_r}$$

The discharge correction coefficient for weir submergence $C_v$ was computed based on Villamonte's equation (Reference 9).

$$C_V := \left[1 - \left(\frac{h_2}{h_1}\right)^{1.5}\right]^{0.385} \qquad (6.3.7)$$

The variables in the equations described in Section 6.3 are defined below:

$Q_w$ = Ladder weir discharge
$Q_o$ = Ladder orifice discharge
$Q_e$ = Main entrance weir discharge
$C_w$ = Discharge coefficient for weir.
$C_v$ = Villamonte's correction coefficient for weir submergence
$C_L$ = Contraction coefficient
$C_o$ = Discharge coefficient for orifice
$C_R$ = Rehbock's discharge coefficient for unsubmerged weir
L = Weir length
P = Depth of channel below weir crest
$h_1$ = Depth from upstream water surface to weir crest
$h_2$ = Depth from downstream water surface to weir crest
$h_0$ = Head on orifice = $h_1 - h_2$
$h_w$ = Head on weir = $h_1 - h_2$
A = Area of orifice

# 7.0 MODEL CALIBRATION AND VERIFICATION

## 7.1 General

The calibration of the model consisted of adjustments to the following properties until agreement with observed data is achieved:

- Head loss coefficients for the various geometric shapes within the AWS,
- Contraction coefficients at the fishway entrances,
- Friction and turbulence loss coefficients within the AWS conduits and the entrance channel.

The credibility of the model must be judged by the ability to accurately compute or verify the observed head differential at the fishway entrances, collection channel, and transportation channel elevations based on a reasonably calibrated model. The data collection from Site Visits 2 and 5 were used to calibrate the **FISHWAY** model, while the data collection from Site Visits 1, 3, and 4 were used to verify the **FISHWAY** model.

## 7.2 Calibration

The data used for step one calibration included:

Picketed lead upstream staff gauge
Tailwater staff gauge elevations at each entrance

Transportation channel staff gauge elevations at each entrance
Entrance Weir Elevations NU-E, ND-E, SU-E, SD-E
Diffuser gates – open or closed status
Turbine Megawatts
Turbine Head

Step 1 consisted of setting appropriate values for the minor losses in **nhcnet**, the losses within the transportation channel, and the weir coefficients for the fishladder weirs in **nhcbonn2**.

The transportation channel loss coefficient ($n_t$) was empirically derived using the water surface data obtained during the five site visits. This loss coefficient includes both friction, and turbulence resulting from diffuser inflow. The coefficient was varied along the channel to reflect the differences in channel configuration etc. As shown below, the coefficient also varies with tailwater elevation.

| **Transportation Channel Loss Coefficients** | | | |
|---|---|---|---|
| | Tailwater Elevation (ft) | | |
| Location: | Low TW | Mid TW | High TW |
| Ladder portion of fishway | 0.013 | 0.013 | 0.013 |
| Powerhouse collection channel | 0.013 | 0.013 | 0.013 |
| North upstream entrance channel | 0.015 | 0.018 | 0.025 |
| North downstream entrance channel | 0.015 | 0.018 | 0.025 |
| South entrance channel | 0.013 | 0.013 | 0.013 |

The weir coefficient for the fishladder is an average value derived empirically from physical model data of the existing 1 vertical to 10 horizontal slope fishladder (see Reference 4). The orifice coefficient is an average theoretical value (see Reference 9). A vertical boundary contraction coefficient was added to the weir calculations at the south upstream entrance. Inspection of this entrance showed that there is a lateral contraction at this entrance. This entrance is located nearly parallel to the flow direction in the fish transportation channel.

| | |
|---|---|
| Unsubmerged weir coefficient in the fishladder | $C_w = 3.80$ |
| Orifice coefficient in the fishladder | $C_0 = 0.70$ |
| Contraction coefficient – south upstream entrance | $C_c = 0.07$ |

The comparison of the recorded and computed transportation channel elevations, and associated differences are shown on Table 7.1.

**TABLE 7.1**
**Step 1 Calibration**

| | **Site Visit 5** | **Site Visit 2** |
|---|---|---|

| | | |
|---|---|---|
| Fishladder Discharge cfs | 76.0 | 94.0 |
| AWS (Turbine) Discharge cfs | 5597 | 6249 |
| Computed Total Discharge cfs | 5673 | 6343 |
| NU-E Tailwater Elevation ft | 12.60 | 22.96 |
| ND-E Tailwater Elevation ft | 12.60 | 22.91 |
| SU-E Tailwater Elevation ft | 12.50 | 22.70 |
| SD-E Tailwater Elevation ft | 12.50 | 22.71 |
| Turbine Head | 58.7 | 46.10 |
| Turbine Megawatts (Turbine 1, Turbine 2) | 12.10, 12.50 | 9.93, 11.30 |
| **North Junction Pool:** | | |
| Observed Elevation ft | 14.31 | 24.50 |
| Computed Elevation ft | 14.31 | 24.57 |
| Difference ft | +0.0 | +0.07 |
| **ND-E Ladder Entrance:** | | |
| Observed Elevation ft | 14.10 | 24.50 |
| Computed Elevation ft | 14.15 | 24.47 |
| Difference ft | +0.05 | -0.03 |
| **SU-E Ladder Entrance:** | | |
| Observed Elevation ft | 13.77 | 24.29 |
| Computed Elevation ft | 13.87 | 24.29 |
| Difference ft | +0.10 | 0.00 |
| **SD-E Ladder Entrance:** | | |
| Observed Elevation ft | 13.70 | 24.20 |
| Computed Elevation ft | 13.74 | 24.26 |
| Difference ft | +0.04 | +0.06 |

The calibration errors ranged from -0.03 to +0.10. Readings from the staff gages are only accurate to ±0.10 ft. Thus the calibration is within the accuracy of the observed staff gage data.

The first model calibration was made for Site Visit 5 data, which is a relatively low tailwater elevation. All parameters were developed to adjust the model to fit this data set. The second model calibration was done for Site Visit 2, which is a reasonably high tailwater elevation.

## 7.3 Verification

Verification of the model was accomplished using Site Visit 1, 3, and 4. Verifying the model with the data from these site visits provided verification over a wide range of tailwater elevations. The comparison of the recorded and computed entrance channel elevations, discharge pool elevations, and associated differences are shown on Table 7.3.

**TABLE 7.3**
**Verification**

| | Computed | Observed | Difference |
|---|---|---|---|
| **Site Visit 3: Tailwater Elev. = 13.6 ft** | | | |
| SD-E | 15.06 | 15.00 | +0.06 |
| SU-E | 15.17 | 15.20 | -0.03 |
| ND-E | 15.60 | 15.50 | +0.10 |
| Junction Pool | 15.82 | 15.83 | -0.01 |
| **Site Visit 4: Tailwater Elev. = 20.9 ft** | | | |
| SD-E | 22.39 | 22.45 | -0.06 |
| SU-E | 22.45 | 22.50 | -0.05 |
| ND-E | 22.64 | 22.68 | -0.04 |
| Junction Pool | 22.76 | 22.95 | -0.19 |
| **Site Visit 1: Tailwater Elev. = 8.4** | | | |
| SD-E | 9.67 | 9.44 | 0.23 |
| SU-E | 9.67 | 9.90 | -0.23 |
| ND-E | 10.06 | 10.16 | -0.10 |
| Junction Pool | 10.19 | 10.46 | -0.27 |

The verification differences for Site Visit 3 are similar to the calibration differences. The verification differences for Site Visit 4 are also acceptable. The Site Visit 4 computed values are within 0.10 of the measured values with the exception of the junction pool with is within 0.19. Since reading the staff gauges to the nearest hundredth of a foot is impractical and there is some fluctuation of the water surface levels, a difference of 0.19 is considered within acceptable limits. Although Site Visit 1 was used for a verification run, the measured data from that site visit is suspect. After studying the Site Visit 1 measurements, it was apparent that the measurements at the upstream and downstream entrances on both sides of the powerhouse may have been transposed. The correction was made for the verification run; however, the quality of the data remains questionable. The maximum differential between the measured and computed values is 0.27 for Site Visit 1.

# 8.0 FISH PASSAGE CRITERIA AND CONSTRAINTS

## 8.1 Criteria

The following adult fish passage hydraulic criteria were used for the fish facility evaluation:

1. Water surface difference at entrances:
   1.0 ft to 2.0 ft, 1.5 ft preferred
2. Unsubmerged water depth on fish ladder weir:
   1.2 to 1.4 ft, 1.3 ft preferred
3. Submerged fishladder weir and transportation channel velocity:
   1.5 to 4.0 fps, 2.0 fps preferred
4. Diffuser inflow to fish ladder, average velocity:
   0.25 to 0.5 fps
5. Entrance weir depth below tailwater elevation:
   ≥ 8.0 ft

## 8.2 Project Constraints

A project constraint typical of most fish ladders is the limited amount of supply water. At Bonneville Second Powerhouse, this water is supplied from the fishladder and the turbines that discharge into the AWS. The fishladder flow is typically around 100 cfs to maintain the required head on the ladder weirs. The two turbines supply the majority of the discharge required to operate the fishway (approximately 3,200 to 7,200 cfs depending on the turbine head and megawatts).

There are some problems associated with the flow distribution in the diffuser chambers along the powerhouse collection channel. Figure 2 shows the pipe network associated with Bays 11,12,17 and 18. This figure shows that there are two gates that feed four diffusers at each of these bays, and the diffuser chambers feeding the four diffusers are interconnected. The result of this configuration is that some of the diffuser discharges are very small, and reversed flow may occur at some of the diffusers (flow entering the AWS through the diffuser from the collection channel). Another constraint involves the control of flow from the AWS to the diffuser chambers in the ladder section. The diffusers in the ladder section have internal weirs that control the flow to the diffusers; however, there are no gates to shut off specific internal weirs. This results in small amounts of flow discharging through several diffusers along the ladder section, resulting in very low diffuser velocities.

## 9.0 FISHWAY OPERATION

### 9.1 Operational Characteristics During Site Visits

The operation of the fishway facility was assessed with respect to the criteria in section 6.2 using the numerical model. A comparison of the criteria range and computed values are shown on Table 9.1. Values shown in bold print indicate that the criteria are not met for that feature.

**TABLE 9.1**
Comparison of Criteria to Computed Conditions

| | Criteria | | Computed | | |
|---|---|---|---|---|---|
| **Location** | **Range** | **Preferred** | **Site Visit 5** | **Site Visit 2** | **Site Visit 3** |
| **Tailwater Elev. (ft)** | | | 12.5 | 22.7 | 13.6 |
| **Head Drop at Entrances (ft)** | 1.0 to 2.0 | 1.5 | | | |
| **Entrance SD-E** | | | 1.08 | 1.46 | 1.43 |
| **Entrance SU-E** | | | 1.37 | 1.59 | 1.27 |
| **Entrance ND-E** | | | 1.45 | 1.51 | 1.92 |
| **Entrance NU-E** | | | 1.46 | 1.48 | 1.74 |
| **Water Depth on Ladder Weirs (ft)** | 1.2 to 1.4 | 1.3 | 1.12 | 1.37 | 1.34 |
| **Channel Velocity (fps)** | 1.5 to 4.0 | 2.0 | | | |
| **South Channel** | | | **0.72** to 3.53 | **1.15** to 2.64 | **1.19 to 4.15** |
| **Across Powerhouse** | | | **1.04** to 3.01 | 1.68 to 2.74 | 1.73 to 3.53 |
| **North Channels** | | | 3.90 to **4.14** | 2.76 to 2.93 | **4.5 to 4.65** |
| **Diffuser Inflow (fps)** | 0.25 to 0.5 | | | | |
| **South Channel** | | | **0.71 to 0.97** | **0.70 to 1.03** | **0.84 to 1.13** |
| **Powerhouse** | | | **-0.24** to 0.46 | **0 to** 0.31 | **-0.23** to 0.50 |
| **Junction Pool** | | | **0.82 to 1.25** | **0.85 to 1.29** | **0.92 to 1.41** |
| **Ladder** | | | **0.08 to 0.16** | **0.11** to 0.26 | **0.08 to 0.24** |
| **Entrance Submergence (ft)** | >=8.0 | | | | |
| **SD-E** | | | 10.6 | 12.7 | 12.4 |
| **SU-E** | | | 11.5 | 13.4 | 12.9 |
| **ND-E** | | | 10.5 | 13.1 | 12.5 |
| **NU-E** | | | 11.4 | 13.9 | 12.8 |

## 10.0 SUMMARY

The numeric simulations of the Bonneville Second Powerhouse Fishway appear to provide accurate information on the hydraulic characteristics of the system. The fact that the verification runs show errors that are approximately the same as the calibration runs indicates the model is suspected to simulate accurately over the calibrated range and to some degree outside of the calibration range. The conclusions can be summarized as:

A. The numerical model algorithm is functioning as intended, and will produce sufficient information to understand the operation of the fishway facility from the tailwater to the ladder control section.

B. The calibration of the model is accurate over the range of the calibration data, and this accuracy is expected to extend at least a half a foot of tailwater elevation on either side of the tailwater elevations used for the calibration data. Beyond these limits the accuracy of the model is expected to diminish.

The analysis of the fishway operation discussed in Section 9.0 shows that due to the complexity of this ladder only part of the fishway hydraulic criteria can be met for the range of tailwater elevations

# FIGURES

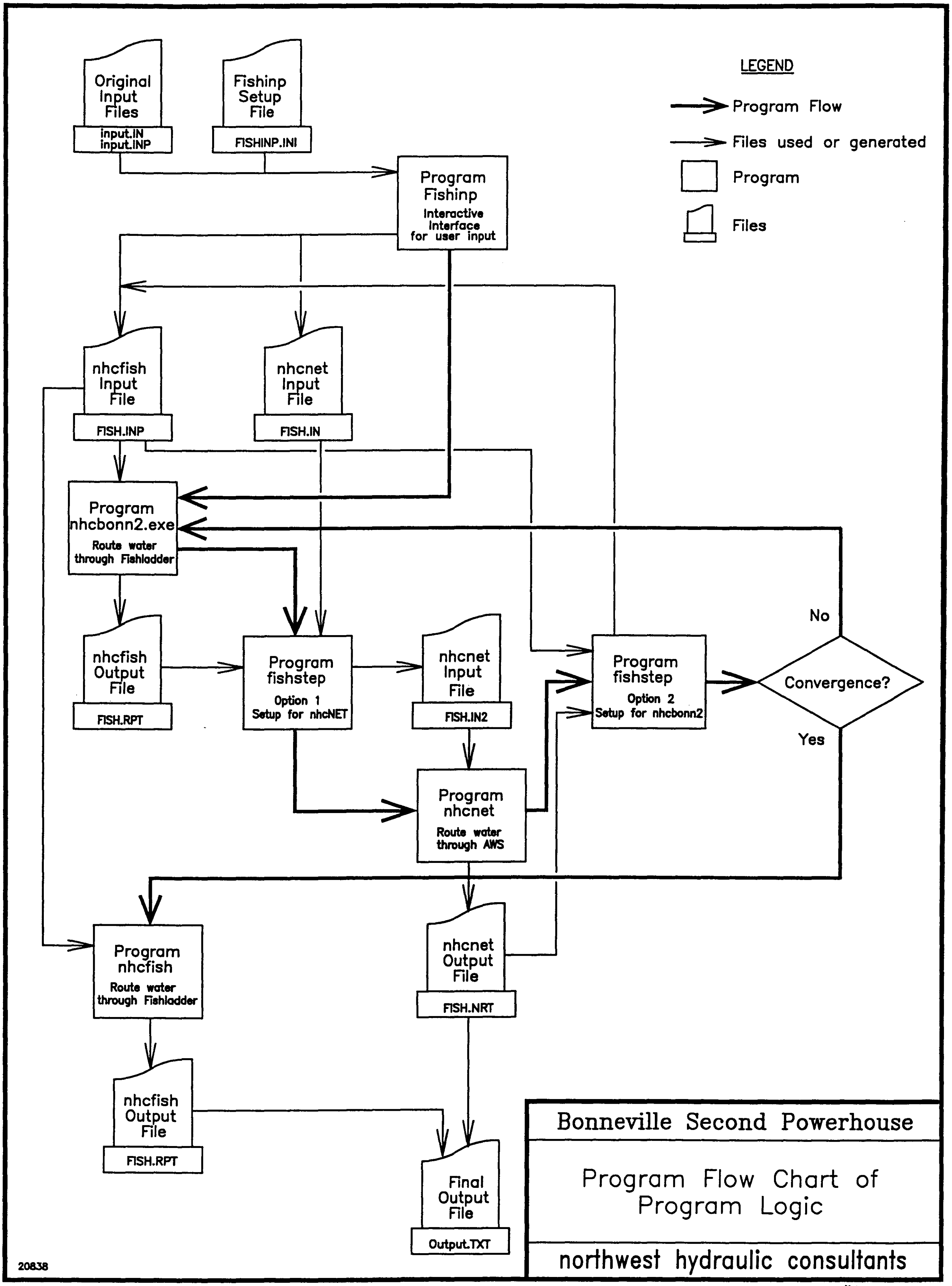
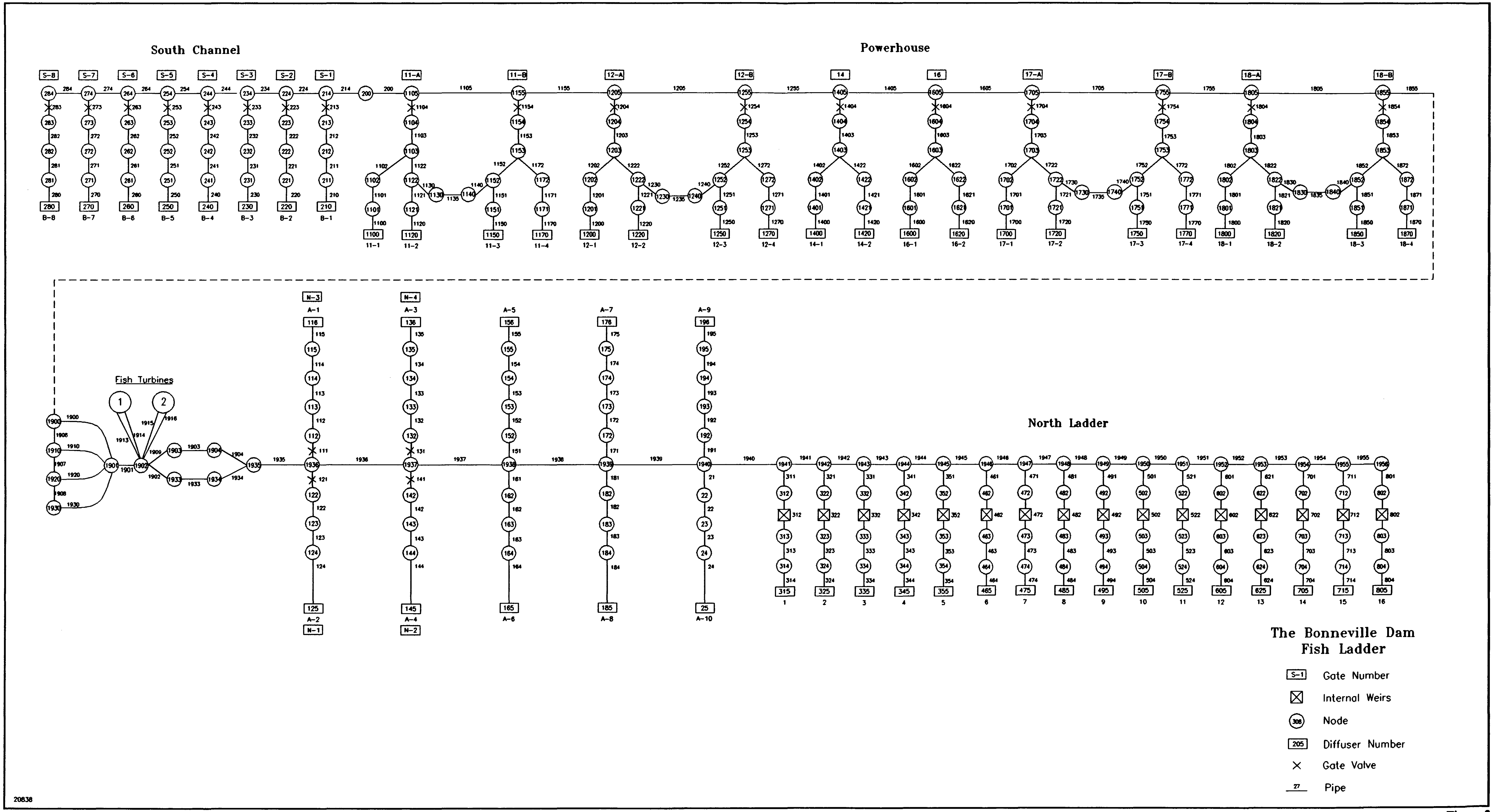

LEGEND
Program Flow
Files used or generated
Program
Files
Original Input Files
input.IN
input.INP
Fishinp Setup File
FISHINP.INI
Program Fishinp
Interactive Interface for user input
nhcfish Input File
FISH.INP
nhcnet Input File
FISH.IN
Program nhcbonn2.exe
Route water through Fishladder
nhcfish Output File
FISH.RPT
Program fishstep
Option 1
Setup for nhcNET
nhcnet Input File
FISH.IN2
Program fishstep
Option 2
Setup for nhcbonn2
Convergence?
No
Yes
Program nhcnet
Route water through AWS
Program nhcfish
Route water through Fishladder
nhcnet Output File
FISH.NRT
nhcfish Output File
FISH.RPT
Final Output File
Output.TXT
Bonneville Second Powerhouse
Program Flow Chart of Program Logic
northwest hydraulic consultants
20838

Figure 1



South Channel
Powerhouse
Fish Turbines
North Ladder
The Bonneville Dam Fish Ladder
Gate Number
Internal Weirs
Node
Diffuser Number
Gate Valve
Pipe
20838


Figure 2

# APPENDIX F

# HYDRAULIC MODEL RESULTS

# Appendix F

## Hydraulic Model Results

### Model Verification:

The fishway numerical model described in Section 4 and Appendix E was used to predict an emergency operating condition with one turbine shut down and all of the floating orifices closed. The computed values were compared to data collected at the project under the same conditions. Field Test 1 consisted of closure of all floating orifices, adjustment of diffuser gates according to the previously recommended schedule, and keeping all four of the main entrance weirs open . Project personnel welded steel plates over the floating orifices for the field test.

**Table 1.0 - Field Test 1**
**TW - 11.5 ft**
**Field Data Collection Settings for**
**Floating Orifices, Entrances, and Diffuser Gates**

| | **TW 12** |
|---|---|
| Model Run | TW12osv |
| SD-E Weir Elevation (ft msl) | 3.00 |
| SU-E Weir Elevation (ft msl) | 2.50 |
| ND-E Weir Elevation (ft msl) | 2.00 |
| NU-E Weir Elevation (ft msl) | 2.00 |
| Closed Floating Orifices | All |
| Closed Entrance Gates | None |
| Closed Diffusers | B-2 thru B-8 |
| Number of Turbines Operating | One |
| Turbine Setting (MW) | 15.5 |

The second field test (Field Test 2) was similar to the first test, except the north entrance gate was closed (NU-E), and the other gates were adjusted as shown in Table 2.0 below.

**Table 2.0 - Field Test 2**
**TW – 11.5 ft**
**Field Data Collection Settings for**
**Floating Orifices, Entrances, and Diffuser Gates**

| | **TW 12** |
|---|---|
| Model Run | TW12ksv |
| SD-E Weir Elevation (ftmsl) | 1.0 |
| SU-E Weir Elevation (ftmsl) | 1.0 |
| ND-E Weir Elevation (ftmsl) | 1.0 |
| NU-E Weir Elevation () | Closed Position |
| Closed Floating Orifices | All |
| Closed Entrance Gates | NU-E |
| Closed Diffusers | B-7 thru B-8 |
| Number of Turbines Operating | One |
| Turbine Setting (MW) | 14.0 |

The following data readings were taken every five minutes during a 15 minute time period.

**Gauge and Gate Dial Readings:**

- NU-E, ND-E, SU-E, SD-E Tailwater Staff Gauge Readings
  Note: Tailwater staff gauges could not be read at all locations.
- NU-E, ND-E, SU-E, SD-E Collection Channel Gauge Readings (water surface elevations)
- NU-E, ND-E, SU-E, SD-E Gate Dial Gauge Readings (Entrance weir elevation)
- Picketed Lead Staff Gauge Reading

**Fishway Control Panel Readings (only one turbine was operating):**

- Fish Turbine Head, Gate % open, Blade Position, Fish Turbine MW
- Entrance Gate Readings for all four entrances (also taken in control room in addition to reading the gauges at the entrances)
- Forebay Elevation (one reading)
- Tailrace Elevation (one reading)

Due to time constraints during the site visit, there were some difficulties with the data collection. The data collection began at about 2:00 p.m on February 28$^{th}$ ,2001. Some of the staff gauges were not readable at all of the weir gate entrances because the gauges do not extend below elevation 13.0 ft msl. Therefore, the tailwater elevation from the fishway control panel was used instead of the local readings in some cases, which introduced some error in the data. There is only one tailwater reading on the fishway control panel. From previous data taken at the second powerhouse, we note that there is some variation in the tailwater elevation between the entrances. A tailrace water surface elevation variation of 0.25 to 0.50 ft from the north to the south end of the powerhouse would not be unusual with the actual variation depending on the powerhouse operating conditions. During a normal data collection set, the tailwater elevations would be measured with water level indicators if the staff gauges are not readable; however, time constraints prevented measuring water surface elevations with water level indicators. Time constraints also prevented taking velocity measurements for Field Test 2.

The model was verified by comparing the computer predicted water surface elevations in the channel with the data collected during the field tests. The values predicted by the computer model were considered to be acceptable when compared to the data collected during the field tests. The most attention was focused on data collected for Field Test 1 for the model verification because that set of data was more complete. The differences between the computed and measured water surface elevations in the channel were less than 0.40 ft. Given the fluctuation and oscillating nature of the observed tailwater elevations about the mean (±0.20 ft) and the difficulty reading staff gauges, the maximum difference of 0.40 ft at one of the data collection locations was considered to be acceptable. The maximum difference of 0.40 ft only occurred at one location, and the maximum difference at other locations was less than or equal to 0.30 ft.

The velocity measurements for Test 1 were taken between Bays 14 and 15 in the collection channel. The measured velocities for Test 1 showed that the collection channel velocity ranged from 1.7 fps (closer to walls) to 2.4 fps (middle of channel), which is within criteria at the location of the measurement. The numerical model computed an average velocity of 2.5 fps at the same location. Velocity measurements could not be taken for Test 2 due to time constraints.

Based on the field data and model run results, the numerical model of the fishway was considered verified without having to modify any of the coefficients used to describe losses in the various water passages in the model. Some minor modifications to these coefficients could be made in the model to reduce the differences between the predicted and measured values; however, the model verification was considered to be within an acceptable range without making any modifications.

Collecting data to verify the model for a low, medium, and high tailwater is recommended. Further verification of the model could not be done because the plates covering the floating orifices were removed immediately after the test for the fish passage season. After the floating orifice closure scheme is implemented, additional testing is recommended. The data from the additional tests would be used to verify the numerical computer model and the operations plan at multiple tailwater elevations.

## Table F-1
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 8.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | 6.39.15.8 | 6.40.15.8 | 6.41.15.8 |
| Computer Filename | TW8Kddr | TW8Pddr | TW8Oddr |
| | | Selected | |
| **Operating Conditions:** | | | |
| Floating Orifices | All Closed | All Closed | All Closed |
| North Diffusers | All Open | All Open | All Open |
| Powerhouse Diffusers | All Open | C1-C5 Closed | All Open |
| South Diffusers | B5-B8 Closed | B3-B8 Closed | B2-B8 Closed |
| **Input Discharges: (cfs)** | | | |
| Ladder | 86.40 | 86.40 | 86.40 |
| Operating Turbine | 2225 | 2950 | 2950 |
| Total | 2311 | 3036 | 3036 |
| **Weir Elevations: (ft)** | | | |
| SD-E | 1.00 | 1.00 | 1.00 |
| SU-E | 1.00 | 1.00 | 1.00 |
| ND-E | 1.75 | 1.00 | 1.00 |
| NU-E | Closed | 1.00 | 1.00 |
| **Entrance Head drop: (ft)** | | | |
| SD-E | 1.46 | 1.29 | 1.29 |
| SU-E | 1.64 | 1.46 | 1.46 |
| ND-E | 2.50 | 1.91 | 1.92 |
| NU-E | Closed | 1.94 | 1.94 |
| **Submergence: (ft)** | | | |
| SD-E | 7.00 | 7.00 | 7.00 |
| SU-E | 7.00 | 7.00 | 7.00 |
| ND-E | 6.75 | 7.00 | 7.00 |
| NU-E | Closed | 7.00 | 7.00 |
| **Collection Channel Velocities: (fps)** | min / max | min / max | min / max |
| South Channel | 1.76 / 4.21 | 2.45 / 3.35 | 3.19 / 3.99 |
| Powerhouse | 0.46 / 2.58 | 1.97 / 3.60 | 1.48 / 4.78 |
| North Channels | 3.98 / 3.99 | 4.01 / 4.05 | 4.01 / 4.05 |
| Junction Pool | 0.45 / 1.36 | 0.18 / 2.92 | 0.85 / 2.77 |
| **Diffuser Velocities: (fps)** | | | |
| B-1 | 0.60 | 0.85 | 0.84 |
| B-2 | 0.65 | 0.82 | 0.00 |
| B-3 | 0.72 | 0.00 | 0.00 |
| B-4 | 0.64 | 0.00 | 0.00 |
| B-5 | 0.00 | 0.00 | 0.00 |
| B-6 | 0.00 | 0.00 | 0.00 |
| B-7 | 0.00 | 0.00 | 0.00 |
| B-8 | 0.00 | 0.00 | 0.00 |
| Powerhouse C1 (11-1) | 0.39 | 0.14 | 0.44 |
| Powerhouse C1 (11-2) | 0.11 | -0.37 | 0.22 |
| Powerhouse C2 (11-3) | -0.32 | 0.44 | -0.40 |
| Powerhouse C2 (11-4) | 0.18 | -0.22 | 0.27 |
| Powerhouse C3 (12-1) | 0.33 | 0.14 | 0.39 |
| Powerhouse C3 (12-2) | 0.12 | -0.37 | 0.17 |
| Powerhouse C4 (12-3) | -0.30 | 0.44 | -0.27 |
| Powerhouse C4 (12-4) | 0.16 | -0.21 | 0.21 |
| Powerhouse C5 (14-1) | 0.23 | 0.16 | 0.27 |
| Powerhouse C5 (14-2) | -0.09 | -0.16 | -0.03 |
| Powerhouse C6 (16-1) | 0.19 | 0.29 | 0.24 |
| Powerhouse C6 (16-2) | -0.06 | -0.04 | -0.01 |
| Powerhouse C7 (17-1) | 0.21 | 0.28 | 0.24 |
| Powerhouse C7 (17-2) | 0.22 | 0.27 | 0.25 |
| Powerhouse C8 (17-3) | -0.30 | -0.24 | -0.18 |
| Powerhouse C8 (17-4) | 0.11 | 0.17 | 0.14 |
| Powerhouse C9 (18-1) | 0.17 | 0.24 | 0.19 |
| Powerhouse C9 (18-2) | 0.26 | 0.26 | 0.24 |
| Powerhouse C10 (18-3) | -0.30 | -0.20 | -0.12 |
| Powerhouse C10 (18-4) | 0.10 | 0.16 | 0.12 |
| A-1 | 0.33 | 0.65 | 0.61 |
| A-2 | 0.30 | 0.58 | 0.55 |
| A-3 | 0.30 | 0.62 | 0.58 |
| A-4 | 0.27 | 0.55 | 0.52 |
| A-5 | 0.28 | 0.60 | 0.57 |
| A-6 | 0.39 | 0.84 | 0.80 |
| A-7 | 0.25 | 0.57 | 0.54 |
| A-8 | 0.35 | 0.80 | 0.76 |
| A-9 | 0.23 | 0.55 | 0.52 |
| A-10 | 0.32 | 0.77 | 0.72 |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-2
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 9.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | | 6.42.15.9 | |
| Computer Filename | | TW9Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| Floating Orifices | | All Closed | |
| North Diffusers | | All Open | |
| Powerhouse Diffusers | | C1-C5 Closed | |
| South Diffusers | | B3-B8 Closed | |
| **Input Discharges: (cfs)** | | | |
| Ladder | | 86.40 | |
| Operating Turbine | | 3010 | |
| Total | | 3096 | |
| **Weir Elevations: (ft)** | | | |
| SD-E | | 1.00 | |
| SU-E | | 1.00 | |
| ND-E | | 1.00 | |
| NU-E | | 1.00 | |
| **Entrance Head drop: (ft)** | | | |
| SD-E | | 1.01 | |
| SU-E | | 1.14 | |
| ND-E | | 1.56 | |
| NU-E | | 1.58 | |
| **Submergence: (ft)** | | | |
| SD-E | | 8.00 | |
| SU-E | | 8.00 | |
| ND-E | | 8.00 | |
| NU-E | | 8.00 | |
| **Collection Channel Velocities: (fps)** | min / max | min / max | min / max |
| South Channel | | 2.40 / 3.84 | |
| Powerhouse | | 1.92 / 3.80 | |
| North Channels | | 3.91 / 3.95 | |
| Junction Pool | | 0.20 / 2.85 | |
| **Diffuser Velocities: (fps)** | | | |
| B-1 | | 0.83 | |
| B-2 | | 0.86 | |
| B-3 | | 0.00 | |
| B-4 | | 0.00 | |
| B-5 | | 0.00 | |
| B-6 | | 0.00 | |
| B-7 | | 0.00 | |
| B-8 | | 0.00 | |
| Powerhouse C1 (11-1) | | 0.18 | |
| Powerhouse C1 (11-2) | | 0.01 | |
| Powerhouse C2 (11-3) | | -0.37 | |
| Powerhouse C2 (11-4) | | 0.19 | |
| Powerhouse C3 (12-1) | | 0.13 | |
| Powerhouse C3 (12-2) | | -0.35 | |
| Powerhouse C4 (12-3) | | 0.43 | |
| Powerhouse C4 (12-4) | | -0.21 | |
| Powerhouse C5 (14-1) | | 0.16 | |
| Powerhouse C5 (14-2) | | -0.16 | |
| Powerhouse C6 (16-1) | | 0.27 | |
| Powerhouse C6 (16-2) | | -0.01 | |
| Powerhouse C7 (17-1) | | 0.26 | |
| Powerhouse C7 (17-2) | | 0.28 | |
| Powerhouse C8 (17-3) | | -0.22 | |
| Powerhouse C8 (17-4) | | 0.17 | |
| Powerhouse C9 (18-1) | | 0.22 | |
| Powerhouse C9 (18-2) | | 0.26 | |
| Powerhouse C10 (18-3) | | -0.16 | |
| Powerhouse C10 (18-4) | | 0.14 | |
| A-1 | | 0.66 | |
| A-2 | | 0.58 | |
| A-3 | | 0.63 | |
| A-4 | | 0.56 | |
| A-5 | | 0.61 | |
| A-6 | | 0.85 | |
| A-7 | | 0.58 | |
| A-8 | | 0.82 | |
| A-9 | | 0.56 | |
| A-10 | | 0.79 | |

Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.
2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

**Table F-3**
**Numerical Model Results**
**One Turbine Operating Scenario**
**Tailwater Elevation 10.0 ft**

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | | 6.43.15.10 | |
| Computer Filename | | TW10Pddr | |
| | | | |
| Operating Conditions: | | | |
| Floating Orifices | | All Closed | |
| North Diffusers | | All Open | |
| Powerhouse Diffusers | | C1-C5 Closed | |
| South Diffusers | | B3-B8 Closed | |
| Input Discharges: (cfs) | | | |
| Ladder | | 86.40 | |
| Operating Turbine | | 3090 | |
| Total | | 3176 | |
| Weir Elevations: (ft) | | | |
| SD-E | | 2.00 | |
| SU-E | | 2.00 | |
| ND-E | | 2.00 | |
| NU-E | | 2.00 | |
| Entrance Head drop: (ft) | | | |
| SD-E | | 1.23 | |
| SU-E | | 1.35 | |
| ND-E | | 1.69 | |
| NU-E | | 1.72 | |
| Submergence: (ft) | | | |
| SD-E | | 8.00 | |
| SU-E | | 8.00 | |
| ND-E | | 8.00 | |
| NU-E | | 8.00 | |
| Collection Channel Velocities: (fps) | min / max | min / max | min / max |
| South Channel | | 2.43 / 3.75 | |
| Powerhouse | | 2.10 / 3.80 | |
| North Channels | | 3.62 / 3.66 | |
| Junction Pool | | 0.22 / 2.74 | |
| Diffuser Velocities: (fps) | | | |
| B-1 | | 0.81 | |
| B-2 | | 0.83 | |
| B-3 | | 0.00 | |
| B-4 | | 0.00 | |
| B-5 | | 0.00 | |
| B-6 | | 0.00 | |
| B-7 | | 0.00 | |
| B-8 | | 0.00 | |
| Powerhouse C1 (11-1) | | 0.14 | |
| Powerhouse C1 (11-2) | | -0.33 | |
| Powerhouse C2 (11-3) | | 0.39 | |
| Powerhouse C2 (11-4) | | -0.20 | |
| Powerhouse C3 (12-1) | | 0.14 | |
| Powerhouse C3 (12-2) | | -0.32 | |
| Powerhouse C4 (12-3) | | 0.35 | |
| Powerhouse C4 (12-4) | | -0.17 | |
| Powerhouse C5 (14-1) | | 0.14 | |
| Powerhouse C5 (14-2) | | -0.14 | |
| Powerhouse C6 (16-1) | | 0.25 | |
| Powerhouse C6 (16-2) | | 0.01 | |
| Powerhouse C7 (17-1) | | 0.26 | |
| Powerhouse C7 (17-2) | | 0.26 | |
| Powerhouse C8 (17-3) | | -0.17 | |
| Powerhouse C8 (17-4) | | 0.14 | |
| Powerhouse C9 (18-1) | | 0.22 | |
| Powerhouse C9 (18-2) | | 0.25 | |
| Powerhouse C10 (18-3) | | -0.14 | |
| Powerhouse C10 (18-4) | | 0.14 | |
| A-1 | | 0.67 | |
| A-2 | | 0.60 | |
| A-3 | | 0.64 | |
| A-4 | | 0.57 | |
| A-5 | | 0.62 | |
| A-6 | | 0.87 | |
| A-7 | | 0.60 | |
| A-8 | | 0.84 | |
| A-9 | | 0.58 | |
| A-10 | | 0.81 | |

Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.
2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

## Table F-4
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 11.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | | 6.44.15.11 | |
| Computer Filename | | TW11Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| Floating Orifices | | All Closed | |
| North Diffusers | | All Open | |
| Powerhouse Diffusers | | C1-C5 Closed | |
| South Diffusers | | B3-B8 Closed | |
| **Input Discharges: (cfs)** | | | |
| Ladder | | 86.40 | |
| Operating Turbine | | 3165 | |
| Total | | 3251 | |
| **Weir Elevations: (ft)** | | | |
| SD-E | | 2.50 | |
| SU-E | | 2.50 | |
| ND-E | | 2.50 | |
| NU-E | | 2.50 | |
| **Entrance Head drop: (ft)** | | | |
| SD-E | | 1.18 | |
| SU-E | | 1.30 | |
| ND-E | | 1.61 | |
| NU-E | | 1.63 | |
| **Submergence: (ft)** | | | |
| SD-E | | 8.50 | |
| SU-E | | 8.50 | |
| ND-E | | 8.50 | |
| NU-E | | 8.50 | |
| **Collection Channel Velocities: (fps)** | min / max | min / max | min / max |
| South Channel | | 2.41 / 3.64 | |
| Powerhouse | | 2.10 / 3.74 | |
| North Channels | | 3.48 / 3.52 | |
| Junction Pool | | 0.23 / 2.66 | |
| **Diffuser Velocities: (fps)** | | | |
| B-1 | | 0.81 | |
| B-2 | | 0.83 | |
| B-3 | | 0.00 | |
| B-4 | | 0.00 | |
| B-5 | | 0.00 | |
| B-6 | | 0.00 | |
| B-7 | | 0.00 | |
| B-8 | | 0.00 | |
| Powerhouse C1 (11-1) | | 0.14 | |
| Powerhouse C1 (11-2) | | -0.26 | |
| Powerhouse C2 (11-3) | | 0.26 | |
| Powerhouse C2 (11-4) | | -0.15 | |
| Powerhouse C3 (12-1) | | 0.14 | |
| Powerhouse C3 (12-2) | | -0.33 | |
| Powerhouse C4 (12-3) | | 0.37 | |
| Powerhouse C4 (12-4) | | -0.18 | |
| Powerhouse C5 (14-1) | | 0.12 | |
| Powerhouse C5 (14-2) | | -0.12 | |
| Powerhouse C6 (16-1) | | 0.21 | |
| Powerhouse C6 (16-2) | | 0.05 | |
| Powerhouse C7 (17-1) | | 0.24 | |
| Powerhouse C7 (17-2) | | 0.28 | |
| Powerhouse C8 (17-3) | | -0.18 | |
| Powerhouse C8 (17-4) | | 0.15 | |
| Powerhouse C9 (18-1) | | 0.22 | |
| Powerhouse C9 (18-2) | | 0.28 | |
| Powerhouse C10 (18-3) | | -0.15 | |
| Powerhouse C10 (18-4) | | 0.13 | |
| A-1 | | 0.68 | |
| A-2 | | 0.60 | |
| A-3 | | 0.65 | |
| A-4 | | 0.58 | |
| A-5 | | 0.64 | |
| A-6 | | 0.89 | |
| A-7 | | 0.62 | |
| A-8 | | 0.86 | |
| A-9 | | 0.60 | |
| A-10 | | 0.84 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

# Table F-5
# Numerical Model Results
# One Turbine Operating Scenario
# Tailwater Elevation 12.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.45.15.12 | 6.46.15.12 | 6.47.15.12 |
| **Computer Filename** | TW 12Kddr | TW12Pddr | TW12Oddr |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | All Closed |
| **North Diffusers** | All Open | All Open | All Open |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | All Open |
| **South Diffusers** | B5-B8 Closed | B2-B8 Closed | B2-B8 Closed |
| **Input Discharges: (cfs)** | | | |
| **Ladder** | 86.40 | 86.40 | 86.40 |
| **Operating Turbine** | 3230 | 3230 | 3230 |
| **Total** | 3316 | 3316 | 3316 |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 1.00 | 3.40 | 3.50 |
| **SU-E** | 1.00 | 3.40 | 3.50 |
| **ND-E** | 3.50 | 3.40 | 3.50 |
| **NU-E** | Closed | 3.40 | 3.50 |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.35 | 1.13 | 1.18 |
| **SU-E** | 1.58 | 1.22 | 1.28 |
| **ND-E** | 2.70 | 1.85 | 1.88 |
| **NU-E** | Closed | 1.88 | 1.90 |
| **Submergence: (ft)** | | | |
| **SD-E** | 11.00 | 8.60 | 8.50 |
| **SU-E** | 11.00 | 8.60 | 8.50 |
| **ND-E** | 8.50 | 8.60 | 8.50 |
| **NU-E** | Closed | 8.60 | 8.50 |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.46 / 4.78 | 2.52 / 3.31 | 2.62 / 3.3 |
| **Powerhouse** | 1.45 / 3.61 | 2.01 / 3.6 | 1.07 / 3.84 |
| **North Channels** | 4.11 / 4.12 | 3.47 / 3.4 | 3.43 / 3.4 |
| **Junction Pool** | 0.61 / 1.67 | 0.82 / 2.64 | 0.74 / 2.3 |
| **Diffuser Velocities: (fps)** | | | |
| **B-1** | 0.78 | 1.11 | 1.00 |
| **B-2** | 0.82 | 0.00 | 0.00 |
| **B-3** | 0.88 | 0.00 | 0.00 |
| **B-4** | 0.76 | 0.00 | 0.00 |
| **B-5** | 0.00 | 0.00 | 0.00 |
| **B-6** | 0.00 | 0.00 | 0.00 |
| **B-7** | 0.00 | 0.00 | 0.00 |
| **B-8** | 0.00 | 0.00 | 0.00 |
| **Powerhouse C1 (11-1)** | 0.45 | 0.26 | 0.51 |
| **Powerhouse C1 (11-2)** | 0.19 | -0.04 | 0.23 |
| **Powerhouse C2 (11-3)** | -0.37 | -0.38 | -0.35 |
| **Powerhouse C2 (11-4)** | 0.21 | 0.16 | 0.21 |
| **Powerhouse C3 (12-1)** | 0.40 | 0.25 | 0.44 |
| **Powerhouse C3 (12-2)** | 0.16 | -0.38 | 0.22 |
| **Powerhouse C4 (12-3)** | -0.31 | 0.40 | -0.28 |
| **Powerhouse C4 (12-4)** | 0.18 | -0.27 | 0.18 |
| **Powerhouse C5 (14-1)** | 0.28 | 0.20 | 0.28 |
| **Powerhouse C5 (14-2)** | -0.08 | -0.20 | -0.02 |
| **Powerhouse C6 (16-1)** | 0.26 | 0.40 | 0.27 |
| **Powerhouse C6 (16-2)** | -0.07 | -0.09 | -0.02 |
| **Powerhouse C7 (17-1)** | 0.27 | 0.38 | 0.27 |
| **Powerhouse C7 (17-2)** | 0.23 | 0.34 | 0.28 |
| **Powerhouse C8 (17-3)** | -0.26 | -0.33 | -0.19 |
| **Powerhouse C8 (17-4)** | 0.13 | 0.18 | 0.13 |
| **Powerhouse C9 (18-1)** | 0.23 | 0.33 | 0.22 |
| **Powerhouse C9 (18-2)** | 0.24 | 0.32 | 0.27 |
| **Powerhouse C10 (18-3)** | -0.25 | -0.26 | -0.15 |
| **Powerhouse C10 (18-4)** | 0.12 | 0.16 | 0.12 |
| **A-1** | 0.48 | 0.76 | 0.65 |
| **A-2** | 0.42 | 0.67 | 0.58 |
| **A-3** | 0.45 | 0.71 | 0.61 |
| **A-4** | 0.40 | 0.63 | 0.55 |
| **A-5** | 0.42 | 0.68 | 0.59 |
| **A-6** | 0.59 | 0.95 | 0.82 |
| **A-7** | 0.40 | 0.64 | 0.55 |
| **A-8** | 0.56 | 0.89 | 0.77 |
| **A-9** | 0.38 | 0.61 | 0.52 |
| **A-10** | 0.53 | 0.85 | 0.73 |

Notes: 1. **Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

2. **Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-5a
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 12.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | | 6.48.15.12 | |
| **Computer Filename** | | TW12P2dr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | | All Closed | |
| **North Diffusers** | | All Open | |
| **Powerhouse Diffusers** | | C1-C5 Closed | |
| **South Diffusers** | | B3-B8 Closed | |
| **Input Discharges: (cfs)** | | | |
| **Ladder** | | 86.40 | |
| **Operating Turbine** | | 3230 | |
| **Total** | | 3316 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | | 3.40 | |
| **SU-E** | | 3.40 | |
| **ND-E** | | 3.40 | |
| **NU-E** | | 3.40 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | | 1.18 | |
| **SU-E** | | 1.27 | |
| **ND-E** | | 1.80 | |
| **NU-E** | | 1.82 | |
| **Submergence: (ft)** | | | |
| **SD-E** | | 8.60 | |
| **SU-E** | | 8.60 | |
| **ND-E** | | 8.60 | |
| **NU-E** | | 8.60 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | | 2.00 / 3.37 | |
| **Powerhouse** | | 1.46 / 3.04 | |
| **North Channels** | | 3.41 / 3.44 | |
| **Junction Pool** | | 0.26 / 2.44 | |
| **Diffuser Velocities: (fps)** | | | |
| **B-1** | | 0.94 | |
| **B-2** | | 0.99 | |
| **B-3** | | 0.00 | |
| **B-4** | | 0.00 | |
| **B-5** | | 0.00 | |
| **B-6** | | 0.00 | |
| **B-7** | | 0.00 | |
| **B-8** | | 0.00 | |
| **Powerhouse C1 (11-1)** | | 0.22 | |
| **Powerhouse C1 (11-2)** | | 0.00 | |
| **Powerhouse C2 (11-3)** | | -0.33 | |
| **Powerhouse C2 (11-4)** | | 0.12 | |
| **Powerhouse C3 (12-1)** | | 0.17 | |
| **Powerhouse C3 (12-2)** | | -0.17 | |
| **Powerhouse C4 (12-3)** | | 0.15 | |
| **Powerhouse C4 (12-4)** | | -0.15 | |
| **Powerhouse C5 (14-1)** | | 0.00 | |
| **Powerhouse C5 (14-2)** | | 0.00 | |
| **Powerhouse C6 (16-1)** | | 0.32 | |
| **Powerhouse C6 (16-2)** | | -0.04 | |
| **Powerhouse C7 (17-1)** | | 0.32 | |
| **Powerhouse C7 (17-2)** | | 0.31 | |
| **Powerhouse C8 (17-3)** | | -0.27 | |
| **Powerhouse C8 (17-4)** | | 0.16 | |
| **Powerhouse C9 (18-1)** | | 0.27 | |
| **Powerhouse C9 (18-2)** | | 0.31 | |
| **Powerhouse C10 (18-3)** | | -0.22 | |
| **Powerhouse C10 (18-4)** | | 0.13 | |
| **A-1** | | 0.69 | |
| **A-2** | | 0.62 | |
| **A-3** | | 0.65 | |
| **A-4** | | 0.58 | |
| **A-5** | | 0.62 | |
| **A-6** | | 0.87 | |
| **A-7** | | 0.58 | |
| **A-8** | | 0.81 | |
| **A-9** | | 0.56 | |
| **A-10** | | 0.77 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-6
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 13.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | | 6.49.15.13 | |
| Computer Filename | | TW13Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| Floating Orifices | | All Closed | |
| North Diffusers | | All Open | |
| Powerhouse Diffusers | | C1-C5 Closed | |
| South Diffusers | | B3-B8 Closed | |
| **Input Discharges:** | | | |
| Ladder | | 86.40 | |
| Operating Turbine | | 3340 | |
| Total | | 3426 | |
| **Weir Elevations: (ft)** | | | |
| SD-E | | 4.00 | |
| SU-E | | 4.00 | |
| ND-E | | 4.00 | |
| NU-E | | 4.00 | |
| **Entrance Head drop: (ft)** | | | |
| SD-E | | 1.29 | |
| SU-E | | 1.39 | |
| ND-E | | 1.66 | |
| NU-E | | 1.68 | |
| **Submergence: (ft)** | | | |
| SD-E | | 9.00 | |
| SU-E | | 9.00 | |
| ND-E | | 9.00 | |
| NU-E | | 9.00 | |
| **Collection Channel Velocities: (fps)** | min / max | min / max | min / max |
| South Channel | | 2.34 / 3.44 | |
| Powerhouse | | 2.14 / 3.50 | |
| North Channels | | 3.21 / 3.24 | |
| Junction Pool | | 0.26 / 2.51 | |
| **Diffuser Velocities:** | | | |
| B-1 | | 0.82 | |
| B-2 | | 0.84 | |
| B-3 | | 0.00 | |
| B-4 | | 0.00 | |
| B-5 | | 0.00 | |
| B-6 | | 0.00 | |
| B-7 | | 0.00 | |
| B-8 | | 0.00 | |
| Powerhouse C1 (11-1) | | 0.15 | |
| Powerhouse C1 (11-2) | | -0.02 | |
| Powerhouse C2 (11-3) | | 0.02 | |
| Powerhouse C2 (11-4) | | -0.15 | |
| Powerhouse C3 (12-1) | | 0.13 | |
| Powerhouse C3 (12-2) | | -0.22 | |
| Powerhouse C4 (12-3) | | 0.22 | |
| Powerhouse C4 (12-4) | | -0.14 | |
| Powerhouse C5 (14-1) | | 0.00 | |
| Powerhouse C5 (14-2) | | 0.00 | |
| Powerhouse C6 (16-1) | | 0.20 | |
| Powerhouse C6 (16-2) | | 0.07 | |
| Powerhouse C7 (17-1) | | 0.23 | |
| Powerhouse C7 (17-2) | | 0.30 | |
| Powerhouse C8 (17-3) | | -0.17 | |
| Powerhouse C8 (17-4) | | 0.15 | |
| Powerhouse C9 (18-1) | | 0.21 | |
| Powerhouse C9 (18-2) | | 0.27 | |
| Powerhouse C10 (18-3) | | -0.13 | |
| Powerhouse C10 (18-4) | | 0.14 | |
| A-1 | | 0.71 | |
| A-2 | | 0.63 | |
| A-3 | | 0.68 | |
| A-4 | | 0.61 | |
| A-5 | | 0.67 | |
| A-6 | | 0.94 | |
| A-7 | | 0.65 | |
| A-8 | | 0.91 | |
| A-9 | | 0.63 | |
| A-10 | | 0.88 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-7
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 14.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | | 6.50.15.14 | |
| **Computer Filename** | | TW14Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | | All Closed | |
| **North Diffusers** | | All Open | |
| **Powerhouse Diffusers** | | C1-C5 Closed | |
| **South Diffusers** | | B3-B8 Closed | |
| **Input Discharges:** | | | |
| **Ladder** | | 86.40 | |
| **Operating Turbine** | | 3400 | |
| **Total** | | 3486 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | | 4.50 | |
| **SU-E** | | 4.50 | |
| **ND-E** | | 4.50 | |
| **NU-E** | | 4.50 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | | 1.22 | |
| **SU-E** | | 1.32 | |
| **ND-E** | | 1.57 | |
| **NU-E** | | 1.59 | |
| **Submergence: (ft)** | | | |
| **SD-E** | | 9.50 | |
| **SU-E** | | 9.50 | |
| **ND-E** | | 9.50 | |
| **NU-E** | | 9.50 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | | 2.29 / 3.34 | |
| **Powerhouse** | | 2.12 / 3.35 | |
| **North Channels** | | 3.11 / 3.13 | |
| **Junction Pool** | | 0.26 / 2.44 | |
| **Diffuser Velocities:** | | | |
| **B-1** | | 0.83 | |
| **B-2** | | 0.85 | |
| **B-3** | | 0.00 | |
| **B-4** | | 0.00 | |
| **B-5** | | 0.00 | |
| **B-6** | | 0.00 | |
| **B-7** | | 0.00 | |
| **B-8** | | 0.00 | |
| **Powerhouse C1 (11-1)** | | 0.14 | |
| **Powerhouse C1 (11-2)** | | -0.14 | |
| **Powerhouse C2 (11-3)** | | 0.15 | |
| **Powerhouse C2 (11-4)** | | -0.15 | |
| **Powerhouse C3 (12-1)** | | 0.03 | |
| **Powerhouse C3 (12-2)** | | 0.08 | |
| **Powerhouse C4 (12-3)** | | 0.03 | |
| **Powerhouse C4 (12-4)** | | -0.14 | |
| **Powerhouse C5 (14-1)** | | 0.00 | |
| **Powerhouse C5 (14-2)** | | 0.00 | |
| **Powerhouse C6 (16-1)** | | 0.21 | |
| **Powerhouse C6 (16-2)** | | 0.06 | |
| **Powerhouse C7 (17-1)** | | 0.23 | |
| **Powerhouse C7 (17-2)** | | 0.28 | |
| **Powerhouse C8 (17-3)** | | -0.13 | |
| **Powerhouse C8 (17-4)** | | 0.15 | |
| **Powerhouse C9 (18-1)** | | 0.21 | |
| **Powerhouse C9 (18-2)** | | 0.26 | |
| **Powerhouse C10 (18-3)** | | -0.10 | |
| **Powerhouse C10 (18-4)** | | 0.14 | |
| **A-1** | | 0.71 | |
| **A-2** | | 0.64 | |
| **A-3** | | 0.69 | |
| **A-4** | | 0.62 | |
| **A-5** | | 0.68 | |
| **A-6** | | 0.95 | |
| **A-7** | | 0.66 | |
| **A-8** | | 0.93 | |
| **A-9** | | 0.65 | |
| **A-10** | | 0.90 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-8
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 15.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.74.15.15 | 6.51.15.15 | |
| **Computer Filename** | TW15Kddr | TW15Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | |
| **North Diffusers** | All Open | All Open | |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | |
| **South Diffusers** | B5-B8 Closed | B3-B8 Closed | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | 86.40 | |
| **Operating Turbine** | 3520 | 3520 | |
| **Total** | 3606 | 3606 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 2.50 | 5.00 | |
| **SU-E** | 2.50 | 5.00 | |
| **ND-E** | 2.50 | 5.00 | |
| **NU-E** | Closed | 5.00 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.03 | 1.20 | |
| **SU-E** | 1.20 | 1.29 | |
| **ND-E** | 1.65 | 1.53 | |
| **NU-E** | Closed | 1.55 | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.50 | 10.00 | |
| **SU-E** | 12.50 | 10.00 | |
| **ND-E** | 12.50 | 10.00 | |
| **NU-E** | Closed | 10.00 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.71 / 4.36 | 2.27 / 3.30 | |
| **Powerhouse** | 2.07 / 3.72 | 2.11 / 3.43 | |
| **North Channels** | 4.35 / 4.36 | 3.05 / 3.08 | |
| **Junction Pool** | 0.27 / 1.89 | 0.27 / 2.41 | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.66 | 0.85 | |
| **B-2** | 0.68 | 0.88 | |
| **B-3** | 0.70 | 0.00 | |
| **B-4** | 0.60 | 0.00 | |
| **B-5** | 0.00 | 0.00 | |
| **B-6** | 0.00 | 0.00 | |
| **B-7** | 0.00 | 0.00 | |
| **B-8** | 0.00 | 0.00 | |
| **Powerhouse C1 (11-1)** | 0.29 | 0.00 | |
| **Powerhouse C1 (11-2)** | 0.19 | 0.00 | |
| **Powerhouse C2 (11-3)** | -0.16 | 0.00 | |
| **Powerhouse C2 (11-4)** | 0.13 | 0.00 | |
| **Powerhouse C3 (12-1)** | 0.26 | 0.13 | |
| **Powerhouse C3 (12-2)** | 0.21 | -0.25 | |
| **Powerhouse C4 (12-3)** | -0.16 | 0.26 | |
| **Powerhouse C4 (12-4)** | 0.14 | -0.14 | |
| **Powerhouse C5 (14-1)** | 0.18 | 0.00 | |
| **Powerhouse C5 (14-2)** | 0.03 | 0.00 | |
| **Powerhouse C6 (16-1)** | 0.18 | 0.21 | |
| **Powerhouse C6 (16-2)** | 0.04 | 0.07 | |
| **Powerhouse C7 (17-1)** | 0.19 | 0.21 | |
| **Powerhouse C7 (17-2)** | 0.21 | 0.32 | |
| **Powerhouse C8 (17-3)** | -0.10 | -0.14 | |
| **Powerhouse C8 (17-4)** | 0.11 | 0.14 | |
| **Powerhouse C9 (18-1)** | 0.17 | 0.19 | |
| **Powerhouse C9 (18-2)** | 0.23 | 0.29 | |
| **Powerhouse C10 (18-3)** | -0.12 | -0.08 | |
| **Powerhouse C10 (18-4)** | 0.11 | 0.12 | |
| **A-1** | 0.57 | 0.74 | |
| **A-2** | 0.51 | 0.66 | |
| **A-3** | 0.55 | 0.71 | |
| **A-4** | 0.49 | 0.64 | |
| **A-5** | 0.54 | 0.70 | |
| **A-6** | 0.76 | 0.98 | |
| **A-7** | 0.53 | 0.68 | |
| **A-8** | 0.74 | 0.96 | |
| **A-9** | 0.52 | 0.67 | |
| **A-10** | 0.72 | 0.93 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

# Table F-9
# Numerical Model Results
# One Turbine Operating Scenario
# Tailwater Elevation 16.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.52.15.16 | 6.53.15.16 | 6.54.15.16 |
| **Computer Filename** | TW16Kddr | TW16Pddr | TW16Oddr |
| | | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | All Closed |
| **North Diffusers** | All Open | All Open | All Open |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | All Open |
| **South Diffusers** | B5-B8 Closed | B2-B8 Closed | B2-B8 Closed |
| **Input Discharges: (cfs)** | | | |
| **Ladder** | 86.40 | 86.40 | 86.40 |
| **Operating Turbine** | 3515 | 3515 | 3515 |
| **Total** | 3601 | 3601 | 3601 |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 3.25 | 6.50 | 6.50 |
| **SU-E** | 3.25 | 6.50 | 6.50 |
| **ND-E** | 4.25 | 6.50 | 6.50 |
| **NU-E** | Closed | 6.50 | 6.50 |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.07 | 1.44 | 1.42 |
| **SU-E** | 1.22 | 1.52 | 1.51 |
| **ND-E** | 1.99 | 1.73 | 1.74 |
| **NU-E** | Closed | 1.75 | 1.76 |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.75 | 9.50 | 9.50 |
| **SU-E** | 12.75 | 9.50 | 9.50 |
| **ND-E** | 11.75 | 9.50 | 9.50 |
| **NU-E** | Closed | 9.50 | 9.50 |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.35 / 4.18 | 2.52 / 3.14 | 2.51 / 3.13 |
| **Powerhouse** | 1.56 / 3.43 | 2.63 / 3.94 | 1.72 / 3.92 |
| **North Channels** | 3.99 / 4.01 | 2.84 / 2.87 | 2.85 / 2.88 |
| **Junction Pool** | 0.60 / 1.65 | 0.82 / 2.45 | 0.74 / 2.18 |
| **Diffuser Velocities: (fps)** | | | |
| **B-1** | 0.76 | 0.94 | 0.84 |
| **B-2** | 0.80 | 0.00 | 0.00 |
| **B-3** | 0.84 | 0.00 | 0.00 |
| **B-4** | 0.71 | 0.00 | 0.00 |
| **B-5** | 0.00 | 0.00 | 0.00 |
| **B-6** | 0.00 | 0.00 | 0.00 |
| **B-7** | 0.00 | 0.00 | 0.00 |
| **B-8** | 0.00 | 0.00 | 0.00 |
| **Powerhouse C1 (11-1)** | 0.38 | 0.14 | 0.29 |
| **Powerhouse C1 (11-2)** | 0.19 | -0.20 | 0.24 |
| **Powerhouse C2 (11-3)** | -0.21 | 0.20 | -0.13 |
| **Powerhouse C2 (11-4)** | 0.12 | -0.14 | 0.15 |
| **Powerhouse C3 (12-1)** | 0.35 | 0.13 | 0.26 |
| **Powerhouse C3 (12-2)** | 0.19 | -0.25 | 0.24 |
| **Powerhouse C4 (12-3)** | -0.24 | 0.23 | -0.13 |
| **Powerhouse C4 (12-4)** | 0.15 | -0.11 | 0.15 |
| **Powerhouse C5 (14-1)** | 0.24 | 0.12 | 0.19 |
| **Powerhouse C5 (14-2)** | -0.02 | -0.12 | 0.07 |
| **Powerhouse C6 (16-1)** | 0.24 | 0.22 | 0.19 |
| **Powerhouse C6 (16-2)** | -0.03 | 0.07 | 0.07 |
| **Powerhouse C7 (17-1)** | 0.24 | 0.24 | 0.20 |
| **Powerhouse C7 (17-2)** | 0.26 | 0.30 | 0.23 |
| **Powerhouse C8 (17-3)** | -0.22 | -0.10 | -0.06 |
| **Powerhouse C8 (17-4)** | 0.12 | 0.13 | 0.12 |
| **Powerhouse C9 (18-1)** | 0.22 | 0.22 | 0.18 |
| **Powerhouse C9 (18-2)** | 0.25 | 0.30 | 0.24 |
| **Powerhouse C10 (18-3)** | -0.19 | -0.11 | -0.04 |
| **Powerhouse C10 (18-4)** | 0.10 | 0.15 | 0.11 |
| **A-1** | 0.53 | 0.78 | 0.69 |
| **A-2** | 0.48 | 0.70 | 0.62 |
| **A-3** | 0.51 | 0.76 | 0.67 |
| **A-4** | 0.45 | 0.68 | 0.60 |
| **A-5** | 0.49 | 0.75 | 0.66 |
| **A-6** | 0.69 | 1.05 | 0.92 |
| **A-7** | 0.47 | 0.73 | 0.65 |
| **A-8** | 0.65 | 1.02 | 0.90 |
| **A-9** | 0.45 | 0.72 | 0.63 |
| **A-10** | 0.63 | 1.00 | 0.88 |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-9a
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 16.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | | 6.55.15.16 | |
| **Computer Filename** | | TW16P2dr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | | All Closed | |
| **North Diffusers** | | All Open | |
| **Powerhouse Diffusers** | | C1-C5 Closed | |
| **South Diffusers** | | B3-B8 Closed | |
| **Input Discharges: (cfs)** | | | |
| **Ladder** | | 86.40 | |
| **Operating Turbine** | | 3515 | |
| **Total** | | 3601 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | | 6.00 | |
| **SU-E** | | 6.00 | |
| **ND-E** | | 6.00 | |
| **NU-E** | | 6.00 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | | 1.26 | |
| **SU-E** | | 1.35 | |
| **ND-E** | | 1.55 | |
| **NU-E** | | 1.57 | |
| **Submergence: (ft)** | | | |
| **SD-E** | | 10.00 | |
| **SU-E** | | 10.00 | |
| **ND-E** | | 10.00 | |
| **NU-E** | | 10.00 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | | 2.19 / 3.16 | |
| **Powerhouse** | | 2.07 / 3.21 | |
| **North Channels** | | 2.88 / 2.90 | |
| **Junction Pool** | | 0.27 / 2.30 | |
| **Diffuser Velocities: (fps)** | | | |
| **B-1** | | 0.85 | |
| **B-2** | | 0.86 | |
| **B-3** | | 0.00 | |
| **B-4** | | 0.00 | |
| **B-5** | | 0.00 | |
| **B-6** | | 0.00 | |
| **B-7** | | 0.00 | |
| **B-8** | | 0.00 | |
| **Powerhouse C1 (11-1)** | | 0.00 | |
| **Powerhouse C1 (11-2)** | | 0.00 | |
| **Powerhouse C2 (11-3)** | | 0.00 | |
| **Powerhouse C2 (11-4)** | | 0.00 | |
| **Powerhouse C3 (12-1)** | | 0.13 | |
| **Powerhouse C3 (12-2)** | | -0.23 | |
| **Powerhouse C4 (12-3)** | | 0.24 | |
| **Powerhouse C4 (12-4)** | | -0.14 | |
| **Powerhouse C5 (14-1)** | | 0.00 | |
| **Powerhouse C5 (14-2)** | | 0.00 | |
| **Powerhouse C6 (16-1)** | | 0.19 | |
| **Powerhouse C6 (16-2)** | | 0.08 | |
| **Powerhouse C7 (17-1)** | | 0.22 | |
| **Powerhouse C7 (17-2)** | | 0.28 | |
| **Powerhouse C8 (17-3)** | | -0.12 | |
| **Powerhouse C8 (17-4)** | | 0.15 | |
| **Powerhouse C9 (18-1)** | | 0.19 | |
| **Powerhouse C9 (18-2)** | | 0.27 | |
| **Powerhouse C10 (18-3)** | | -0.05 | |
| **Powerhouse C10 (18-4)** | | 0.11 | |
| **A-1** | | 0.73 | |
| **A-2** | | 0.65 | |
| **A-3** | | 0.71 | |
| **A-4** | | 0.63 | |
| **A-5** | | 0.70 | |
| **A-6** | | 0.98 | |
| **A-7** | | 0.68 | |
| **A-8** | | 0.95 | |
| **A-9** | | 0.67 | |
| **A-10** | | 0.93 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

# Table F-10
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 17.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.75.15.17 | 6.56.15.17 | |
| **Computer Filename** | TW17Kddr | TW17Pddr | |
| | | Selected | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | |
| **North Diffusers** | All Open | All Open | |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | |
| **South Diffusers** | B5-B8 Closed | B3-B8 Closed | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | 86.40 | |
| **Operating Turbine** | 3560 | 3560 | |
| **Total** | 3646 | 3646 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 4.00 | 7.00 | |
| **SU-E** | 4.00 | 7.00 | |
| **ND-E** | 4.00 | 7.00 | |
| **NU-E** | Closed | 7.00 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.11 | 1.34 | |
| **SU-E** | 1.25 | 1.42 | |
| **ND-E** | 1.61 | 1.61 | |
| **NU-E** | Closed | 1.64 | |
| **Submergence: (ft)** | | | |
| **SD-E** | 13.00 | 10.00 | |
| **SU-E** | 13.00 | 10.00 | |
| **ND-E** | 13.00 | 10.00 | |
| **NU-E** | 13.00 | 10.00 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.57 / 4.05 | 2.13 / 3.05 | |
| **Powerhouse** | 2.09 / 3.60 | 2.04 / 3.16 | |
| **North Channels** | 3.91 / 3.93 | 2.76 / 2.79 | |
| **Junction Pool** | 0.27 / 1.77 | 0.28 / 2.22 | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.66 | 0.85 | |
| **B-2** | 0.67 | 0.87 | |
| **B-3** | 0.69 | 0.00 | |
| **B-4** | 0.58 | 0.00 | |
| **B-5** | 0.00 | 0.00 | |
| **B-6** | 0.00 | 0.00 | |
| **B-7** | 0.00 | 0.00 | |
| **B-8** | 0.00 | 0.00 | |
| **Powerhouse C1 (11-1)** | 0.26 | 0.14 | |
| **Powerhouse C1 (11-2)** | 0.25 | -0.19 | |
| **Powerhouse C2 (11-3)** | -0.20 | 0.19 | |
| **Powerhouse C2 (11-4)** | 0.15 | -0.14 | |
| **Powerhouse C3 (12-1)** | 0.24 | 0.02 | |
| **Powerhouse C3 (12-2)** | 0.24 | 0.05 | |
| **Powerhouse C4 (12-3)** | -0.17 | 0.07 | |
| **Powerhouse C4 (12-4)** | 0.13 | -0.14 | |
| **Powerhouse C5 (14-1)** | 0.17 | 0.00 | |
| **Powerhouse C5 (14-2)** | 0.04 | 0.00 | |
| **Powerhouse C6 (16-1)** | 0.16 | 0.20 | |
| **Powerhouse C6 (16-2)** | 0.05 | 0.07 | |
| **Powerhouse C7 (17-1)** | 0.19 | 0.21 | |
| **Powerhouse C7 (17-2)** | 0.23 | 0.25 | |
| **Powerhouse C8 (17-3)** | -0.11 | -0.06 | |
| **Powerhouse C8 (17-4)** | 0.11 | 0.13 | |
| **Powerhouse C9 (18-1)** | 0.16 | 0.19 | |
| **Powerhouse C9 (18-2)** | 0.26 | 0.29 | |
| **Powerhouse C10 (18-3)** | -0.12 | -0.08 | |
| **Powerhouse C10 (18-4)** | 0.10 | 0.12 | |
| **A-1** | 0.57 | 0.73 | |
| **A-2** | 0.51 | 0.65 | |
| **A-3** | 0.56 | 0.71 | |
| **A-4** | 0.50 | 0.64 | |
| **A-5** | 0.55 | 0.70 | |
| **A-6** | 0.77 | 0.98 | |
| **A-7** | 0.54 | 0.69 | |
| **A-8** | 0.75 | 0.96 | |
| **A-9** | 0.53 | 0.68 | |
| **A-10** | 0.73 | 0.94 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-11
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 18.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.57.15.18 | 6.76.15.18 | |
| **Computer Filename** | TW18Kddr | TW18Pddr | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | |
| **North Diffusers** | All Open | All Open | |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | |
| **South Diffusers** | B5-B8 Closed | B3-B5 Closed | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | 86.40 | |
| **Operating Turbine** | 3575 | 3575 | |
| **Total** | 3661 | 3661 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 5.00 | 7.00 | |
| **SU-E** | 5.00 | 7.00 | |
| **ND-E** | 5.00 | 7.00 | |
| **NU-E** | Closed | 7.00 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.21 | 1.09 | |
| **SU-E** | 1.34 | 1.16 | |
| **ND-E** | 1.67 | 1.34 | |
| **NU-E** | Closed | 1.36 | |
| **Submergence: (ft)** | | | |
| **SD-E** | 13.00 | 11.00 | |
| **SU-E** | 13.00 | 11.00 | |
| **ND-E** | 13.00 | 11.00 | |
| **NU-E** | Closed | 11.00 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.51 / 3.91 | 2.07 / 2.96 | |
| **Powerhouse** | 2.08 / 3.73 | 1.97 / 3.02 | |
| **North Channels** | 3.71 / 3.72 | 2.69 / 2.71 | |
| **Junction Pool** | 0.28 / 1.71 | 0.26 / 2.16 | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.65 | 0.85 | |
| **B-2** | 0.67 | 0.87 | |
| **B-3** | 0.68 | 0.00 | |
| **B-4** | 0.57 | 0.00 | |
| **B-5** | 0.00 | 0.00 | |
| **B-6** | 0.00 | 0.00 | |
| **B-7** | 0.00 | 0.00 | |
| **B-8** | 0.00 | 0.00 | |
| **Powerhouse C1 (11-1)** | 0.24 | 0.00 | |
| **Powerhouse C1 (11-2)** | 0.22 | 0.00 | |
| **Powerhouse C2 (11-3)** | -0.14 | 0.00 | |
| **Powerhouse C2 (11-4)** | 0.13 | 0.00 | |
| **Powerhouse C3 (12-1)** | 0.23 | 0.00 | |
| **Powerhouse C3 (12-2)** | 0.23 | 0.00 | |
| **Powerhouse C4 (12-3)** | -0.14 | 0.00 | |
| **Powerhouse C4 (12-4)** | 0.12 | 0.00 | |
| **Powerhouse C5 (14-1)** | 0.17 | 0.00 | |
| **Powerhouse C5 (14-2)** | 0.05 | 0.00 | |
| **Powerhouse C6 (16-1)** | 0.15 | 0.21 | |
| **Powerhouse C6 (16-2)** | 0.06 | 0.07 | |
| **Powerhouse C7 (17-1)** | 0.18 | 0.21 | |
| **Powerhouse C7 (17-2)** | 0.20 | 0.24 | |
| **Powerhouse C8 (17-3)** | -0.06 | -0.04 | |
| **Powerhouse C8 (17-4)** | 0.09 | 0.13 | |
| **Powerhouse C9 (18-1)** | 0.16 | 0.18 | |
| **Powerhouse C9 (18-2)** | 0.22 | 0.24 | |
| **Powerhouse C10 (18-3)** | -0.08 | -0.02 | |
| **Powerhouse C10 (18-4)** | 0.10 | 0.12 | |
| **A-1** | 0.57 | 0.74 | |
| **A-2** | 0.51 | 0.66 | |
| **A-3** | 0.56 | 0.72 | |
| **A-4** | 0.50 | 0.64 | |
| **A-5** | 0.55 | 0.71 | |
| **A-6** | 0.77 | 0.99 | |
| **A-7** | 0.54 | 0.70 | |
| **A-8** | 0.75 | 0.97 | |
| **A-9** | 0.53 | 0.68 | |
| **A-10** | 0.74 | 0.95 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-12
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 19.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.58.15.19 | 6.77.15.19 | |
| **Computer Filename** | TW19Kddr | TW19Pddr | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | |
| **North Diffusers** | All Open | All Open | |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | |
| **South Diffusers** | B5-B8 Closed | B3-B8 Closed | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | 86.40 | |
| **Operating Turbine** | 3535 | 3535 | |
| **Total** | 3621 | 3621 | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 6.00 | 8.00 | |
| **SU-E** | 6.00 | 8.00 | |
| **ND-E** | 6.00 | 8.00 | |
| **NU-E** | Closed | 8.00 | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.26 | 1.11 | |
| **SU-E** | 1.37 | 1.17 | |
| **ND-E** | 1.67 | 1.33 | |
| **NU-E** | Closed | 1.35 | |
| **Submergence: (ft)** | | | |
| **SD-E** | 13.00 | 11.00 | |
| **SU-E** | 13.00 | 11.00 | |
| **ND-E** | 13.00 | 11.00 | |
| **NU-E** | Closed | 11.00 | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.40 / 3.72 | 1.98 / 2.82 | |
| **Powerhouse** | 2.03 / 3.58 | 1.90 / 2.89 | |
| **North Channels** | 3.49 / 3.50 | 2.53 / 2.56 | |
| **Junction Pool** | 0.28 / 1.63 | 0.25 / 2.05 | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.64 | 0.84 | |
| **B-2** | 0.65 | 0.85 | |
| **B-3** | 0.67 | 0.00 | |
| **B-4** | 0.55 | 0.00 | |
| **B-5** | 0.00 | 0.00 | |
| **B-6** | 0.00 | 0.00 | |
| **B-7** | 0.00 | 0.00 | |
| **B-8** | 0.00 | 0.00 | |
| **Powerhouse C1 (11-1)** | 0.24 | 0.00 | |
| **Powerhouse C1 (11-2)** | 0.21 | 0.00 | |
| **Powerhouse C2 (11-3)** | -0.12 | 0.00 | |
| **Powerhouse C2 (11-4)** | 0.12 | 0.00 | |
| **Powerhouse C3 (12-1)** | 0.22 | 0.00 | |
| **Powerhouse C3 (12-2)** | 0.20 | 0.00 | |
| **Powerhouse C4 (12-3)** | -0.13 | 0.00 | |
| **Powerhouse C4 (12-4)** | 0.13 | 0.00 | |
| **Powerhouse C5 (14-1)** | 0.15 | 0.00 | |
| **Powerhouse C5 (14-2)** | 0.06 | 0.00 | |
| **Powerhouse C6 (16-1)** | 0.15 | 0.17 | |
| **Powerhouse C6 (16-2)** | 0.06 | 0.10 | |
| **Powerhouse C7 (17-1)** | 0.16 | 0.19 | |
| **Powerhouse C7 (17-2)** | 0.21 | 0.28 | |
| **Powerhouse C8 (17-3)** | -0.05 | -0.08 | |
| **Powerhouse C8 (17-4)** | 0.09 | 0.14 | |
| **Powerhouse C9 (18-1)** | 0.16 | 0.18 | |
| **Powerhouse C9 (18-2)** | 0.21 | 0.23 | |
| **Powerhouse C10 (18-3)** | -0.06 | -0.01 | |
| **Powerhouse C10 (18-4)** | 0.09 | 0.12 | |
| **A-1** | 0.57 | 0.73 | |
| **A-2** | 0.50 | 0.65 | |
| **A-3** | 0.55 | 0.71 | |
| **A-4** | 0.49 | 0.63 | |
| **A-5** | 0.54 | 0.70 | |
| **A-6** | 0.76 | 0.98 | |
| **A-7** | 0.53 | 0.69 | |
| **A-8** | 0.74 | 0.96 | |
| **A-9** | 0.52 | 0.67 | |
| **A-10** | 0.73 | 0.94 | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-13
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 20.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | 6.59.15.20 | 6.60.15.20 | 6.61.15.20 |
| Computer Filename | TW20Kddr | TW20Pddr | Tw20Oddr |
| | Selected | | |
| **Operating Conditions:** | | | |
| Floating Orifices | All Closed | All Closed | All Closed |
| North Diffusers | All Open | All Open | All Open |
| Powerhouse Diffusers | All Open | C1-C5 Closed | All Open |
| South Diffusers | B4-B8 Closed | B3-B8 Closed | All Closed |
| **Input Discharges: (cfs)** | | | |
| Ladder | 86.40 | 86.40 | 86.40 |
| Operating Turbine | 3520 | 3520 | 3520 |
| Total | 3606 | 3606 | 3606 |
| **Weir Elevations: (ft)** | | | |
| SD-E | 8.20 | 9.50 | 10.00 |
| SU-E | 8.20 | 9.50 | 10.00 |
| ND-E | 7.50 | 9.50 | 9.50 |
| NU-E | Closed | 9.50 | 9.50 |
| **Entrance Head drop: (ft)** | | | |
| SD-E | 1.64 | 1.13 | 1.37 |
| SU-E | 1.74 | 1.20 | 1.42 |
| ND-E | 1.95 | 1.34 | 1.54 |
| NU-E | Closed | 1.36 | 1.57 |
| **Submergence: (ft)** | | | |
| SD-E | 11.80 | 11.00 | 10.00 |
| SU-E | 11.80 | 11.00 | 10.00 |
| ND-E | 12.50 | 11.00 | 10.50 |
| NU-E | Closed | 11.00 | 10.50 |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| South Channel | 2.47 / 3.48 | 2.01 / 2.71 | 2.11 / 2.66 |
| Powerhouse | 2.16 / 3.69 | 1.86 / 2.79 | 1.93 / 3.88 |
| North Channels | 3.36 / 3.37 | 2.41 / 2.42 | 2.44 / 2.46 |
| Junction Pool | 0.62 / 1.64 | 0.26 / 1.97 | 0.70 / 2.00 |
| **Diffuser Velocities: (fps)** | | | |
| B-1 | 0.67 | 0.84 | 0.00 |
| B-2 | 0.68 | 0.83 | 0.00 |
| B-3 | 0.70 | 0.00 | 0.00 |
| B-4 | 0.00 | 0.00 | 0.00 |
| B-5 | 0.00 | 0.00 | 0.00 |
| B-6 | 0.00 | 0.00 | 0.00 |
| B-7 | 0.00 | 0.00 | 0.00 |
| B-8 | 0.00 | 0.00 | 0.00 |
| Powerhouse C1 (11-1) | 0.24 | 0.00 | 0.27 |
| Powerhouse C1 (11-2) | 0.24 | 0.00 | 0.26 |
| Powerhouse C2 (11-3) | -0.16 | 0.00 | -0.12 |
| Powerhouse C2 (11-4) | 0.14 | 0.00 | 0.16 |
| Powerhouse C3 (12-1) | 0.22 | 0.00 | 0.24 |
| Powerhouse C3 (12-2) | 0.24 | 0.00 | 0.26 |
| Powerhouse C4 (12-3) | -0.13 | 0.00 | -0.07 |
| Powerhouse C4 (12-4) | 0.11 | 0.00 | 0.11 |
| Powerhouse C5 (14-1) | 0.16 | 0.00 | 0.18 |
| Powerhouse C5 (14-2) | 0.06 | 0.00 | 0.10 |
| Powerhouse C6 (16-1) | 0.15 | 0.17 | 0.18 |
| Powerhouse C6 (16-2) | 0.07 | 0.09 | 0.09 |
| Powerhouse C7 (17-1) | 0.17 | 0.19 | 0.20 |
| Powerhouse C7 (17-2) | 0.21 | 0.23 | 0.23 |
| Powerhouse C8 (17-3) | -0.06 | -0.01 | -0.02 |
| Powerhouse C8 (17-4) | 0.10 | 0.11 | 0.11 |
| Powerhouse C9 (18-1) | 0.16 | 0.17 | 0.17 |
| Powerhouse C9 (18-2) | 0.23 | 0.23 | 0.26 |
| Powerhouse C10 (18-3) | -0.08 | -0.01 | -0.03 |
| Powerhouse C10 (18-4) | 0.10 | 0.11 | 0.12 |
| A-1 | 0.58 | 0.72 | 0.73 |
| A-2 | 0.52 | 0.64 | 0.65 |
| A-3 | 0.57 | 0.70 | 0.71 |
| A-4 | 0.51 | 0.62 | 0.64 |
| A-5 | 0.56 | 0.69 | 0.70 |
| A-6 | 0.79 | 0.97 | 0.98 |
| A-7 | 0.55 | 0.68 | 0.69 |
| A-8 | 0.77 | 0.95 | 0.97 |
| A-9 | 0.54 | 0.67 | 0.68 |
| A-10 | 0.75 | 0.93 | 0.95 |

Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.

2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

# Table F-14
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 21.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.62.15.21 | | |
| **Computer Filename** | TW21Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3510 | | |
| **Total** | 3596 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 8.20 | | |
| **SU-E** | 8.20 | | |
| **ND-E** | 8.20 | | |
| **NU-E** | Closed | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.42 | | |
| **SU-E** | 1.52 | | |
| **ND-E** | 1.75 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.45 / 3.43 | | |
| **Powerhouse** | 2.20 / 3.68 | | |
| **North Channels** | 3.13 / 3.14 | | |
| **Junction Pool** | 0.29 / 1.58 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.67 | | |
| **B-2** | 0.68 | | |
| **B-3** | 0.70 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.21 | | |
| **Powerhouse C1 (11-2)** | 0.25 | | |
| **Powerhouse C2 (11-3)** | -0.15 | | |
| **Powerhouse C2 (11-4)** | 0.15 | | |
| **Powerhouse C3 (12-1)** | 0.23 | | |
| **Powerhouse C3 (12-2)** | 0.18 | | |
| **Powerhouse C4 (12-3)** | -0.06 | | |
| **Powerhouse C4 (12-4)** | 0.09 | | |
| **Powerhouse C5 (14-1)** | 0.16 | | |
| **Powerhouse C5 (14-2)** | 0.06 | | |
| **Powerhouse C6 (16-1)** | 0.15 | | |
| **Powerhouse C6 (16-2)** | 0.06 | | |
| **Powerhouse C7 (17-1)** | 0.17 | | |
| **Powerhouse C7 (17-2)** | 0.21 | | |
| **Powerhouse C8 (17-3)** | -0.05 | | |
| **Powerhouse C8 (17-4)** | 0.10 | | |
| **Powerhouse C9 (18-1)** | 0.16 | | |
| **Powerhouse C9 (18-2)** | 0.21 | | |
| **Powerhouse C10 (18-3)** | -0.06 | | |
| **Powerhouse C10 (18-4)** | 0.10 | | |
| **A-1** | 0.59 | | |
| **A-2** | 0.52 | | |
| **A-3** | 0.57 | | |
| **A-4** | 0.51 | | |
| **A-5** | 0.56 | | |
| **A-6** | 0.79 | | |
| **A-7** | 0.55 | | |
| **A-8** | 0.77 | | |
| **A-9** | 0.54 | | |
| **A-10** | 0.76 | | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-15
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 22.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.63.15.22 | | |
| **Computer Filename** | TW22Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3505 | | |
| **Total** | 3591 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 9.20 | | |
| **SU-E** | 9.20 | | |
| **ND-E** | 9.20 | | |
| **NU-E** | Closed | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.46 | | |
| **SU-E** | 1.56 | | |
| **ND-E** | 1.77 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.37 / 3.31 | | |
| **Powerhouse** | 2.16 / 3.57 | | |
| **North Channels** | 2.99 / 3.0C | | |
| **Junction Pool** | 0.29 / 1.53 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.66 | | |
| **B-2** | 0.67 | | |
| **B-3** | 0.68 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.20 | | |
| **Powerhouse C1 (11-2)** | 0.25 | | |
| **Powerhouse C2 (11-3)** | -0.10 | | |
| **Powerhouse C2 (11-4)** | 0.10 | | |
| **Powerhouse C3 (12-1)** | 0.20 | | |
| **Powerhouse C3 (12-2)** | 0.24 | | |
| **Powerhouse C4 (12-3)** | -0.15 | | |
| **Powerhouse C4 (12-4)** | 0.14 | | |
| **Powerhouse C5 (14-1)** | 0.15 | | |
| **Powerhouse C5 (14-2)** | 0.07 | | |
| **Powerhouse C6 (16-1)** | 0.15 | | |
| **Powerhouse C6 (16-2)** | 0.06 | | |
| **Powerhouse C7 (17-1)** | 0.15 | | |
| **Powerhouse C7 (17-2)** | 0.26 | | |
| **Powerhouse C8 (17-3)** | -0.11 | | |
| **Powerhouse C8 (17-4)** | 0.12 | | |
| **Powerhouse C9 (18-1)** | 0.14 | | |
| **Powerhouse C9 (18-2)** | 0.23 | | |
| **Powerhouse C10 (18-3)** | -0.08 | | |
| **Powerhouse C10 (18-4)** | 0.12 | | |
| **A-1** | 0.58 | | |
| **A-2** | 0.52 | | |
| **A-3** | 0.57 | | |
| **A-4** | 0.50 | | |
| **A-5** | 0.56 | | |
| **A-6** | 0.79 | | |
| **A-7** | 0.55 | | |
| **A-8** | 0.77 | | |
| **A-9** | 0.54 | | |
| **A-10** | 0.75 | | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-16
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 23.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.64.15.23 | | |
| **Computer Filename** | TW23Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3505 | | |
| **Total** | 3591 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 10.20 | | |
| **SU-E** | 10.20 | | |
| **ND-E** | 10.20 | | |
| **NU-E** | Closed | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.45 | | |
| **SU-E** | 1.54 | | |
| **ND-E** | 1.90 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.17 / 3.15 | | |
| **Powerhouse** | 1.81 / 3.19 | | |
| **North Channels** | 2.95 / 2.95 | | |
| **Junction Pool** | 0.30 / 1.41 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.74 | | |
| **B-2** | 0.76 | | |
| **B-3** | 0.79 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.30 | | |
| **Powerhouse C1 (11-2)** | 0.23 | | |
| **Powerhouse C2 (11-3)** | -0.20 | | |
| **Powerhouse C2 (11-4)** | 0.13 | | |
| **Powerhouse C3 (12-1)** | 0.28 | | |
| **Powerhouse C3 (12-2)** | 0.20 | | |
| **Powerhouse C4 (12-3)** | -0.15 | | |
| **Powerhouse C4 (12-4)** | 0.11 | | |
| **Powerhouse C5 (14-1)** | 0.19 | | |
| **Powerhouse C5 (14-2)** | 0.03 | | |
| **Powerhouse C6 (16-1)** | 0.18 | | |
| **Powerhouse C6 (16-2)** | 0.03 | | |
| **Powerhouse C7 (17-1)** | 0.19 | | |
| **Powerhouse C7 (17-2)** | 0.25 | | |
| **Powerhouse C8 (17-3)** | -0.12 | | |
| **Powerhouse C8 (17-4)** | 0.09 | | |
| **Powerhouse C9 (18-1)** | 0.18 | | |
| **Powerhouse C9 (18-2)** | 0.24 | | |
| **Powerhouse C10 (18-3)** | -0.13 | | |
| **Powerhouse C10 (18-4)** | 0.10 | | |
| **A-1** | 0.56 | | |
| **A-2** | 0.50 | | |
| **A-3** | 0.54 | | |
| **A-4** | 0.48 | | |
| **A-5** | 0.53 | | |
| **A-6** | 0.74 | | |
| **A-7** | 0.51 | | |
| **A-8** | 0.71 | | |
| **A-9** | 0.50 | | |
| **A-10** | 0.70 | | |

**Notes:** 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.

2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

## Table F-17
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 24.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Model Run Number | 6.65.15.24 | 6.66.15.24 | 6.67.15.24 |
| Computer Filename | TW24Kddr | TW24Pddr | TW24Oddr |
| | Selected | | |
| **Operating Conditions:** | | | |
| Floating Orifices | All Closed | All Closed | All Closed |
| North Diffusers | All Open | All Open | All Open |
| Powerhouse Diffusers | All Open | C1-C5 Closed | All Open |
| South Diffusers | B4-B8 Closed | B2-B8 Closed | All Closed |
| **Input Discharges: (cfs)** | | | |
| Ladder | 86.40 | 86.40 | 86.40 |
| Operating Turbine | 3535 | 3535 | 3535 |
| Total | 3621 | 3621 | 3621 |
| **Weir Elevations: (ft)** | | | |
| SD-E | 11.20 | 14.00 | 14.00 |
| SU-E | 11.20 | 14.00 | 14.00 |
| ND-E | 11.20 | 15.00 | 14.00 |
| NU-E | Closed | 15.00 | 14.00 |
| **Entrance Head drop: (ft)** | | | |
| SD-E | 1.52 | 1.74 | 1.49 |
| SU-E | 1.60 | 1.79 | 1.53 |
| ND-E | 1.94 | 1.87 | 1.77 |
| NU-E | Closed | 1.90 | 1.79 |
| **Submergence: (ft)** | | | |
| SD-E | 12.80 | 10.00 | 10.00 |
| SU-E | 12.80 | 10.00 | 10.00 |
| ND-E | 12.80 | 9.00 | 10.00 |
| NU-E | Closed | 9.00 | 10.00 |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| South Channel | 2.13 / 3.07 | 1.99 / 2.47 | 1.84 / 2.32 |
| Powerhouse | 1.82 / 3.14 | 2.30 / 3.12 | 1.70 / 3.39 |
| North Channels | 2.85 / 3.82 | 1.91 / 1.92 | 2.07 / 2.09 |
| Junction Pool | 0.30 / 1.38 | 0.67 / 1.81 | 0.63 / 1.72 |
| **Diffuser Velocities: (fps)** | | | |
| B-1 | 0.74 | 0.86 | 0.00 |
| B-2 | 0.76 | 0.00 | 0.00 |
| B-3 | 0.78 | 0.00 | 0.00 |
| B-4 | 0.00 | 0.00 | 0.00 |
| B-5 | 0.00 | 0.00 | 0.00 |
| B-6 | 0.00 | 0.00 | 0.00 |
| B-7 | 0.00 | 0.00 | 0.00 |
| B-8 | 0.00 | 0.00 | 0.00 |
| Powerhouse C1 (11-1) | 0.28 | 0.00 | 0.31 |
| Powerhouse C1 (11-2) | 0.24 | 0.00 | 0.31 |
| Powerhouse C2 (11-3) | -0.18 | 0.00 | -0.18 |
| Powerhouse C2 (11-4) | 0.13 | 0.00 | 0.15 |
| Powerhouse C3 (12-1) | 0.27 | 0.00 | 0.32 |
| Powerhouse C3 (12-2) | 0.21 | 0.00 | 0.25 |
| Powerhouse C4 (12-3) | -0.14 | 0.00 | -0.13 |
| Powerhouse C4 (12-4) | 0.11 | 0.00 | 0.13 |
| Powerhouse C5 (14-1) | 0.17 | 0.00 | 0.20 |
| Powerhouse C5 (14-2) | 0.04 | 0.00 | 0.08 |
| Powerhouse C6 (16-1) | 0.17 | 0.14 | 0.20 |
| Powerhouse C6 (16-2) | 0.05 | 0.13 | 0.07 |
| Powerhouse C7 (17-1) | 0.20 | 0.19 | 0.22 |
| Powerhouse C7 (17-2) | 0.23 | 0.28 | 0.29 |
| Powerhouse C8 (17-3) | -0.12 | -0.06 | -0.11 |
| Powerhouse C8 (17-4) | 0.10 | 0.12 | 0.13 |
| Powerhouse C9 (18-1) | 0.17 | 0.18 | 0.21 |
| Powerhouse C9 (18-2) | 0.25 | 0.23 | 0.25 |
| Powerhouse C10 (18-3) | -0.12 | 0.00 | -0.07 |
| Powerhouse C10 (18-4) | 0.09 | 0.12 | 0.12 |
| A-1 | 0.56 | 0.75 | 0.72 |
| A-2 | 0.50 | 0.66 | 0.64 |
| A-3 | 0.54 | 0.73 | 0.70 |
| A-4 | 0.48 | 0.65 | 0.62 |
| A-5 | 0.53 | 0.72 | 0.68 |
| A-6 | 0.74 | 1.01 | 0.95 |
| A-7 | 0.52 | 0.71 | 0.66 |
| A-8 | 0.72 | 0.99 | 0.93 |
| A-9 | 0.50 | 0.70 | 0.65 |
| A-10 | 0.70 | 0.98 | 0.90 |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-18
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 25.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.68.15.25 | | |
| **Computer Filename** | TW25Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3535 | | |
| **Total** | 3621 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 12.20 | | |
| **SU-E** | 12.20 | | |
| **ND-E** | 12.20 | | |
| **NU-E** | Closed | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.47 | | |
| **SU-E** | 1.54 | | |
| **ND-E** | 1.85 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 2.02 / 2.91 | | |
| **Powerhouse** | 1.74 / 2.99 | | |
| **North Channels** | 2.68 / 3.59 | | |
| **Junction Pool** | 0.29 / 1.31 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.71 | | |
| **B-2** | 0.73 | | |
| **B-3** | 0.75 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.25 | | |
| **Powerhouse C1 (11-2)** | 0.23 | | |
| **Powerhouse C2 (11-3)** | -0.13 | | |
| **Powerhouse C2 (11-4)** | 0.10 | | |
| **Powerhouse C3 (12-1)** | 0.26 | | |
| **Powerhouse C3 (12-2)** | 0.21 | | |
| **Powerhouse C4 (12-3)** | -0.13 | | |
| **Powerhouse C4 (12-4)** | 0.10 | | |
| **Powerhouse C5 (14-1)** | 0.17 | | |
| **Powerhouse C5 (14-2)** | 0.04 | | |
| **Powerhouse C6 (16-1)** | 0.15 | | |
| **Powerhouse C6 (16-2)** | 0.06 | | |
| **Powerhouse C7 (17-1)** | 0.18 | | |
| **Powerhouse C7 (17-2)** | 0.23 | | |
| **Powerhouse C8 (17-3)** | -0.12 | | |
| **Powerhouse C8 (17-4)** | 0.10 | | |
| **Powerhouse C9 (18-1)** | 0.17 | | |
| **Powerhouse C9 (18-2)** | 0.23 | | |
| **Powerhouse C10 (18-3)** | -0.11 | | |
| **Powerhouse C10 (18-4)** | 0.09 | | |
| **A-1** | 0.55 | | |
| **A-2** | 0.49 | | |
| **A-3** | 0.53 | | |
| **A-4** | 0.47 | | |
| **A-5** | 0.52 | | |
| **A-6** | 0.72 | | |
| **A-7** | 0.50 | | |
| **A-8** | 0.70 | | |
| **A-9** | 0.49 | | |
| **A-10** | 0.68 | | |

Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.
2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

**Table F-19**
**Numerical Model Results**
**One Turbine Operating Scenario**
**Tailwater Elevation 26.0 ft**

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.69.15.26 | | |
| **Computer Filename** | TW26Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3365 | | |
| **Total** | 3451 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 13.20 | | |
| **SU-E** | 13.20 | | |
| **ND-E** | 13.20 | | |
| **NU-E** | 13.20 | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.44 | | |
| **SU-E** | 1.51 | | |
| **ND-E** | 1.78 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 1.94 / 2.77 | | |
| **Powerhouse** | 1.71 / 2.87 | | |
| **North Channels** | 2.53 / 3.39 | | |
| **Junction Pool** | 0.27 / 1.26 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.68 | | |
| **B-2** | 0.71 | | |
| **B-3** | 0.72 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.24 | | |
| **Powerhouse C1 (11-2)** | 0.24 | | |
| **Powerhouse C2 (11-3)** | -0.14 | | |
| **Powerhouse C2 (11-4)** | 0.10 | | |
| **Powerhouse C3 (12-1)** | 0.24 | | |
| **Powerhouse C3 (12-2)** | 0.21 | | |
| **Powerhouse C4 (12-3)** | -0.14 | | |
| **Powerhouse C4 (12-4)** | 0.11 | | |
| **Powerhouse C5 (14-1)** | 0.16 | | |
| **Powerhouse C5 (14-2)** | 0.05 | | |
| **Powerhouse C6 (16-1)** | 0.15 | | |
| **Powerhouse C6 (16-2)** | 0.05 | | |
| **Powerhouse C7 (17-1)** | 0.16 | | |
| **Powerhouse C7 (17-2)** | 0.21 | | |
| **Powerhouse C8 (17-3)** | -0.07 | | |
| **Powerhouse C8 (17-4)** | 0.09 | | |
| **Powerhouse C9 (18-1)** | 0.16 | | |
| **Powerhouse C9 (18-2)** | 0.21 | | |
| **Powerhouse C10 (18-3)** | -0.08 | | |
| **Powerhouse C10 (18-4)** | 0.08 | | |
| **A-1** | 0.54 | | |
| **A-2** | 0.48 | | |
| **A-3** | 0.52 | | |
| **A-4** | 0.46 | | |
| **A-5** | 0.51 | | |
| **A-6** | 0.71 | | |
| **A-7** | 0.50 | | |
| **A-8** | 0.69 | | |
| **A-9** | 0.49 | | |
| **A-10** | 0.68 | | |

**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**
**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**

## Table F-20
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 27.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.70.15.27 | | |
| **Computer Filename** | TW27Kddr | | |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | | |
| **North Diffusers** | All Open | | |
| **Powerhouse Diffusers** | All Open | | |
| **South Diffusers** | B4-B8 Closed | | |
| **Input Discharges:** | | | |
| **Ladder** | 86.40 | | |
| **Operating Turbine** | 3285 | | |
| **Total** | 3371 | | |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 14.20 | | |
| **SU-E** | 14.20 | | |
| **ND-E** | 14.20 | | |
| **NU-E** | Closed | | |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.40 | | |
| **SU-E** | 1.46 | | |
| **ND-E** | 1.70 | | |
| **NU-E** | Closed | | |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | | |
| **SU-E** | 12.80 | | |
| **ND-E** | 12.80 | | |
| **NU-E** | Closed | | |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 1.88 / 2.63 | | |
| **Powerhouse** | 1.64 / 2.75 | | |
| **North Channels** | 2.38 / 3.19 | | |
| **Junction Pool** | 0.26 / 1.20 | | |
| **Diffuser Velocities:** | | | |
| **B-1** | 0.66 | | |
| **B-2** | 0.68 | | |
| **B-3** | 0.70 | | |
| **B-4** | 0.00 | | |
| **B-5** | 0.00 | | |
| **B-6** | 0.00 | | |
| **B-7** | 0.00 | | |
| **B-8** | 0.00 | | |
| **Powerhouse C1 (11-1)** | 0.23 | | |
| **Powerhouse C1 (11-2)** | 0.21 | | |
| **Powerhouse C2 (11-3)** | -0.13 | | |
| **Powerhouse C2 (11-4)** | 0.11 | | |
| **Powerhouse C3 (12-1)** | 0.22 | | |
| **Powerhouse C3 (12-2)** | 0.21 | | |
| **Powerhouse C4 (12-3)** | -0.11 | | |
| **Powerhouse C4 (12-4)** | 0.09 | | |
| **Powerhouse C5 (14-1)** | 0.16 | | |
| **Powerhouse C5 (14-2)** | 0.04 | | |
| **Powerhouse C6 (16-1)** | 0.15 | | |
| **Powerhouse C6 (16-2)** | 0.05 | | |
| **Powerhouse C7 (17-1)** | 0.16 | | |
| **Powerhouse C7 (17-2)** | 0.22 | | |
| **Powerhouse C8 (17-3)** | -0.10 | | |
| **Powerhouse C8 (17-4)** | 0.09 | | |
| **Powerhouse C9 (18-1)** | 0.15 | | |
| **Powerhouse C9 (18-2)** | 0.21 | | |
| **Powerhouse C10 (18-3)** | -0.07 | | |
| **Powerhouse C10 (18-4)** | 0.07 | | |
| **A-1** | 0.53 | | |
| **A-2** | 0.47 | | |
| **A-3** | 0.51 | | |
| **A-4** | 0.46 | | |
| **A-5** | 0.50 | | |
| **A-6** | 0.70 | | |
| **A-7** | 0.49 | | |
| **A-8** | 0.68 | | |
| **A-9** | 0.48 | | |
| **A-10** | 0.66 | | |

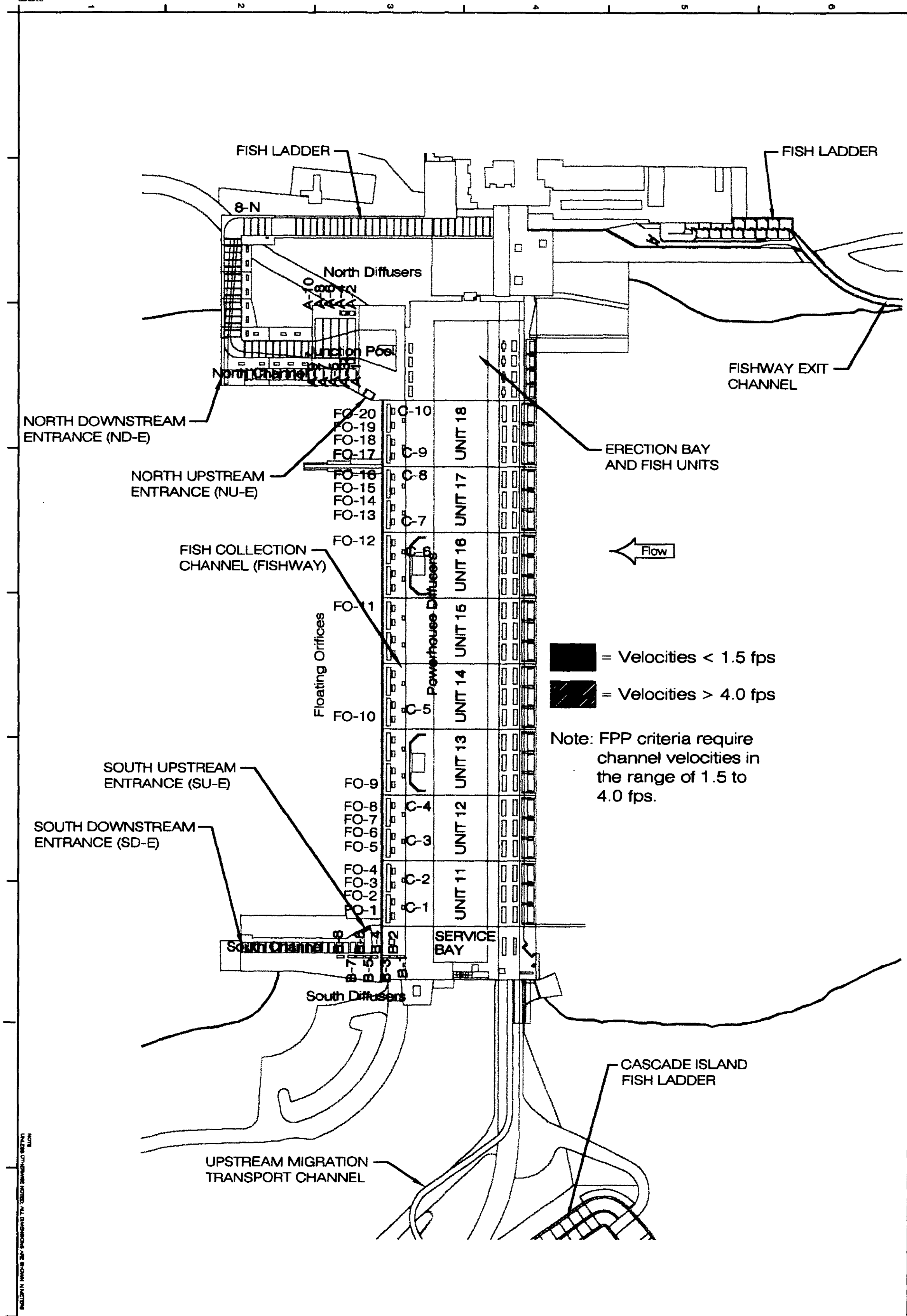
Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.
2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.

## Table F-21
## Numerical Model Results
## One Turbine Operating Scenario
## Tailwater Elevation 28.0 ft

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| **Model Run Number** | 6.71.15.28 | 6.72.15.28 | 6.73.15.28 |
| **Computer Filename** | TW28Kddr | TW28Pddr | TW28Oddr |
| | Selected | | |
| **Operating Conditions:** | | | |
| **Floating Orifices** | All Closed | All Closed | All Closed |
| **North Diffusers** | All Open | All Open | All Open |
| **Powerhouse Diffusers** | All Open | C1-C5 Closed | All Open |
| **South Diffusers** | B3-B8 Closed | B2-B8 Closed | All Closed |
| **Input Discharges: (cfs)** | | | |
| **Ladder** | 86.40 | 86.40 | 86.40 |
| **Operating Turbine** | 3160 | 3160 | 3160 |
| **Total** | 3246 | 3246 | 3246 |
| **Weir Elevations: (ft)** | | | |
| **SD-E** | 15.20 | 18.00 | 17.00 |
| **SU-E** | 15.20 | 18.00 | 17.00 |
| **ND-E** | 15.20 | 19.00 | 17.80 |
| **NU-E** | Closed | 19.00 | 17.80 |
| **Entrance Head drop: (ft)** | | | |
| **SD-E** | 1.32 | 1.45 | 1.12 |
| **SU-E** | 1.38 | 1.48 | 1.15 |
| **ND-E** | 1.58 | 1.59 | 1.29 |
| **NU-E** | Closed | 1.61 | 1.31 |
| **Submergence: (ft)** | | | |
| **SD-E** | 12.80 | 10.00 | 11.00 |
| **SU-E** | 12.80 | 10.00 | 11.00 |
| **ND-E** | 12.80 | 9.00 | 10.20 |
| **NU-E** | Closed | 9.00 | 10.20 |
| **Collection Channel Velocities: (fps)** | **min / max** | **min / max** | **min / max** |
| **South Channel** | 1.94 / 2.47 | 1.57 / 1.96 | 1.55 / 1.95 |
| **Powerhouse** | 1.78 / 2.89 | 1.80 / 2.46 | 1.51 / 2.84 |
| **North Channels** | 2.22 / 2.23 | 1.52 / 1.53 | 1.57 / 1.59 |
| **Junction Pool** | 0.46 / 1.19 | 0.54 / 1.43 | 0.49 / 1.38 |
| **Diffuser Velocities: (fps)** | | | |
| **B-1** | 0.69 | 0.80 | 0.00 |
| **B-2** | 0.71 | 0.00 | 0.00 |
| **B-3** | 0.00 | 0.00 | 0.00 |
| **B-4** | 0.00 | 0.00 | 0.00 |
| **B-5** | 0.00 | 0.00 | 0.00 |
| **B-6** | 0.00 | 0.00 | 0.00 |
| **B-7** | 0.00 | 0.00 | 0.00 |
| **B-8** | 0.00 | 0.00 | 0.00 |
| **Powerhouse C1 (11-1)** | 0.23 | 0.00 | 0.26 |
| **Powerhouse C1 (11-2)** | 0.24 | 0.00 | 0.22 |
| **Powerhouse C2 (11-3)** | -0.15 | 0.00 | -0.06 |
| **Powerhouse C2 (11-4)** | 0.12 | 0.00 | 0.09 |
| **Powerhouse C3 (12-1)** | 0.23 | 0.14 | 0.24 |
| **Powerhouse C3 (12-2)** | 0.21 | -0.07 | 0.23 |
| **Powerhouse C4 (12-3)** | -0.11 | -0.04 | -0.07 |
| **Powerhouse C4 (12-4)** | 0.09 | -0.03 | 0.10 |
| **Powerhouse C5 (14-1)** | 0.15 | 0.00 | 0.16 |
| **Powerhouse C5 (14-2)** | 0.06 | 0.00 | 0.08 |
| **Powerhouse C6 (16-1)** | 0.15 | 0.16 | 0.17 |
| **Powerhouse C6 (16-2)** | 0.05 | 0.09 | 0.07 |
| **Powerhouse C7 (17-1)** | 0.17 | 0.18 | 0.18 |
| **Powerhouse C7 (17-2)** | 0.22 | 0.27 | 0.25 |
| **Powerhouse C8 (17-3)** | -0.09 | -0.07 | -0.06 |
| **Powerhouse C8 (17-4)** | 0.09 | 0.11 | 0.10 |
| **Powerhouse C9 (18-1)** | 0.16 | 0.20 | 0.17 |
| **Powerhouse C9 (18-2)** | 0.21 | 0.21 | 0.24 |
| **Powerhouse C10 (18-3)** | -0.06 | -0.04 | -0.05 |
| **Powerhouse C10 (18-4)** | 0.08 | 0.11 | 0.10 |
| **A-1** | 0.54 | 0.66 | 0.65 |
| **A-2** | 0.48 | 0.59 | 0.58 |
| **A-3** | 0.53 | 0.65 | 0.63 |
| **A-4** | 0.47 | 0.58 | 0.56 |
| **A-5** | 0.52 | 0.63 | 0.62 |
| **A-6** | 0.72 | 0.89 | 0.87 |
| **A-7** | 0.50 | 0.62 | 0.61 |
| **A-8** | 0.70 | 0.86 | 0.84 |
| **A-9** | 0.49 | 0.61 | 0.60 |
| **A-10** | 0.69 | 0.85 | 0.83 |

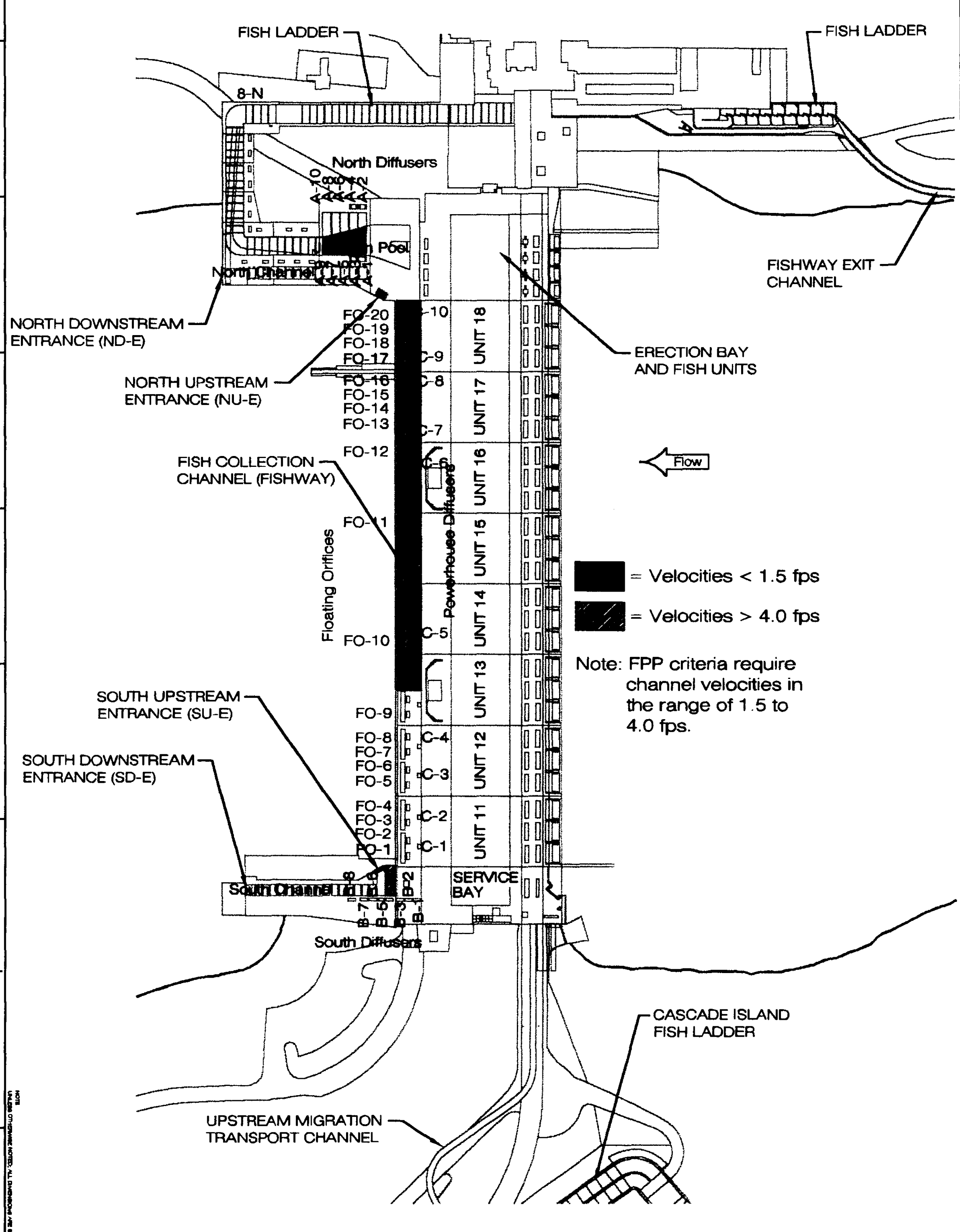
**Notes: 1. Powerhouse Diffuser configuration allows flow into the diffuser chamber via the collection channel even though the diffuser gate is closed in some cases.**

**2. Fish ladder diffuser velocities are not shown because velocities are always less than 0.5 fps.**




| | | | | | |
|---|---|---|---|---|---|
| PLATE 2 | DRAWING NO. | DRAWING STATUS: | COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>FEATURE LOCATION KEY | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E.<br>Acting Chief, Struct. & Arch. Design | Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager: |

Figure F-1

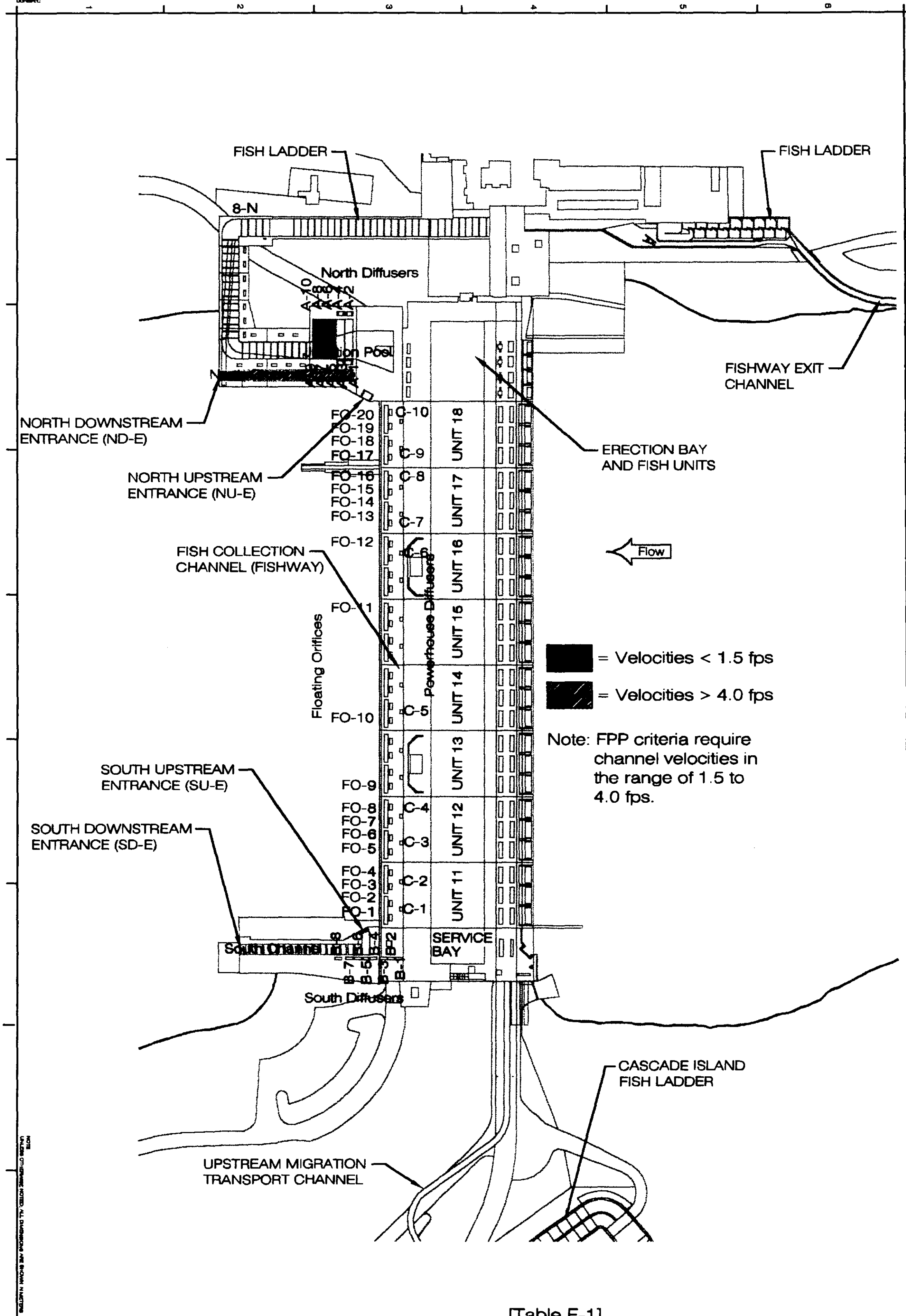



[Table F-1]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 8<br>CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch Design | Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager |

PLATE 2

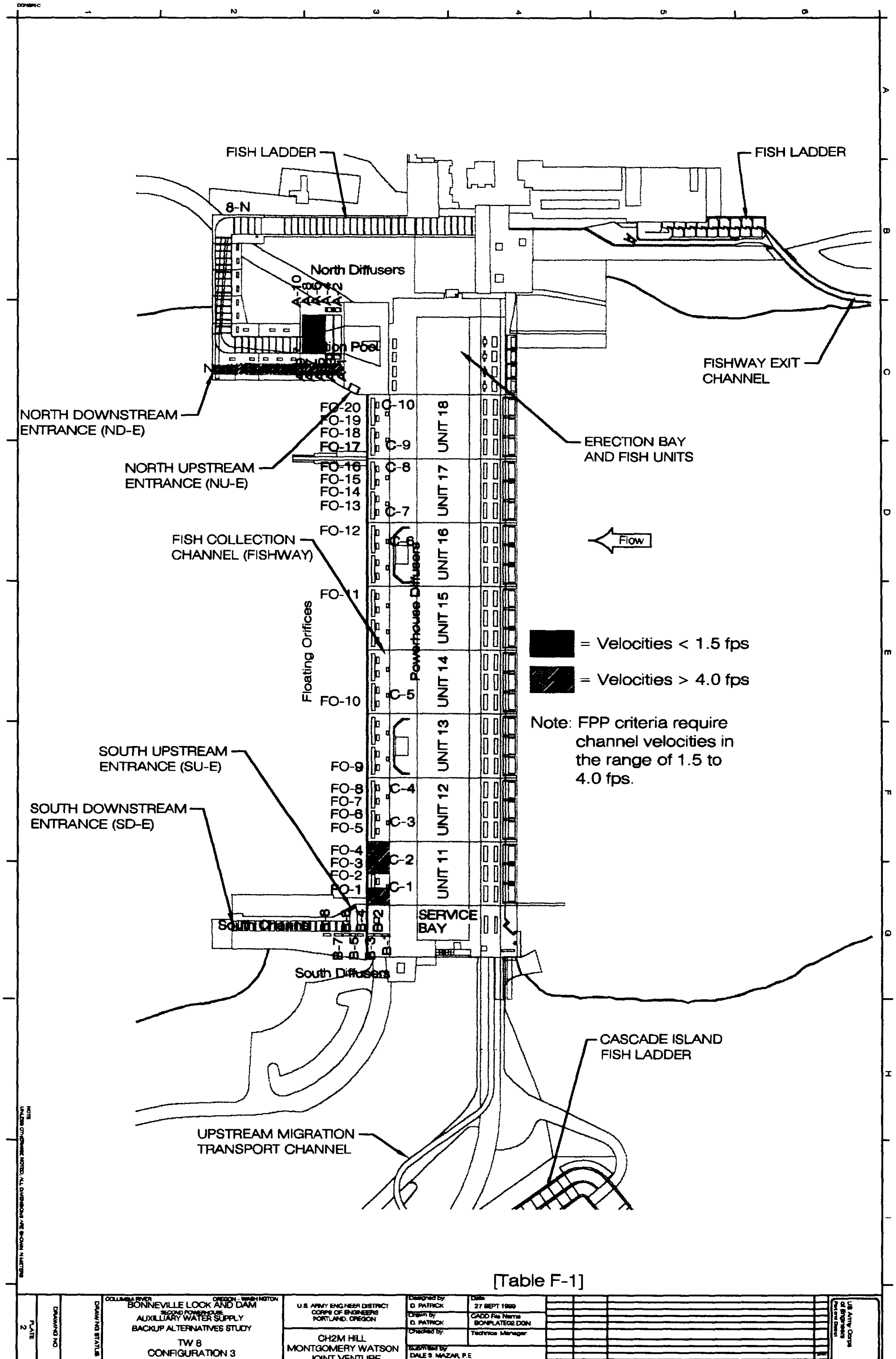
Figure F-2




[Table F-1]

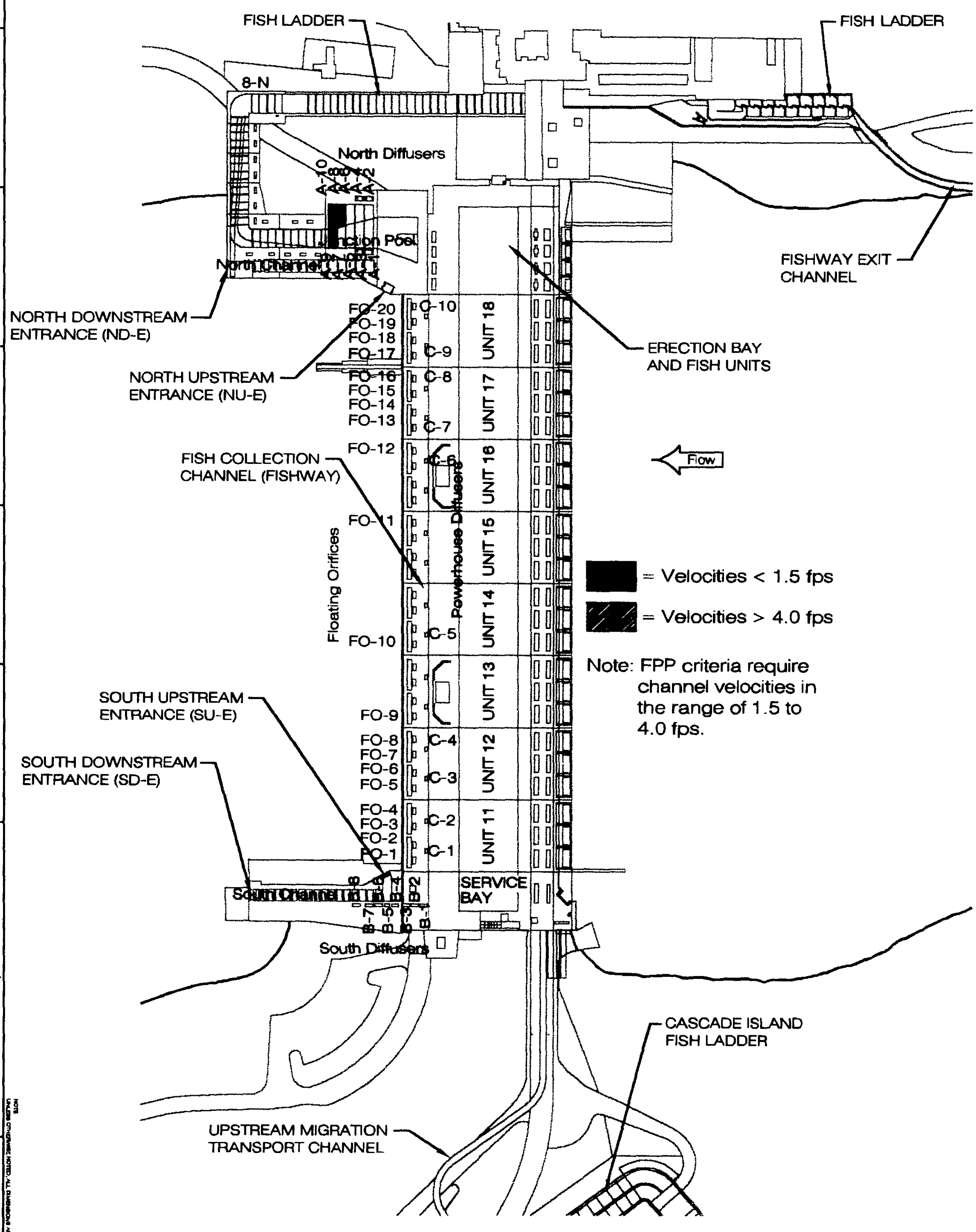
| | | | |
|---|---|---|---|
| PLATE 2 | COLUMBIA RIVER, OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 8<br>CONFIGURATION 2 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct & Arch Design<br>Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager |

Figure F-3




[Table F-1]

Figure F-4




[Table F-2]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER OREGON - WASHINGTON BONNEVILLE LOCK AND DAM SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP ALTERNATIVES STUDY TW 9 CONFIGURATION 3 | U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON CH2M HILL MONTGOMERY WATSON JOINT VENTURE | Designed by D. PATRICK; Drawn by D. PATRICK; Checked by; Submitted by DALE S. MAZAR, P.E. Acting Chief Struct & Arch Design | Date 27 SEPT 1999; CADD File Name BONPLATE02.DGN; Technical Manager |

PLATE 2

Figure F-5

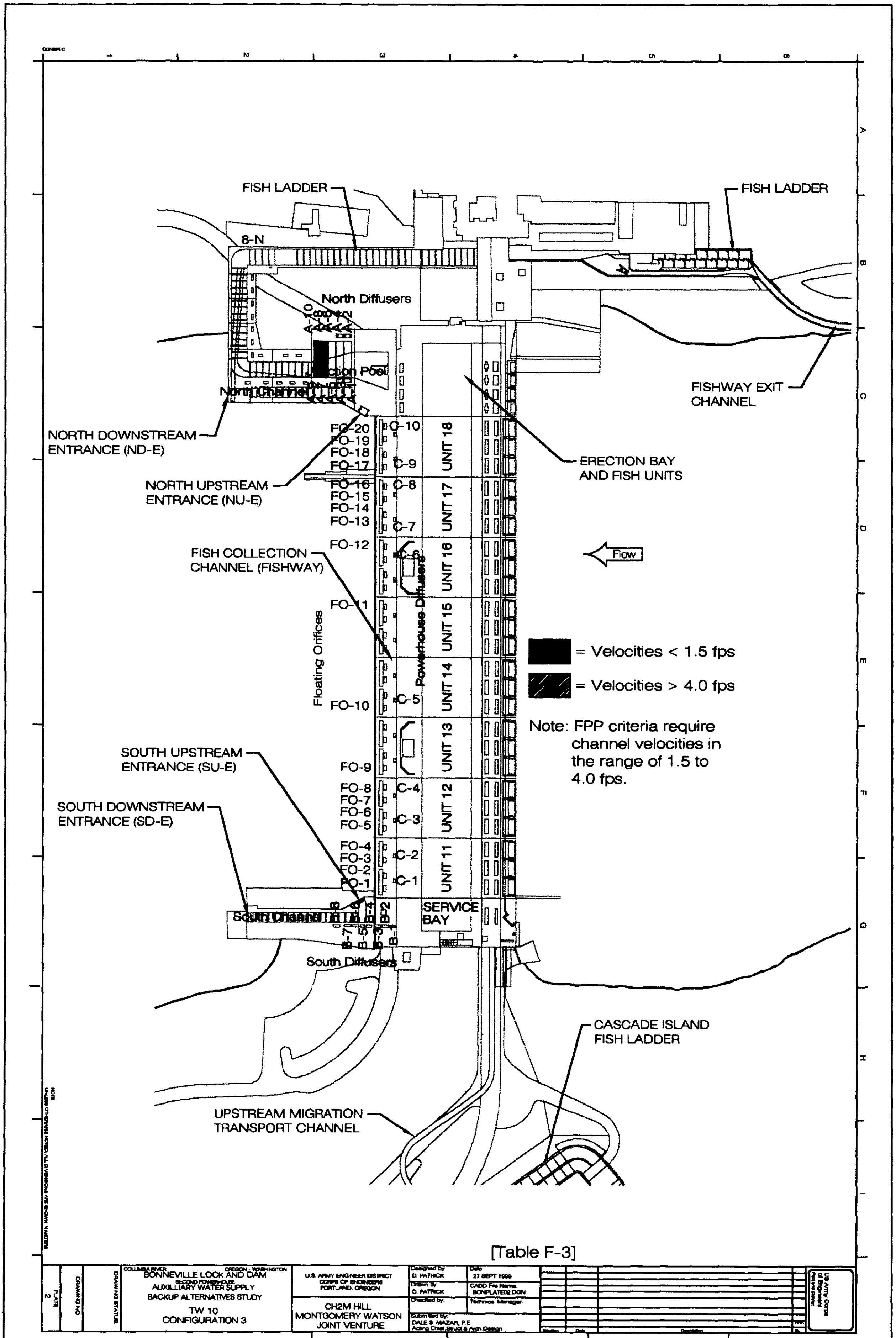
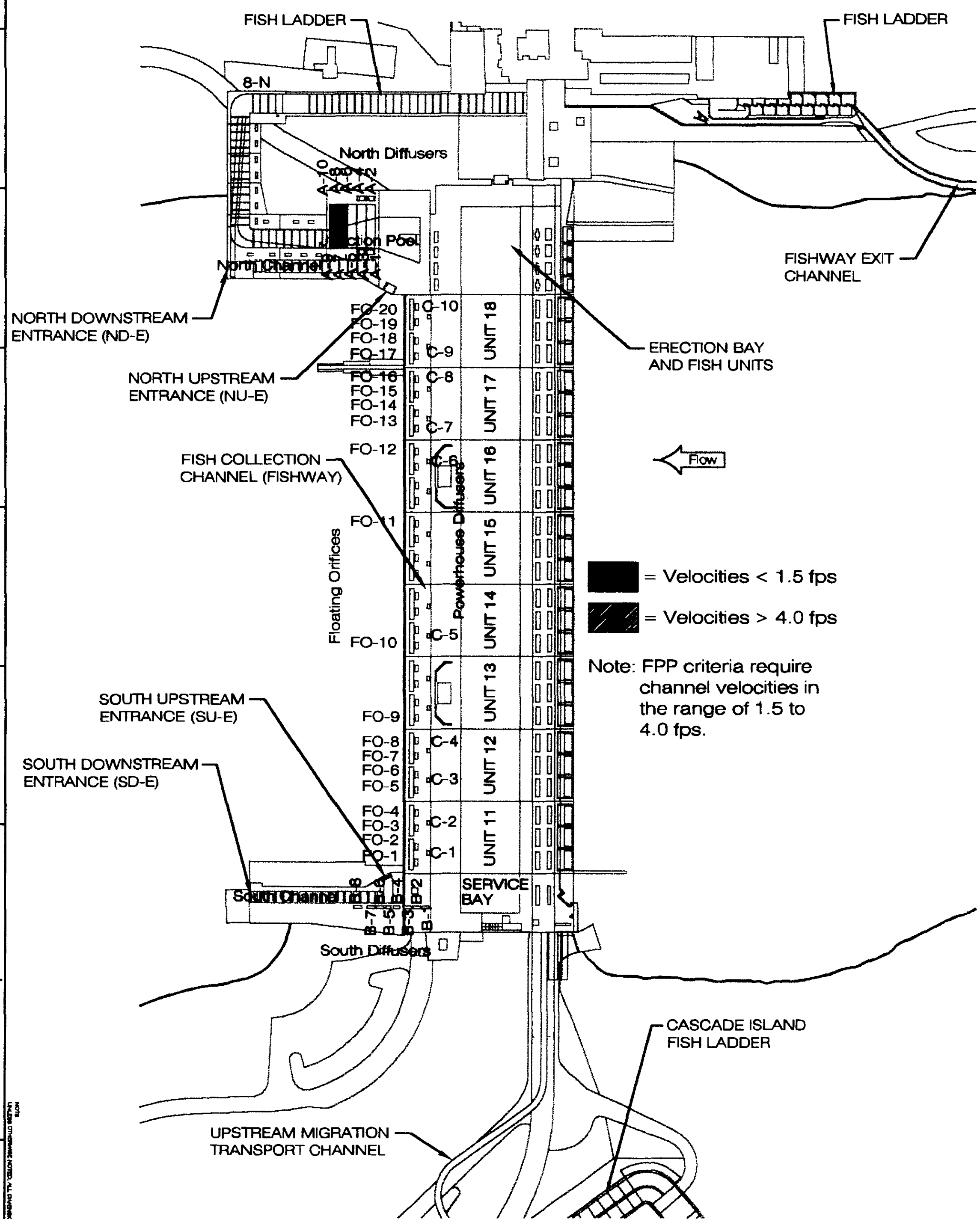

FISH LADDER
FISH LADDER
North Diffusers
Junction Pool
North Channel
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
FISH COLLECTION CHANNEL (FISHWAY)
Floating Orifices
Powerhouse Diffusers
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
South Diffusers
SERVICE BAY
UNIT 11
UNIT 12
UNIT 13
UNIT 14
UNIT 15
UNIT 16
UNIT 17
UNIT 18
FISHWAY EXIT CHANNEL
ERECTION BAY AND FISH UNITS
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-3]
BONNEVILLE LOCK AND DAM
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 10
CONFIGURATION 3
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE
PLATE 2

Figure F-6

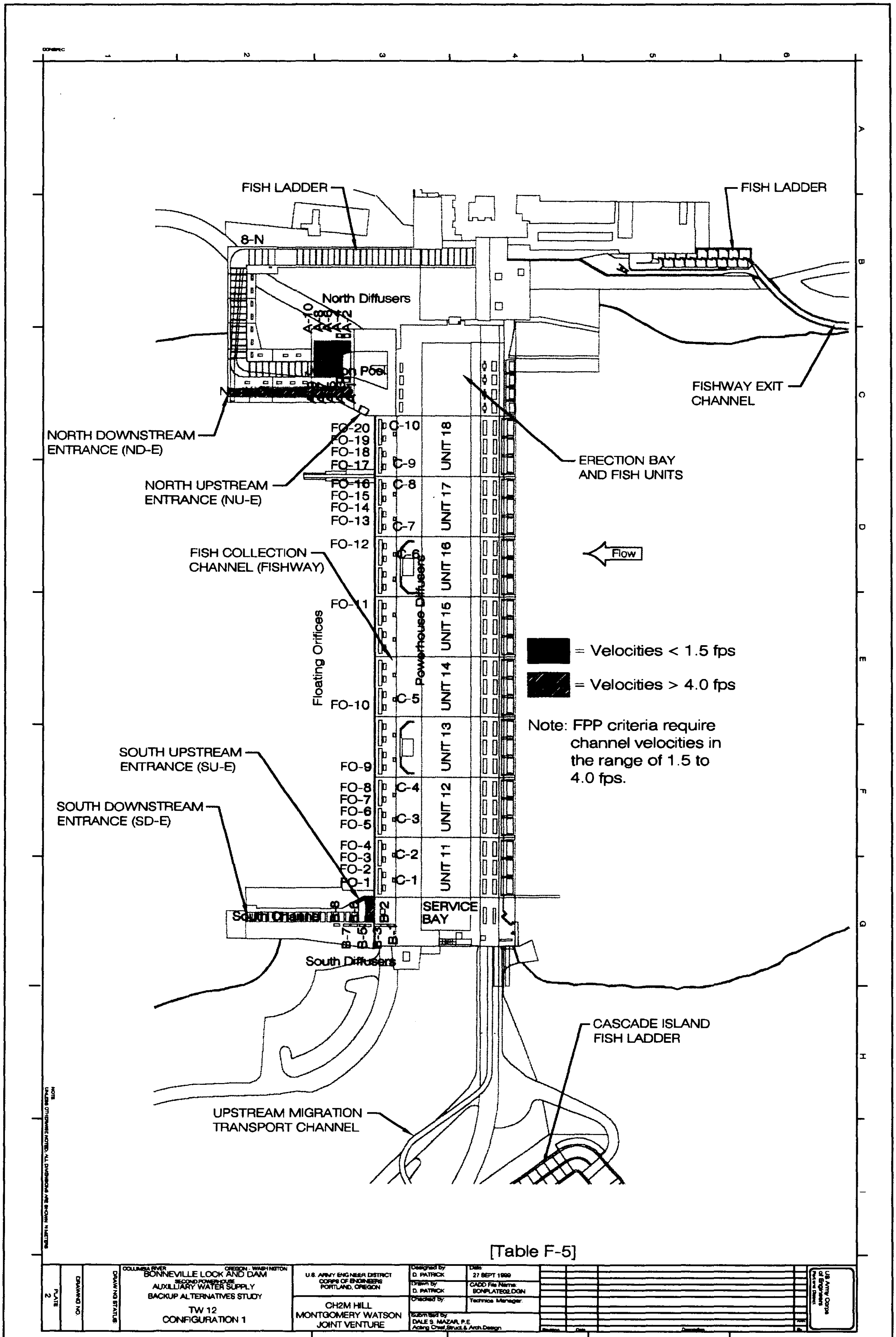



[Table F-4]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 11<br>CONFIGURATION 3 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct & Arch Design | Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager: |

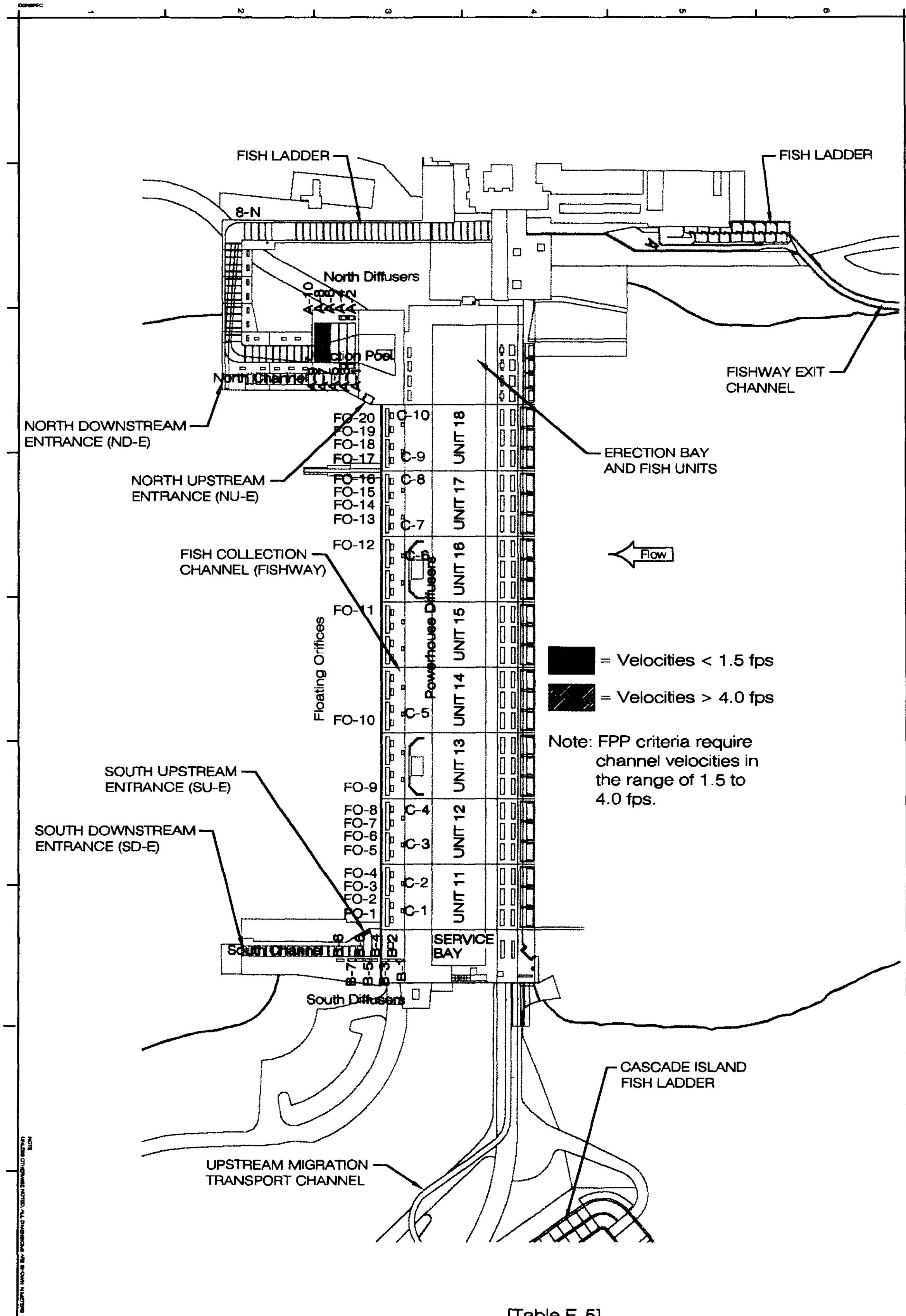
PLATE 2

Figure F-7



FISH LADDER
FISH LADDER
8-N
North Diffusers
FISHWAY EXIT CHANNEL
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
ERECTION BAY AND FISH UNITS
FO-20
FO-19
FO-18
FO-17
FO-16
FO-15
FO-14
FO-13
FO-12
FO-11
FO-10
FO-9
FO-8
FO-7
FO-6
FO-5
FO-4
FO-3
FO-2
FO-1
C-10
C-9
C-8
C-7
C-6
C-5
C-4
C-3
C-2
C-1
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
Flow
FISH COLLECTION CHANNEL (FISHWAY)
Floating Orifices
Powerhouse Diffusers
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
SERVICE BAY
South Channel
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-5]
COLUMBIA RIVER
OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 12
CONFIGURATION 1
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE
Designed by D. PATRICK
Drawn by D. PATRICK
Checked by
Submitted by DALE S. MAZAR, P.E.
Acting Chief, Struct. & Arch. Design
Date 27 SEPT 1999
CADD File Name BONPLATE02.DGN
Technical Manager
PLATE 2
US Army Corps of Engineers

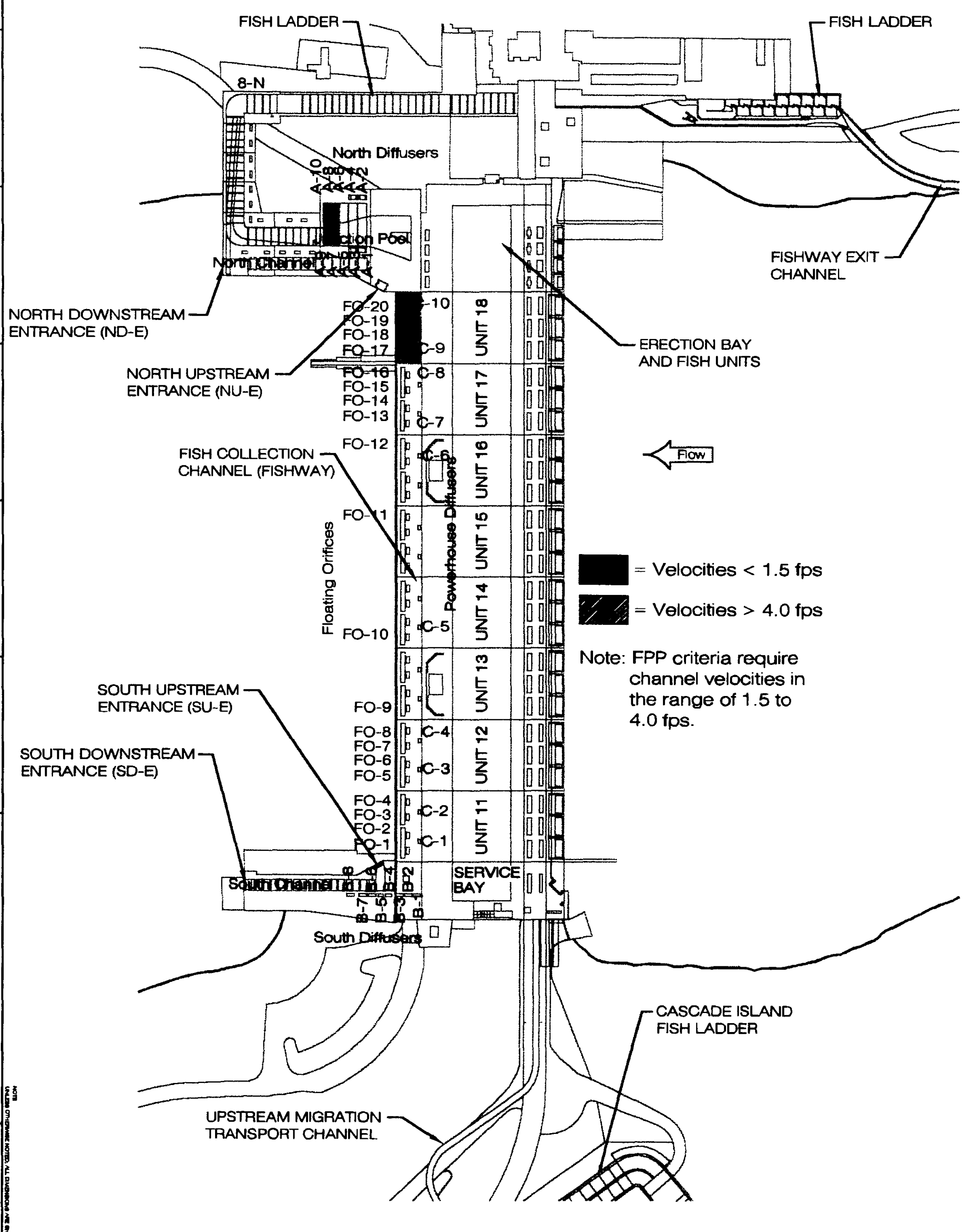

Figure F-8




[Table F-5]

| | | | |
|---|---|---|---|
| PLATE 2 | COLUMBIA RIVER OREGON - WASHINGTON BONNEVILLE LOCK AND DAM SECOND POWERHOUSE AUXILLIARY WATER SUPPLY BACKUP ALTERNATIVES STUDY TW 12 CONFIGURATION 2 | U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON<br>CH2M HILL MONTGOMERY WATSON JOINT VENTURE | Designed by: D. PATRICK; Date: 27 SEPT 1999; Drawn by: D. PATRICK; CADD File Name: BONPLATE02.DGN; Checked by:; Technical Manager:; Submitted by: DALE S. MAZAR, P.E. Acting Chief Struct. & Arch. Design |

Figure F-9

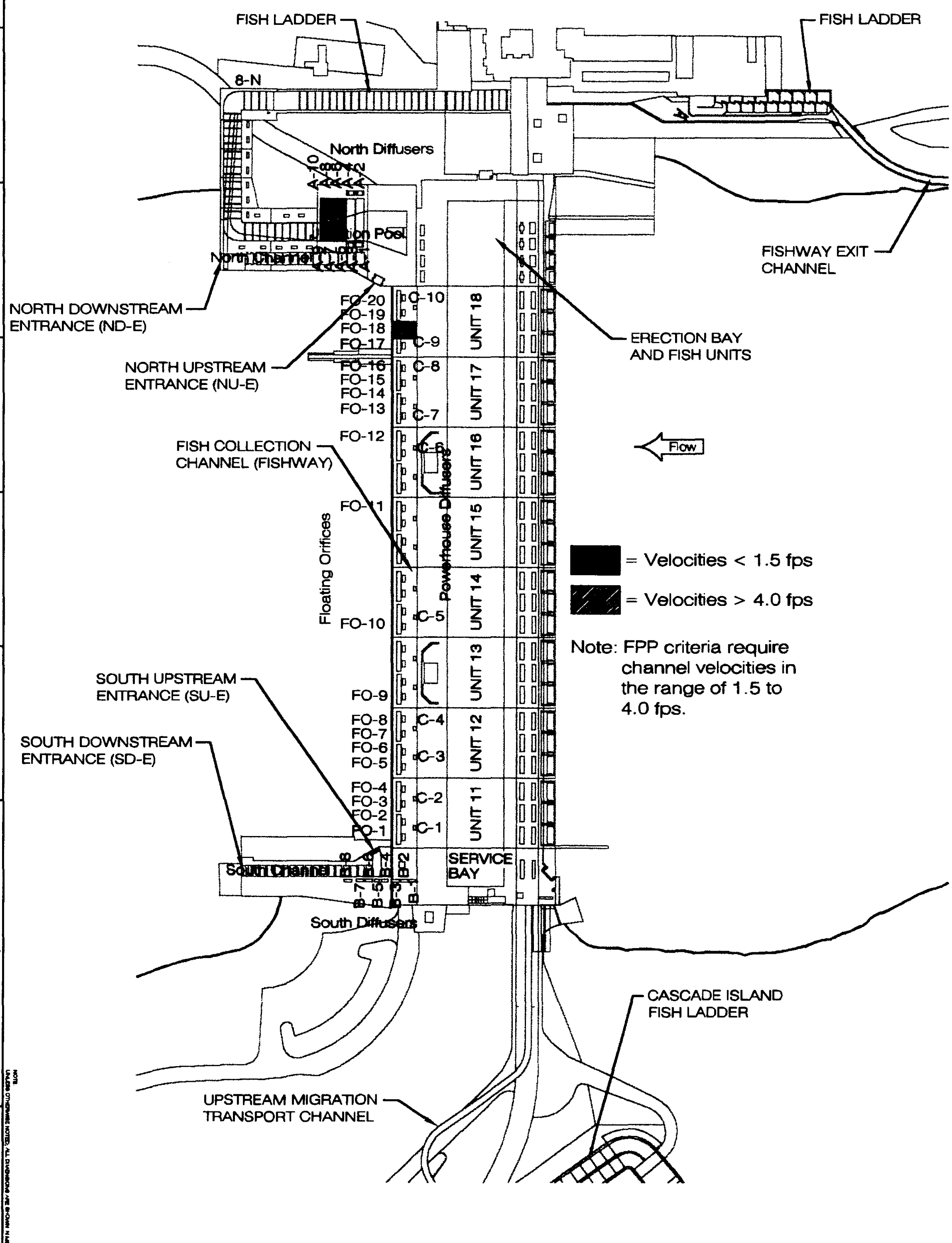



[Table F-5]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 12<br>CONFIGURATION 3 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK<br>Drawn by D. PATRICK<br>Checked by<br>Submitted by DALE S. MAZAR, P.E.<br>Acting Chief, Struct. & Arch Design | Date 27 SEPT 1999<br>CADD File Name BONPLATE02.DGN<br>Technical Manager |

PLATE 2

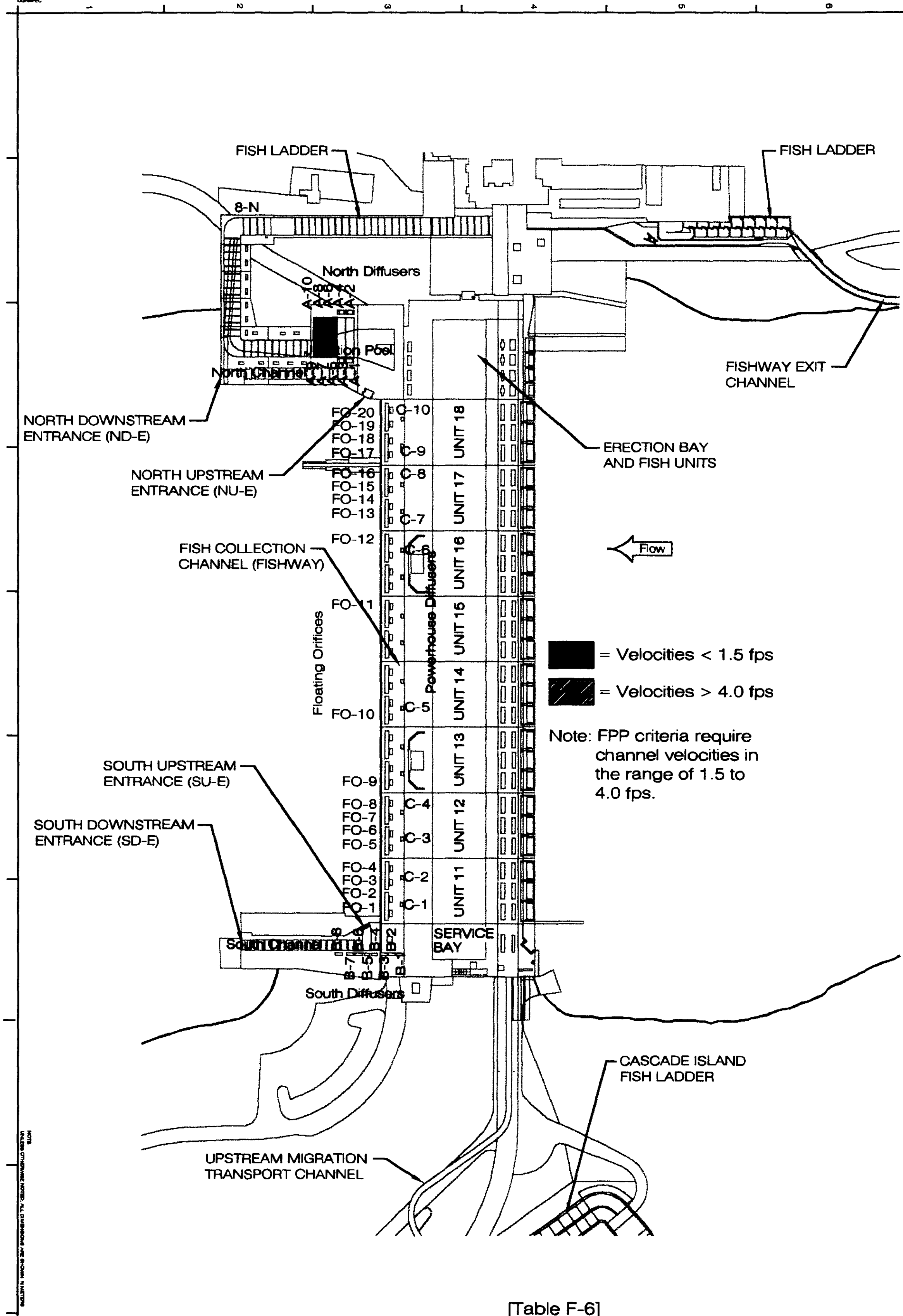
Figure F-10




[Table F-5a]

| | | | | | |
|---|---|---|---|---|---|
| PLATE 2 | DRAWING NO. | DRAWING STATUS: | COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 12<br>CONFIGURATION 2 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Date: 27 SEPT 1999<br>Drawn by: D. PATRICK<br>CADD File Name: BONPLATE02.DGN<br>Checked by:<br>Technical Manager:<br>Submitted by: DALE S. MAZAR, P.E.<br>Acting Chief, Struct & Arch Design |

Figure F-11




[Table F-6]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 13
CONFIGURATION 2

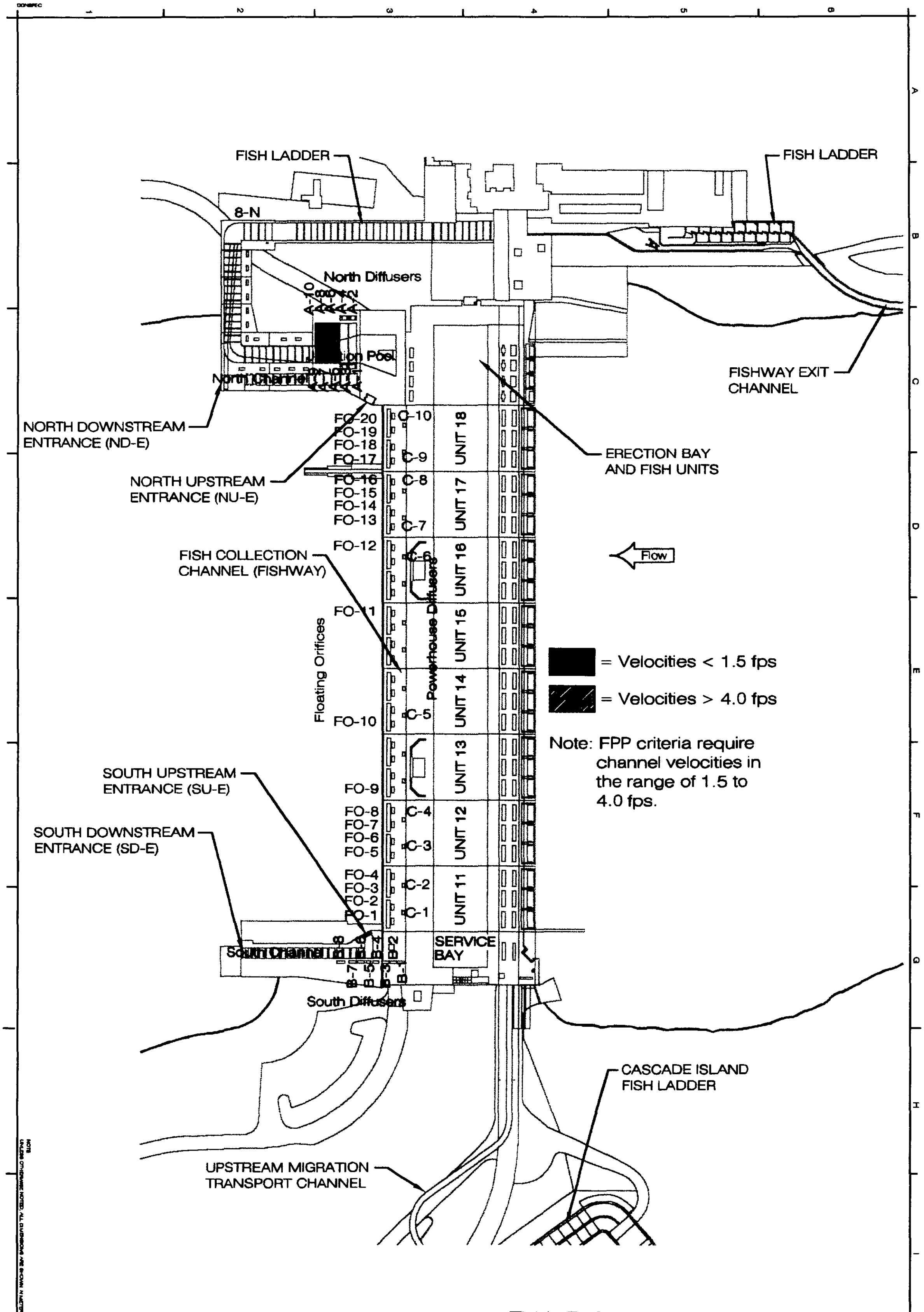
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK — Date: 27 SEPT 1999
Drawn by: D. PATRICK — CADD File Name: BONPLATE02.DGN
Checked by: — Technical Manager:
Submitted by: DALE S. MAZAR, P.E., Acting Chief, Struct. & Arch. Design

PLATE 2

Figure F-12




[Table F-7]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 14
CONFIGURATION 2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

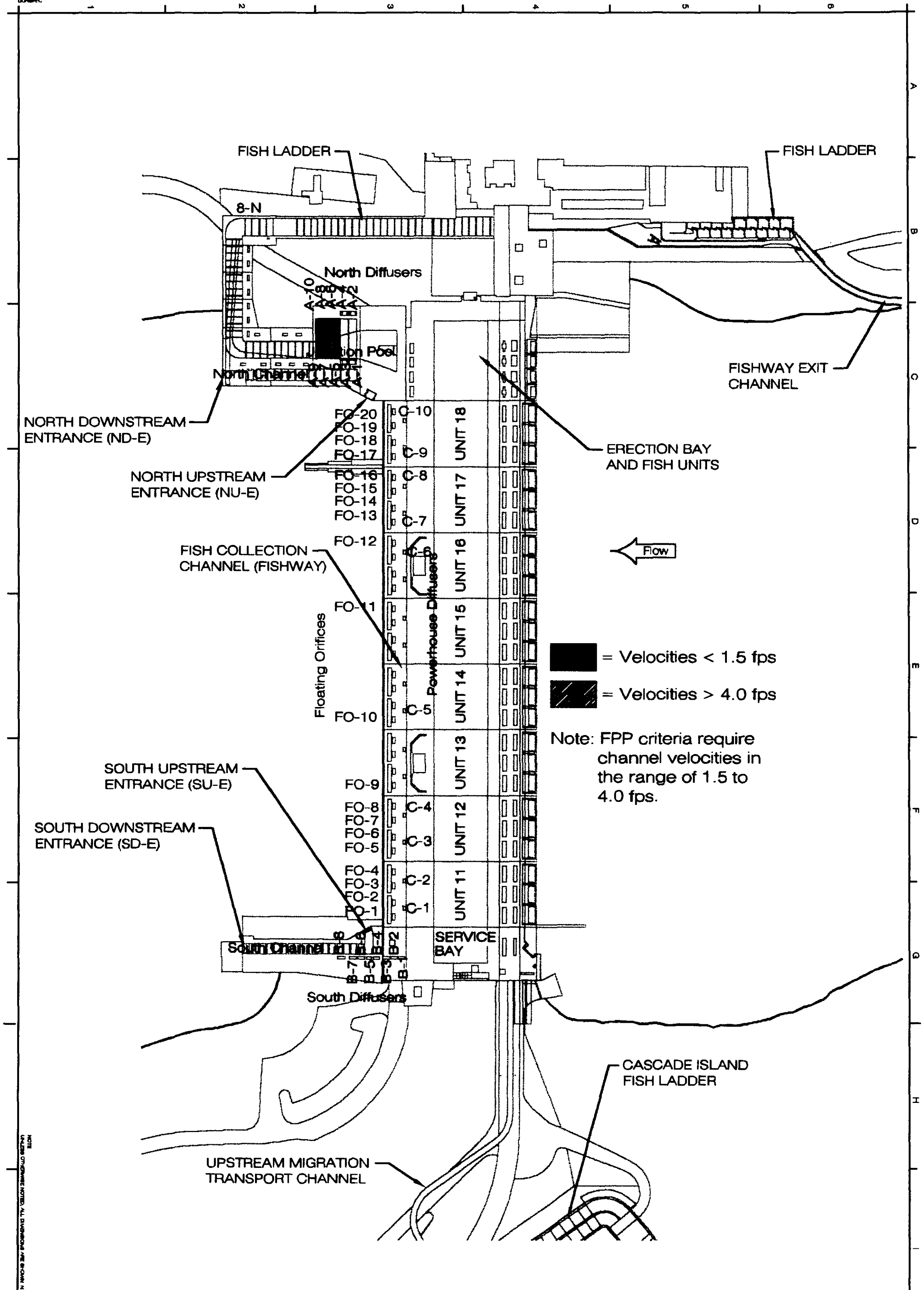
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK
Date: 27 SEPT 1999
Drawn by: D. PATRICK
CADD File Name: BONPLATE02.DGN
Checked by:
Technical Manager:
Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct & Arch Design

US Army Corps of Engineers Portland District

PLATE 2

Figure F-13




[Table F-8]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 15
CONFIGURATION 2

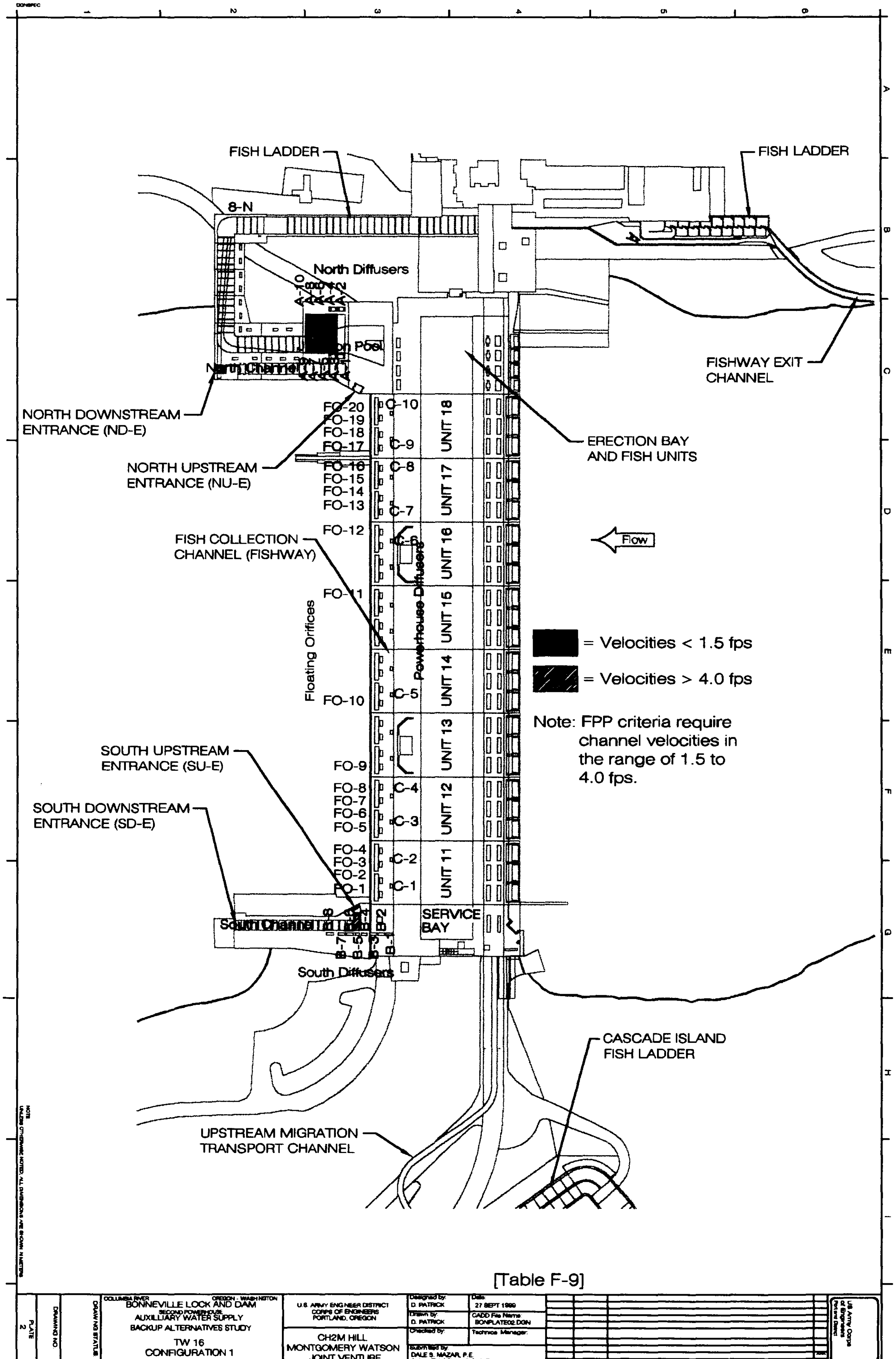
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK
Date: 27 SEPT 1999
Drawn by: D. PATRICK
CADD File Name: BONPLATE02.DGN
Checked by:
Technical Manager:
Submitted by: DALE S. MAZAR, P.E., Acting Chief, Struct & Arch Design

PLATE 2

Figure F-14




[Table F-9]

Figure F-15

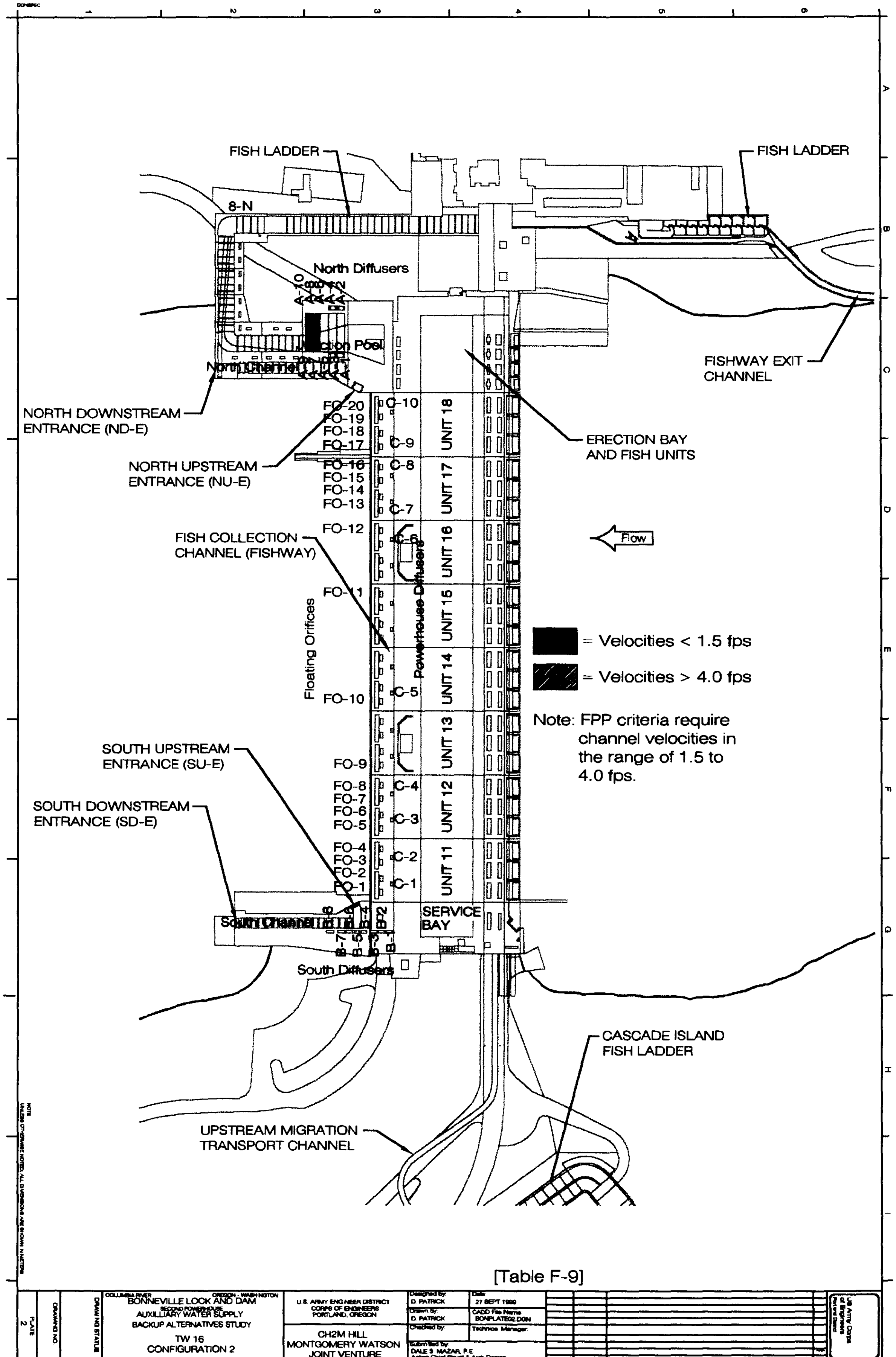
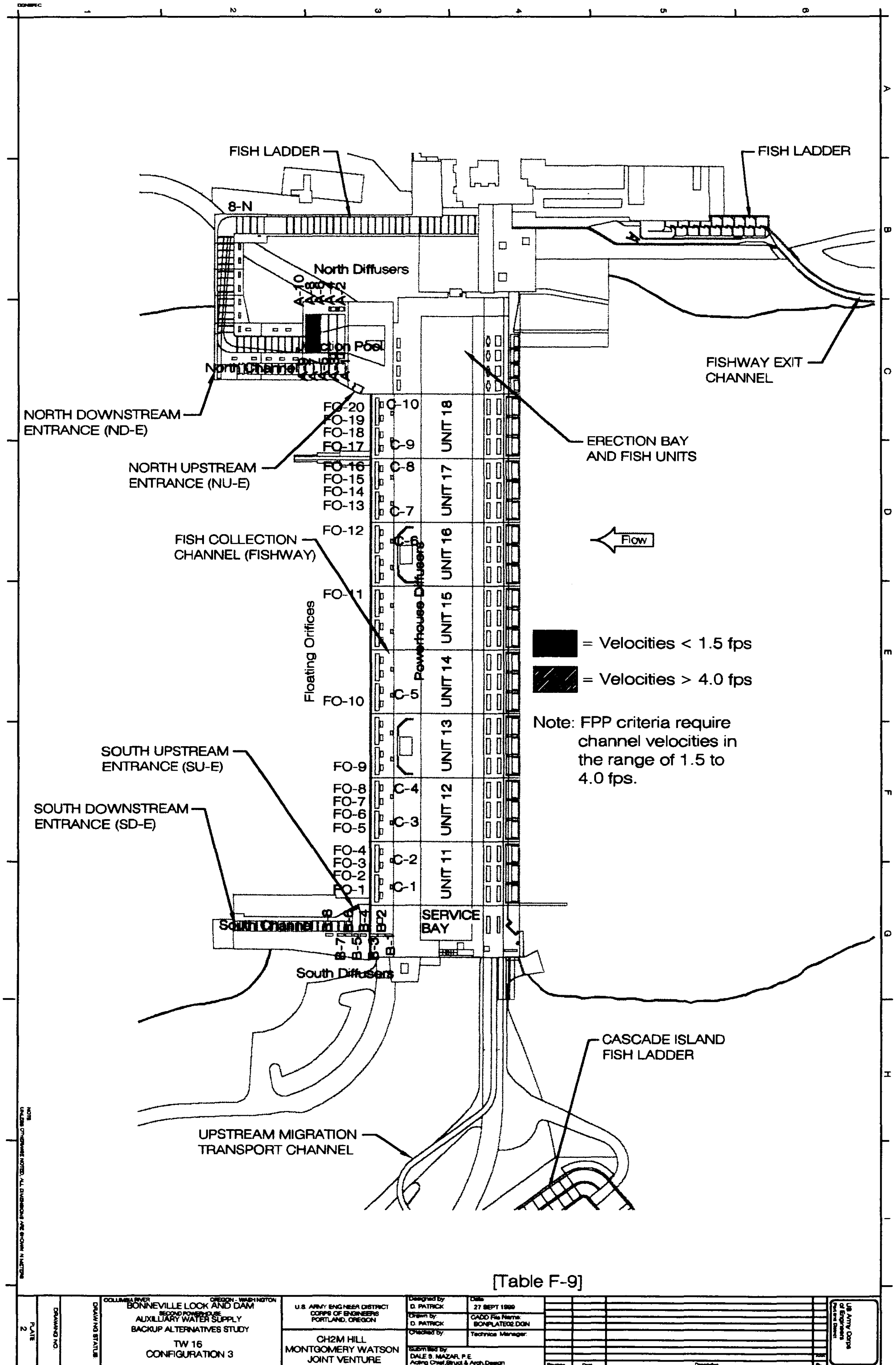
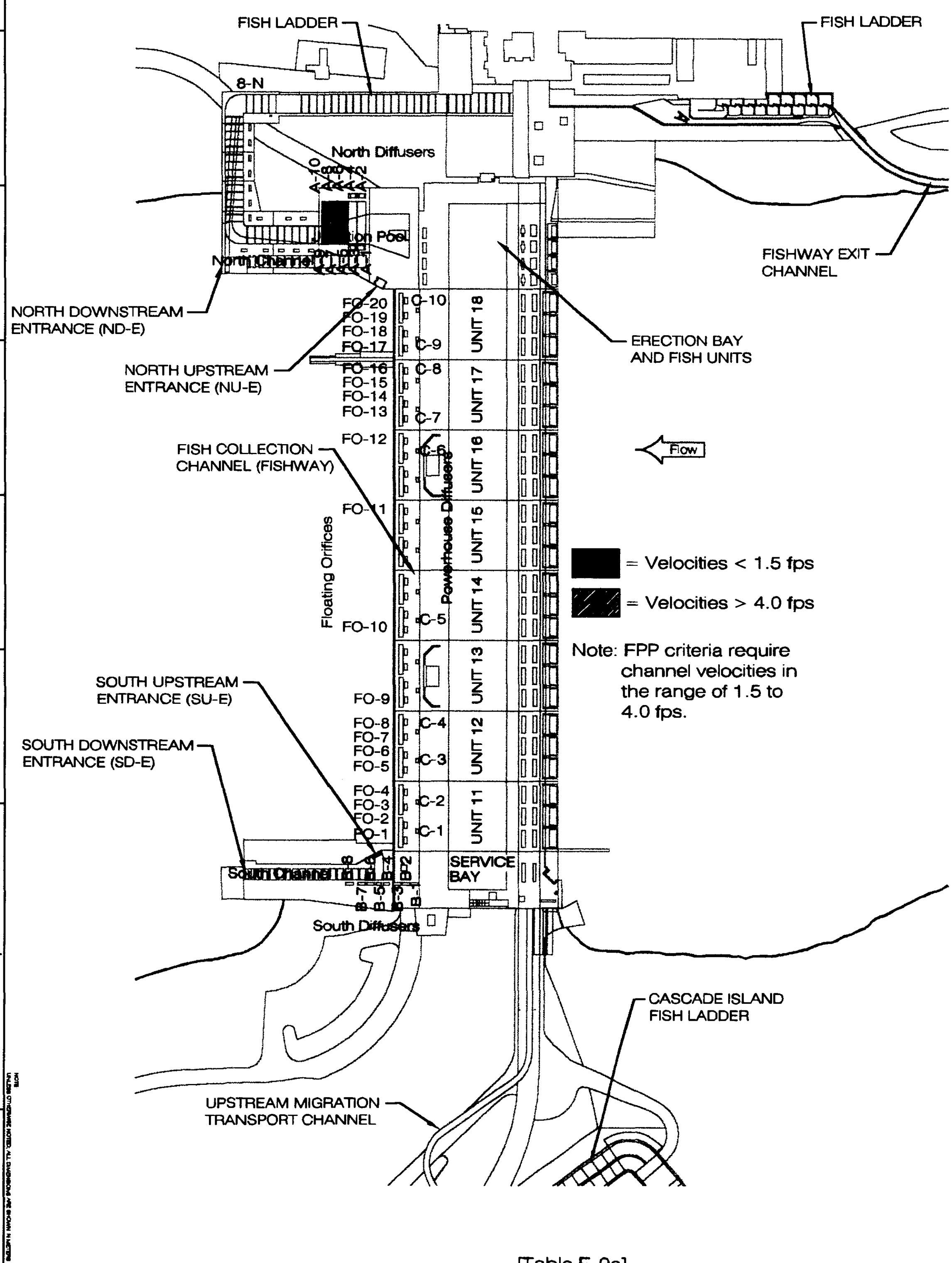

FISH LADDER
FISH LADDER
8-N
North Diffusers
A-10
Erection Pool
North Channel
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
FISHWAY EXIT CHANNEL
ERECTION BAY AND FISH UNITS
FO-20
FO-19
FO-18
FO-17
FO-16
FO-15
FO-14
FO-13
FO-12
FO-11
FO-10
FO-9
FO-8
FO-7
FO-6
FO-5
FO-4
FO-3
FO-2
FO-1
C-10
C-9
C-8
C-7
C-6
C-5
C-4
C-3
C-2
C-1
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
SERVICE BAY
Powerhouse Diffusers
Floating Orifices
FISH COLLECTION CHANNEL (FISHWAY)
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
B-1
B-2
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-9]
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 16
CONFIGURATION 2
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE
Designed by D. PATRICK
Drawn by D. PATRICK
Date 27 SEPT 1999
Submitted by DALE S. MAZAR, P.E.
PLATE 2

Figure F-16


FISH LADDER
FISH LADDER
8-N
North Diffusers
Junction Pool
North Channel
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
FISHWAY EXIT CHANNEL
ERECTION BAY AND FISH UNITS
FO-20
FO-19
FO-18
FO-17
FO-16
FO-15
FO-14
FO-13
FO-12
FO-11
FO-10
FO-9
FO-8
FO-7
FO-6
FO-5
FO-4
FO-3
FO-2
FO-1
C-10
C-9
C-8
C-7
C-6
C-5
C-4
C-3
C-2
C-1
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
SERVICE BAY
FISH COLLECTION CHANNEL (FISHWAY)
Floating Orifices
Powerhouse Diffusers
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-9]
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 16
CONFIGURATION 3
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE
D. PATRICK
27 SEPT 1999
D. PATRICK
BONPLATE02.DGN
DALE S. MAZAR, P.E.
PLATE
2
Figure F-17




[Table F-9a]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 16
CONFIGURATION 2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by D. PATRICK
Date 27 SEPT 1999
Drawn by D. PATRICK
CADD File Name BONPLATE02.DGN
Checked by
Technical Manager
Submitted by DALE S. MAZAR, P.E.
Acting Chief, Struct & Arch.Design

PLATE 2

Figure F-18

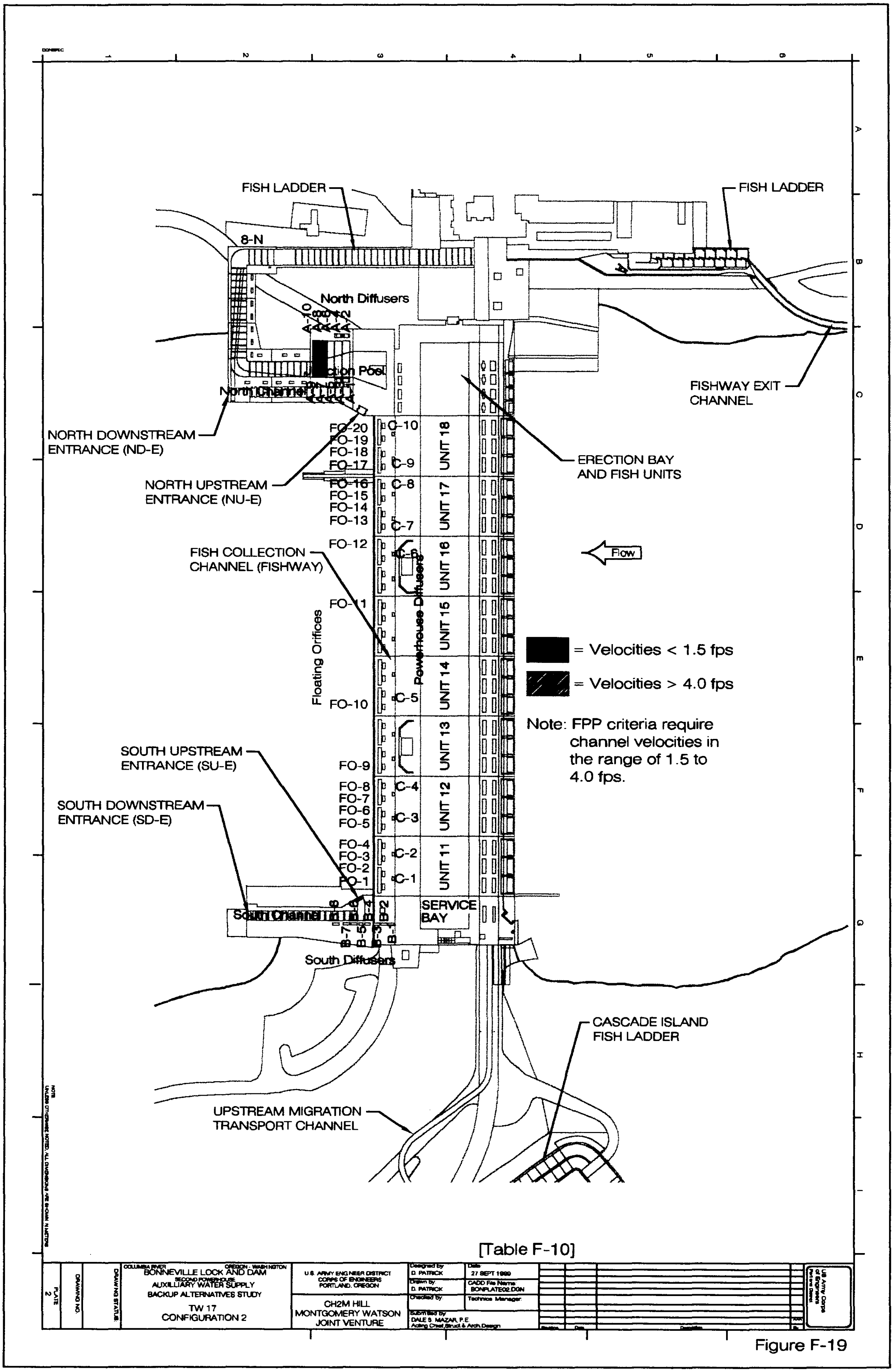
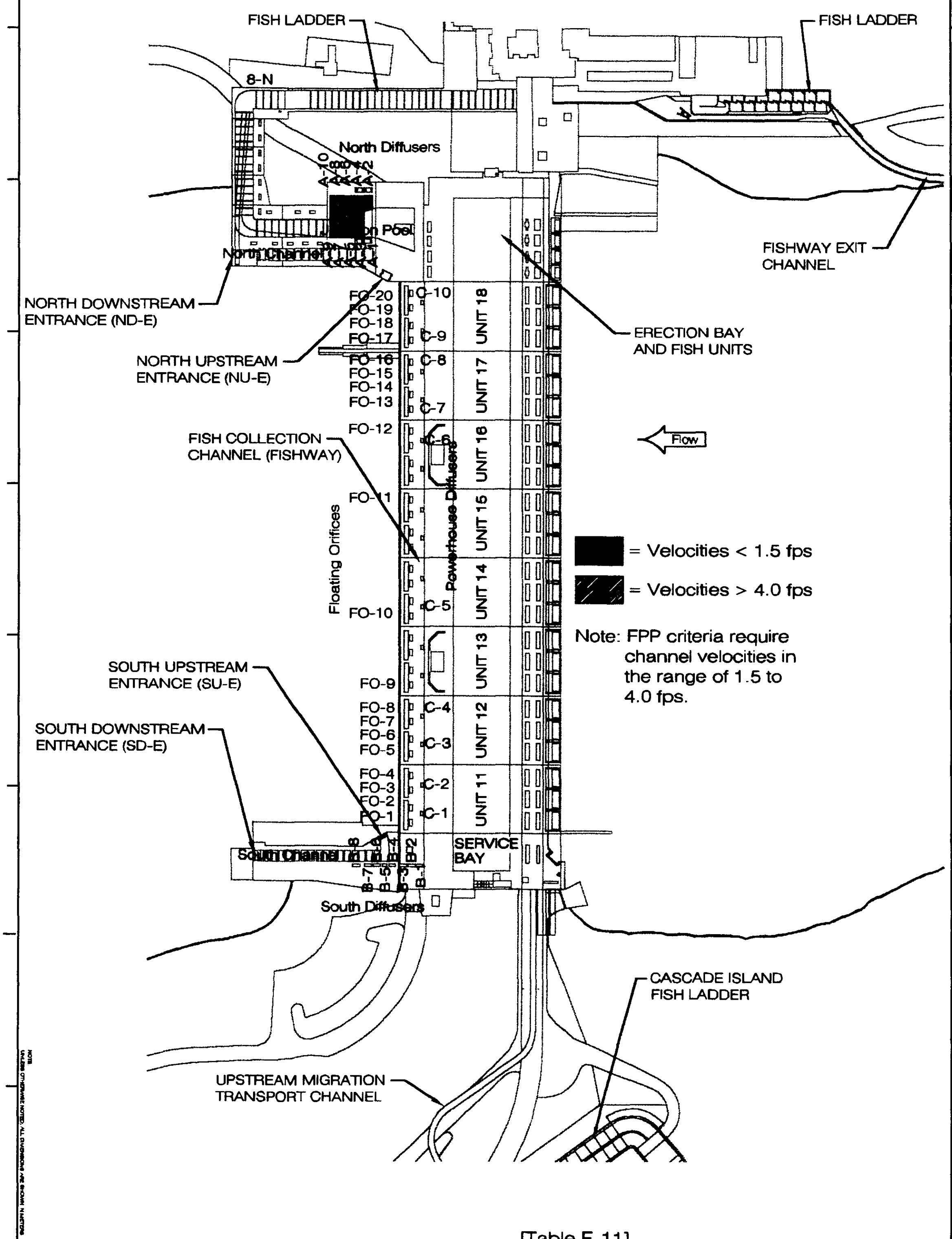

FISH LADDER
FISH LADDER
8-N
North Diffusers
Junction Pool
North Channel
FISHWAY EXIT CHANNEL
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
ERECTION BAY AND FISH UNITS
FISH COLLECTION CHANNEL (FISHWAY)
Floating Orifices
Powerhouse Diffusers
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
SERVICE BAY
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-10]
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 17
CONFIGURATION 2
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON
CH2M HILL MONTGOMERY WATSON JOINT VENTURE
Designed by D. PATRICK
Drawn by D. PATRICK
Date 27 SEPT 1999
CADD File Name BONPLATE02.DGN
Technical Manager
Submitted by DALE S. MAZAR, P.E.
PLATE 2

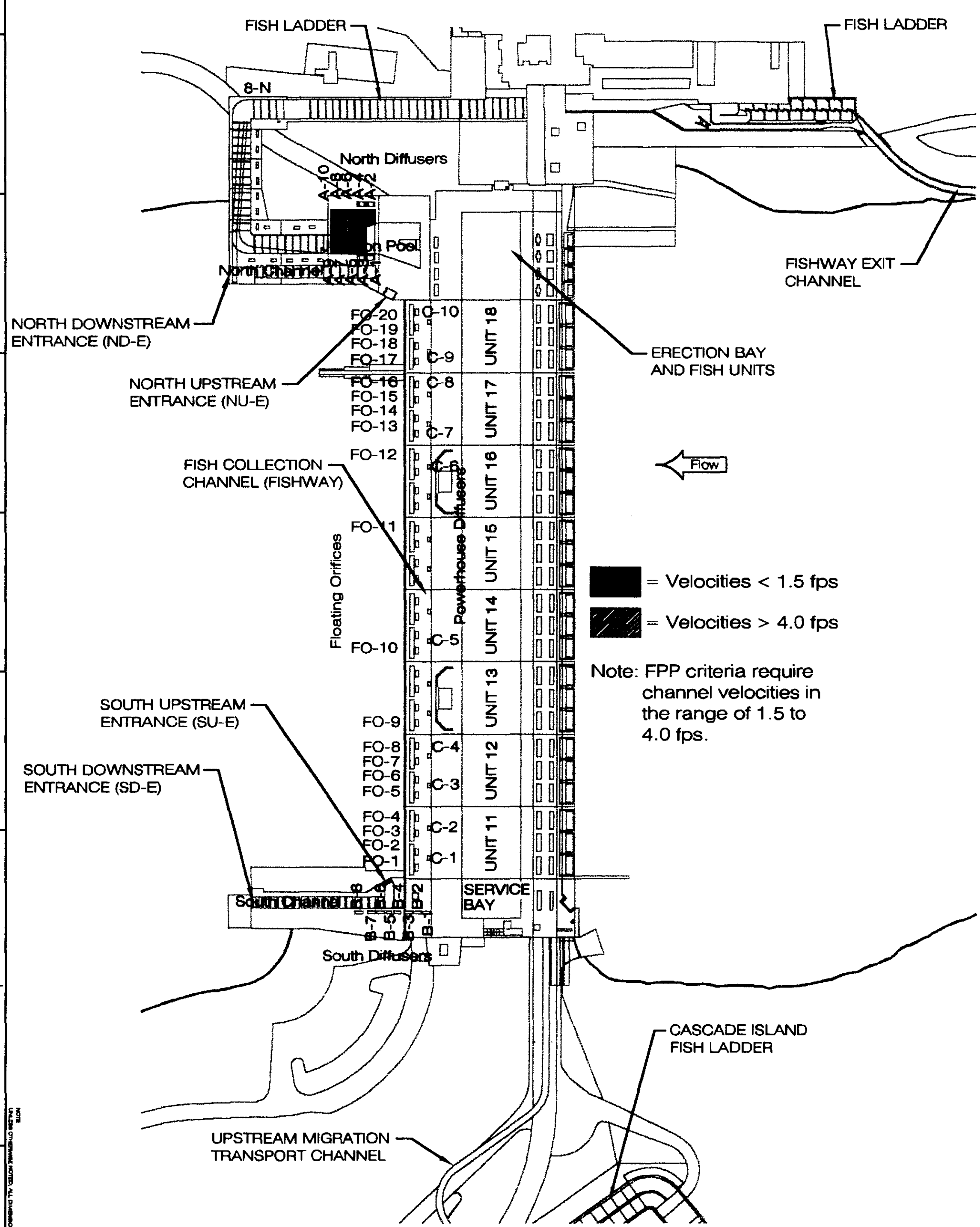
Figure F-19




[Table F-11]

| | | | | |
|---|---|---|---|---|
| PLATE 2 | COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 18<br>CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design | Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager: |

Figure F-20




[Table F-12]

BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 19
CONFIGURATION 1

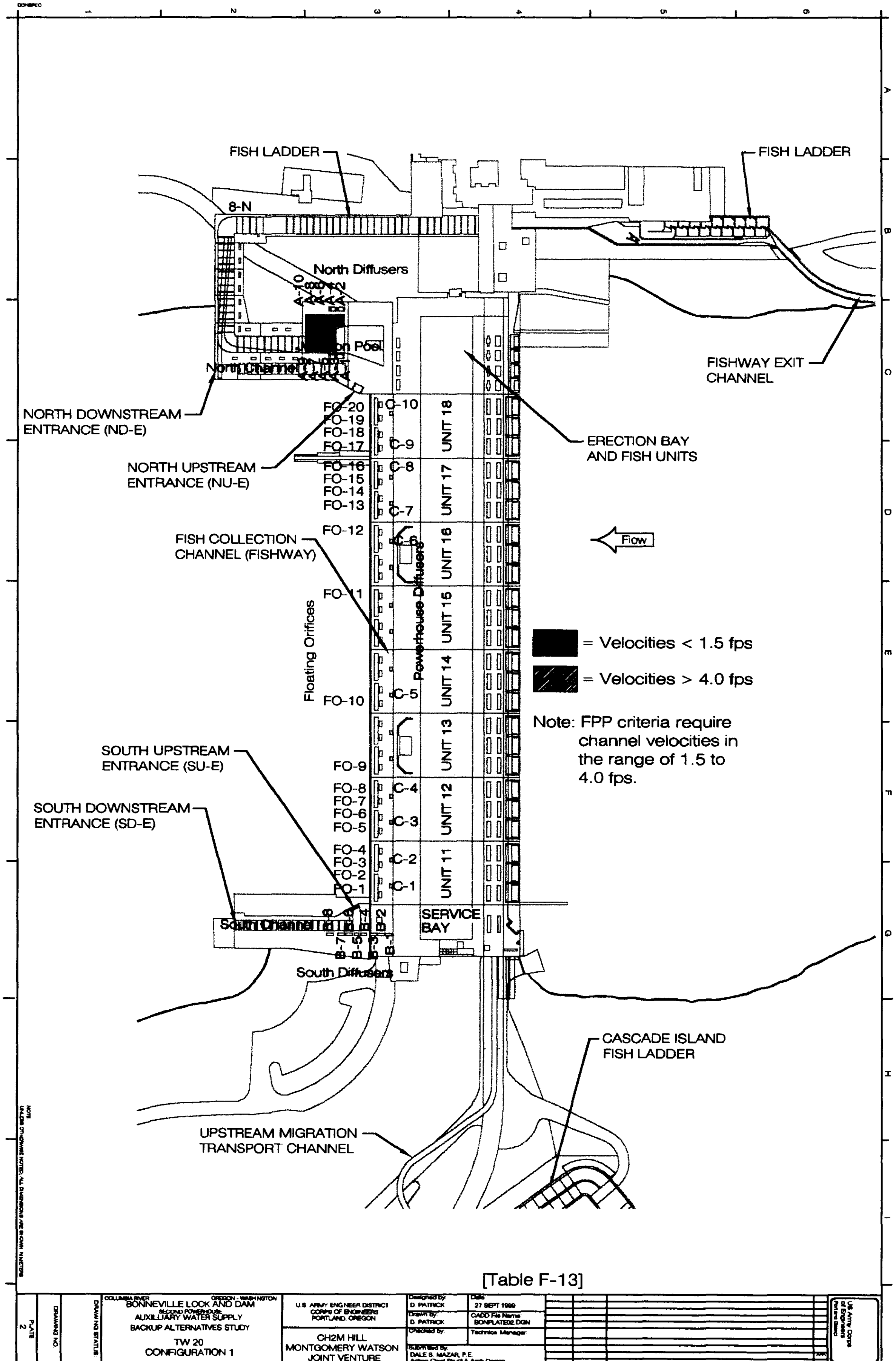
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by D. PATRICK | Date 27 SEPT 1999
Drawn by D. PATRICK | CADD File Name BONPLATE02.DGN
Checked by | Technical Manager
Submitted by DALE S. MAZAR, P.E. Acting Chief, Struct & Arch Design

PLATE 2

Figure F-21


FISH LADDER
FISH LADDER
8-N
North Diffusers
A-10
North Channel
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
FISHWAY EXIT CHANNEL
ERECTION BAY AND FISH UNITS
FO-20
FO-19
FO-18
FO-17
FO-16
FO-15
FO-14
FO-13
FO-12
FO-11
FO-10
FO-9
FO-8
FO-7
FO-6
FO-5
FO-4
FO-3
FO-2
FO-1
C-10
C-9
C-8
C-7
C-6
C-5
C-4
C-3
C-2
C-1
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
FISH COLLECTION CHANNEL (FISHWAY)
Floating Orifices
Powerhouse Diffusers
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
SERVICE BAY
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-13]
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 20
CONFIGURATION 1
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE
Designed by D. PATRICK
Date 27 SEPT 1999
Drawn by D. PATRICK
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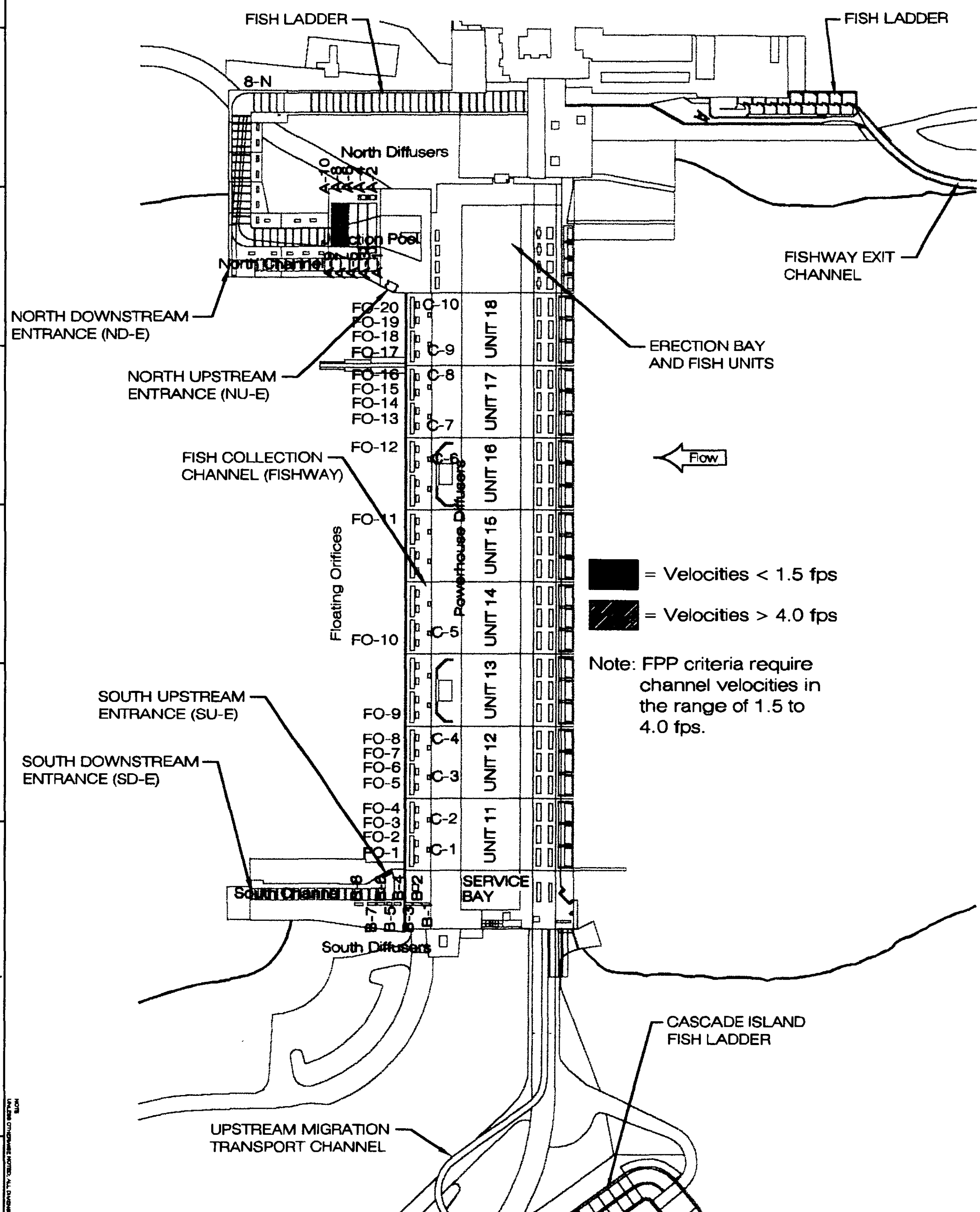
Acting Chief, Struct. & Arch. Design
PLATE 2
US Army Corps of Engineers
Portland District

Figure F-22

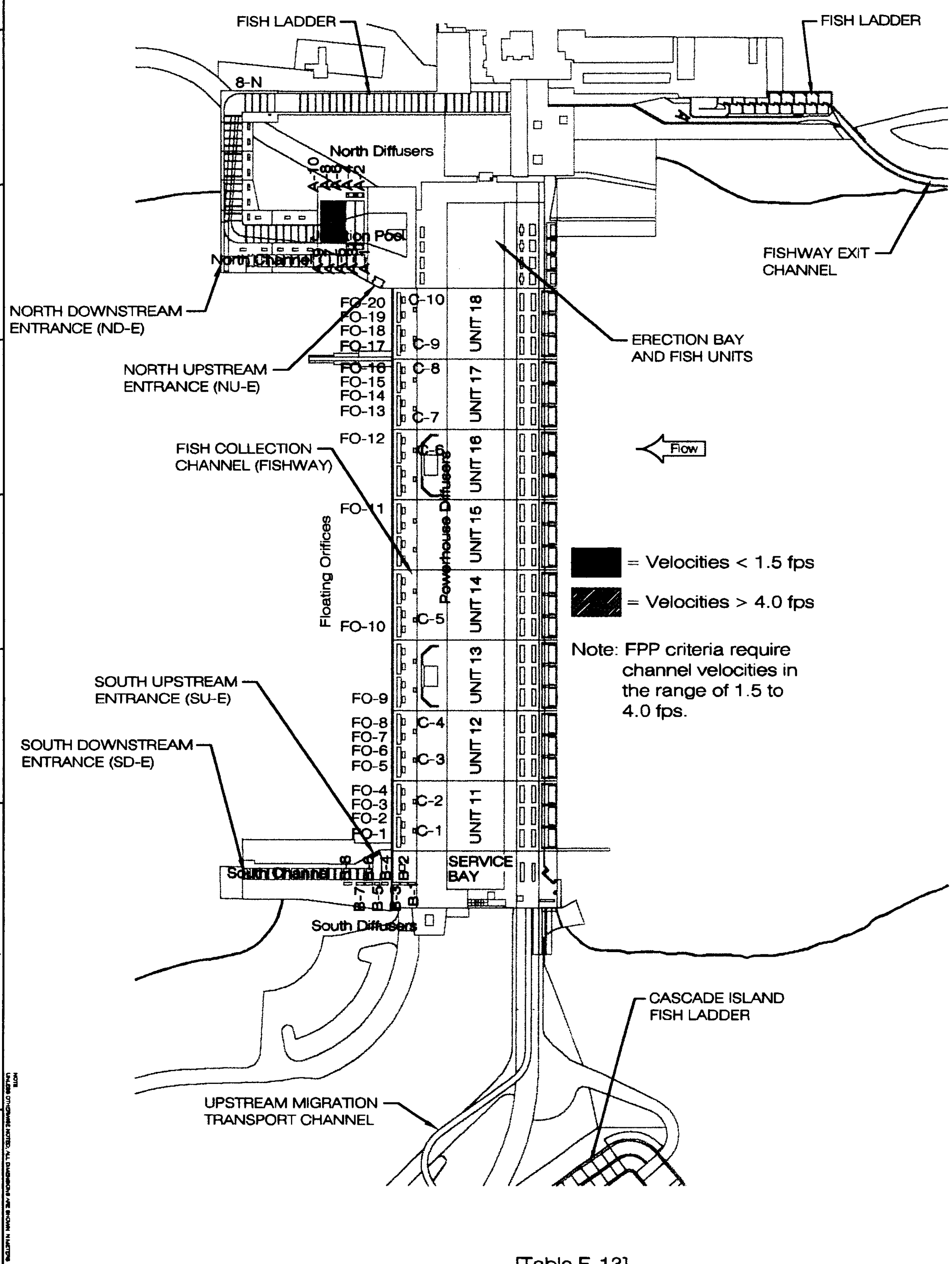



[Table F-13]

| | | |
|---|---|---|
| BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 20<br>CONFIGURATION 2 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK; Date 27 SEPT 1999; Drawn by D. PATRICK; CADD File Name BONPLATE02.DGN; Checked by; Technical Manager; Submitted by DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design |

PLATE 2

Figure F-23

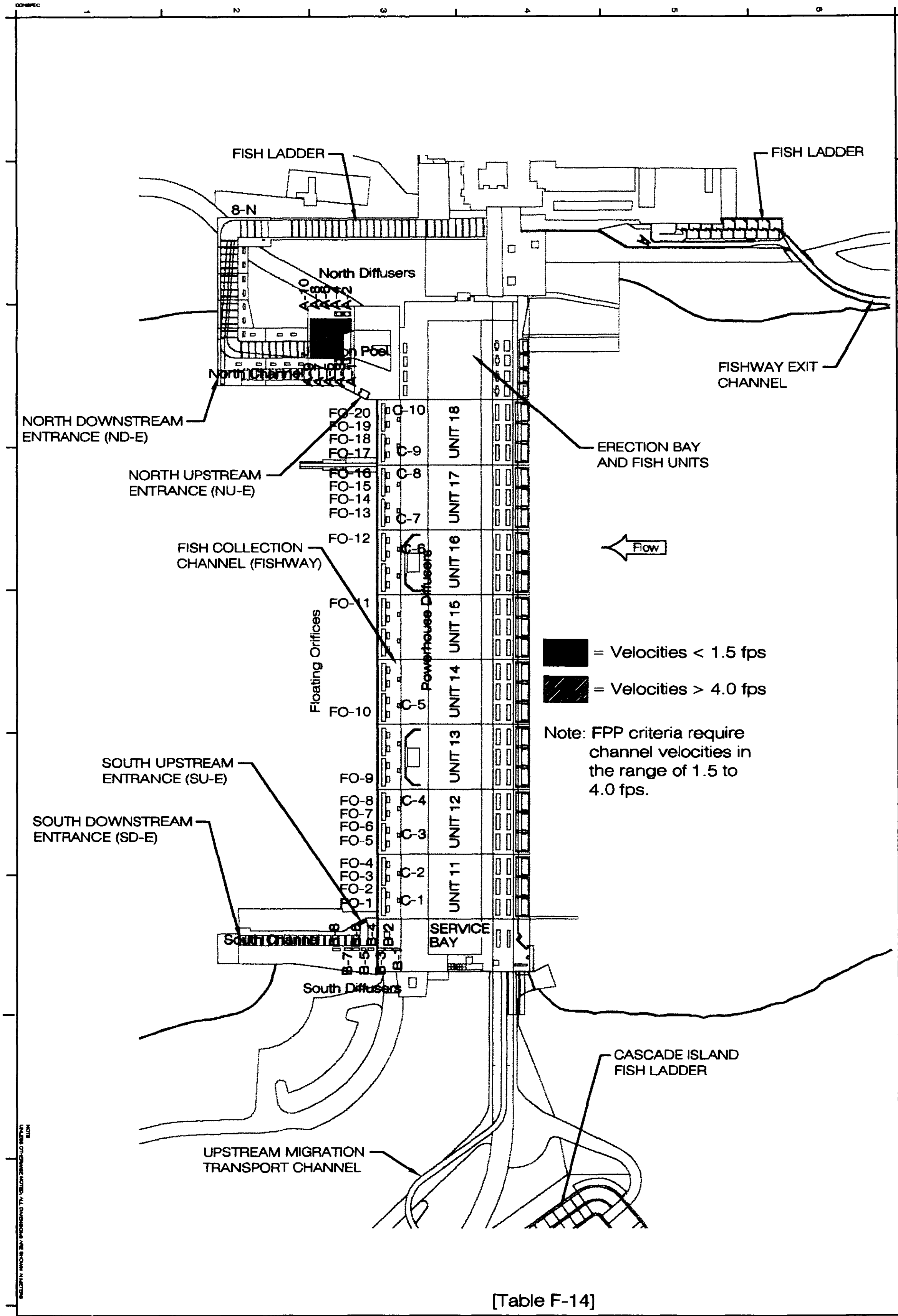



[Table F-13]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 20<br>CONFIGURATION 3 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK<br>Drawn by D. PATRICK<br>Checked by<br>Submitted by DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design | Date 27 SEPT 1999<br>CADD File Name BONPLATE02.DGN<br>Technical Manager |

PLATE 2

Figure F-24




[Table F-14]

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 21
CONFIGURATION 1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

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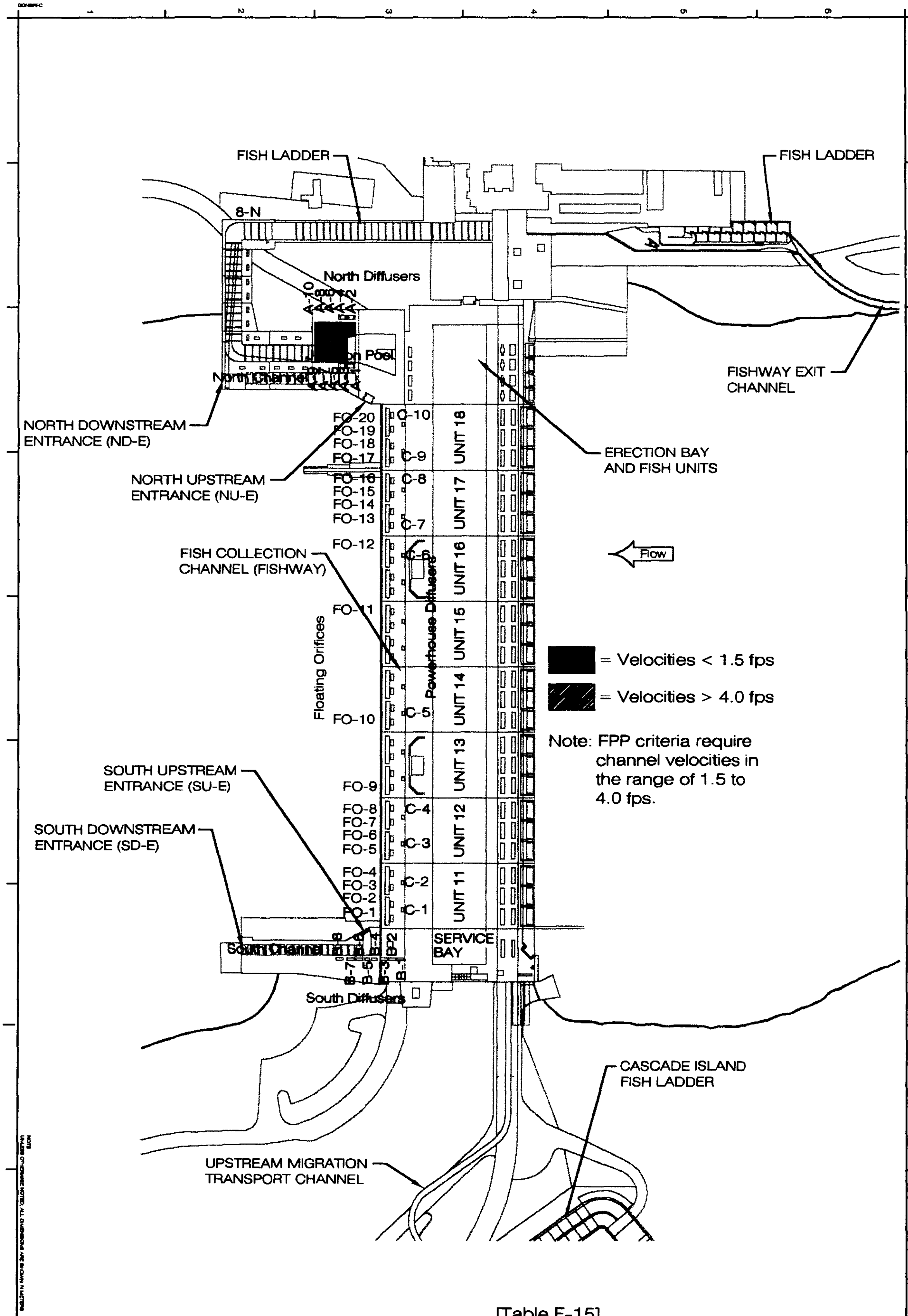
Date: 27 SEPT 1999
Drawn by: D. PATRICK
CADD File Name: BONPLATE02.DGN
Checked by: Technical Manager
Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design

PLATE 2

Figure F-25




[Table F-15]

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 22
CONFIGURATION 1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK
Date: 27 SEPT 1999
Drawn by: D. PATRICK
CADD File Name: BONPLATE02.DGN
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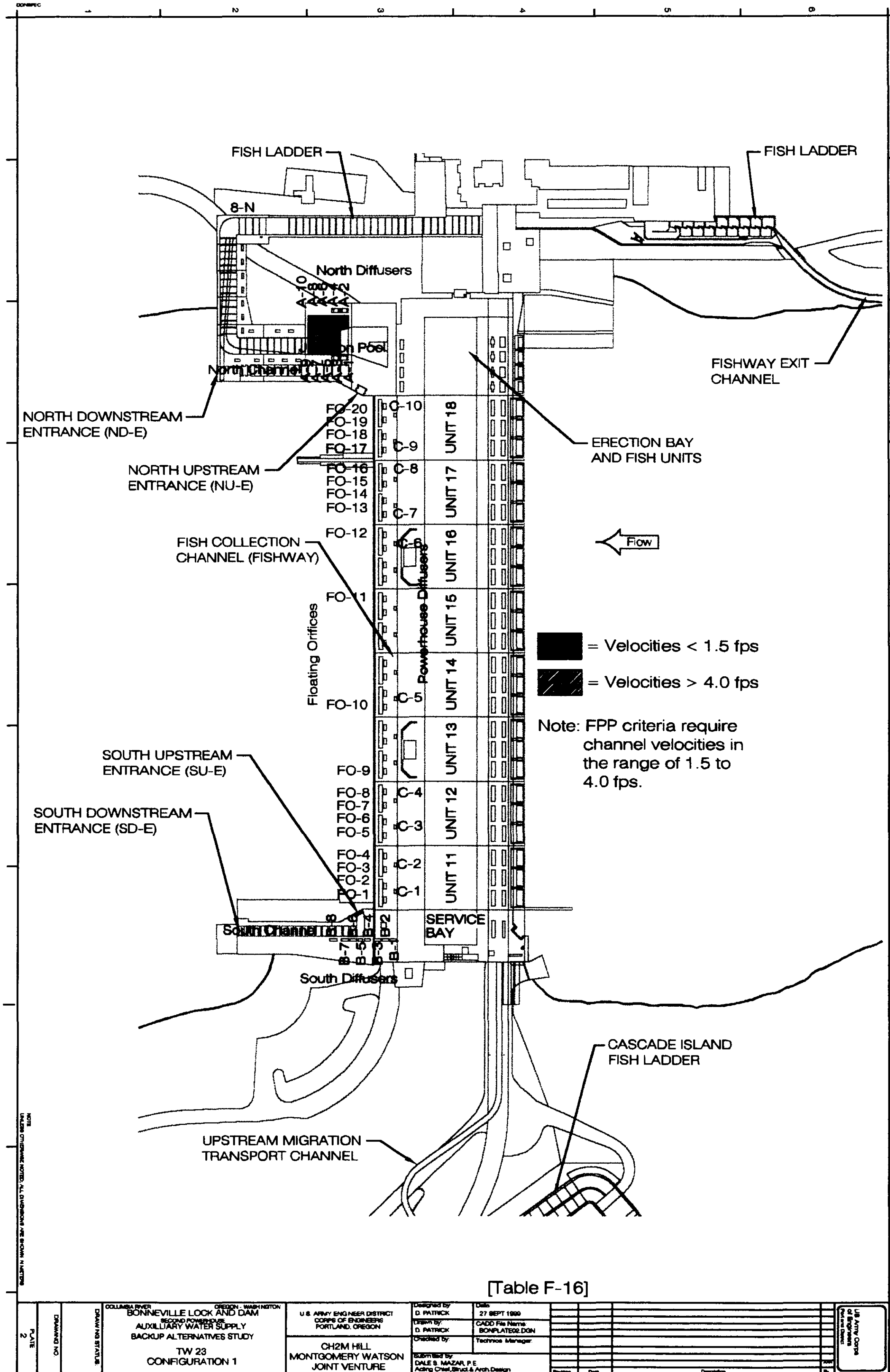
Technical Manager:
Submitted by: DALE S. MAZAR, P.E.
Acting Chief Struct.& Arch.Design

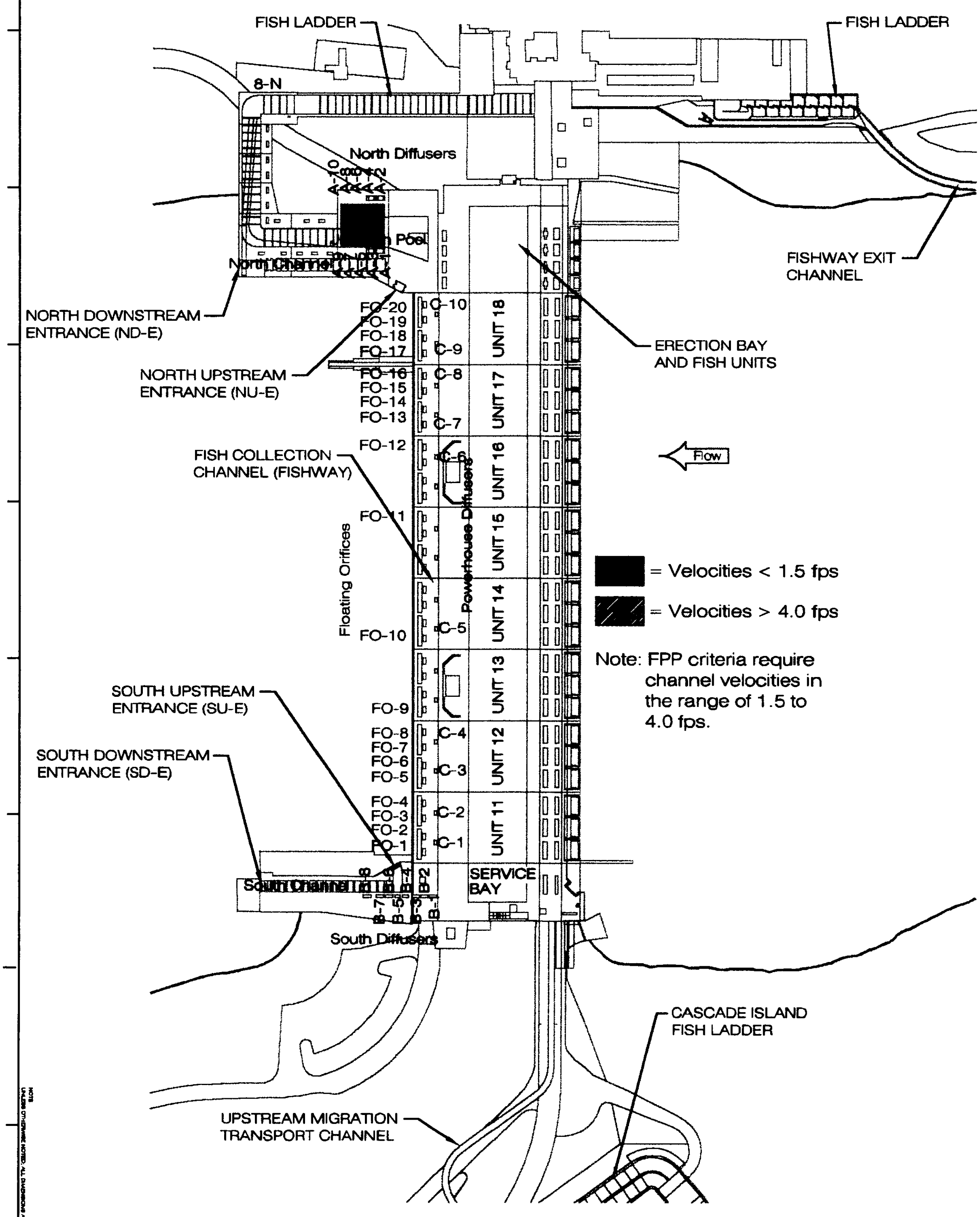
PLATE 2
DRAWING NO.
DRAWING STATUS

Figure F-26




[Table F-16]

Figure F-27

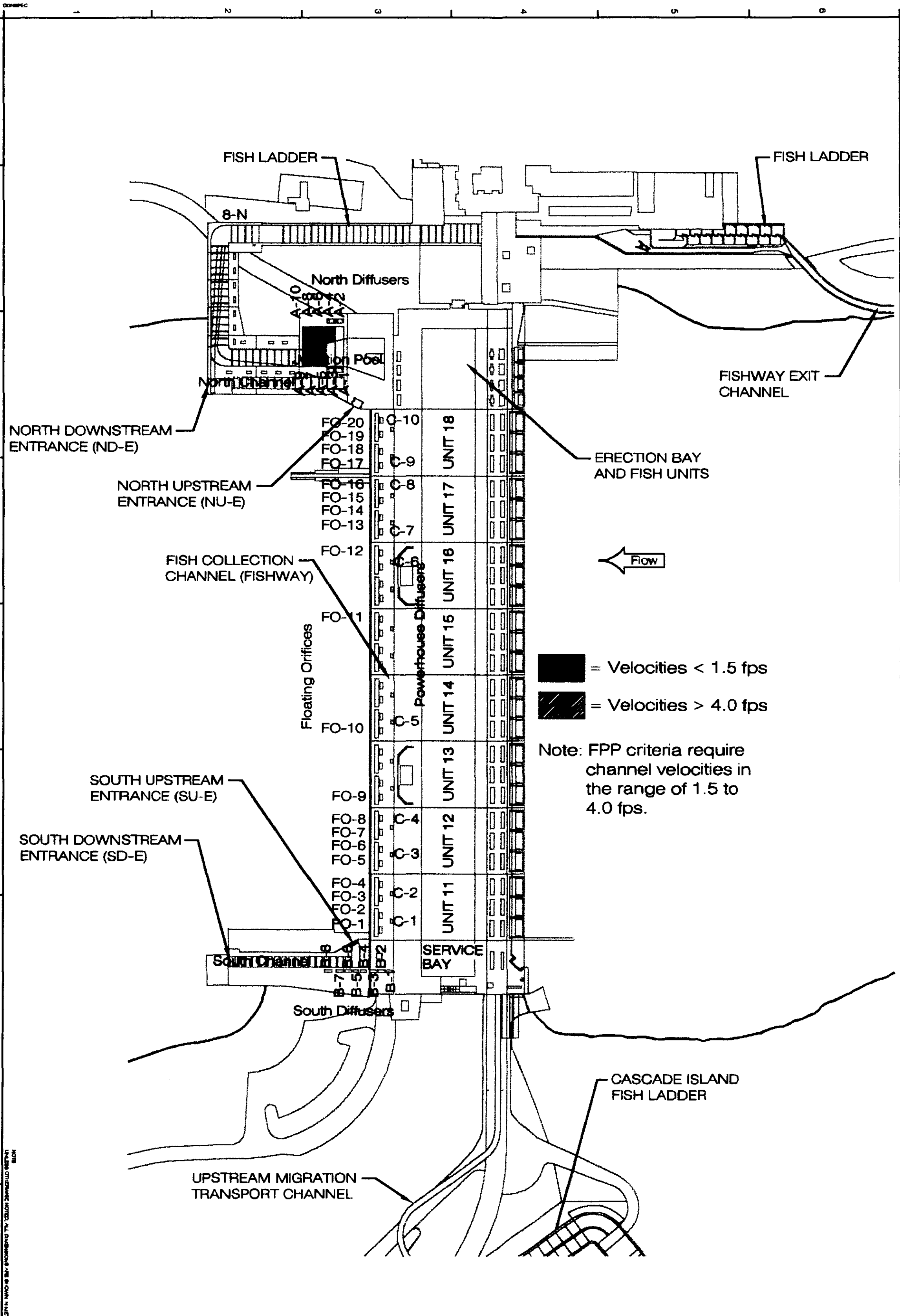



[Table F-17]

| | | | |
|---|---|---|---|
| BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 24<br>CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK<br>Drawn by D. PATRICK<br>Checked by<br>Submitted by DALE S. MAZAR, P.E. | Date 27 SEPT 1999<br>CADD File Name BONPLATE02.DGN |

PLATE 2

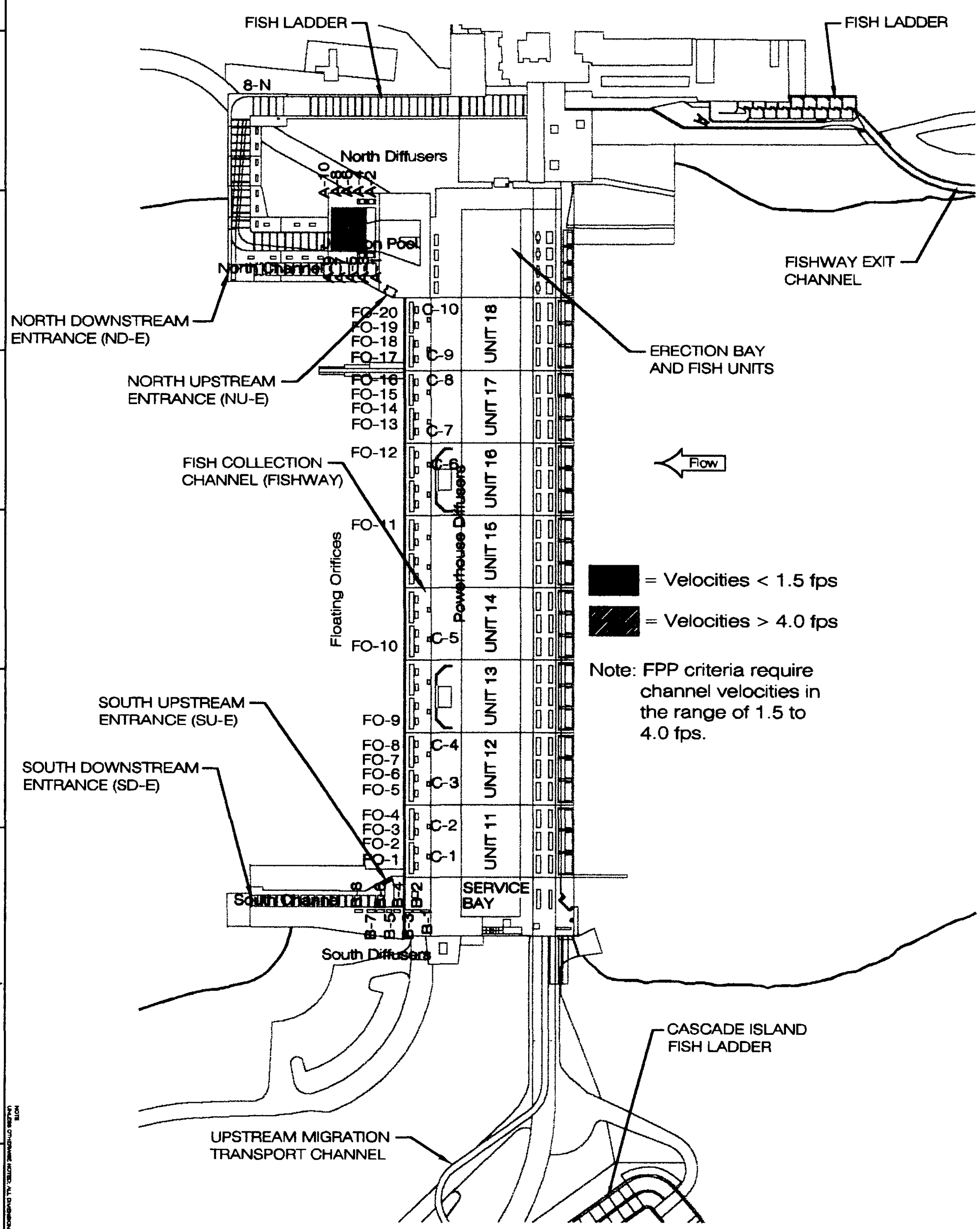
Figure F-28




[Table F-17]

| | | | | |
|---|---|---|---|---|
| COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 24<br>CONFIGURATION 2 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E.<br>Acting Chief, Struct. & Arch. Design | Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager | PLATE 2 |

Figure F-29

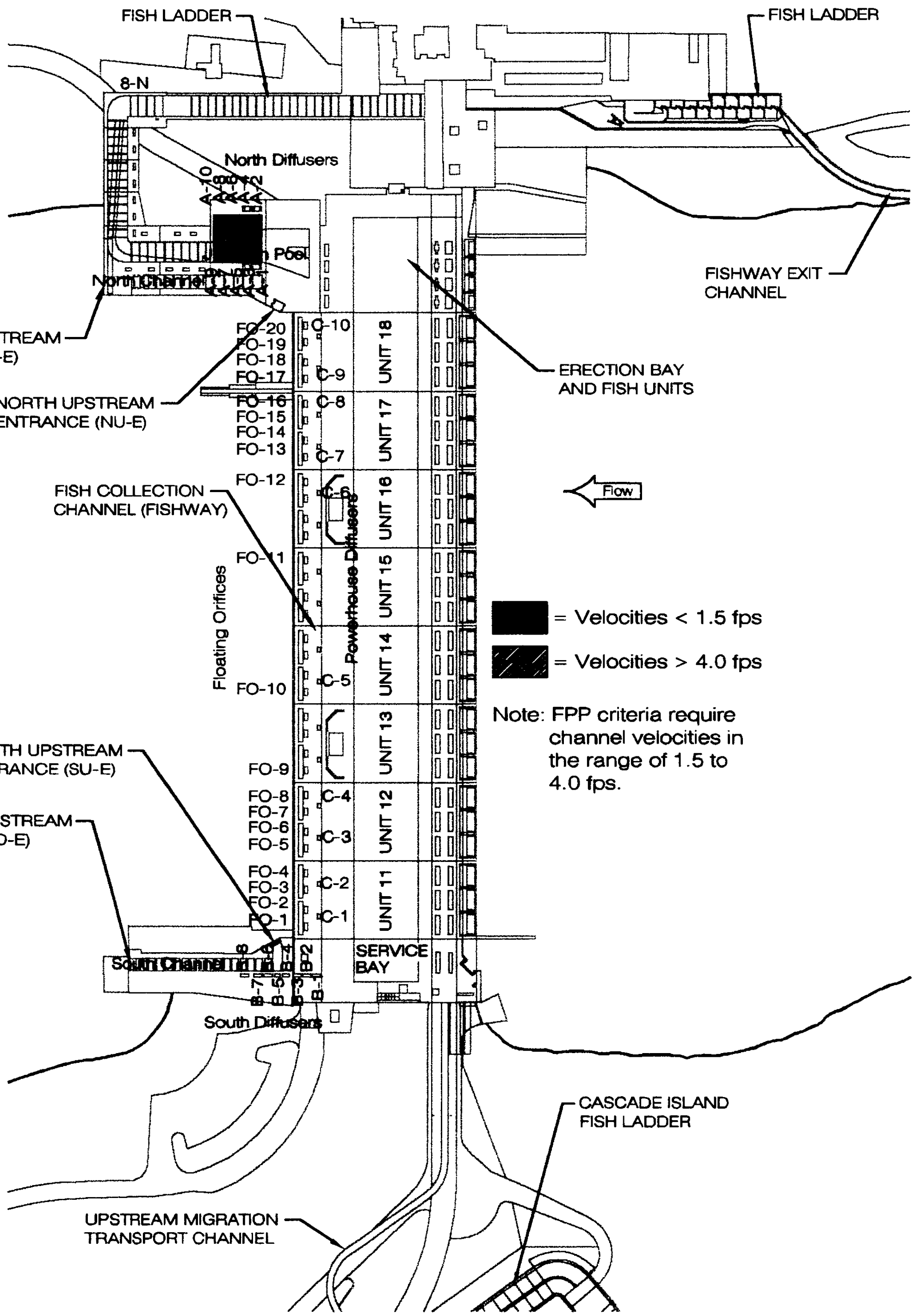



[Table F-17]

| | | |
|---|---|---|
| COLUMBIA RIVER OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 24<br>CONFIGURATION 3 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: D. PATRICK<br>Drawn by: D. PATRICK<br>Checked by:<br>Submitted by: DALE S. MAZAR, P.E. Acting Chief Struct. & Arch. Design<br>Date: 27 SEPT 1999<br>CADD File Name: BONPLATE02.DGN<br>Technical Manager |

PLATE 2

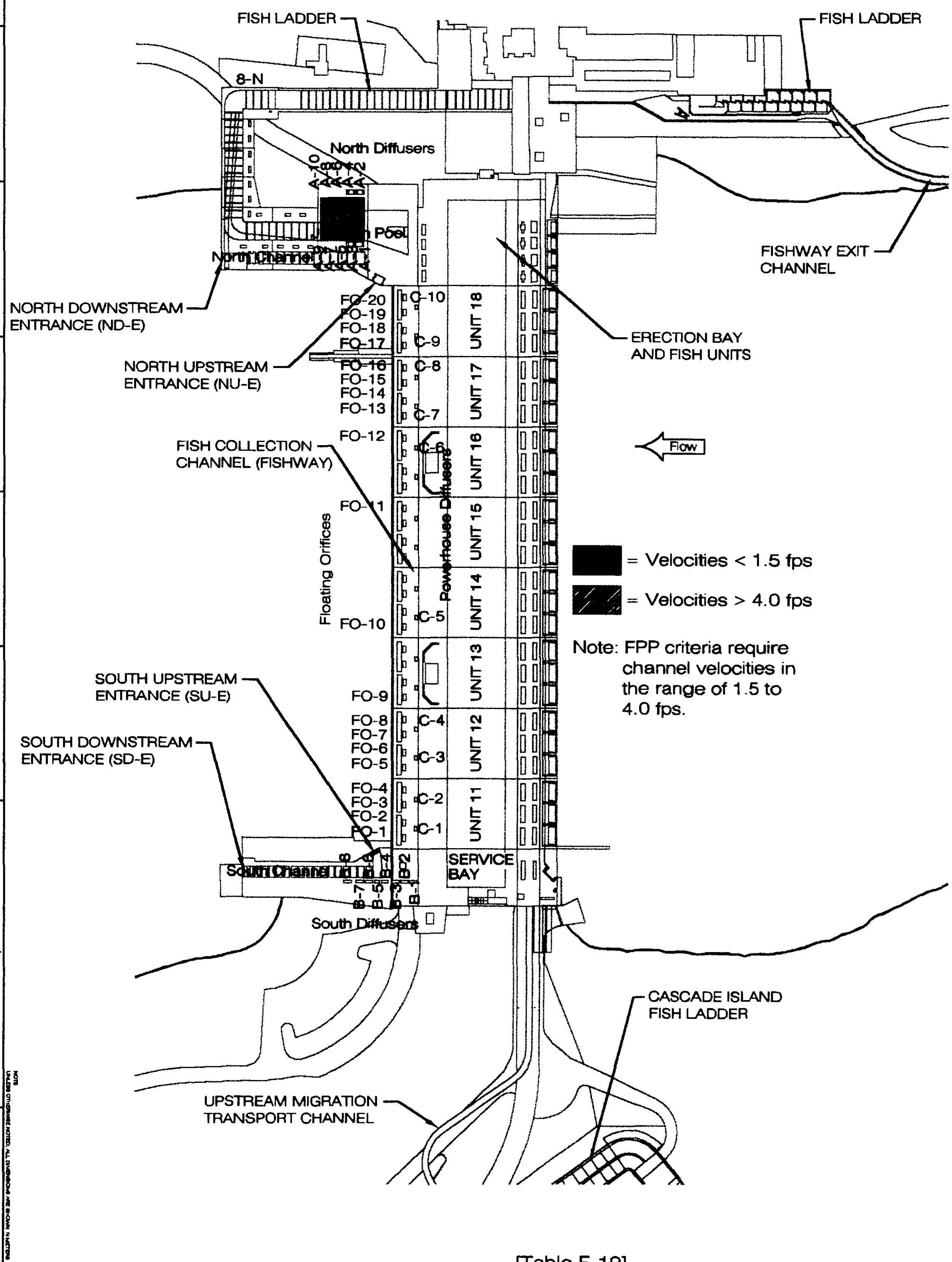
Figure F-30




[Table F-18]

| | | | |
|---|---|---|---|
| PLATE 2 | COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 25<br>CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK; Date 27 SEPT 1999; Drawn by D. PATRICK; CADD File Name BONPLATE02.DGN; Checked by; Technical Manager; Submitted by DALE S. MAZAR, P.E. Acting Chief Struct. & Arch Design |

Figure F-31

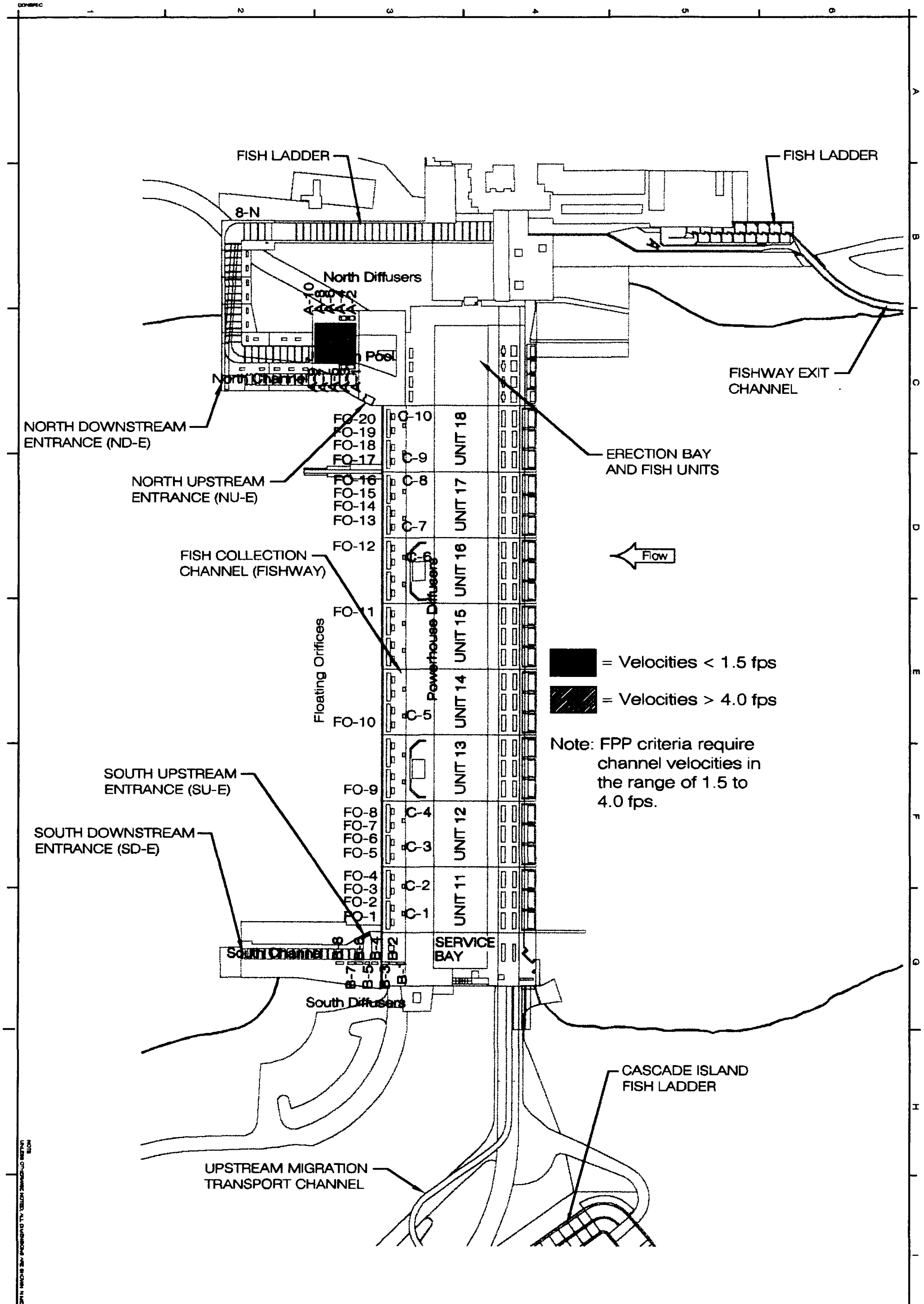



[Table F-19]

| | | | |
|---|---|---|---|
| COLUMBIA RIVER OREGON - WASHINGTON BONNEVILLE LOCK AND DAM SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP ALTERNATIVES STUDY TW 26 CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON CH2M HILL MONTGOMERY WATSON JOINT VENTURE | Designed by: D. PATRICK Drawn by: D. PATRICK Checked by: Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design | Date: 27 SEPT 1999 CADD File Name: BONPLATE02.DGN Technical Manager: |

PLATE 2

Figure F-32




[Table F-20]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 27
CONFIGURATION 1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK — Date: 27 SEPT 1999
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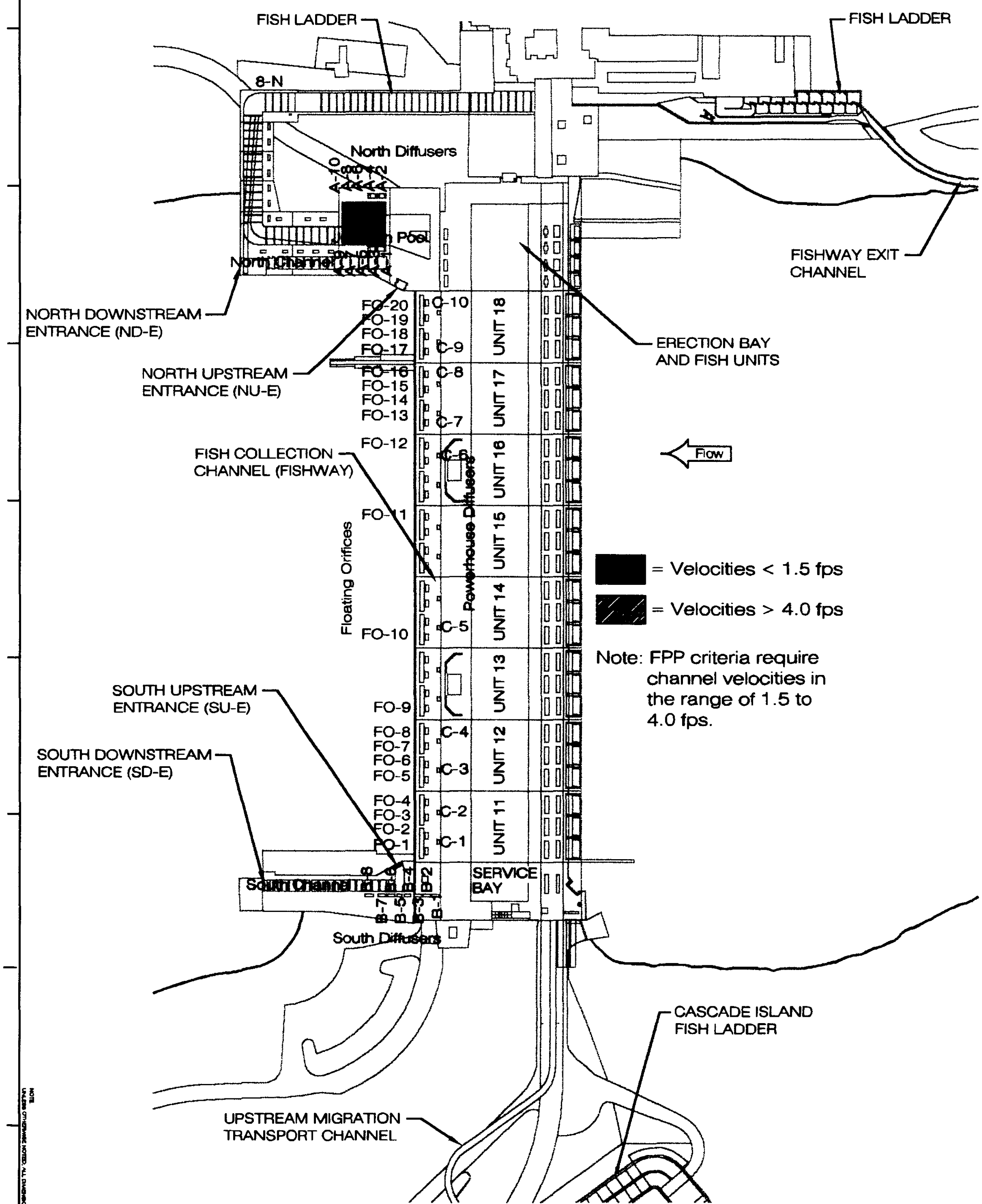
Checked by: — Technical Manager:
Submitted by: DALE S. MAZAR, P.E., Acting Chief, Struct & Arch Design

PLATE 2

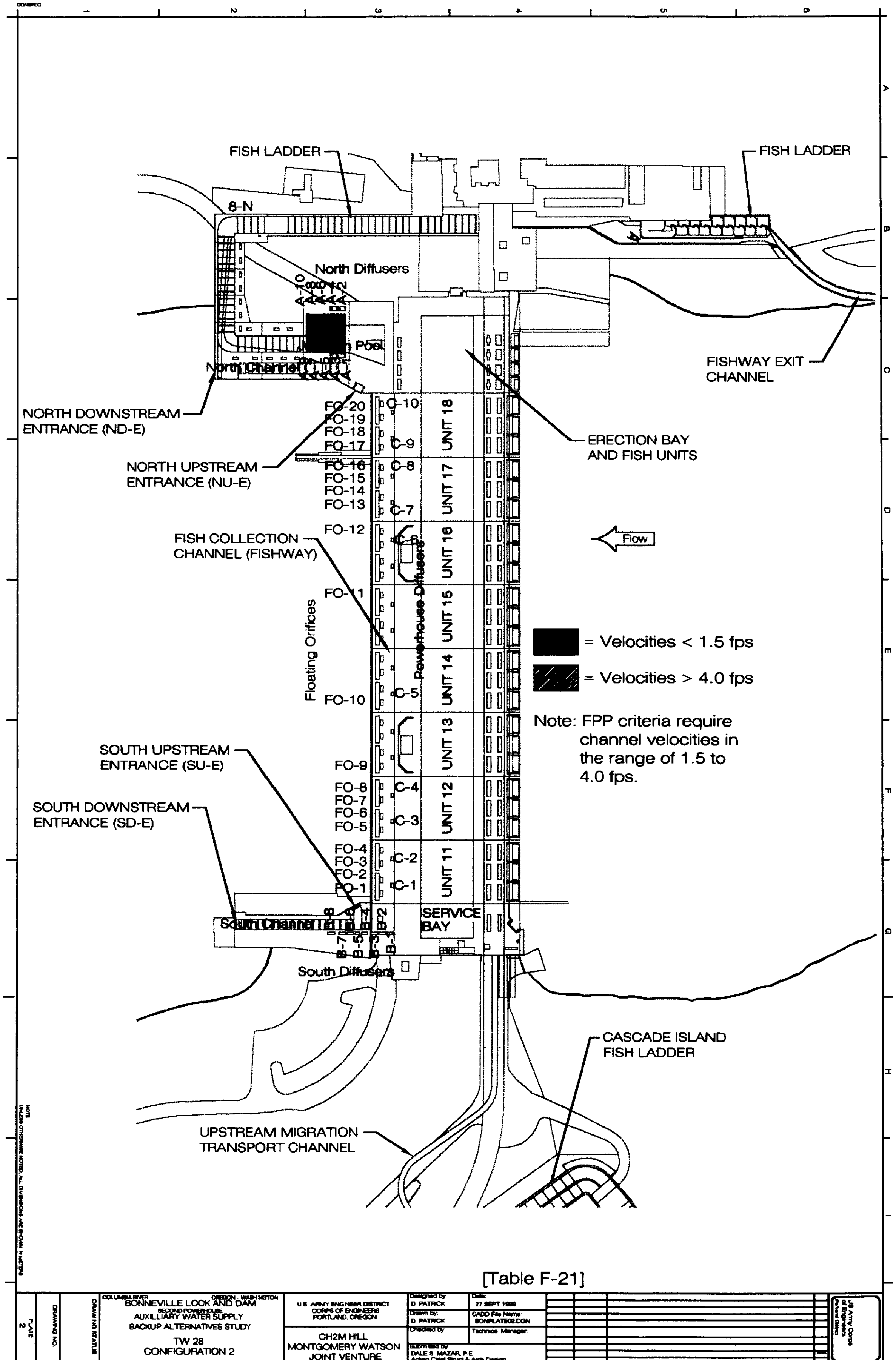
Figure F-33




[Table F-21]

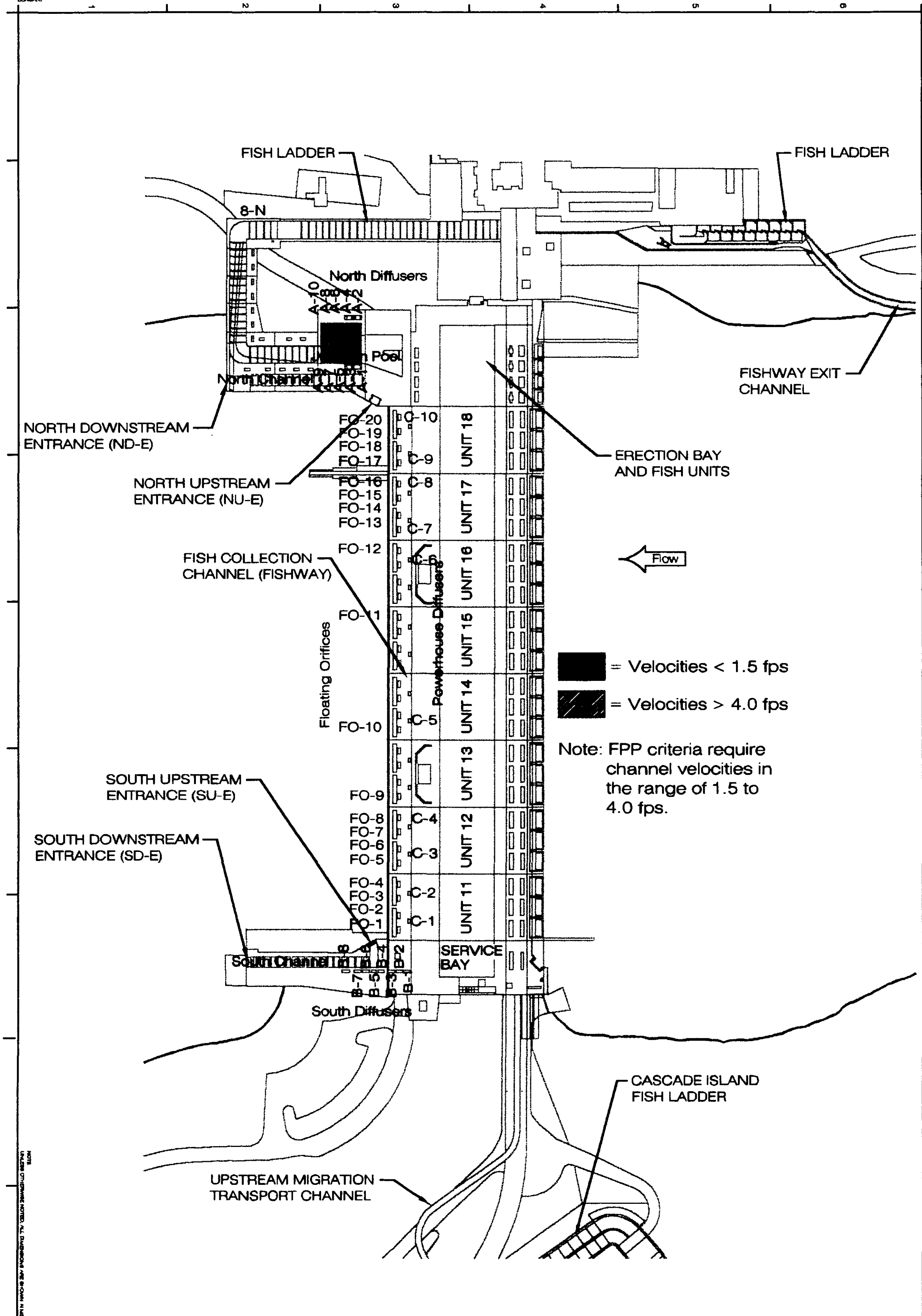
| | | | |
|---|---|---|---|
| PLATE 2 | BONNEVILLE LOCK AND DAM<br>SECOND POWERHOUSE<br>AUXILLIARY WATER SUPPLY<br>BACKUP ALTERNATIVES STUDY<br>TW 28<br>CONFIGURATION 1 | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by D. PATRICK; Drawn by D. PATRICK; Date 27 SEPT 1999; CADD File Name BONPLATE02.DGN; Submitted by DALE S. MAZAR, P.E. |

Figure F-34



FISH LADDER
FISH LADDER
8-N
North Diffusers
Pool
North Channel
NORTH DOWNSTREAM ENTRANCE (ND-E)
NORTH UPSTREAM ENTRANCE (NU-E)
FISHWAY EXIT CHANNEL
ERECTION BAY AND FISH UNITS
FO-20
FO-19
FO-18
FO-17
FO-16
FO-15
FO-14
FO-13
FO-12
FO-11
FO-10
FO-9
FO-8
FO-7
FO-6
FO-5
FO-4
FO-3
FO-2
FO-1
C-10
C-9
C-8
C-7
C-6
C-5
C-4
C-3
C-2
C-1
UNIT 18
UNIT 17
UNIT 16
UNIT 15
UNIT 14
UNIT 13
UNIT 12
UNIT 11
Powerhouse Diffusers
Floating Orifices
FISH COLLECTION CHANNEL (FISHWAY)
Flow
= Velocities < 1.5 fps
= Velocities > 4.0 fps
Note: FPP criteria require channel velocities in the range of 1.5 to 4.0 fps.
SOUTH UPSTREAM ENTRANCE (SU-E)
SOUTH DOWNSTREAM ENTRANCE (SD-E)
South Channel
SERVICE BAY
South Diffusers
CASCADE ISLAND FISH LADDER
UPSTREAM MIGRATION TRANSPORT CHANNEL
[Table F-21]
BONNEVILLE LOCK AND DAM
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 28
CONFIGURATION 2
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE


Figure F-35




[Table F-21]

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
AUXILLIARY WATER SUPPLY
BACKUP ALTERNATIVES STUDY
TW 28
CONFIGURATION 3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

Designed by: D. PATRICK — Date: 27 SEPT 1999
Drawn by: D. PATRICK — CADD File Name: BONPLATE02.DGN
Checked by: — Technical Manager:
Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct & Arch Design

PLATE 2

Figure F-36

# APPENDIX G

# OPERATIONS MANUAL

## APPENDIX G

## SECTION 1 -- BONNEVILLE SECOND POWERHOUSE EMERGENCY OPERATIONS MANUAL

### 1.1 INTRODUCTION

a. This manual was developed in the *Bonneville Second Powerhouse AWS Backup Design Documentation Report* (DDR), and is designed for inclusion in the *Fish Passage Plan* (FPP). The emergency operations manual provides a guide for configuring turbine flows, floating orifices, diffuser gates, and main gates during emergency situations when one of the Bonneville Second Powerhouse (B2) fish turbines has failed or been taken out of service. Many model runs using the *Bonneville Second Powerhouse Fishway Numerical Model* were analysed in order to determine the optimal operational configuration for the range of tailwater elevations experienced at the fishway entrances. Table 1 presents the recommended settings for each tailwater.

b. Emergency Operations Table.

| TW (ft) | Turbine MW | Turbine Q (cfs) | Floating Orifice Gates Closed | South "B" Diffuser Gates Closed | Power-House Diffuser Gates Closed | Main Entrance Gates Closed |
|---|---|---|---|---|---|---|
| 8 | 13.90 | 2950 | all | B3-8 | C1-5 | None |
| 9 | 13.95 | 3010 | all | B3-8 | C1-5 | None |
| 10 | 14.05 | 3090 | all | B3-8 | C1-5 | None |
| 11 | 14.15 | 3165 | all | B3-8 | C1-5 | None |
| 12 | 14.20 | 3230 | all | B3-8 | C1-5 | None |
| 13 | 14.40 | 3340 | all | B3-8 | C1-5 | None |
| 14 | 14.40 | 3400 | all | B3-8 | C1-5 | None |
| 15 | 14.60 | 3520 | all | B3-8 | C1-5 | None |
| 16 | 14.30 | 3515 | all | B3-8 | C1-5 | None |
| 17 | 14.20 | 3560 | all | B3-8 | C1-5 | None |
| 18 | 14.00 | 3575 | all | B5-8 | None | NU-E |
| 19 | 13.60 | 3535 | all | B5-8 | None | NU-E |
| 20 | 13.30 | 3520 | all | B4-8 | None | NU-E |
| 21 | 13.00 | 3510 | all | B4-8 | None | NU-E |
| 22 | 12.70 | 3505 | all | B4-8 | None | NU-E |
| 23 | 12.40 | 3505 | all | B4-8 | None | NU-E |
| 24 | 12.20 | 3535 | all | B4-8 | None | NU-E |
| 25 | 11.60 | 3535 | all | B4-8 | None | NU-E |
| 26 | 11.10 | 3365 | All | B4-8 | None | NU-E |
| 27 | 10.60 | 3285 | All | B4-8 | None | NU-E |
| 28 | 10.00 | 3160 | All | B3-8 | None | NU-E |

c. Sensitivity Analysis Table.

(1) Since it may be difficult for project personnel to change from Configuration 1 to 2 between tailwater elevations 17.0 ft and 18.0 ft, a sensitivity analysis was done to determine the hydraulic conditions that would results if the configuration is not changed at the selected break point. Additional computer simulations were done to provide the hydraulic characteristics associated with both Configurations 1 and 2 for tailwater elevations between 15.0 ft and 20.0 ft. The following table provides the results associated with both Configuration 1 and 2 for this tailwater elevation range. The results of these additional computer simulations show that the powerhouse collection channel velocities would meet criteria with either configuration for this range of tailwater elevations. The only difference would be that the entrance head drops meet criteria more closely in the selected configuration for each tailwater elevation. As discussed previously, the entrance head criteria were given the highest priority when selecting the optimum configuration for each tailwater elevation. Outside of the 15.0 ft to 20.0 ft range, operating at configurations other than the selected configuration is not recommended because the optimum configuration does provide significantly better results at some tailwater elevations.

## Sensitivity Analysis

| | Configuration 1 | | | | | Configuration 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Tailwater | Entrance Gate Head Difference | Entrance Gate Submergence | PH Collection Channel Velocity Range | % of PH Channel Out of Velocity Criteria | Diffuser Velocity Range (min/max) | Entrance Gate Head Difference | Entrance Gate Submergence | PH Collection Channel Velocity Range | % of PH Channel Out of Velocity Criteria | Diffuser Velocity Range |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | 1.03 to 1.65 | 12.5 | 2.07 to 3.72 | 0 | 0.16 to 0.76 | 1.20 to 1.55 | 10 | 2.11 to 3.43 | 0 | -0.25 to 0.98 |
| 16 | 1.07 to 1.99 | 11.75 to 12.75 | 1.56 to 3.43 | 0 | -0.24 to 0.84 | 1.26 to 1.57 | 10 | 2.07 to 3.20 | 0 | -0.23 to 0.98 |
| 17 | 1.11 to 1.61 | 13 | 2.08 to 3.60 | 0 | -0.20 to 0.77 | 1.34 to 1.64 | 10 | 2.08 to 3.60 | 0 | -0.19 to 0.96 |
| 18 | 1.21 to 1.67 | 13 | 2.08 to 3.73 | 0 | -0.14 to 0.77 | 1.09 to 1.36 | 11 | 1.97 to 3.02 | 0 | -0.04 to 0.97 |
| 19 | 1.26 to 1.67 | 13 | 2.03 to 3.58 | 0 | -0.13 to 0.76 | 1.11 to 1.35 | 11 | 1.90 to 2.89 | 0 | -0.08 to 0.98 |
| 20 | 1.64 to 1.95 | 11.8 to 12.5 | 2.16 to 3.69 | 0 | -0.16 to 0.79 | 1.13 to 1.36 | 11 | 1.86 to 2.79 | 0 | -0.01 to 0.97 |
| 21 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 28 | | | | | | | | | | |

Configuration 2 not recommended in this range (Configuration 1, tailwater 8–14)

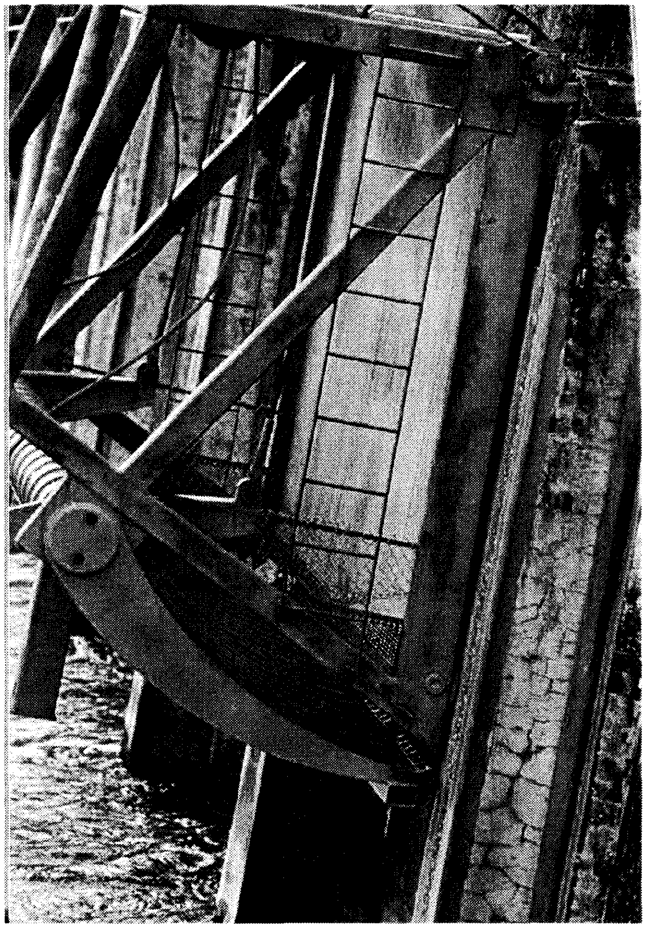
Recommended break point. (between tailwater 17 and 18)

Configuration 1 not recommended in this range (Configuration 2, tailwater 21–28)

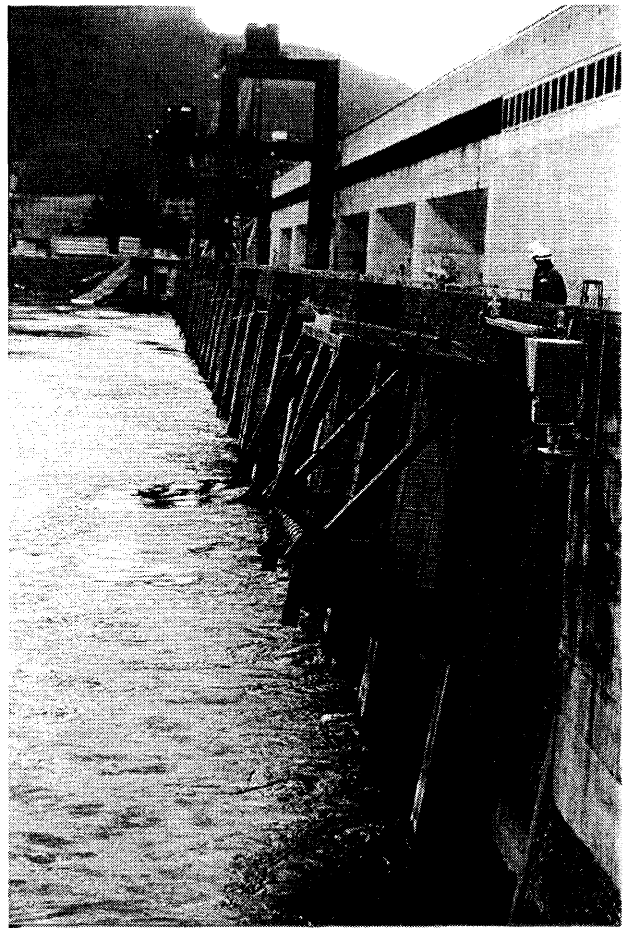
Sensitivity Analysis Table

# APPENDIX H

# PHOTOS

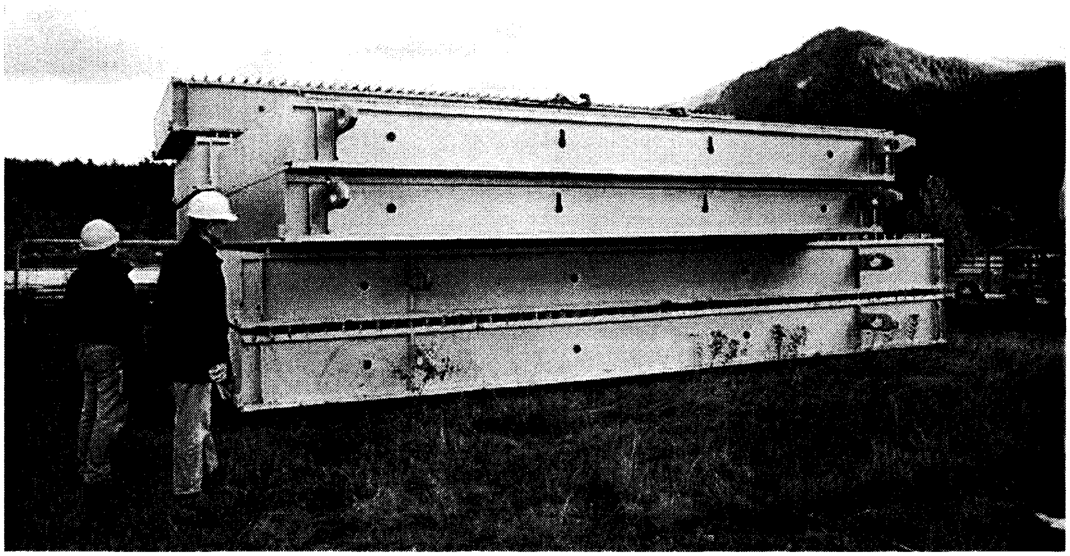


H1 Existing Rake



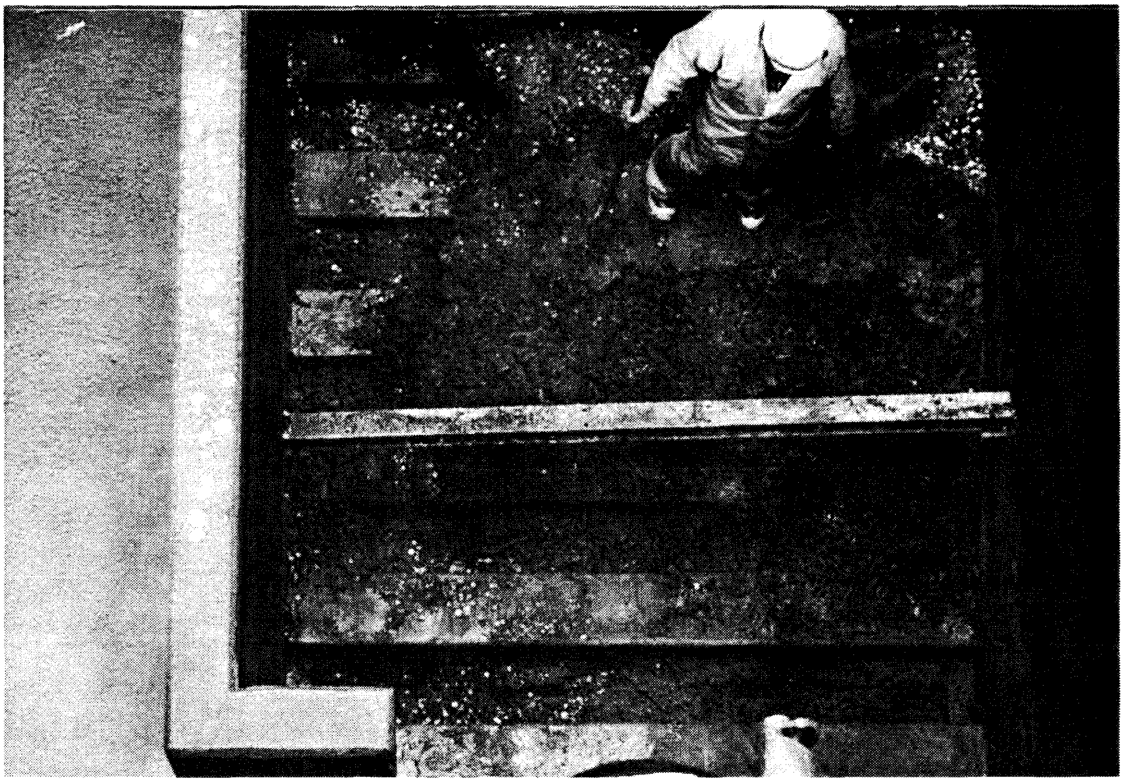
H2 Forebay and Rake

H3 Plugged Traskrack



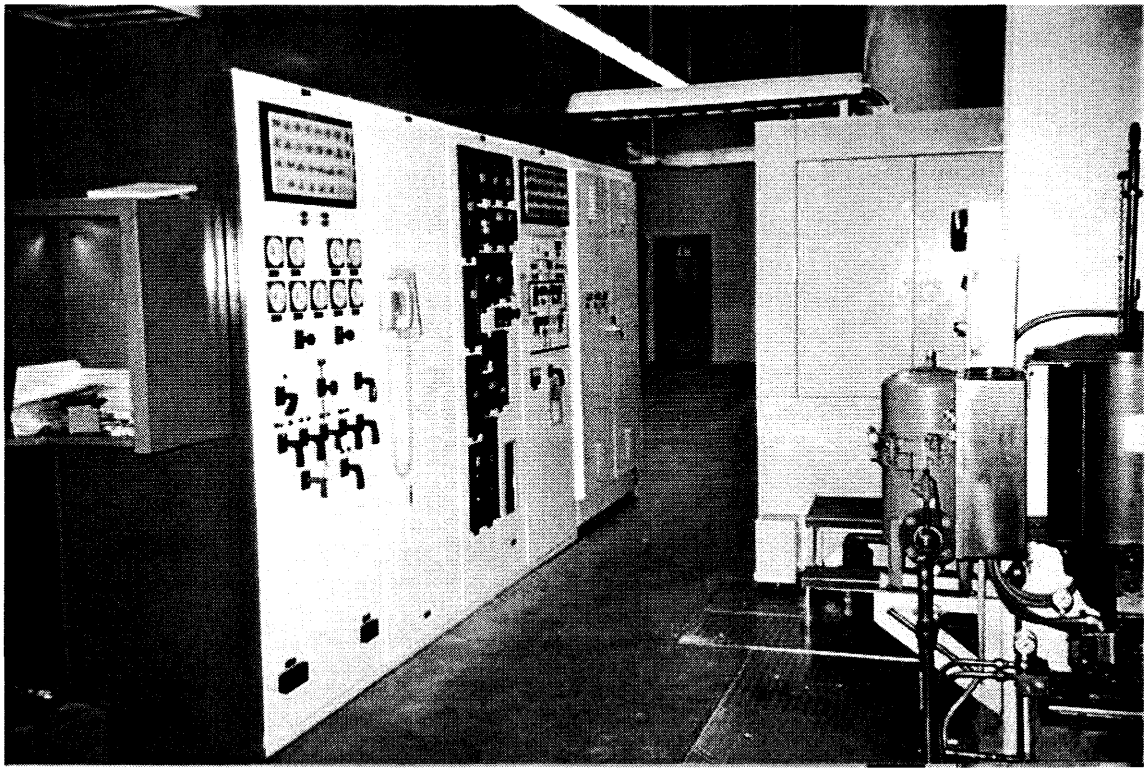
H4 Spare Trashrack

H5 Diffuser B Gate Actuator

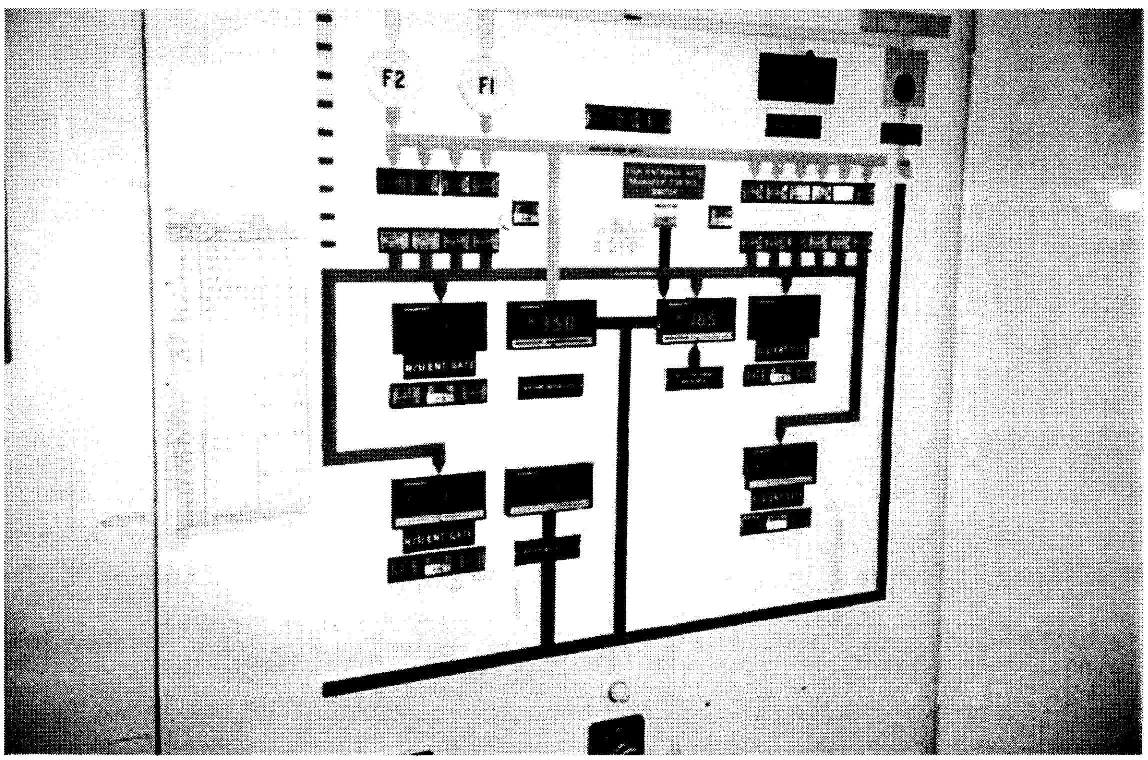


H6 Diffuser Sediment

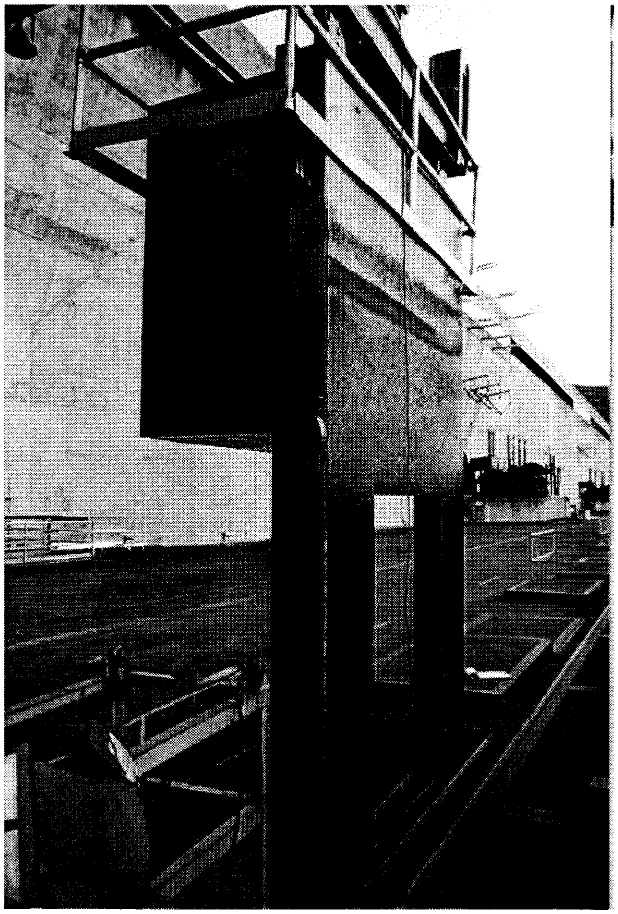
H7 Sediment in the AWS Conduit



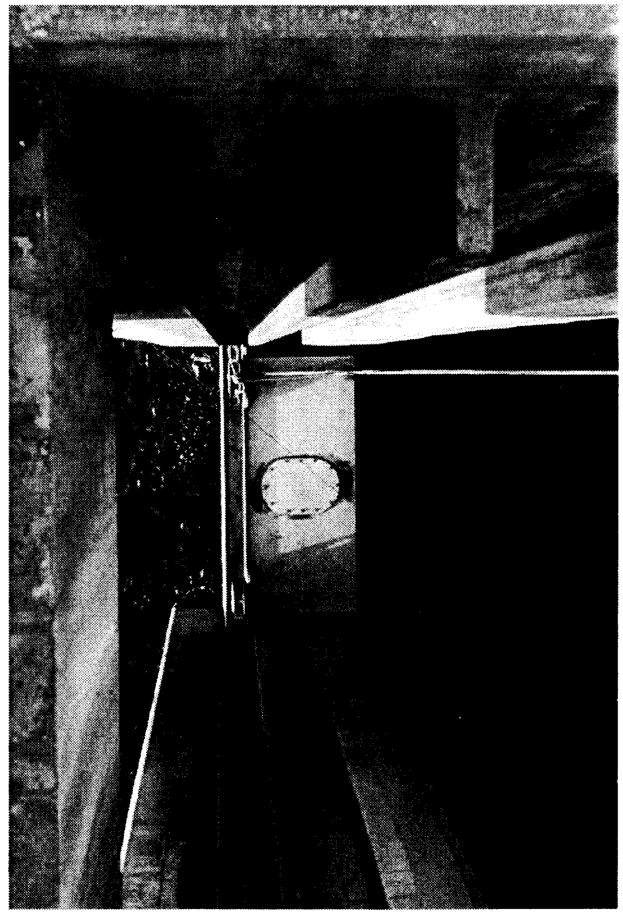
H8 SA24 Panel



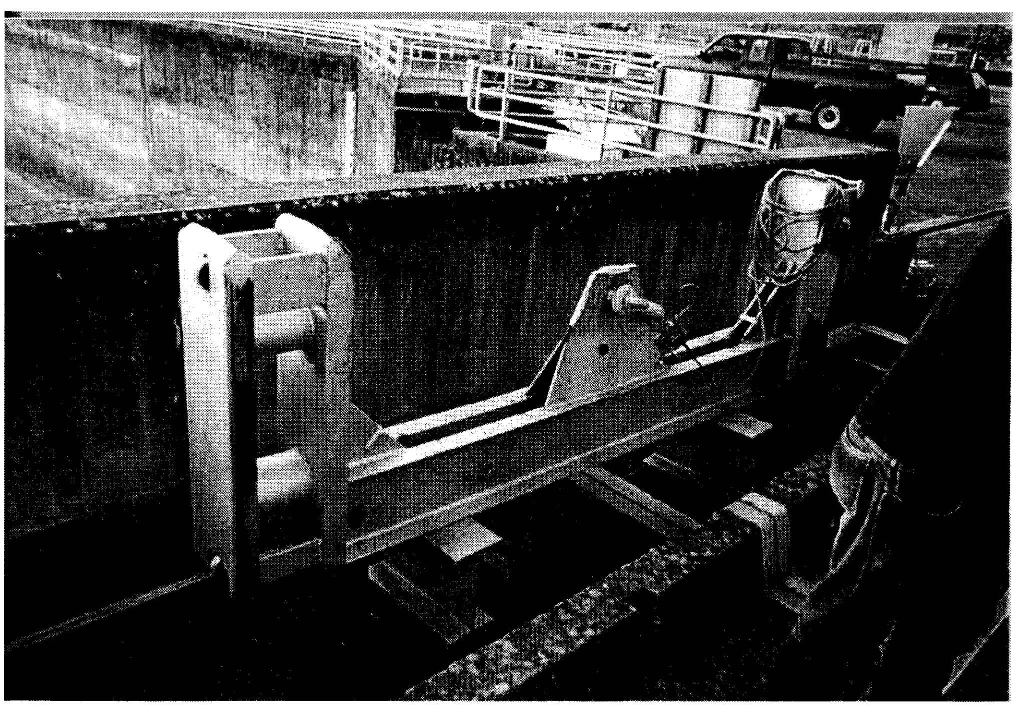

H9 SA24 Annunciator



H10 Floating Orifice Gate



H11 Floating Orifice Gate in slot Viewed from EL55 Deck



H12 Floating Orifice Gate Lifting Mechanism

# APPENDIX I

# MEETING REPORTS

**DRAFT**

**MONTGOMERY WATSON**

## SITE VISIT AND KICKOFF MEETING REPORT

**Project Name :** Bonneville 2 Auxiliary Water System (AWS) Backup Alternatives Study

**Contract :** DACW57-97-D-0004, TASK ORDER NO. 23

**Meeting Date :** November 27 & 28, 2000

**Location :** Bonneville Project & Portland Office

**Subject :** Site Visit and Kickoff Meeting

**Attendees Site Meeting:** Pat Hunter, CENWP-OP-B; Andy DeBriae, CENWP-OP-B; Dennis Schwartz, CENWP-EC-E, Jennifer Sturgill, CENWP-CO-B, Jerry Carroll, CENWP-CO-B; Dennis Dorratcague, Frank Postlewaite, and Chris Deerkop, Montgomery Watson; Lee Miesbauer, CivilTech; Lisa Larson and Eric Vandermeere, NHC.

**Attendees Kickoff Meeting:** Jerry Maurseth, CENWP-CE-DS; Randy Lee, CENWP-EC-HD; Dwayne Weston, CENWP-PE-DE, Mark Dasso, CENWP-CO-NWC, Corps of Engineers; Dennis Schwartz, CENWP-EC-E; Dennis Dorratcague, Montgomery Watson; Ed Zapel, NHC; Lee Miesbauer, CivilTech.

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Action items are underlined in the meeting report below.

### SITE VISIT

The site visit started with a meeting in the conference room of the operations building at the Bonneville Project. Gathering data for model calibration was discussed. Lisa Larsen said that obtaining velocity and water level data with a few of the orifices closed would help the model calibration. However, gathering data while all the orifices were closed would be the preferred and would provide the best model results. Andy DeBriae said that he could close all the orifices in two days. He would raise the orifices out of the water and weld a plate over the opening. He thought that it could be done without completely removing the orifices gates, thus keeping the fishway in operation. Andy said that he would need to have a budget for obtaining materials and doing the work.

Jennifer said that the The B2 fishway would be taken out of service on January 9 would be returned to service by January 23 when the Cascade Island fishway would be taken out of service. The fishway would be dewatered at the north end only at the north end only. When to cover the orifices and take the measurements were discussed. A resolution of the schedule was reached at the kickoff meeting the next day. See below. Dennis Schwartz said that it is imperative that the model be calibrated as fully as possible. Therefore, it was decided that the data should be collected with all orifice gates closed.

Dennis mentioned that Frank Postlewaite, the mechanical engineer, would like to inspect the diffuser gates to ascertain their condition. The gates to be inspected would be located at the south end of the collection channel and the south monolith. Since only the north part of the fishway is scheduled for dewatering it would not be possible to inspect the gates. Pat Hunter said that the gates underwent routine maintenance within the last two years. The gates are operated and tested during the fishway maintenance period, and many of these gates are operated during normal fishways operations. So, the gates should be in good condition. It was decided that Frank would coordinate with Pat Hunter and visit the site to witness the gate operation and testing. This would be done under normal operating conditions. Andy DeBriae said that the gates stuck and would not operate when they were trying to water up the AWS channel. However, this is not a usual operating mode. Prior to operating the gates Frank will check with a District mechanical engineer to make sure the gates would not be operated outside their design range.

The meeting ended at about 11:30. After lunch Chris Deerkop went with Carl Allen to inspect the electrical facilities. Frank Postlewaite, Dennis Dorratcague, and Lee Miesbauer went with Randy Price to look at the gates, collect a sample of the debris from the 1997 AWS cleaning, and inspect the spare fish unit trashracks. Lisa Larson and Eric went to B2 to obtain velocities and water surface elevations for model calibration purposes.

At about 3 PM Frank and Dennis returned to the Operations Building to obtain some drawings that had been requested earlier and look for more drawings.

The site visit ended at about 4 PM.

## KICKOFF MEETING

The meeting started at 8:00 AM on November 28,2000 at the Corps offices in Duncan Plaza building. Dennis Dorratcague stated that the work on this DDR is a continuation of the feasibility study that was just completed. Since the feasibility study selected final alternatives, the first submittal would be the 60% submittal. The notice to proceed (NTP) was issued on October 31, but Montgomery did not receive it until 12 days later. So, it looked as if the schedule would have to be extended. Mark Dasso saw not problem with that since the money for final design and construction was not authorized.

Dennis described the site visit and conclusions reached at that meeting. Obtaining velocity and water elevation data with the orifices blocked was discussed. It was decided that the 60% submittal could be delayed until after the field data were obtained and the model calibrated. This means that model runs with a calibrated model would be available for the 60% submittal. Dennis said that this would delay the 60% submittal until the end of January. Dennis Dorratcague will prepare a new schedule and submit it to Jerry for review.

The schedule that was discussed included the following:

- January 2 – 4 Weld plates over the orifices in all twelve orifice gates
- January 5 NHC will collect velocity and water level data

# DRAFT

- January 8 Begin taking the fishway out of service
- After January 8 Remove orifice cover plates, if necessary
- January 8 – 29 Calibrate model, make model runs, develop the 60% submittal

Dennis Schwartz will talk to the project about scheduling installing the orifice cover plates between January 2 and 4 and NHC taking data on January 5. Mark Dasso will arrange the budget for the project to obtain the steel plates and weld them over the orifice gate openings.

Mark Dasso mentioned that it would be advantageous to leave the orifice plates in place for about one year. This would allow for collecting not only velocity data but also biological data of fishway use by upstream migrants. Dennis Schwartz will contact NMFS and explore with them leaving the orifices covered for one year.

The meeting ended at 9:15 AM.

MONTGOMERY WATSON

# PROGRESS REVIEW MEETING REPORT

**Project Name :** Bonneville Second Powerhouse Auxiliary Water Supply Backup System Design Documentation Report

**Contract :** DACW57-97-D-0004, TASK ORDER NO. 23

**Meeting Date :** April 16, 2001

**Location :** Summit Room, District Offices in Portland

**Subject :** Progress Review Meeting 60% Report

**Attendees :** Jerry Maurseth, Randy Lee, Michael Moran, Dennis Schwartz, Dwayne Weston Portland District COE; Christine Mallette ODFW; Ed Myer, NMFS, Ed Zapel, Lisa Larson, Northwest Hydraulic Consultants; Lee Miesbauer, CivilTech; Dennis Dorratcague, Frank Postlewaite Peter Barton, Montgomery Watson.

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The action items are underlined in the following meeting report.

**Overview**

The meeting began at 10:00 AM. Dennis Dorratacague gave a brief overview of the progress to date. The objective of the meeting was defined as achieving a consensus on which alternative(s) would be developed to the 90% level. The layout of the report was then described.

**Alternatives Presentation**

- **AWS Operations Alternative** – Lisa Larson provided an overview of the modeling effort to date. Three alternative fishway configurations are being modeled from which the best run for a tailwater is identified. The hierarchy of criteria established in the earlier study is used to guide model run evaluations along with operational considerations that take into account the frequency and location of diffuser gate closures. The following was decided: Because diffuser gates B1 and B2 do not have motorized actuators, other gate closure combinations will be investigated to see if not using these gates has a large impact on conditions in the fishway. If it necessary to operate these gates, modifications will be recommended that an actuator nut be added to the manual hand wheel and a hand actuator drive be acquired.

  Dennis Schwartz recommended that the operational plan being developed through the modeling effort be considered a guide, or a starting point, from which project operators can begin to optimize the fishway during an emergency. After setting the gates according the results of the modeling effort, the operators would then take measurements to verify that the fishway is behaving as predicted. Dennis doesn't want the operations plan to be adopted into the FPP before the verification effort.

**Floating Orifice Gate Closure Schemes** – Frank Postlewaite described the floating orifice closure schemes. Alternative 3 –Lower Bulkhead From Above was selected as the preferred alternative. There are two variations of this alternative – (1) place the stab closure plate in slots on the tailrace side of the orifice gate, and (2) place the stab plate on the collection channel side of the orifice. It was decided that variation (1) is preferred. This alternative will require that the operations staff verify the available horizontal clearance between the deck and the floating orifice as it is being removed through the deck. If the stab plates will not fit on the downstream face, variation No. 2 would be preferred, In this case the stab plates would be installed on the upstream face of the floating orifice gates. This would require rebuilding the floatation tanks to allow the stab plates to be withdrawn through them.

It was agreed that Dennis Schwartz would coordinate an effort to collect data at each gate slot to verify the horizontal clearance between the gates and the deck hatches. The data collection effort will occur in the summer lull in fish passage, which will probably occur during the second week of June. Precise measurements of existing freeboard will be taken. Montgomery Watson will prepare a memorandum describing the data to be collected and the methods to be used. Project staff at B2 will take the measurements. It was recognized that the schedule for the 90% submittal would be delayed by these activities.

A suggestion to bolt plates to the floating orifices was considered. However, because the fishway would be shut down to install the plates, for at least an 8-12 hour time period, with the potential for longer delays to pull the gates and install the plates, it was decided not to pursue this idea.

Ed Meyer thought that although the ability to close all the floating orifice gates within 2 hours would be beneficial, the cost associated with motorized actuation probably can't be justified. Ed thought that an alternative that could close the gates within one night (6 to 8 hours) would be accepted by the fisheries agencies.

Alternative 4 – Permanent Closure – This alternative can not be implemented without further biological testing of the effectiveness of the floating orifice gates. It was decided to keep it in the report.

**Diffuser Gates** – Frank described the field effort to evaluate the B diffuser gates. It was agreed that Montgomery would contact Andy Debrie at the project, in order to assess the C diffuser gates.

**Stockpile Crucial Spare Parts** – Work will continue to develop the spare parts list. Dennis Schwartz requested that he be able to review the list before the conclusion of the DDR.

**Sediment Accumulation** – Frank Postlewaite described the sediment accumulation problem, and it was agreed to block off the bottom portion of the trashracks in front of the fish units and to implement a yearly maintenance dredging program. Closing off the lower portion of the trashracks will allow yearly maintenance dredging to occur during the in-water work period. Jerry Maurseth will contact HDC in order explore the impacts on turbine efficiency due to closing off the bottom portion of the trashracks. It may be necessary to install a transition piece behind the blank panels in order to reduce turbulence.

**Trashrack Debris Accumulation and Diffuser Rack Clogging** – The most difficult question remaining is the choice between a telescoping rake, or an automatic traveling grip rake. Both rakes have advantages and disadvantages. This area of the forebay could be subject to high velocity cross currents (i. e. currents along the face of the powerhouse). Because the trash rack is over 100 feet below the surface of the EL 90 deck, alignment of either cleaning unit could be problematic. It was agreed that Jerry Maurseth would coordinate a conference call that would include Portland District COE staff, B2 operations staff, and MW in order to make a decision.

Randy Lee agreed to provide velocity data taken in the forebay in front of the powerhouse.

Cathodic protection and coatings for the new trashracks were discussed.

**Install Pressure Gage in AWS Conduit** – It was agreed to install pressure gages in locations where problems have occurred in the past. This would include the location selected in the B diffuser gallery, at the junction pool on the north end, and possibly a short distance up the ladder. It may be possible to use existing cable conduit to route the signal back to the generator switchboard, SA24 located near the fish units.

Concern was expressed about bolt fatigue induced by transients caused by starting the fish turbines. Pressure gages could measure the transients. If the debris is kept out of the AWS, headloss through the diffuser gratings would be very low.

**Other Issues** – It is assumed that AWS unwatering scheme would continue unchanged by the corner collector installation. Provisions should be made in the corner collector for a pipe to discharge from the "chimney" area into the sluiceway. The corner collector will discharge 5000 cfs. The amount of flow introduced by the unwatering pumps would be very small. Because the AWS would be unwatered during the in-water work period, it is unlikely that the AWS would be unwatered while the corner collector was in operation or juvenile fish are present.

**Future Work** – The schedule impacts of the floating orifice data collection effort will be assessed and communicated to Jerry Maurseth in order to establish dates for the 90% submittal and PRM.

**Summary of Additional Data Collection:**

- **MW** –
  - ➢ Montgomery will contact Andy Debrie at the project, in order to assess the C diffuser gates.
  - ➢ Prepare a memorandum describing the data to be collected and the methods to collect the data on gate clearances.
- **Dennis Schwartz** – Coordinate effort to measure gate clearance.
- **B2 Operations Staff** – Measure gate clearances and floating orifice freeboard.
- **Randy Lee** – Provide velocity data for area in front of the fish turbine intakes.
- **Jerry Maurseth** –
  - ➢ Contact HDC in order to explore the impacts on turbine efficiency due to closing off the bottom portion of the trashracks.
  - ➢ Coordinate a conference call that would include Portland District COE staff, B2 operations staff, and MW in order to make a decision on which trash rake alternative to select.

MONTGOMERY WATSON

# PROGRESS REVIEW MEETING REPORT

**Project Name :** Bonneville Second Powerhouse Auxiliary Water Supply Backup System Design Documentation Report

**Contract :** DACW57-97-D-0004, TASK ORDER NO. 23

**Meeting Date :** September 4, 2001

**Location :** Cascade Room, District Offices in Portland

**Subject :** Progress Review Meeting 90% Report

**Attendees :** Jerry Maurseth, Randy Lee, Dennis Schwartz, Dwayne Weston, Duncan Kwong, Patrick Hunter, Mark Dasso, Dave Illias, Portland District COE; Gary Fredricks, Ed Myer, NMFS; Ed Zapel, Lisa Larson, Northwest Hydraulic Consultants; Lee Miesbauer, CivilTech; Dennis Dorratcague, Frank Postlewaite Peter Barton, Montgomery Watson Harza.

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The action items are underlined in the following meeting report.

**Overview**

The meeting began at 10:00 AM. Dennis Dorratacague gave a brief overview of the progress to date. The objective of the meeting was defined as achieving a consensus on which trash rake would carried into the 100% report.

**Alternatives Presentation**

- **AWS Operations Alternative** – Lisa Larson provided an overview of the modeling effort to date. Three operating configurations were identified that produce optimum fishway conditions for low, medium, and high tailwaters. The 90% effort simulated the intermediate tailwaters, defining operating configurations in 1-foot increments from tailwater elevation 8 feet to 28 feet.

  The NMFS expressed some concern that the NUE would be closed under some operating configurations. <u>The NMFS will examine their records and determine if closing the NUE would have too large an impact on the returning fish and if it would be better to close a different gate.</u> It was explained that closing the NUE gate produced the largest beneficial effect on the hydraulic conditions in the powerhouse collection channel.

  The NMFS requested that a dead band be identified that would provide guidance to operators about the sensitivity of the fishway to the changes proposed in operations plan. <u>Nhc will review their model runs and show the effects on the fishway hydraulics if it is operated in</u>

the alternative 1 configuration past the break point where it is recommended that the gates be reconfigured to the alternative 2 mode for tailwaters 1-foot, 2 feet, and three feet above and below the break points. Similarly, they will examine the break points between the alternative 2 and alternative 3 configurations. This information will be included in Appendix G.

A discussion followed that compared the effort required to close all the floating orifice gates and adjust the diffuser gates to the current method of closing the ice and trash sluiceway and spilling additional into the AWS over a weir. More man hours will be required when the operations plan is implemented.

It was agreed that the operations plan would be presented as a table for inclusion in the FPP. The language of the FPP will be modified by others.

**Floating Orifice Gate Closure Schemes** – Frank Postlewaite described the results from a field effort to measure the clearance between the floating orifice gates and deck openings on the EL 55 deck. He then described the evolution of the preferred gate closure scheme: an aluminum slide plate installed at deck level, and uninstalled by use of a tag line. Consensus was reached to proceed with this scheme. It was agreed that a rack to store the aluminum slide plates would be described in the text of the DDR. A sketch could be included.

**Stockpile Crucial Spare Parts** – The final list of spare parts was presented. It was noted that the list of parts no longer includes computer controller for the turbine cams. The B1 computer upgrades provide a source of compatible spare parts.

**Sediment Accumulation** – Frank Postlewaite described the sediment accumulation problem, and it was agreed to block off the bottom portion of the trashracks in front of the fish units and to implement a yearly maintenance dredging program. Closing off the lower portion of the trashracks will raise the invert of the fish unit intakes by 13.5 feet, thereby creating an adequate area for sediment to accumulate to allow yearly maintenance dredging to occur during the in-water work period. The HDC has stated that a blank panel will not produce a measurable effect on the efficiency of the fish unit turbines.

NMFS inquired about the structural alternatives modeled at WES (berms located upstream of trash racks). The COE replied the structural alternatives were too expensive so the option of installing a blank panel and maintaining a dredging program was chosen.

**Trashrack Debris Accumulation and Diffuser Rack Clogging** – It was agreed to move forward with the gripper type trash rake. Project staff feel it would be more difficult to maintain the Cross type rake because of its large size and more extensive hydraulics. The gripper type machine hangs over the water on a rail, leaving more deck space clear. The Cross type machine is powered by 50 HP motor. The gripper type trash rake is powered by a 5 HP motor to close the teeth and two 1.5 HP motors to lift it. The power requirements differ because the gripper descends by gravity, while the Cross type machine descends by means of an hydraulic boom. It would be simpler to supply the power to the gripper type machine. The Cross type machine needs much more hydraulic fluid than the gripper style machine. The hydraulics of the Cross type machine however are contained within the protection of the boom. The gripper style machine is powered by means a more exposed hydraulic line extending into the water. Both machines scrape the material from between the trash rack bars. However, both machines may have trouble containing the material scraped off. It was thought that the gripper style would be able to retain more material due to its opposing teeth. ( the gripper has two jaws, while the Cross style machine has one).

NMFS expressed concern that the hydraulics from either rake will leak. It is not possible to actuate the gripper with cables. Frank Postlewaite will determine if the gripper could be reconfigured to operate pneumatically. If pneumatic operation is not possible, it was agreed that a preventive maintenance program would be developed that would systematically change the seals and hoses to the gripper hydraulics in order to stop leakage before it occurs.

Concern was expressed that the either rake would scrape debris off the rack only to suspend it briefly before it lodged on the screen again. Frank Postlewaite will investigate the possibility that the gripper could be modified to retain smaller debris.

A barrier was considered to prevent accumulations of logs in the path of the trash rake. This barrier would allow the trash rake to clean the trashrack without first removing the floating debris. However, the inclusion of the barrier could make it difficult to remove sunken or semi-buoyant logs with the gantry crane. A large submerged log could become wedged if either cleaner brought it to the top underneath the barrier. It was decided to not include the log barrier or a log boom as part of the design. It could be included at a later date if needed.

**Install Pressure Gage in AWS Conduit** – Conduit runs to the junction pool area at the north end of the powerhouse have been identified for the transducer installations. Powering the pressure transducers was discussed. Power will travel on the same wires as the digital signal returning to the control panel. This scheme will require 2-wire submersible level transmitters. It was pointed that these are not typically used at the Project.

**Other Issues** – The schedule will deleted. It was suggested to break the work into three parts and only describe the tasks in terms of critical durations. Lead times will be identified for key elements of the various tasks described in the DDR. This will enable various parts of the work to be appended to other work orders.

**Future Work** – The schedule the final submittal will be worked out with Jerry Maurseth.

**Summary of Additional Data Collection:**

- **MWH**–
  - Include a discussion of a storage rack for the aluminum slide plates.
  - Determine if the gripper trash rake can be actuated with air power.
  - Determine if the gripper trash rake can modified to retain material when closed.
  - Provide more detail on the gripper trashrake, including information on the tines and the hydraulic hose.
- **Gary Fredricks** – Will contact Jerry Maurseth if the NUE should not be closed.
- **Nhc**– Will provide dead band information for operations manual.

# APPENDIX J

# SITE VISIT REPORTS

**DRAFT**

**MONTGOMERY WATSON**

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## DIFFUSER B GATE TESTING SITE VISIT REPORT

**Project Name :** Bonneville 2 Auxiliary Water System (AWS) Backup Alternatives Study

**Contract :** DACW57-97-D-0004, TASK ORDER NO. 23

**Meeting Date :** January 3, 2001

**Location :** Bonneville Project

**Subject :** Diffuser B Gates Testing

**Attendees Site Meeting:** Pat Hunter, Andy DeBriae, and Frank Postlewaite

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Action items are underlined in the meeting report below.

### SITE VISIT

The purpose of this site visit was to test the B Diffuser Gate actuators. Emergency operation may require the gates to operate with a higher than normal hydraulic head across the gate. This test is intended to measure the gate performance while subjecting the gates to head conditions expected during emergency operation. The test requires measuring the hydraulic differential across the gate (between the chamber downstream of the gate and the Auxiliary Water System (AWS) Conduit) while measuring the electrical performance of the actuator motor.

The site visit started at the Bonneville Powerhouse south monolith. Pat Hunter, Andy DeBriae, and Frank Postlewaite discussed testing the B Diffuser Gates. Originally Frank Postlewaite had intended to measure the AWS water surface elevation through a shaft leading down to the AWS conduit from the Service Bay deck adjacent to the ice and trash chute. Unfortunately, one of the Fish Turbines was out of service and supplemental water was being discharged down this shaft from the ice and trash chute. This prevented direct measurements of the AWS conduit water surface elevation.

To work around this problem, the headloss through a given diffuser gate was estimated, while the water surface elevations of the collection channel and the chamber down stream of the diffuser gates was measured directly. Water surface elevations were measured with a well sounder, allowing measurements to within 0.25-inches. The differential across a fully open gate is estimated by calculating the flowrate based on the differential across the orifice between the chamber downstream of the diffuser gate and the collection channel. The gate differential is then calculated using this flowrate.

**DRAFT**

Pat Hunter, Operations Personal for operating the gates, an Electrician, and Frank Postlewaite sequentially opened and closed gates, measured motor current and voltage, and sounded the water surface levels. The results of this testing are summarized in the following table.

At about 1:30 PM Frank returned to the Operations Building to obtain some drawings.

The site visit ended at about 2 PM.

Field observations and estimated hydraulic differentials across the gates are summarized in the attached table titled "B Diffuser Gate Testing, 1/3/01".

| B Diffuser Gate Testing, 1/3/01 | | | | |
|---|---|---|---|---|
| | **Condition 1** | **Condition 2** | **Condition 3** | **Condition 4** |
| Open Gates | B1, B2, B3, B4, B5 | B1, B2, B3, B4 | B1, B2, B3 | B2 |
| Closed Gates | B6, B7, B8 | B5, B6, B7, B8 | B4, B5, B6, B7, B8 | B1, B3,B4, B5, B6, B7, B8 |
| Collection Channel Location | B6 | B5 | B4 | B3 |
| Collection Channel Reading | 33.25 | 33.25 | 33.18 | 33.33 |
| Gate Reading | 32.5 | 32.17 | 31.58 | 31.58 |
| Collection Channel Elevation | 12.75 | 12.75 | 12.82 | 12.67 |
| Gate Chimney Elevation, fmsl | 13.5 | 13.83 | 14.42 | 14.42 |
| Differential, ft | 0.75 | 1.08 | 1.6 | 1.75 |
| Area of Outlet, sf | 23.01 | 38.68 | 38.68 | 38.68 |
| *Flowrate, cfs* | 119.9 | 241.9 | 294.5 | 308.0 |
| Area of Gate, sf | 18.0 | 36.0 | 36.0 | 36.0 |
| *Gate to AWS Differential, ft* | 1.0 | 1.0 | 1.4 | 1.6 |
| ***Total Differential with the Gate closed, ft*** | **1.7** | **2.1** | **3.0** | **3.3** |
| ***Note: Italized Parameters are Estimated*** | | | | |
| | | | | |
| **Gate 3** | | | | |
| **Start Closing** | | | **5.40** | |
| **50% Closed** | | | **5.24** | |
| **75% Closed** | | | **5.30** | |
| **90% Closed** | | | **5.46** | |
| **Start Opening** | | | **7.10** | **7.60** |
| | | | | |
| **Gate 4** | | | | |
| **Start Closing** | | **5.50** | | |
| **50% Closed** | | **4.98** | | |
| **75% Closed** | | **5.00** | | |
| **90% Closed** | | **4.95** | | |
| **Start Opening** | | **6.00** | | **6.50** |
| | | | | |
| **Gate 5** | | | | |
| **Start Closing** | **3.50** | | | |
| **50% Closed** | **3.20** | | | |
| **75% Closed** | **3.30** | | | |
| **90% Closed** | **3.07** | | | |
| **Start Opening** | **3.40** | | | **3.70** |
| | | | | |
| **Gate 6** | | | | |
| **Start Opening** | | | | **3.68** |

| | | | | |
|---|---|---|---|---|
| | | | | |
| **Gate 7** | | | | |
| **Start Opening** | | | | **4.00** |
| | | | | |
| **Gate 8** | | | | |
| **Start Opening** | | | | **3.8** |
| | | | | |
| **Typical Voltage:** | **205 to 208 VAC** | | | |
| | | | | |
| Gates: | Size | Actuator | Actuator FLA | Maximum Reading |
| B1 | 72" x 72" | Manual | N.A. | N.A. |
| B2 | 72" x 72" | Manual | N.A. | N.A. |
| B3 | 72" x 72" | Electric | 7.30 | 7.60 |
| B4 | 72" x 72" | Electric | 7.30 | 6.50 |
| B5 | 36" x 72" | Electric | 3.96 | 3.70 |
| B6 | 36" x 72" | Electric | 3.96 | 3.68 |
| B7 | 36" x 72" | Electric | 3.96 | 4.00 |
| B8 | 36" x 72" | Electric | 3.96 | 3.80 |

**DRAFT**

**MONTGOMERY WATSON**

# SITE VISIT REPORT - FLOATING ORIFICE MEASUREMENTS, C DIFFUSER GATES, AND RACEWAYS FOR LEVEL TRANSMITTERS IN THE TRANSPORTATION CHANNEL AT MONOLITH 1N.

**Project Name :** Bonneville 2 Auxiliary Water System (AWS) Backup Alternatives Study

**Contract :** DACW57-97-D-0004, TASK ORDER NO. 23

**Meeting Date :** June 7, 2001

**Location :** Bonneville Project

**Subject :** Floating orifice measurements and information gathering on existing raceways, and C Diffuser gates.

**Attendees Site Meeting:** Pat Hunter and Frank Postlewaite

Action items are underlined in the meeting report below.

## SITE VISIT

The purpose of this site visit was to measure the clearance between the floating orifices gates and the concrete deck (elevation 55) as the gates are withdrawn. The existing raceways to the AWS Diffuser Gates at monolith 1N were evaluated for use by level transmitters. Information was gathered on the C Diffuser gate actuators to determine a safe operating differential head across the gate.

The site visit started at the Bonneville Maintenance building. Pat Hunter and Frank Postlewaite discussed the necessary routing for future level transmitters in the junction pool at monolith 1N. Drawing sheets depicting the embedded conduits where located and copied for the conduits of interest. These sheets include: 87 (BDF-4-11/4), 156 (BDP-1-6-1C1/2), 158 (BDP-1-6-1C1/4), 160 (BDP-1-6-1C1/6), 161 (BDP-1-6-1C1/7). Drawing sheet for the C Diffuser gates were also found. These sheets include 74 (BDP-1-3-2/70), 74.1(BDP-1-3-2/71), and 74.2 (BDP-1-3-2/72).

After investigating the available drawings, Pat Hunter and Frank Postlewaite met with Pete Hammerlink (Electrical Foreman). The conduits identified on the drawings were located in the field. Four sets of conduits extend from the elevation 28 level in the erection bay out to the respective control and power connections to abandoned gate actuators on the north and south side of the junction pool. The control conduits terminate in a junction box and the power conduits in a lighting panel. A 3" conduit extends down from the control junction box into panel SA24, which is the ultimate destination for the new conductor. Based on this investigation it appears the existing diffuser gate conduits will serve well as raceways for the proposed level transmitter conductors.

After site investigations were completed a 4:30 PM, Frank met with the lead Rigger and discussed plans for measuring the floating orifice gates later that evening. The lead rigger observed that gate slots that are not used for several years are likely to silt up, making it difficult to install the gate.

Starting at 8:00PM the Riggers (a crew of 5) began preparing for removing the floating orifice gates. The first gate, starting at the north end of the powerhouse, was pulled at 8:30 PM. The gate removal required removing the top slabs and relocating 6 bulkheads (the bulkheads are hung in slots adjacent to the floating orifice gate slots and must be removed to remove the floating orifice gates). The process was delayed by the failure of the boom truck at about 9:00 PM. All the work was performed with the gantry crane.

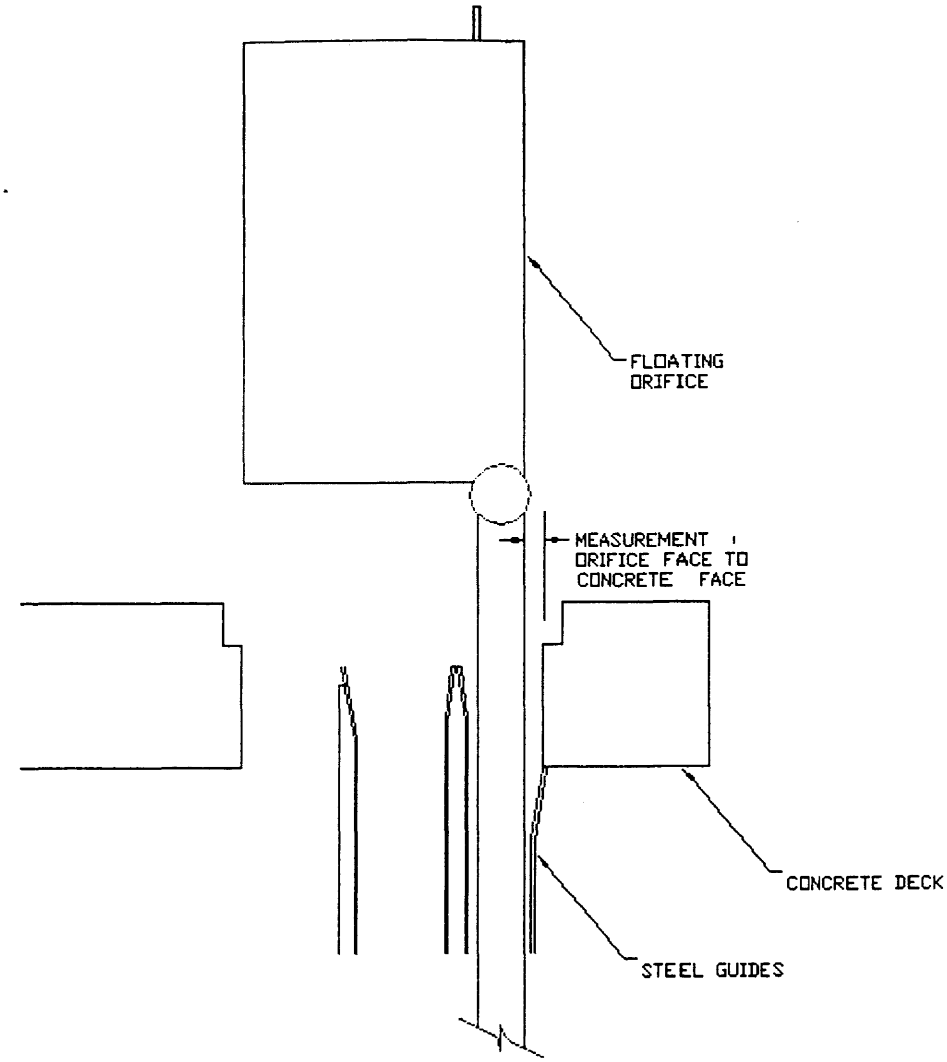
The measurements are summarized on the attached table. Minimum and maximum measurements were taken by shifting the crane position to deflect the floating orifice gate to the upstream limits of positioning the gate (maximum) and the downstream limit (minimum). The locations of the measurements on the gate are depicted on the attached figure (tif file) "Measureb2". The freeboard measurements were difficult to discern from the existing scum lines and wetted surface (the weight of the lifting yoke and hoist block forced the gate down and unknown depth). The last floating orifice gate was replaced at 1:45 AM on Friday. The total elapsed time from pulling the first floating orifice gate to replacing the last was 5.25-hours.

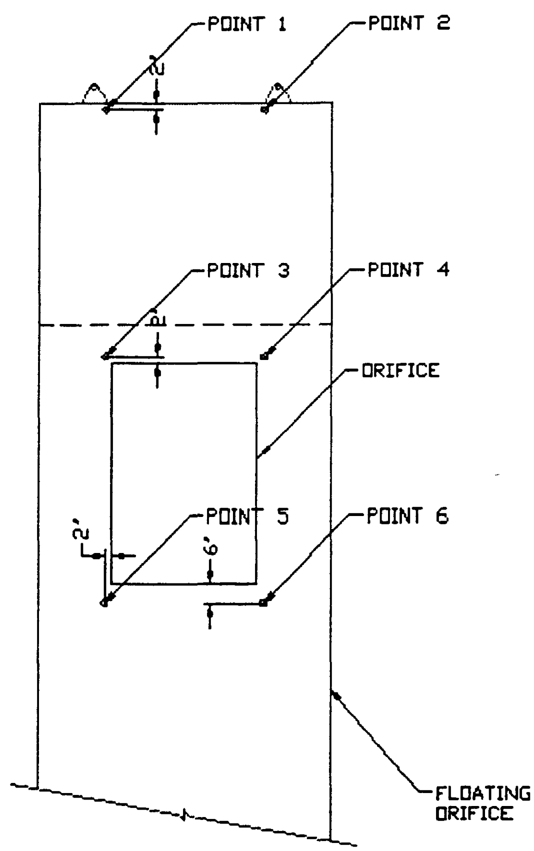
The site visit ended at about 2 AM.

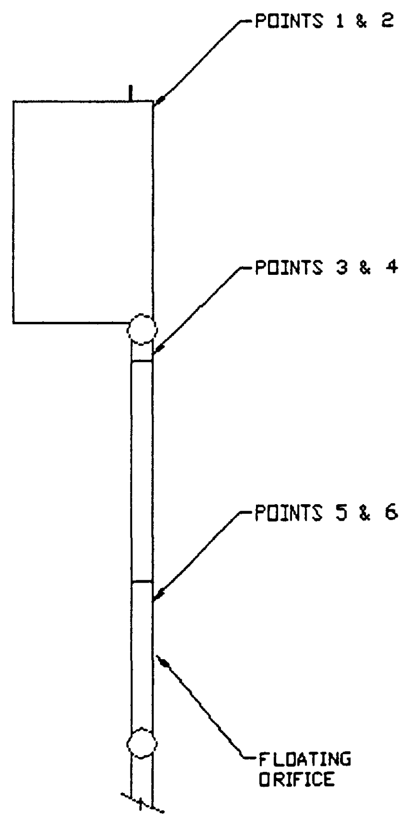
## B2 AWS DDR - Floating Orifice Gate Measurements

| Gate | 1 - Top North Min. | 1 - Top North Max | 2 - Top South Min. | 2 - Top South Max | 3 - Middle North Min. | 3 - Middle North Max | 4 - Middle South Min. | 4 - Middle South Max | 5 - Bottom North Min. | 5 - Bottom North Max | 6 - Bottom South Min. | 6 - Bottom South Max | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.5 | 3.6 | 2.9 | 3.8 | 0.3 | 5.6 | 0.5 | 3.1 | 2.0 | 4.6 | 2.1 | 4.8 | **2.8** |
| 3 | 3.6 | 4.3 | 3.8 | 4.3 | 2.0 | 6.6 | 2.1 | 6.8 | 3.0 | 5.6 | 3.1 | 5.7 | **4.1** |
| 5 | 3.4 | 4.5 | 3.4 | 4.2 | 1.8 | 6.6 | 1.4 | 6.8 | 2.6 | 5.4 | 2.7 | 5.5 | **4.1** |
| 7 | 3.5 | 4.0 | 3.6 | 4.1 | 1.8 | 6.4 | 1.9 | 6.5 | 2.4 | 5.0 | 2.5 | 5.1 | **4.1** |
| 9 | 3.8 | 1.1 | 3.8 | 4.1 | 1.6 | 6.7 | 1.9 | 6.9 | 1.5 | 4.8 | 1.6 | 4.9 | **4.0** |
| 10 | 3.5 | 3.8 | 3.5 | 3.9 | 2.0 | 7.1 | 2.1 | 7.1 | 2.6 | 5.4 | 5.3 | 2.4 | **4.5** |
| 11 | 2.7 | 3.4 | 2.8 | 3.6 | 0.4 | 5.5 | 0.5 | 5.6 | 1.3 | 3.9 | 1.6 | 4.3 | **3.6** |
| 12 | 3.3 | 3.6 | 3.3 | 3.8 | 1.3 | 6.4 | 1.4 | 6.5 | 2.2 | 4.8 | 2.3 | 4.8 | **4.3** |
| 14 | 3.5 | 3.8 | 3.5 | 3.9 | 1.5 | 6.3 | 1.6 | 6.5 | 2.5 | 5.3 | 2.6 | 5.3 | **4.6** |
| 16 | 3.6 | 3.4 | 3.6 | 3.8 | 1.6 | 6.0 | 1.8 | 5.9 | 2.6 | 5.0 | 2.7 | 5.1 | **4.7** |
| 18 | 3.9 | 4.1 | 3.9 | 4.1 | 3.1 | 4.8 | 3.1 | 4.6 | 3.9 | 5.1 | 3.9 | 5.1 | **5.2** |
| 20 | 4.1 | 4.1 | 4.1 | 4.1 | 3.1 | 4.3 | 2.9 | 4.3 | 3.1 | 4.1 | 3.1 | 4.3 | **5.0** |
| Average | 3.4 | 3.6 | 3.5 | 4.0 | 1.7 | 6.0 | 1.8 | 5.9 | 2.5 | 4.9 | 2.8 | 4.8 | |
| Minimum | 2.5 | 1.1 | 2.8 | 3.6 | 0.3 | 4.3 | 0.5 | 3.1 | 1.3 | 3.9 | 1.6 | 2.4 | |
| Maximum | 4.1 | 4.5 | 4.1 | 4.3 | 3.1 | 7.1 | 3.1 | 7.1 | 3.9 | 5.6 | 5.3 | 5.7 | |

| Gate | Orfice Width, Feet | Monolith Location | Freeboard Upstream Min. | Freeboard Upstream Max | Freeboard Downstream Min. | Freeboard Downstream Max |
|---|---|---|---|---|---|---|
| 1 | 4 | 11 A (out) | 29 | 35 | 38 | 42 |
| 3 | 4 | 11 B (in) | 26 | 30 | 36 | 41 |
| 5 | 2 | 12 A (out) | 27 | 33 | 38 | 44 |
| 7 | 2 | 12 B (in) | 27 | 31 | 36 | 47 |
| 9 | 2 | 13 A (out) | 26 | 30 | 40 | 46 |
| 10 | 2 | 14 A (out) | 26 | 33 | 40 | 44 |
| 11 | 2 | 15 B (out) | 26 | 32 | 41 | 48 |
| 12 | 2 | 16 B (out) | 23 | 33 | 42 | 48 |
| 14 | 2 | 17 A (in) | - | 29 | - | 42 |
| 16 | 2 | 17 B (out) | - | 29 | - | 43 |
| 18 | 4 | 18 A (in) | 25 | 28 | - | 42 |
| 20 | 4 | 18 B (out) | - | 26 | - | 41 |


FLOATING
ORIFICE
MEASUREMENT
ORIFICE FACE TO
CONCRETE FACE
CONCRETE DECK
STEEL GUIDES


POINT 1
POINT 2
2'
POINT 3
POINT 4
2'
ORIFICE
POINT 5
POINT 6
2'
6'
FLOATING
ORIFICE


POINTS 1 & 2
POINTS 3 & 4
POINTS 5 & 6
FLOATING
ORIFICE

# MEMORANDUM

**MONTGOMERY WATSON**

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**To:** Jerry Maurseth, Dennis Schwartz, Patrick Hunter, Mark Dasso, Lee Miesbauer

**Date:** 6/20/01

**From:** Frank Postlewaite and Peter Barton

**Reference:**

**Subject:** B2 AWS DDR – Floating Orifice Gates

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This memorandum presents a new alternative for closing the floating orifice gates along the B2 powerhouse. *Alternative 3 – Lower Bulkhead From Above* was selected at the 60% PRM for the *Bonneville Second Powerhouse Auxiliary Water Supply Backup System Design Documentation Report (DDR).* This alternative involved inserting a stab plate into guides on the downstream face of the floating orifice gates from the EL 55 deck using a mechanical lifting device. A field effort was undertaken to verify that the stab plate would fit. During the course of the field work (see June 7, 2001 field report), a modification to the concept was developed with input from Bonneville Project staff. This alternative consists of removable aluminum slide plates, placed by hoisting the floating orifices gates through the deck, and installing the slide plates at the deck level. Then the floating orifices would be lowered into position. A line fixed to the top of the top of the slide plate would extend up to the deck and be dogged off. This would allow the slide plate to be removed without removing the floating orifice gate. Several observations led to this alternative. These include the following:

- A slide plate on the downstream side of the floating orifice gate would be readily installed at deck level.
- The riggers expressed concern about sediment fouling gate slots over an extended period of time and inhibiting stab plate installation.
- Raising the floating orifices gates to the deck level would allow slots for the slide plates to be cleaned out.
- The total length of time to remove all the floating orifices was just over 5 hours. Most of the time involved mobilizing, removing deck slabs, and re-arranging bulkheads. Installing slide plates on the floating orifice gates at deck level would likely take the same length of time as the measurements took. This duration is estimated to be at most 2 hours longer than *Alternative 3 – Lower Bulkhead From Above* described in the DDR.
- If fouling of the slots occurred (for the slide gates or stab plates), the slots would need to be cleaned out at the deck level with a pressure washer.
- Proper seating of the stab plates would be difficult to determine from the deck level.

- The floating orifice gates would need to be pulled up to the deck level if improper seating was observed.

- Removal of the floating orifice gates did not require the fish units to be shut down. The flow was throttled back during the June 7th field work and the floating orifice gate was readily lifted to the deck level and readily and re-installed.

- The slide gates would be less than half the size of the stab plates, making them much easier to handle, easier to store, and be would be less expensive.

- No modification to the foatation chamber is anticipated under the new alternative. Aluminum slide gates would be relatively lightweight and would not require adding additional buoyancy to the floating orifice gate floatation chamber. This would also reduce the cost.

- A lifting cable on the gates would allow removal of the slide gate without lifting the floating orifice gate to the deck level. Only the deck slabs would be removed; the bulkheads hanging in the adjacent slot would not need to be handled. With the new alternative, the slide gate removal process will take less time than removing the stab plates.

Based on these considerations and discussions with Jerry Maurseth, we intend to develop the new alternative in the 90% DDR and recommend that it be carried into design. No further development of *Alternative 3 – Lower Bulkhead From Above* will be pursued.

# APPENDIX K

# BONNEVILLE 2$^{ND}$ POWERHOUSE FISH UNIT DEBRIS STUDY

Bonneville 2nd Powerhouse Fish Unit Debris Study
Reconnaissance Report
Final – July 20, 2000

## *1.0 Introduction*

This document identifies problems caused by the accumulation of debris within the Bonneville Second Powerhouse (B2) auxiliary water supply (AWS) to the adult fishway channels. The accumulation of debris on the fish unit intake screens and diffuser gratings combined with the settlement of bedload material in the supply channel, compromise the reliability of the AWS system. A reconnaissance investigation was conducted and recommendations are made for reducing the potential for downtime and improving overall system reliability. Data and information was collected from site visits and meetings with Project and District personnel, as well as discussion with the A/E contractor conducting the B2-AWS back-up alternative study. A site location map and a plan view of the Bonneville second powerhouse are shown on plates 1 and 2. The location of the two fish units is shown on plate 3.

## *2.0 Background*

Due to heavy runoff seasons and, in particular, the flood of 1996 a large amount of sediment was deposited in and around the fish units and across the forebay of second powerhouse. A purchase order was issued in February of 1997 to dredge directly upstream of the fish units. Approximately 2,850 cy of material was removed. Shortly after the dredging, and possibly due to the sediment and debris stirred up by the dredge operation, the AWS channels became filled with bed load materials consisting of sands, silts and gravels. This was realized only after the AWS diffusers became clogged with sticks and other floating and semi buoyant material. The pressure head across the gratings became so great that many were torn loose, causing an emergency shut down of AWS for inspection and repairs. During this shutdown period the diffuser gratings were repaired and the AWS was excavated to remove the accumulated sediment. A second contract was issued in the fall of 1997 to dredge across the entire length of the powerhouse.

Several problems exist with the AWS system. At tailwater elevations greater than el.12.0 fmsl the turbine discharge is inadequate to operate the fish ladder within criteria. The AWS also experiences head loss due to the buildup of debris across the fish unit intake racks and diffuser gratings. These losses are complimentary to the low discharge condition and inability of the AWS to operate within the criteria that requires one to one and half-foot head differential across the fishway entrances. A poor trash rack cleaning system and the inability to clean AWS diffuser gratings compromises the reliability of the existing AWS. The trash rake does not effectively clean the trash rack. It tends to pack material in between the trash rack bars, clogging the bars and may even push material through bars to accumulate and clog the AWS diffuser gratings. Sedimentation of bed load material in front of the two main fish units and within the AWS channel also restricts the system capacity and ability to meet operating criteria.

Regional fisheries agencies and tribes have asked Portland District to investigate the deficiencies of the AWS and AWS back-up systems. A contract was issued to CH2M Hill/Montgomery Watson to conduct this study. Several alternatives were analyzed and cost estimates for these were prepared. After review by the fisheries agencies, it was decided that the costs of these final alternatives were too high. Emphasis was then put on operational solutions (*Contract No. DACW57-97-D-0004 Task Order No. 0013, Modification case No. 04*). Because a reasonable and cost effective solution has not yet been developed, the performance and reliability of the existing system is critical to the successful operation of the adult fish passage facilities.

### *3.0 Auxiliary Water Supply*

The auxiliary water supply system is a major component of the upstream fish passage system at the Bonneville Second Powerhouse (B2). Water is normally supplied to the AWS by two fish unit turbines on the north side of the powerhouse. The two units discharge into a chamber. This chamber distributes flow to the entrance channel of the north shore ladder and to the AWS conduit running parallel to the collection channel below the powerhouse tailrace deck. Orifices in the AWS conduit discharge into diffusion chambers under the fish collection channel. The attraction water then flows upward through diffuser gratings in the floor of the collection and entrance channels. Each floating orifice along the tailrace deck of the powerhouse discharges approximately 90 cfs from the collection channel and each of the four main entrances discharges approximately 900 to 1000 cfs. The total discharge rate varies with tailwater elevation and the total hydraulic head across the system.

### *4.0 Fish Units*

Two fish unit turbines at the north end of the Bonneville Dam second powerhouse serve as the primary auxiliary water supply to the adult fishway channel. The discharge of each fish unit varies depending on the available head and wicket gate setting. Under ideal conditions each unit can supply up to 2845 cfs to the AWS for a combined flow 5690 cfs. The flow is adjusted to meet requirements of the fishway entrances, within the ability of the existing system. However, at high tailwater elevations the turbines do not supply enough discharge to operate the ladder within criteria. In addition accumulation of debris on the intake trash racks and within the AWS further reduces the hydraulic head and total discharge through the units.

### *5.0 Ice and Trash Sluiceway.*

The existing ice and trash sluiceway was designed and constructed to pass floating debris around the south end of the powerhouse. It also doubles as an inlet supply channel for the AWS back-up system should a fish unit fail or be taken out of service for maintenance. By placing stoplogs at the exit, the chute is back-watered to spill water over a weir, down a shaft and into the south end of the AWS channel. Use of this system is restricted to September 1 to March 31 to reduce the chance for juveniles and adult fish to be pulled into back-up system (ref. *Annual Fish Passage Plan for Corps of Engineers Projects*). When the chute is serving as a backup system the adults can become trapped within the supply channels, and juveniles are impinged on the diffuser gratings. The ice and trash sluiceway will also become and element of the B2 corner collector, eliminating the ability to use this system as part of the AWS back-up supply.

### *6.0 Forebay Hydraulic Conditions.*

The approach flow conditions to the second powerhouse split near the center of the channel, with a flow current circulating to the north in front of the fish units, and one to the south in front of the ice and trash sluiceway intake. During the high flow runoff periods floating debris accumulates within the eddy that forms just upstream of the fish units. Model study investigations also indicate that these same flow patterns will transport and deposit bedload material near the base of the intake structures blocking the lower trash racks and restricting flow to the AWS.

### *7.0 System Problems*

Problems identified with the existing AWS system include:

1. A sediment buildup within the powerhouse forebay and the AWS conduit.

2. Debris accumulation on the trash rack and an inefficient trash rack cleaning.

3. Accumulation of debris on the AWS diffuser gratings, and

4. Management practices that increase risk of unit outages.

These problems are in addition to, but not independent of, the inability of the system to meet fishway entrance discharge requirements and the limitations of the AWS back-up system.

## Sedimentation

As a result of the damage sustained to the AWS system and its discharge concerns, sedimentation buildup in the AWS and upstream of the intake trash racks has become an issue. As sediment continues to deposit in the powerhouse forebay an increasing amount will pass through the fish units and settle in the AWS channels. Unless prevented or cleaned it will eventually block (or partially block) the supply channels and restrict flow to the adult fishway entrances. Sediment buildup in front of the intake also contributes to headloss across the intake trash racks. The buildup tends to clog the lower trash rack section. This reduces the water passage area and prevents the trash rake from reaching and cleaning to the bottom of the intake.

## Trash Rack Debris

The design of the trash rake and rack system is flawed in several ways:

1. The teeth of the existing rake (photos 1, 2 and 3) do not penetrate between the rack bars. Instead, they tend to push and wedge the smaller floating debris such as small wood chips, pebbles and fir (pine) cones into the small space between the bars (photos 4 and 5).

2. When the rake is lowered it does not have an open position. It pushes much of the larger material downward along the rack adding to the collection of debris and sediment near the bottom of the intake. This creates higher head losses resulting in lower unit discharges.

3. Prior to the 1997 repairs, a large gap at the top of the rack allowed much of the debris being raked to fall back into the units, which then allowed it to collect on the AWS diffuser gratings. This problem has since been corrected.

4. The trash rack openings are the same width but not the same length as the openings of the diffuser gratings. Debris, such as long sticks can pass through the trash racks and collect on the underside of the diffuser gratings.

## AWS Diffuser Grating Debris

The openings within the diffuser gratings in the AWS channels must be small enough to prevent adult fish from swimming into the water supply channels (photo 6, unfortunately no photos were taken of the destroyed diffuser gratings). These openings are approximately one inch wide by 4 inches long. The water supply through the conduits must be sufficient to provide adequate attraction flow through the fishway entrances. Entrance flow criteria is typically a one to one and a half-foot head differential across the entrance with exit flow velocities of near 8 feet per second. Any hydraulic losses across the gratings result in less head over the turbine units and lower auxiliary water supply discharges.

The diffusers are easily clogged by debris such as straw, lake weeds and sticks that pass through the fish unit trash racks and there is no method of cleaning the diffusers without shutting down the AWS and de-watering the channel. A pressure sensor in the supply conduit measures the head differential between the supply conduit and collection channel. This single sensor does not have the resolution to measure a pressure increase that may cause damage to any specific diffuser. Relying on this sensor to determine if debris has accumulated on any of the diffuser gratings may give a false sense of acceptable conditions.

Operations

The fish units are shut down approximately 3 hours each night to allow debris to drift away from the fish unit trash racks. This operation increases the "wear and tear" on the fish units resulting in higher maintenance cost and an increased risk of emergency shut downs. Thermal cycling, brake wear and wear due to bearing oil film thickness on start-up are all major causes.

### *8.0 Management Practices and Maintenance Costs*

Sedimentation of the Forebay

Occasional dredging is required to remove the sediment buildup in front of the fish unit intakes. Since the second powerhouse was completed in 1985 the forebay area in front of the fish units was dredge once in 1990 and twice in 1997. Approximately 2,850 cy of material was removed from the base of the fish units in February of 1997 at a unit cost of $27.84/cy. In the fall of 1997 a larger contract was awarded to dredge the entire upstream area of the forebay. A total of 15,582 cy of material was removed from the forebay area across the entire second powerhouse. Of this, 4,550 cy was removed from the area upstream of the fish units. Due to the scope of the work involving large equipment for a short duration, and a contract claim, the unit price rose to $49.69/cy. Assuming that all of material dredged in front of the fish units in 1997 was deposited since 1990, this area would have a fill rate of approximately 1050 cy per year. Assuming a fill rate of 1050 cy per year the annual cost of dredging would be $31,500 at $30.00/cy, and $52,500 at $50.00/cy (not accounting for inflation). However, it is highly likely that that majority of the sedimentation occurred during the most recent high flow events and may not have been a gradual accumulation over a longer period of time.

The 1997 dredging contracts were issued by NWP. Data from those contracts were provided by Mark Dasso, Chief of the Waterways Contract Section of the Operations Division at that time. The 1990 dredging contract was issued by the

Bonneville project; the volume material excavated and the cost of that contract were not available.

Sedimentation within the AWS Channels

In addition to the dredging operations in front of the fish unit intakes, the AWS channel is expected to require periodic excavation. The AWS channels were excavated in 1987 and again in February of 1997. Approximately 2000 cy of material was excavated from the AWS in 1997. Assuming that all of the material removed in 1997 was deposited since 1987 the AWS would have a fill rate of approximately 200 cy per year. The total cost for the 1997 excavation was approximately $100,000, for an annual cost over the ten-year period of $10,000 (not accounting for inflation). Spreading the accumulation rate over the 10-year period may not be entirely accurate. The majority of this accumulation may have occurred over the most recent high flow period or during the 1997 excavation the forebay immediately upstream of the fishway units.

Trash Rack Cleaning and Raking

A 3-hour daily shutdown of the fish units has been adopted to allow accumulated debris to drift away from the trash racks. The effectiveness of this operation is unclear. Some of the material may be drawn through the adjacent powerhouse units and some of it may drift away only to be pulled back into the trash racks and possibly through the units where it may then collect on the diffuser gratings. Incurred costs of daily unit shutdown are minimal, however starting and stopping of the units adds to the wear and tear and higher maintenance costs. These costs have not been identified.

During the spring runoff, trash rack cleaning is typically required two to three times a week but can be daily depending on runoff and debris loading. The project generally cleans the trash racks when the head differential across the trash racks reaches 2 to 3 feet. The estimated annual operating cost of the existing trash rake is $10,000.

Trash Rack Removal

The existing trash racks require a complete removal for cleaning and bar repairs (as needed) once every two years with an estimated total cost of $15,000. Divers are often required to remove debris from the lower rack sections before they can be pulled. In addition to removal and installation costs, the racks are stripped and refinished once every fifteen years at an estimated total cost of $10,000 plus the initial cost of pulling and cleaning.

Monitoring and Maintenance of the Diffuser Gratings

Contract divers inspect the diffuser gratings twice per year, once during the winter in water work period and once during the fish passage season. A pressure sensor is installed within the supply conduit to indicate a build-up of debris by measuring pressure loss across the gratings. The damage to the diffuser gratings in 1997, however was detected only when the biologist noted large "boils" or up-welling of flow in the vicinity of the flow diffusers. This would indicate that the debris accumulation on the diffusers was more or less a sudden event, possibly resulting from the excavation of material in front of the fish units.

The project operational and maintenance information, and cost estimates were provided by Andy DeBriae, project foreman of the structural maintenance crew.

## *9.0 Biological Impacts*

System Reliability

The existing AWS is unable to deliver adequate flow to adult fishway entrance and typically does not meet system criteria when tailwater elevations exceed 12.0 fmsl. A tailwater elevation of 12.0 fmsl during the fish passage season of 1 April to 31 August is exceeded 88 percent of the time. As it exist, the ice and trash sluiceway is only used as a back-up system during the "off" season because of juvenile and adult entrainment concerns. In addition, the ice and trash sluiceway will become an element of the B2 juvenile fish passage corner collector, eliminating any potential use as the AWS back-up.

Without a back-up supply system and the fact that the existing system barely delivers enough flow to keep the entrances within criteria, reliability of the existing system is very critical. Should a unit fail or be taken out of service for cleaning and repair, it is unlikely that the attraction flow exiting the fishway entrances would be sufficient and would likely result in adult passage delays.

Collection of Adults in the AWS Channels

Without the ability to monitor and clean the diffuser gratings daily, the potential for the gratings to be torn loose still exists. If a grating is missing or damaged there is a risk that adult salmon may become trapped within the supply channels.

Operations

The routine operation of shutting down the fish units for three hours for debris removal is scheduled during the night when it has the least impact on adult salmon. However, this operation does not improve the system reliability and may put the system at risk of an unscheduled outage cased by added wear from starting and stopping the units.

### *10.0 System/Management Improvement Alternatives*

Alternatives for improving the existing AWS system and are listed below. These do not include alternatives for the AWS back-up water supply system currently being investigated under the AWS Back-up Supply Alternative Study.

<u>Sedimentation</u>

1. Management and/or Operational Practices.

a. Conduct routine surveys and planned dredging during periods of least impact to water quality, the Columbia River fisheries and to Project personnel.

b. Schedule dredging during the winter period when the fish units are shut down for maintenance.

c. Set unit priorities on the operations of turbine units adjacent the fish units. Operation of these units may draw sediment away from the fish units but may not be consistent with operations proposed for the new corner collector.

d. Conduct and document routine inspections of the AWS channel. The contract divers may be able to accomplish this during the routine inspections of the AWS diffuser gratings. Documentation will aid in planning system outages for excavation of material which may have settled within the ASW channel.

2. Structural Improvements

a. Develop a trash rack system that reaches out beyond the toe of the intake to collect bed load deposits, as well as, the debris collected on the trash racks and caught between the trash rack bars.

b. Large rock berms may be placed in the forebay to redirect the flow patterns and allow the bedload material to deposit in front of the main power units rather than upstream of the fish units. However, this may impact flow patterns upstream of the ice and trash sluiceway intake and may affect the efficiency of the corner collector.

c. Block the lower section of the trash racks. If the trash racks could be easily maintained and kept free of debris, it may be possible to bulkhead off the lower trash rack sections to keep the bed-load of sediments from passing through the fish units and depositing in the water supply channels. The trash racks would have to remain free of debris to prevent additional head loss or differential across the trash racks. Impact to turbine operation would have to be considered.

d. The problem of sedimentation buildup throughout the AWS may be alleviated with the installation of a "bubbler system" along the length of the conduit. A "bubbler system" may prevent finer sediments and debris from collecting along the length of the conduit, however, it would also increase the amount of dissolved gas content of the water.

e. Redesign the AWS conduits to maintain higher velocities. An efficient hydraulic design may reduce and prevent material from settling out in low velocity areas.

Debris

1. Modify the existing trash rake. It may be possible to modify the rake fingers to reach and clean between the vertical trash rack bars. However the rake would still push much of the debris downward, causing an accumulation on the lower trash rack sections.

2. Design and install a new trash raking system. Head loss due to the collection of debris across the face of the trash racks may be reduced with the installation of a more efficient cleaning system. The new rake system should provide for a full sweeping motion of the rack face without the initial engaged downward pass, and it should be able to dislodge and collect debris caught between the trash rack bars. Trash raking systems are available that allow the rake to be lowered in an opened position. When the rake reaches the base of the intake it closes against the rack collecting debris as it is pulled to the surface. The new system would be designed to assure that the rake fingers reach and clean between the trash rack bars.

3. New racks could be constructed of polymer composite material to reduce the weight, maintenance costs and frequency of required maintenance procedures. The improved design may also reduce head loss across the system and could be constructed compatible with industry standard raking systems. A cleaner trash rack with lower head losses may allow the lower sections to be blocked to prevent the transport of bed load materials through the fish units.

### *11.0 Improvements*

The trash rack opening near the intake deck has been closed to prevent trash from falling into the intake as it is pulled to the deck. A survey of the second powerhouse forebay was conducted in March of 2000 prior to the spring run off to determine the rate of infill since the 1997 dredging. A comparison of the March 2000 bathymetric survey data to the post dredging survey data of 1997 show very little, if any, infill since the forebay was dredged in 1997. However, the time between surveys spanned only the two low flow runoff periods of the 97-98 and 98-99 seasons. Though the historical data is limited, this survey would indicate the sediment transport of any significant volume occurs predominantly during high flow years.

A physical hydraulic model study of the Bonneville Second Powerhouse forebay was conducted at the Corps of Engineers Waterways Experiment station in 1998-99. A 1:40 scale model of the second powerhouse and forebay was used to evaluate the flow patterns and to determine what operations contributed to the deposit of material in front of the fish units. The model was also used to evaluate operational and structural alternatives that may prevent material from settling out in front of the two fish units. The most successful alternative was the placement of a large rock berm upstream of the fish units. The berm redirects the flow causing it to settle in front of or pass through the main power units. A final report from WES has yet to be submitted but is expected mid summer year 2000.

### *12.0 Conclusions*

1. The existing trash rack cleaning system is ineffective. It does not clean between the trash rack bars. The trash racks periodically need to be pulled and cleaned to remove debris that has become wedged between the bars.

2. The trash rake pushes much of the debris to the base of the intake on its downward pass. The debris clogs the lower sections of the trash rack and increases the head differential across the racks and reduces the total operating head across the fish units.

3. Some debris can pass through the trash racks but not the diffuser gratings. The debris blocks the flow through the diffuser gratings and can cause them to be torn loose from their mounts by the build-up of pressure. This has occurred only once since the construction of the project in 1985.

4. The pressure sensor in the supply conduit used to determine if there is a debris build-up across the gratings does not have the resolution to evaluate the pressure or build-up on any single specific diffuser.

5. The diffuser gratings are inspected twice per year to make sure they are not damaged. The inspection could be expanded to include the inspection of the AWS channels to monitor and determine the rate of infill.

6. If the diffuser gratings are damaged and torn free, adult fish can enter and become stranded within the AWS supply channels.

7. Based on the volume of material dredged in 1997, the forebay of second powerhouse adjacent the fish units has a sediment infill rate of approximately 1,050 cy per year. Based on recent surveys it is possible that infill occurs during extreme flow events and not a gradual accumulation.

8. Sands, silts and gravels that pass through the fish unit intakes can settle out in the AWS channels. As the channels become filled, flow to the fishway entrances is restricted. Based on the excavation volume of 1997, the channel has a fill rate of approximately 200 cy per year. It is possible that the infill in the AWS channel was the result of keeping the units operational during dredging operations and/or extreme flow events.

### *13.0 Recommendations*

1. Design and install a new trash rake and cleaning system to improve the cleaning efficiency and overall system reliability.

2. Combine the biannual inspection of the diffuser gratings with an inspection of the supply channels, particularly after high flow events.

3. Develop and install an improved monitoring system that will identify a pressure build-up or debris accumulation across each of the supply conduit diffuser gratings

4. Schedule routine surveys of the Bonneville second powerhouse forebay particularly in front of the two fish units, especially after high flow events.

5. Schedule dredging during the winter when the fish units can be shut down.

If the bathymetric surveys of the forebay region and the inspections of the AWS channel indicate a continuing problem of debris accumulation then the recommendations would also include:

6. Model turbine unit operations to determine if sediment can be pulled from the fish unit intake. Re-evaluate current turbine operational priorities to determine if they can be changed without impact to project or fishery operations.

7. Develop a cost estimate for the sediment diversion berm to determine if this is a feasible and cost beneficial alternative to dredging

8. Conduct a hydraulic analysis of the existing trash rack design to determine if the lower section(s) can be blocked to prevent sediment from passing through the turbines. Evaluate impacts to the AWS and turbine operations.

Photo 1. Fish Unit Trash Rack Rake

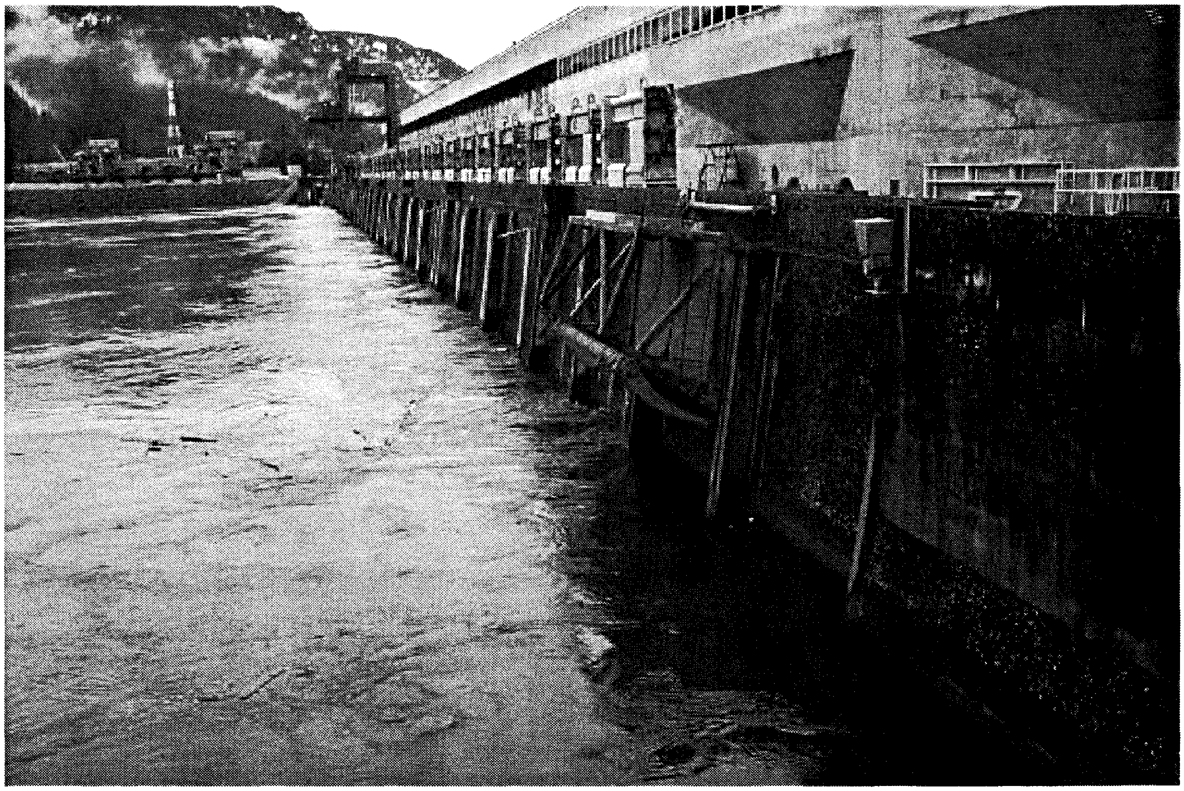


Photo 2. Fish Unit Trash Rack Rake

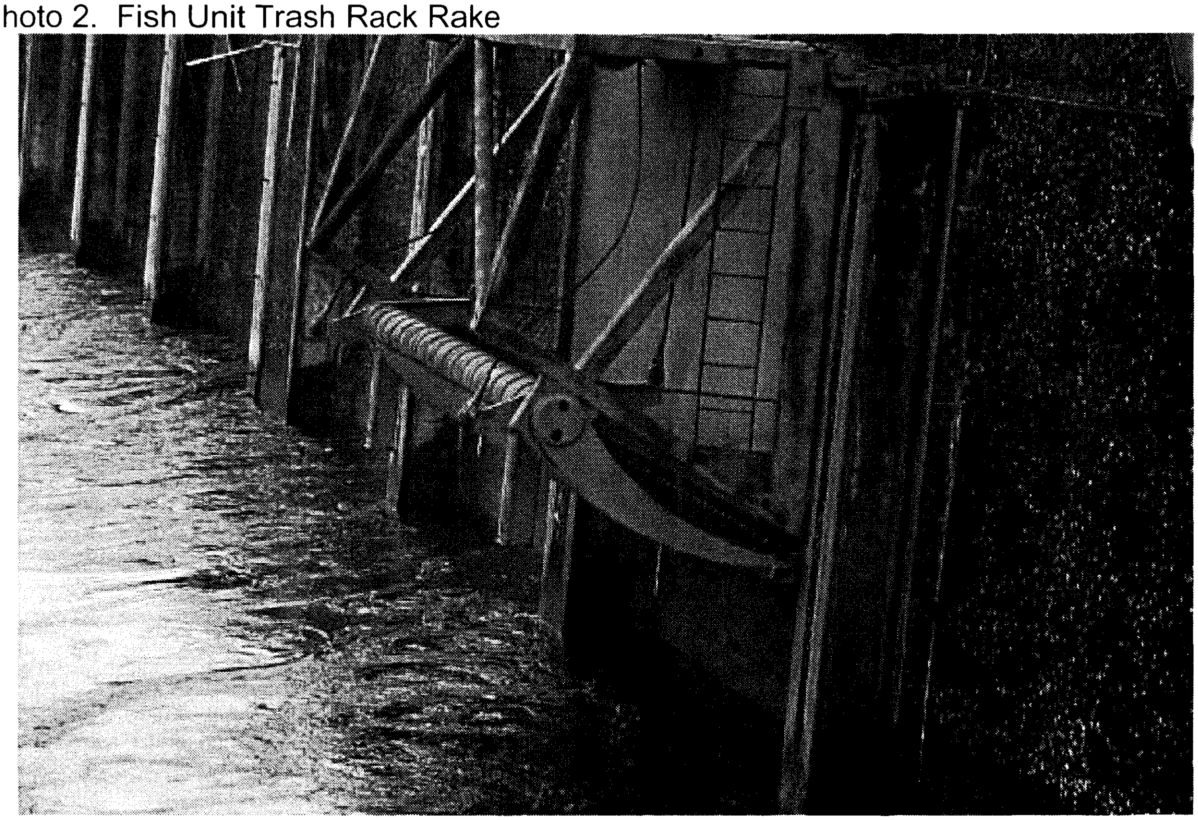


Photo 3. Thrash Rake Teeth

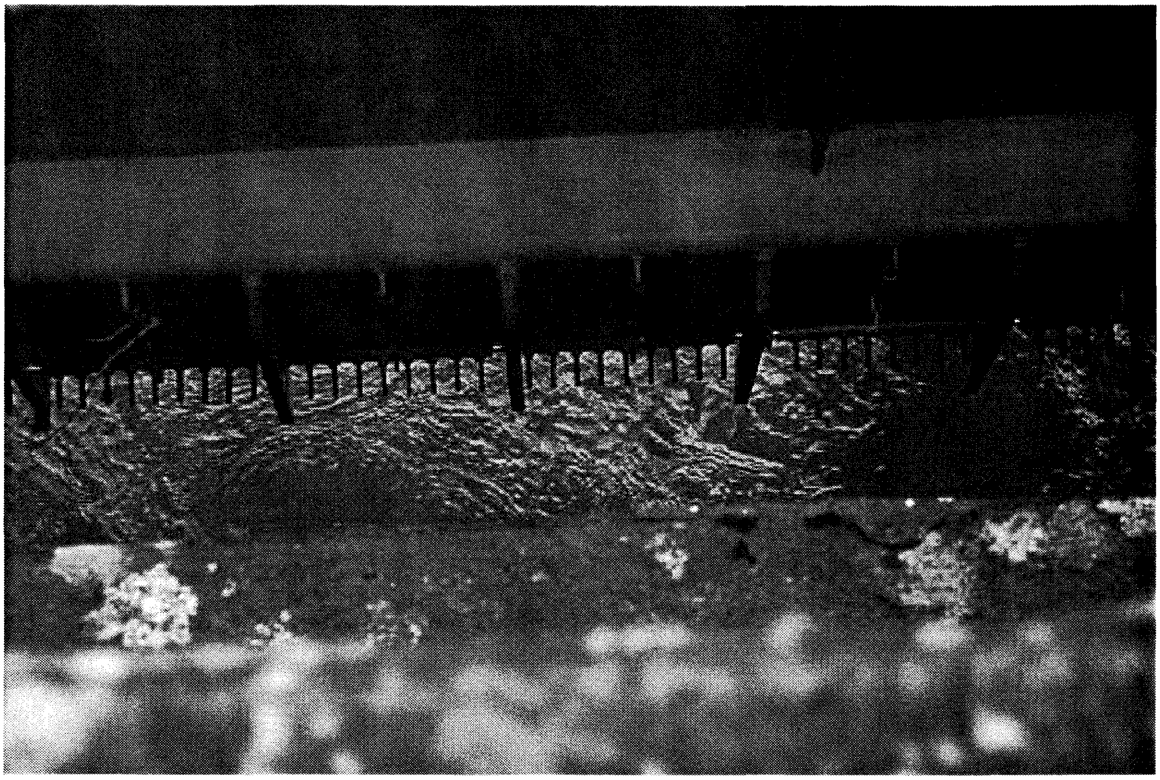


Photo 4. Debris Clogged Fish Unit Trash Rack

Photo 5. Debris Clogged Fish Unit Trash Rack

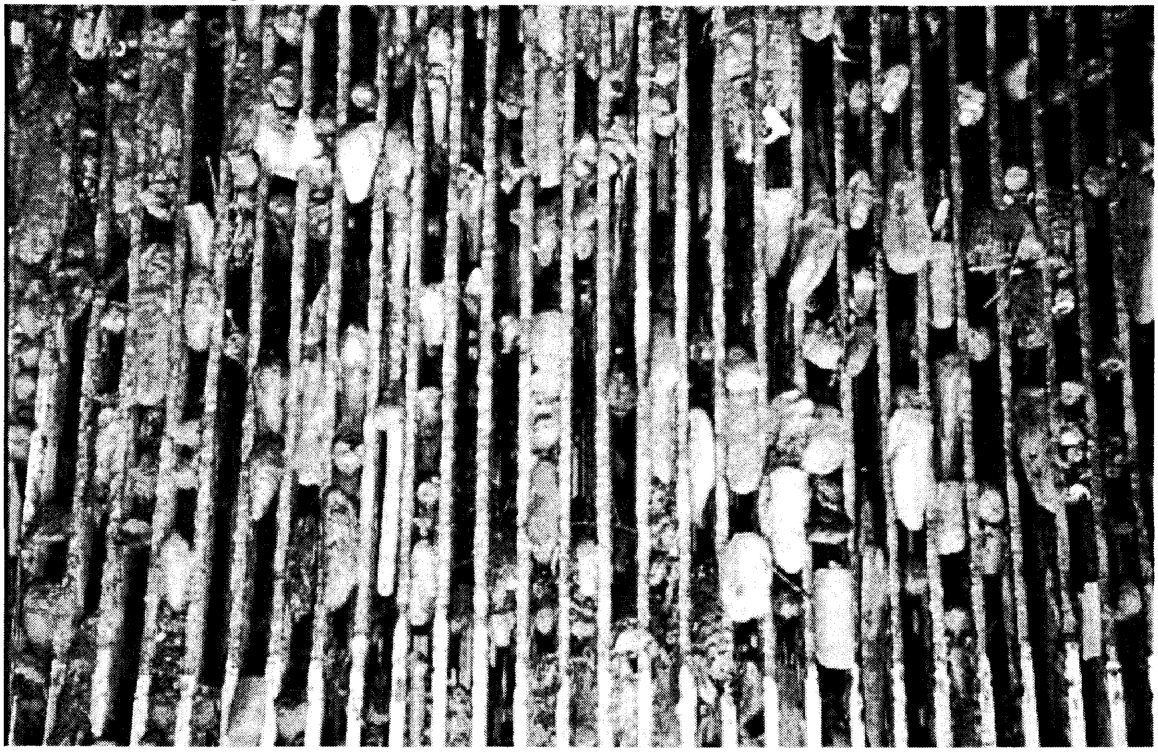
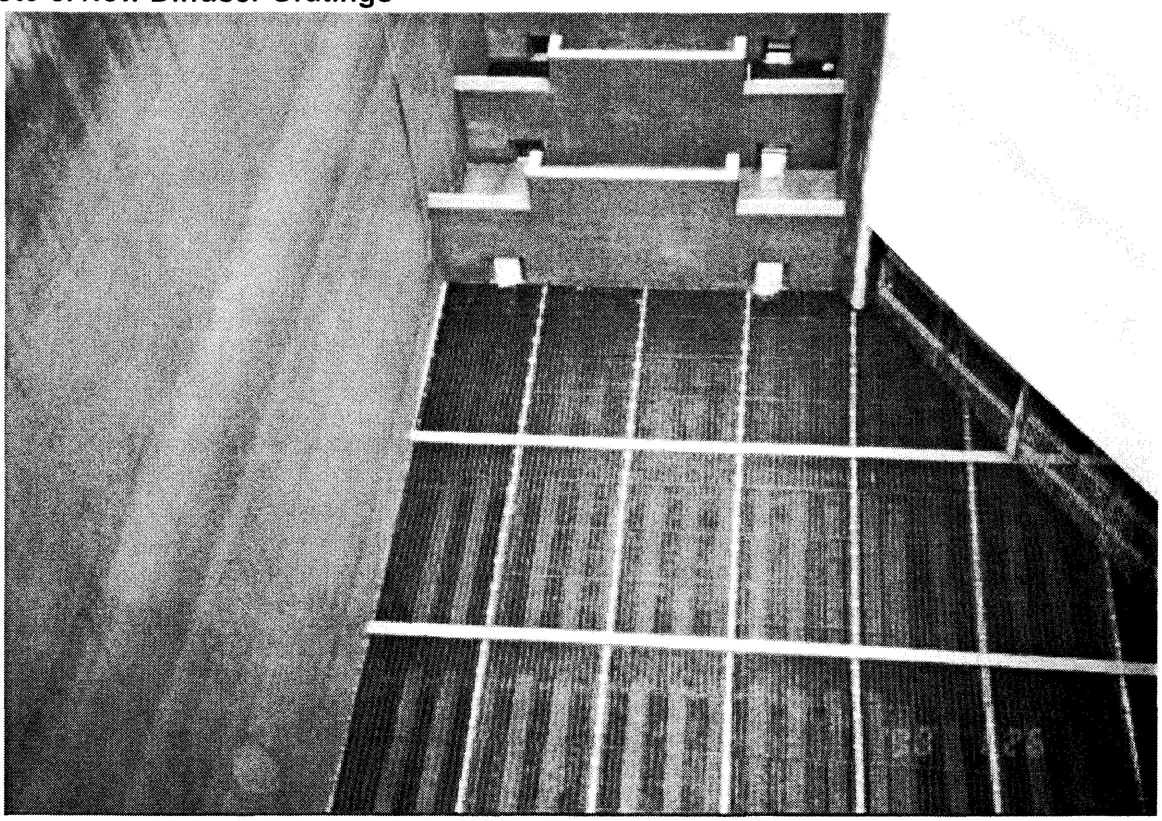
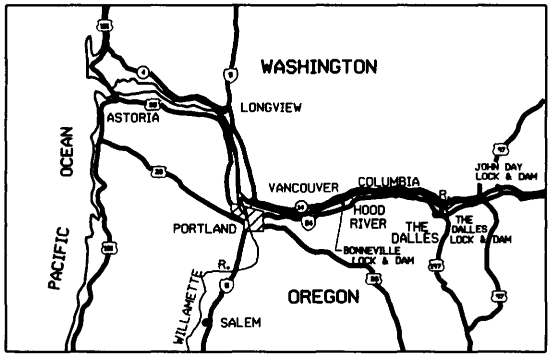
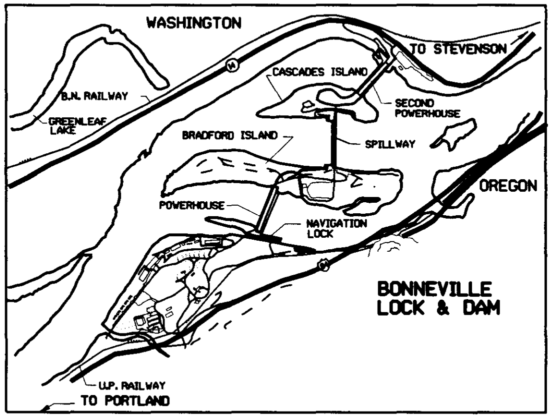


Photo 6. New Diffuser Gratings

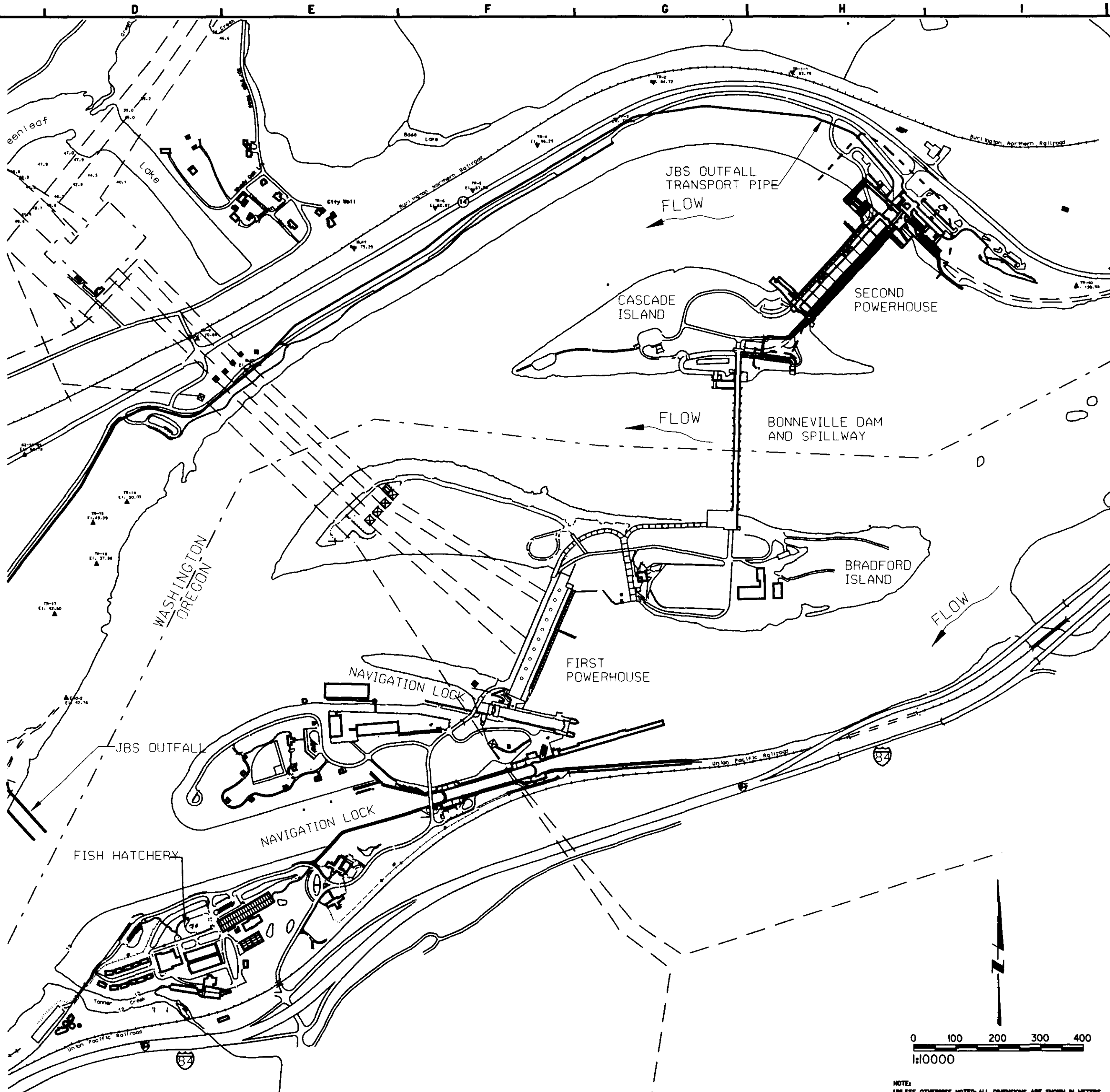





VICINITY MAP




LOCATION MAP




NOTE:
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE SHOWN IN METERS

US Army Corps of Engineers
Portland District

Date: 27 SEPT 1999
CADD File Name: BONPLATE01.DGN
Designed by: D. PATRICK
Drawn by: D. PATRICK
Checked by:
Technical Manager:
Submitted by: DALE S. MAZAR, P.E.
Acting Chief, Struct & Arch Design

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

MONTGOMERY WATSON

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE

LOCATION AND VICINITY MAP AND SITE PLAN

DRAWING STATUS:

DRAWING NO.

PLATE
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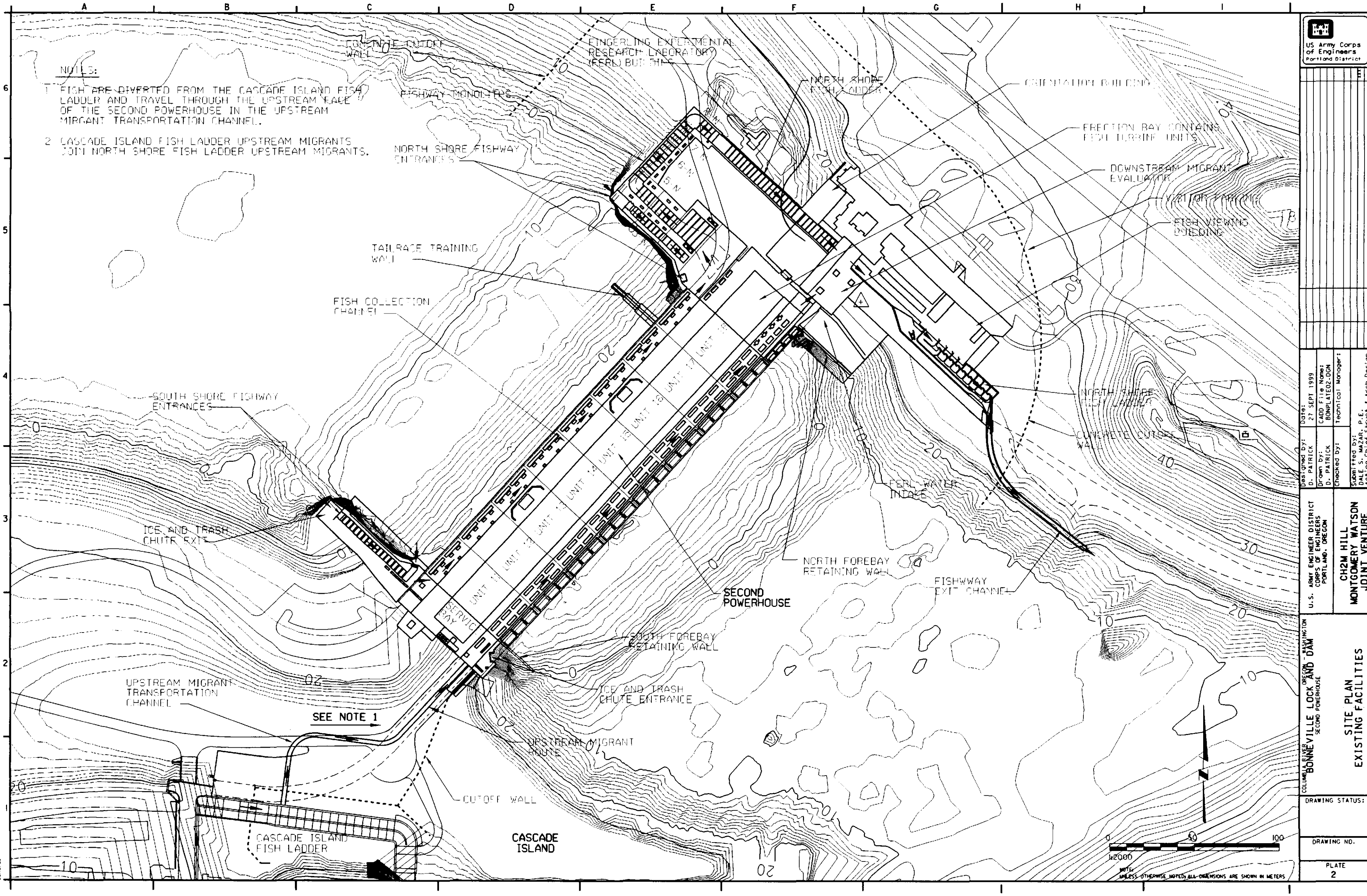
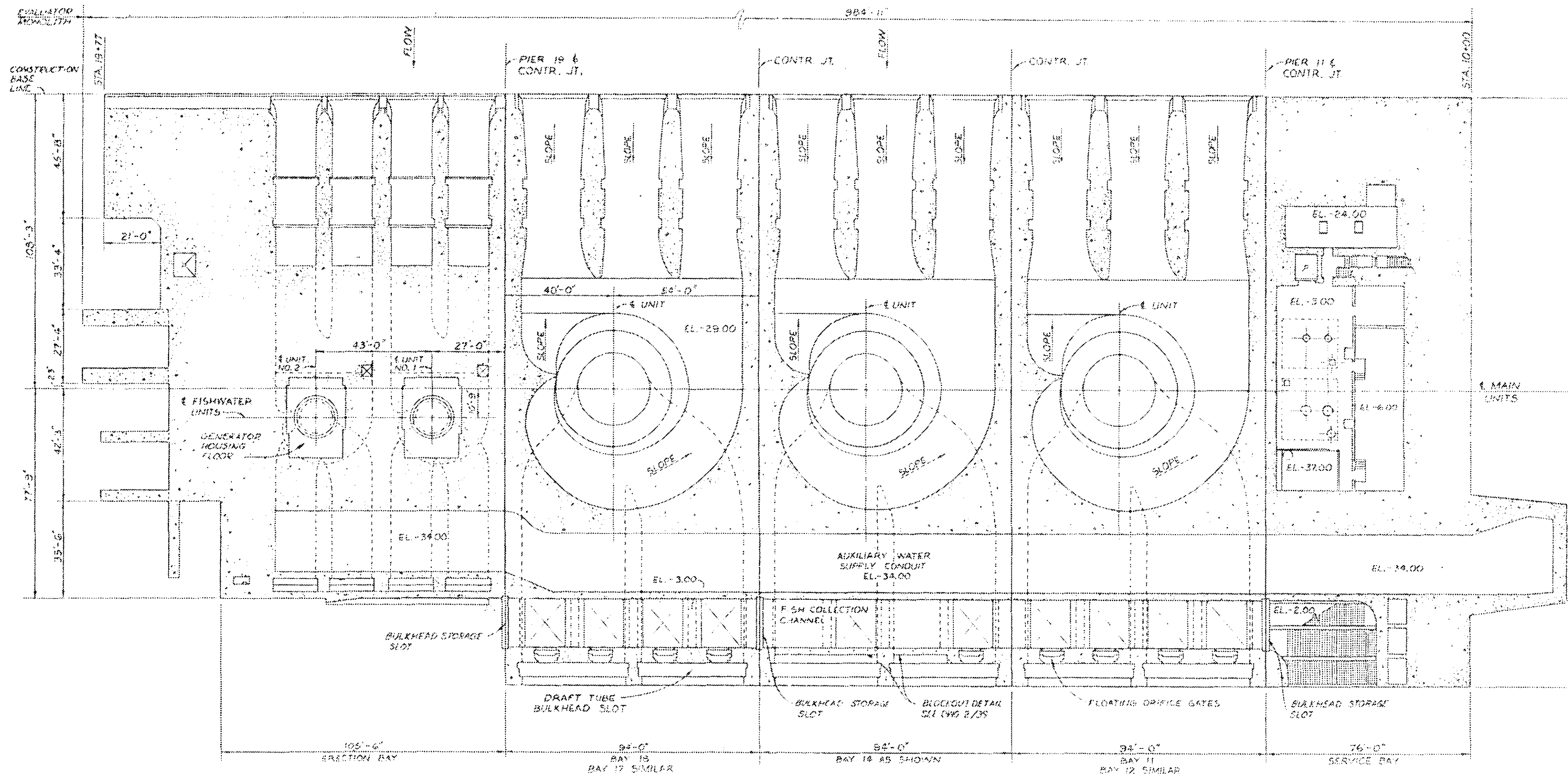

NOTES:
1. FISH ARE DIVERTED FROM THE CASCADE ISLAND FISH LADDER AND TRAVEL THROUGH THE UPSTREAM FACE OF THE SECOND POWERHOUSE IN THE UPSTREAM MIRGANT TRANSPORTATION CHANNEL.
2. CASCADE ISLAND FISH LADDER UPSTREAM MIGRANTS JOIN NORTH SHORE FISH LADDER UPSTREAM MIGRANTS.
CONCRETE CUTOFF WALL
FINGERLING EXPERIMENTAL RESEARCH LABORATORY (FERL) BUILDING
FISHWAY MONOLITHS
NORTH SHORE FISH LADDER
ORIENTATION BUILDING
ERECTION BAY CONTAINS FISH TURBINE UNITS
NORTH SHORE FISHWAY ENTRANCES
DOWNSTREAM MIGRANT EVALUATOR
VISITOR PARKING
FISH VIEWING BUILDING
TAILRACE TRAINING WALL
FISH COLLECTION CHANNEL
SOUTH SHORE FISHWAY ENTRANCES
NORTH SHORE FISH LADDER
CONCRETE CUTOFF WALL
FERL WATER INTAKE
ICE AND TRASH CHUTE EXIT
NORTH FOREBAY RETAINING WALL
FISHWAY EXIT CHANNEL
SECOND POWERHOUSE
SERVICE BAY
SOUTH FOREBAY RETAINING WALL
UPSTREAM MIGRANT TRANSPORTATION CHANNEL
ICE AND TRASH CHUTE ENTRANCE
SEE NOTE 1
UPSTREAM MIGRANT ROUTE
CUTOFF WALL
CASCADE ISLAND FISH LADDER
CASCADE ISLAND
1:2000
NOTE: UNLESS OTHERWISE NOTED ALL DIMENSIONS ARE SHOWN IN METERS
US Army Corps of Engineers Portland District
Designed by: D. PATRICK
Date: 27 SEPT 1999
Drawn by: D. PATRICK
CADD File Name: BONPLATE02.DGN
Checked by:
Technical Manager:
Submitted by: DALE S. MAZAR, P.E. Acting Chief, Struct. & Arch. Design
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON
CH2M HILL MONTGOMERY WATSON JOINT VENTURE
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE LOCK AND DAM
SECOND POWERHOUSE
SITE PLAN EXISTING FACILITIES
DRAWING STATUS:
DRAWING NO.
PLATE 2




PLAN EL. 0.875
SCALE: [illegible]

US Army Corps of Engineers
Portland District

Designed by:
Drawn by: D. PATRICK
Checked by:
Submitted by: DALE S. NAZAR, P.E. Acting Chief, Struct. & Arch. Design
Date: 27 SEPT 1999
CADD File Name:
Technical Manager:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

MONTGOMERY WATSON

COLUMBIA RIVER
BONNEVILLE LOCK AND DAM
OREGON - WASHINGTON

DRAWING STATUS:

DRAWING NO.

# APPENDIX L

# DATA REPORT

CEERD-HR-F (1110-2-1403b) 4 August 2000

MEMORANDUM FOR Commander, U.S. Army Engineer District, Walla Walla,
ATTN: CENWW-ED-D (Mr. Martin Ahmann),
201 North Third Avenue, Walla Walla, WA 99362

SUBJECT: Data Report, Bonneville Second Powerhouse Debris Model Study

1. The attached Memorandum For Record and videotape document the subject study conducted between December 1998 and November 1999. Velocity patterns and sediment tracers for the as-built condition and for 12 alternatives were documented. These included two sill designs, one fill design, eight deflector designs and a dredged channel design.

2. An existing 1:40-scale Bonneville Second Powerhouse model was used to conduct this study. Model controls were recalibrated and the inflow was modified to more closely match observed flow conditions. Model operations were based on full powerhouse flows with ties in place and the upstream pool at elevation 74.5.

3. Any questions regarding the study should be directed to Mr. Chuck Tate at 601-634-2120.

/s/
THOMAS W. RICHARDSON
Acting Director
Coastal and Hydraulics Laboratory

CEERD-HR-F (1110-2-1403b)

MEMORANDUM FOR RECORD

SUBJECT: Data Report, Bonneville Second Powerhouse Debris Study

1. This data report documents the observations for several options for improving the debris accumulation in front of the Fish Units (FU) (originally the Erection Bays) on the north end of the Bonneville Second Powerhouse. A videotape is included as part of the documentation. Debris accumulation in this area has caused clogging of screens associated with fish facilities on the north side of the powerhouse. Based on this problem, this study was conducted to evaluate several alternatives to prevent the debris accumulation in front of the FU. This Memorandum For Record (MFR) documents the subject study conducted between December 1998 and November 1999. Velocity patterns and sediment tracers for the as-built condition and for 12 alternatives were documented. These included two sill designs, one fill design, eight deflector designs and a dredged channel design. This MFR represents all experiments conducted for the study. Non-excluded photographs were forwarded to the Portland District during the study. A videotape of the various flow conditions is presently being edited and will be provided at a later date.

2. This study used the existing 1:40-scale physical model of the forebay of the Bonneville Second Powerhouse (figures 1 and 2). Prototype velocities measured approximately 440 ft upstream of

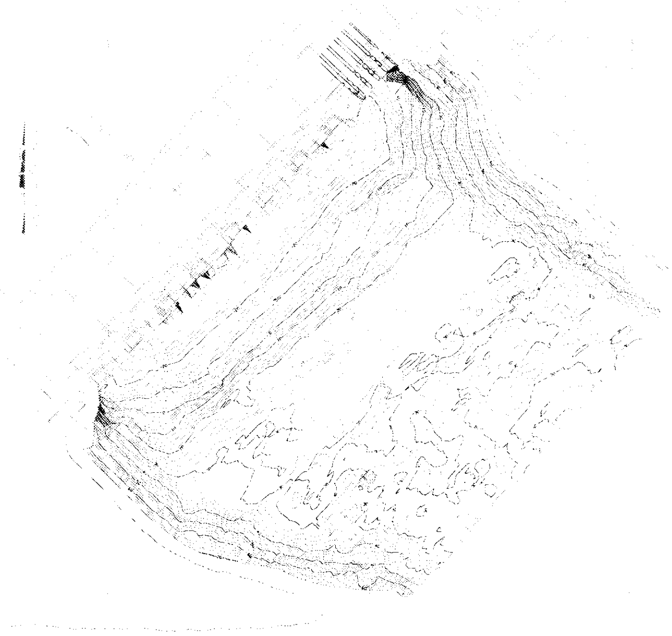


Figure 1: Plan of the Bonneville Second Powerhouse with the 1998 bathymetry

the powerhouse (model range 11) were used to calibrate the inflow distribution (figure 3). The mid-depth flow distribution in the model was adjusted by modifying the inflow distribution. Calibration of the turbine releases was verified using volumetric measurements. Model operations were based on releasing 15,600 cfs through each of the eight turbines and 3,000 cfs through each of the two FU. The turbines were set to release 36.3 percent through bay A, 35.2 percent through bay B, and 28.5 percent through bay C. FU released 3,000 cfs each with flow discharged equally through both bays. The upstream pool was maintained at elevation 74.5. The upstream topography was modified in the spring of 1999 to more closely match the 1998 bathymetry. This modification resulted in adding material to the south bank and removing material from the north bank. During this modification a dredged channel was preformed in the north bank and backfilled to the 1998 bathymetry.


Figure 2: Model from the upstream south shore.

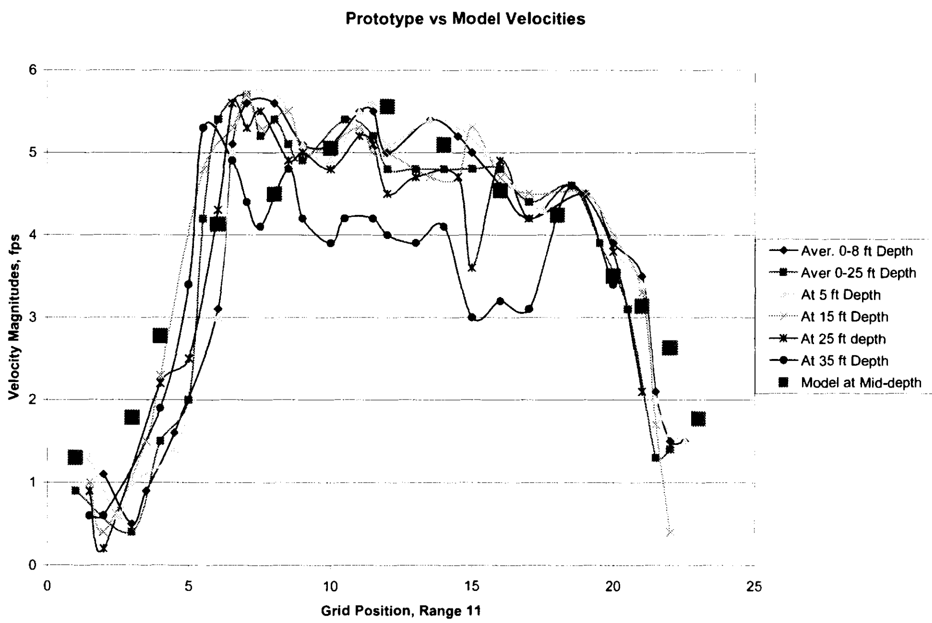



Figure 3: Prototype vs. model velocity magnitude at range 11 (approximately 440 ft upstream of the powerhouse).

4. As-built Design: In general, lateral currents to the north shore started in front of unit 16 and increase in strength in front of units 17 and 18 for surface and bottom flows while mid-level flows entered the turbines with a lateral velocity component. Initial and final tracer patterns are shown in the following photographs (figures 4 and 5).

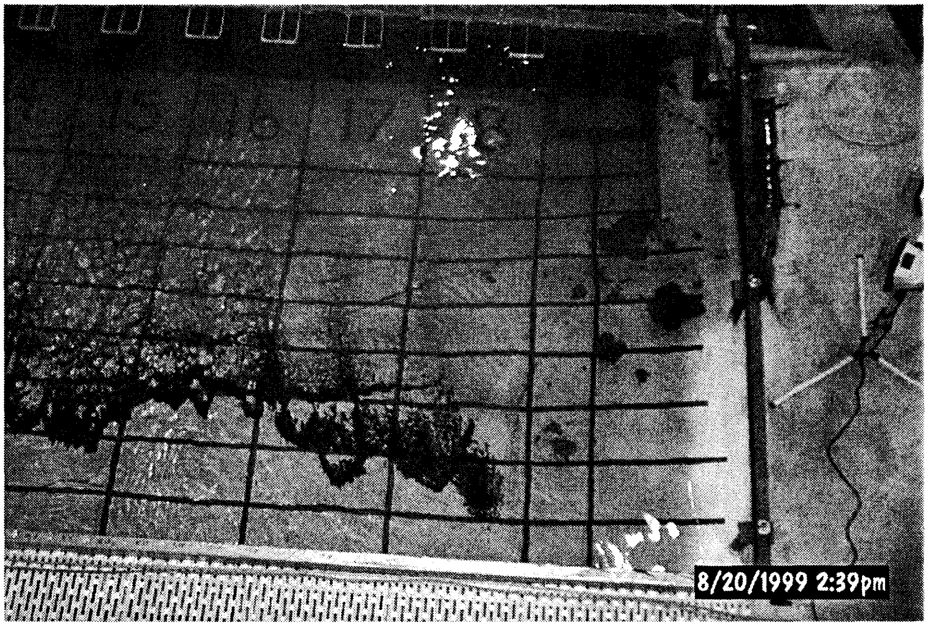



Figure 4: As-built design with initial tracer pattern.


Figure 5: As-built design with final tracer pattern.

5. Sill, Elevation 17.33: A sill with a crest elevation of 17.33 (figure 6) was installed in front of the FU. In general, a clockwise eddy existed in the north corner for surface and bottom flows with mid-level flows being pulled into the turbines. The design and final tracer pattern are shown in the following photograph (figure 7).

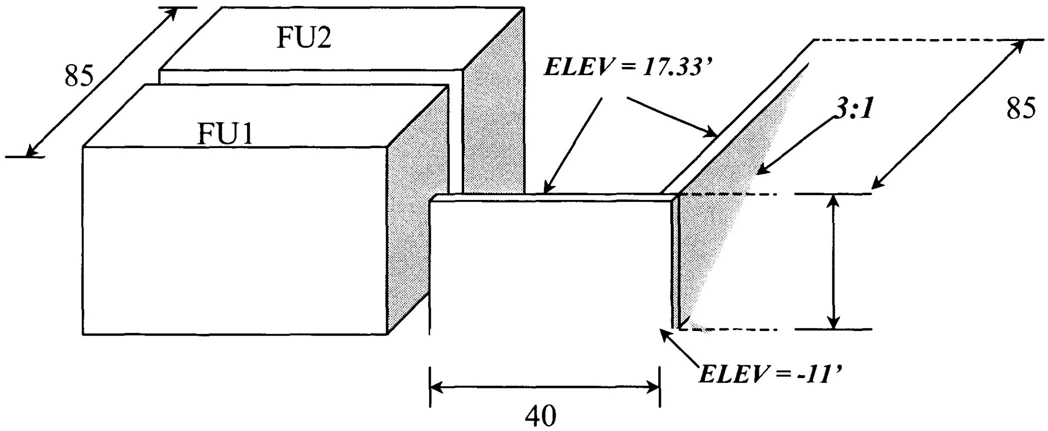



Figure 6: Sill at elevation 17.33: Orthogonal view of sill placed in front of the two fish units on the north shore of Bonneville's Second Powerhouse to prevent debris accumulation in front of and inside of the fish units.

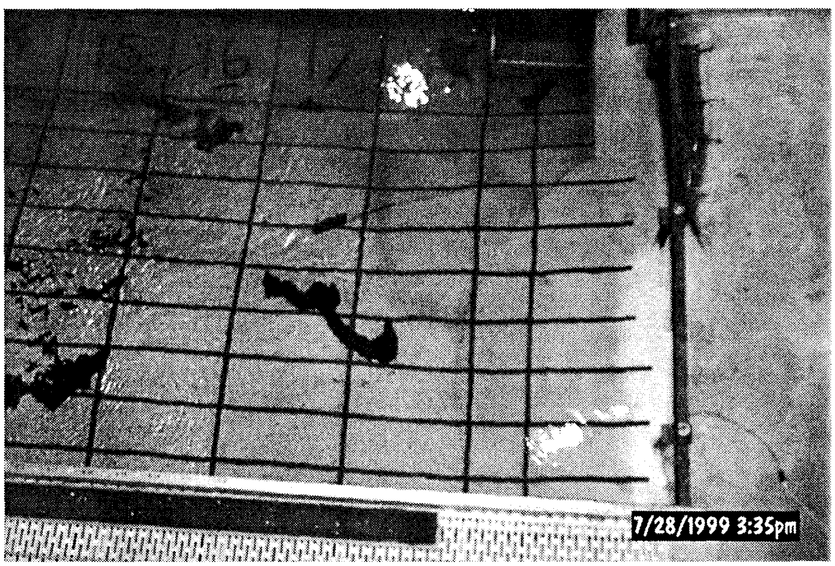



Figure 7: Sill at elevation 17.33 with the final tracer pattern.

6. Sill, Elevation 0.33: A sill at elevation 0.33 was installed in front of the FU as shown in figure 8. Flow patterns were generally the same as for the other sill and the as-built condition. The final tracer pattern is shown in the following photograph (figure 9).

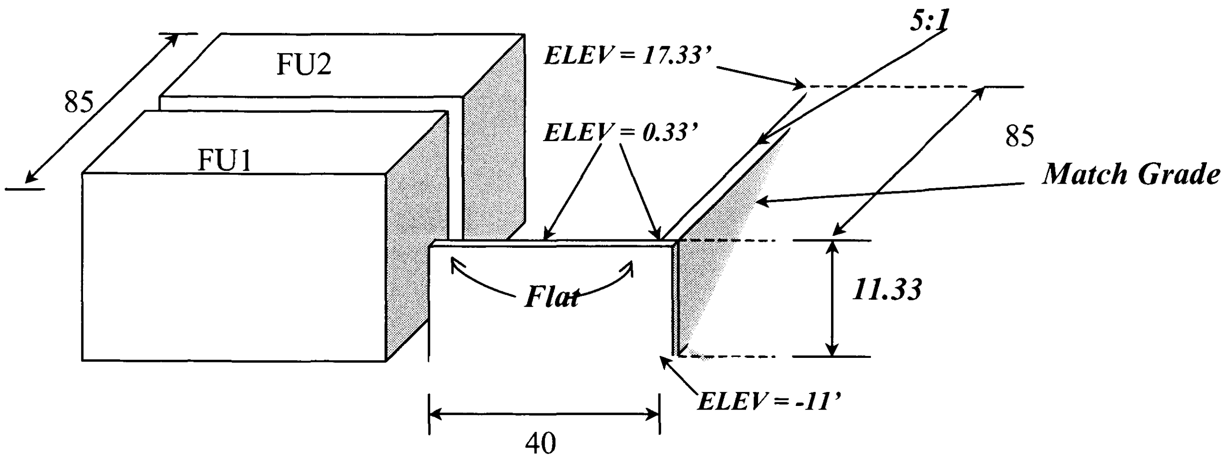



Figure 8: Sill at elevation 0.33

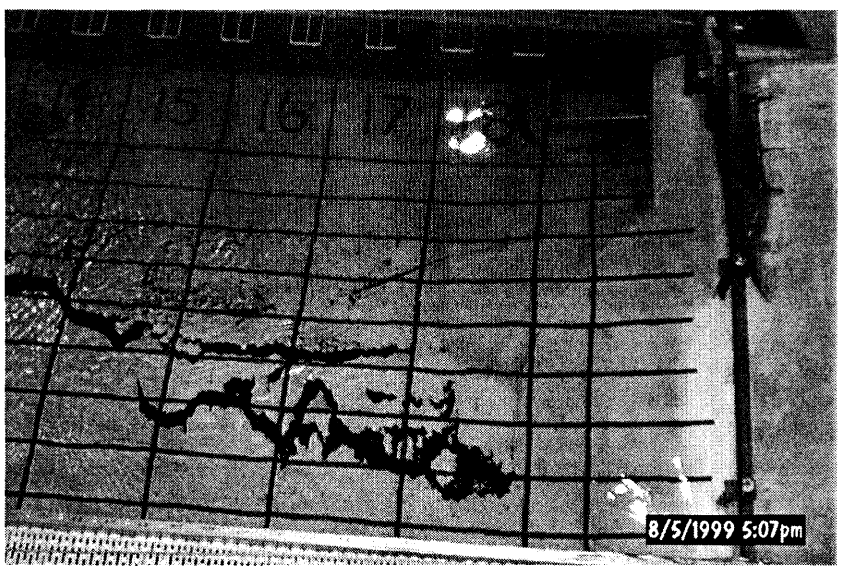



Figure 9: Sill at elevation 0.33 with the final tracer pattern.

7. Sloping fill in front of the FU: Flow conditions were essentially the same as for the as-built design. Lateral flow to the north shore was slightly stronger on the bottom in front of the FU. The design and the residual tracer are shown in the following photograph (figure10).

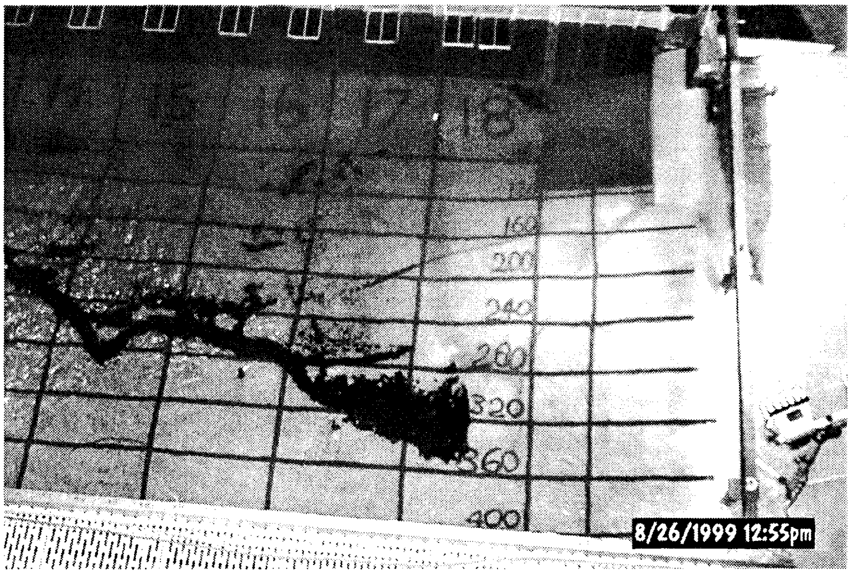



Figure 10: Side slope fill with final tracer photo.

8. Deflectors 1-8: Stone dikes were constructed in front of the northern section of the powerhouse to deflect some of the approaching flow to the north bank with the intention of pushing the flow from the north bank towards unit 18. This would prevent deposits from forming in front of the FU and eliminate the surface eddy in front of the FU. The dikes had approximately 1 on 1 side slopes and were constructed of large stone. All deflector designs formed an eddy between the deflector and the powerhouse. Deflectors 6-8 caused flushing flow in front of the FU but still retained a minor surface eddy along the north shore. Deflector 8 had the least amount of surface eddy. The alignment and final tracer patterns are shown in the following photographs (figures 11-18 ).

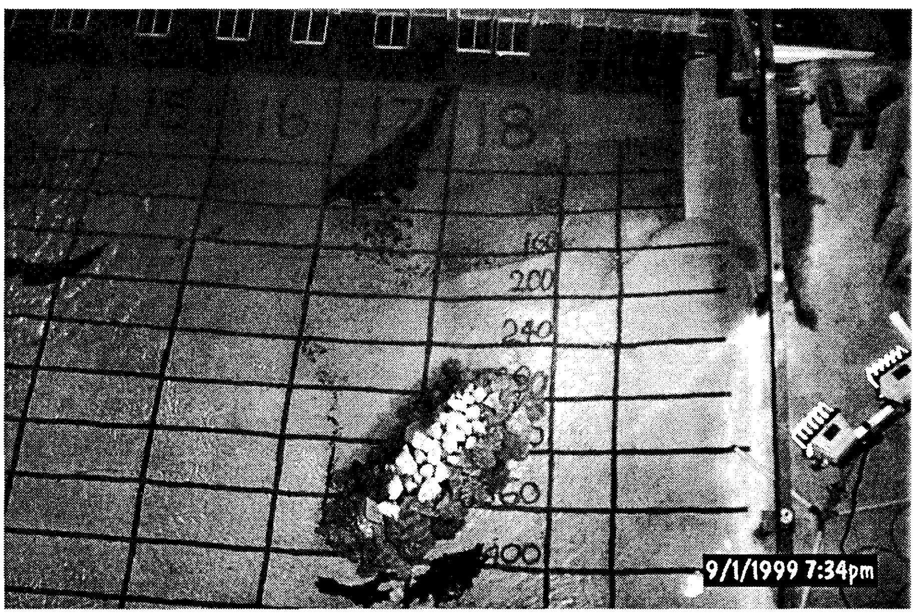



Figure 11: Deflector 1 with the final tracer pattern.


Figure 12: Deflector 2 with the final tracer pattern.

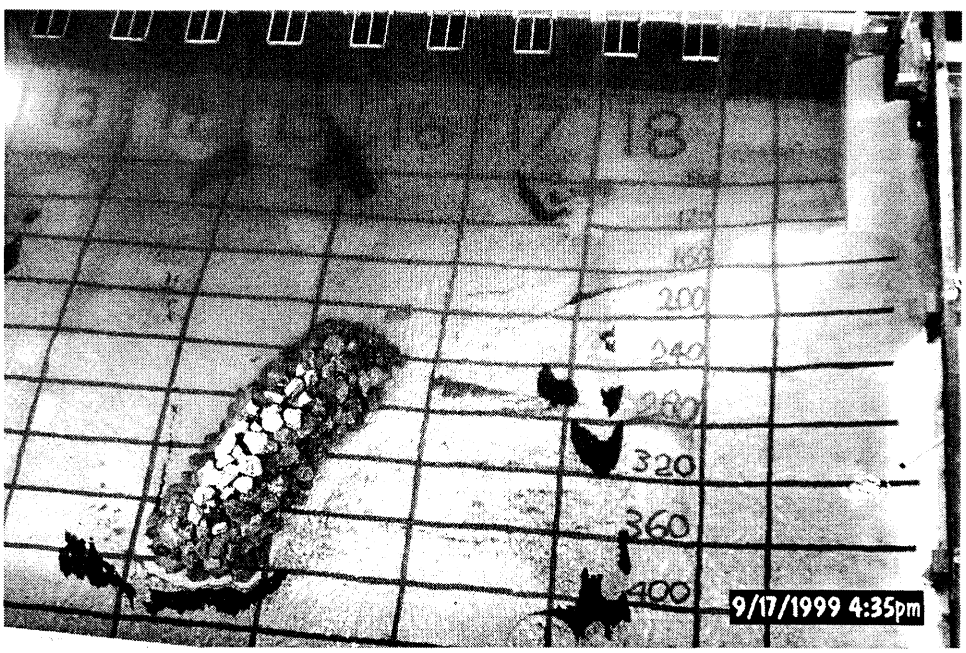



Figure 13: Deflector 3 with the final tracer pattern.

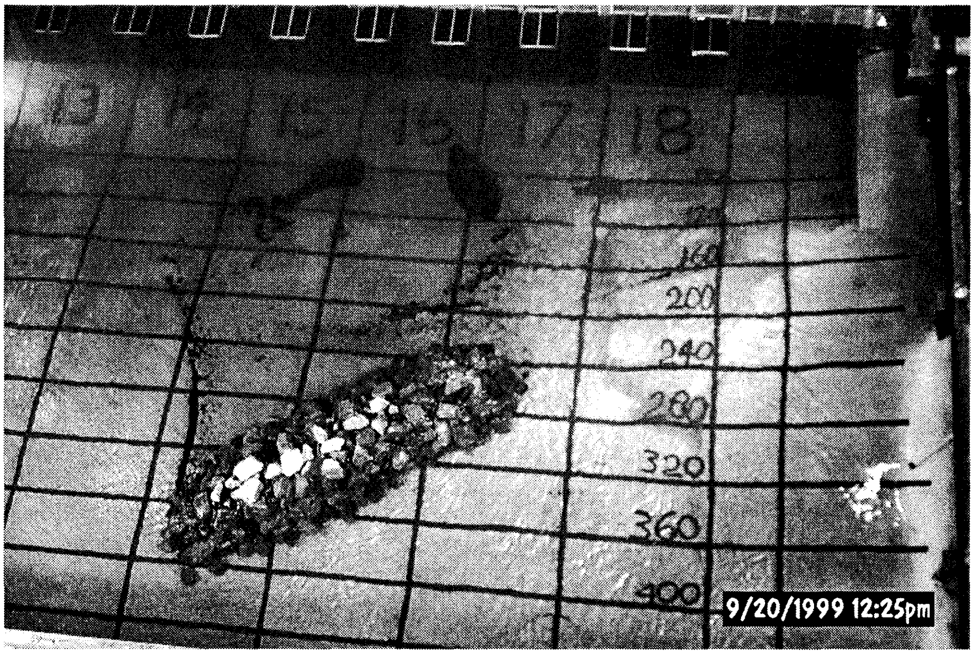



Figure 14: Deflector 4 with the final tracer Pattern.


Figure 15: Deflector 5 with the final tracer pattern.

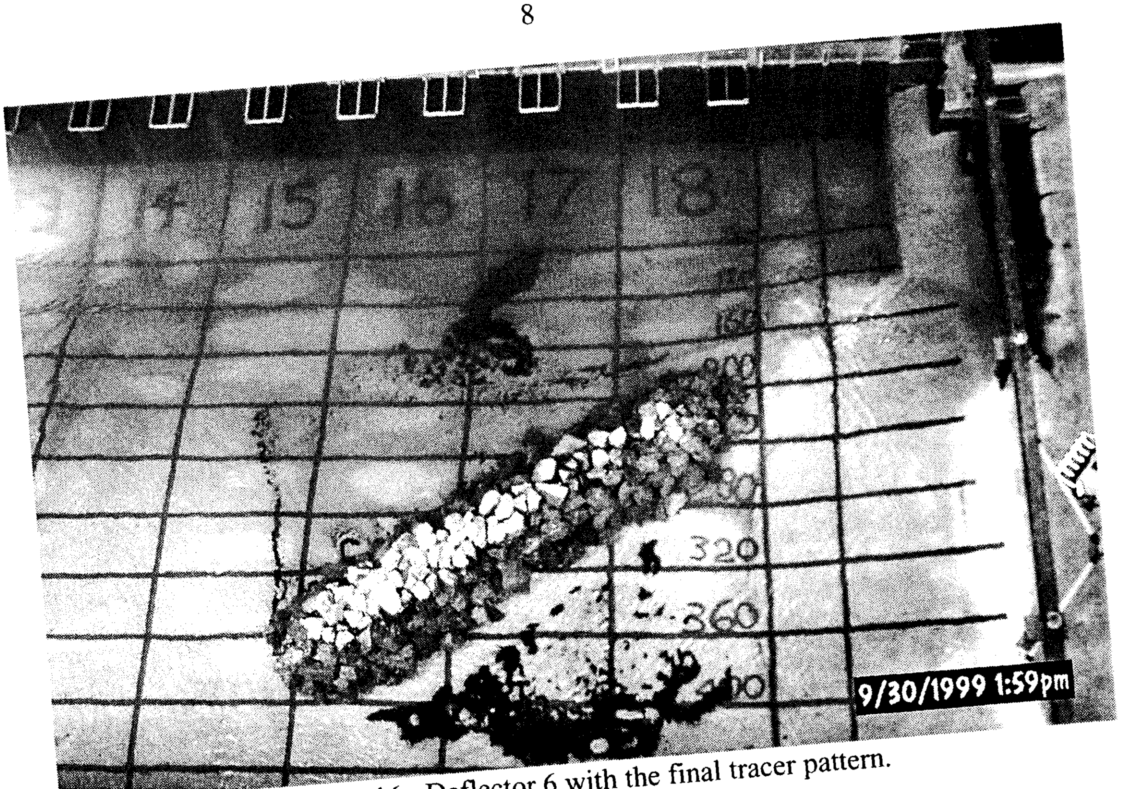



Figure 16: Deflector 6 with the final tracer pattern.

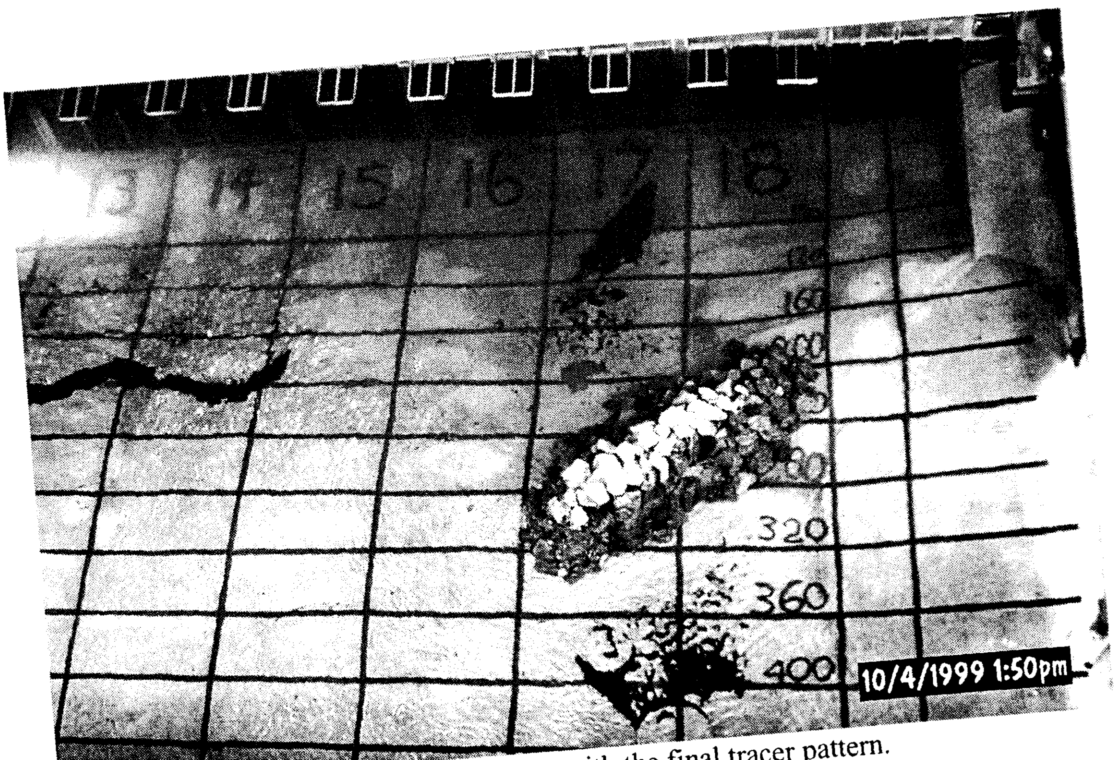



Figure 17: Deflector 7 with the final tracer pattern.

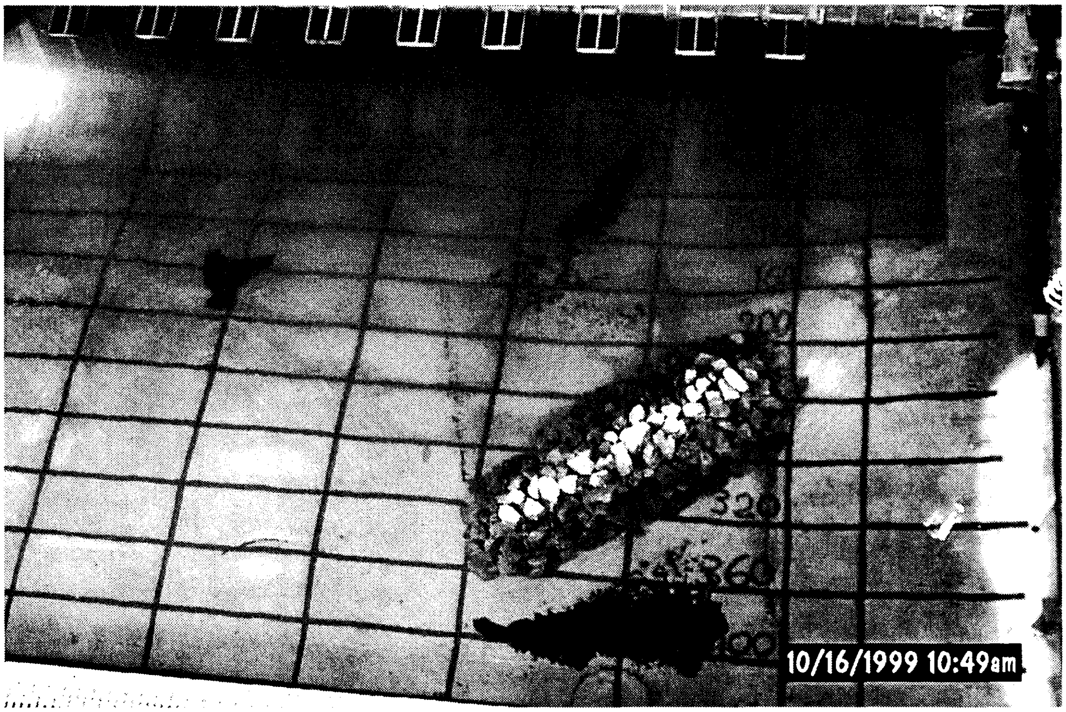



Figure 18: Deflector 8 with the final tracer pattern.

9. Dredged channel: The north shore was reformed to simulate the maximum dredged cut envisioned by NWP personnel. For this design, flow along the face of the powerhouse was changed with approaching flow increased along the north shore and flow along the face of the powerhouse being directed into the turbines or having a southerly directional component. An eddy did exist in front of the FU, however flow was strong enough to flush this area. The final tracer arrangement is shown in the following photograph (figure 19).

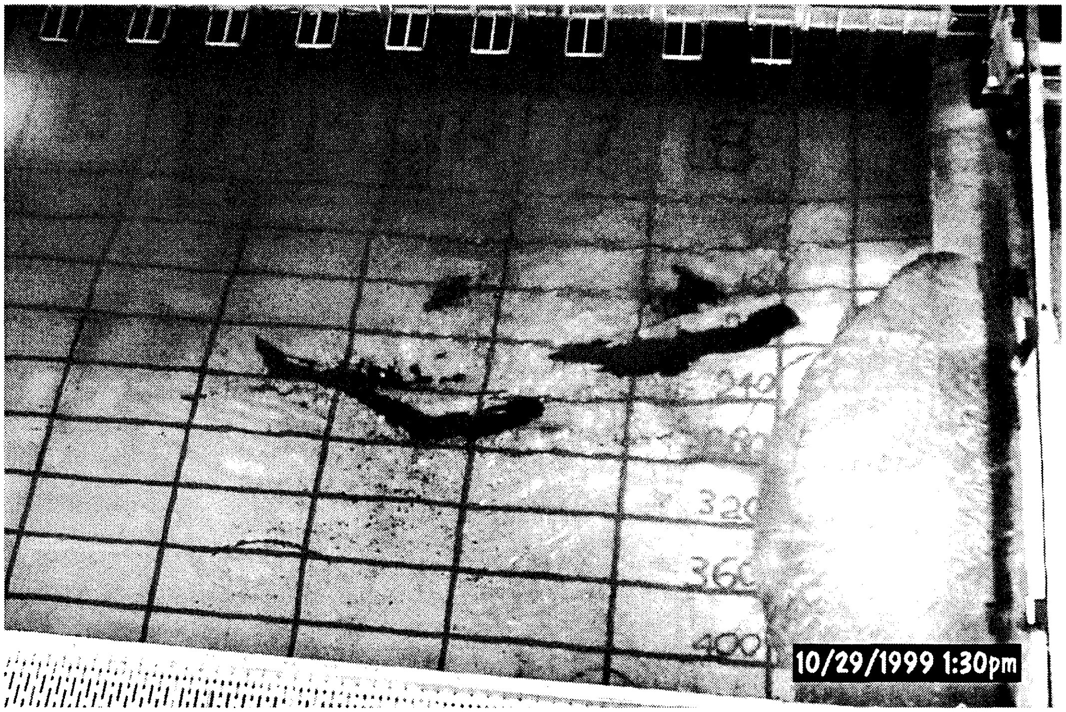


Figure 19: Dredged channel with final tracer pattern.

10. No additional designs were documented. Model operations ended in November 1999.

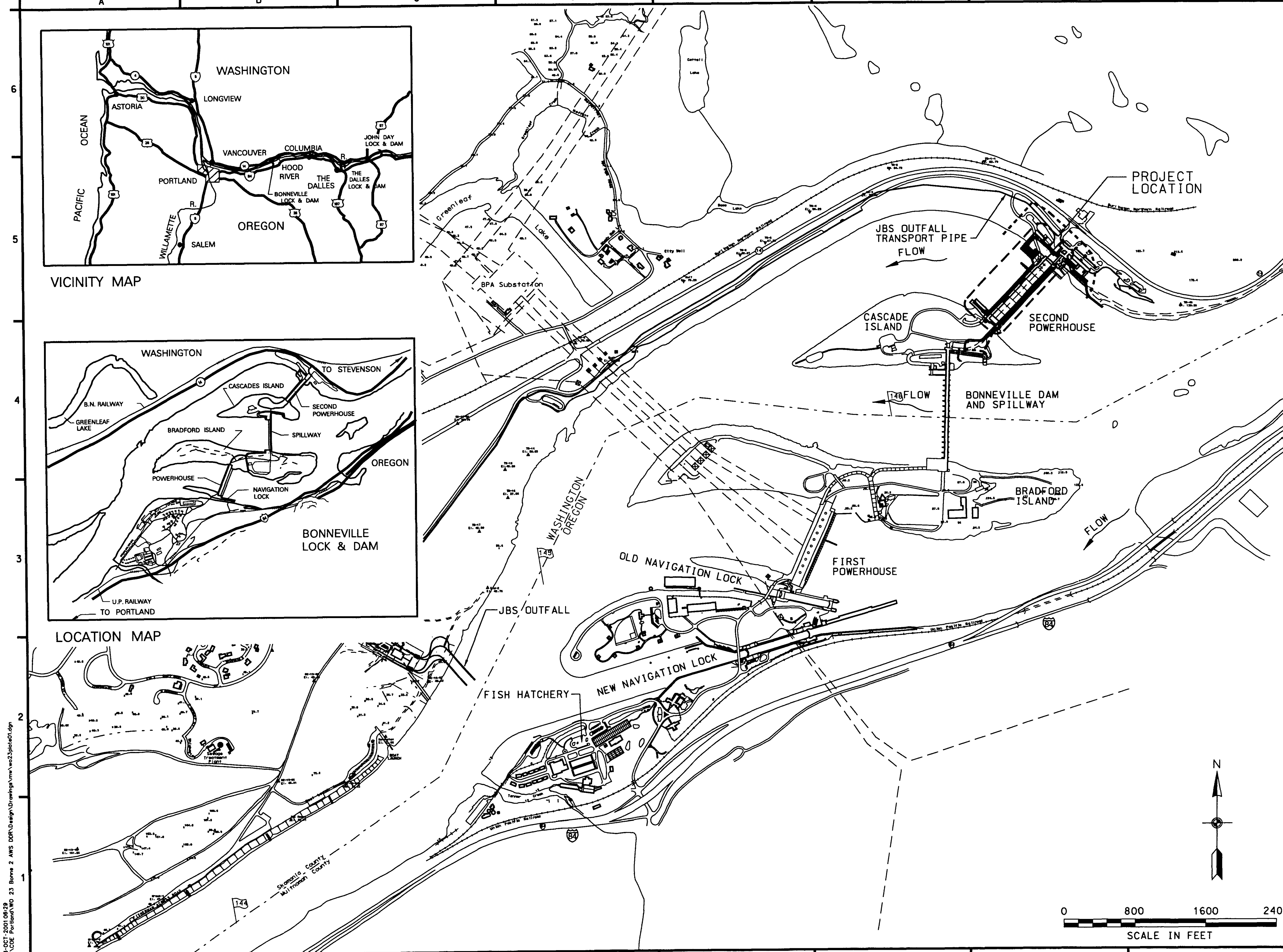
CHUCK TATE
Research Hydraulic Engineer
Coastal and Hydraulics Laboratory

# APPENDIX X

# PLACE HOLDER

# APPENDIX XX

# PLACE HOLDER




US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
|---|---|---|---|

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Drawn by: PATRICK
Checked by:
Submitted by:
Date: 26 SEP 01
CADD File Name: WO23PLATE01.DGN
Technical Manager:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

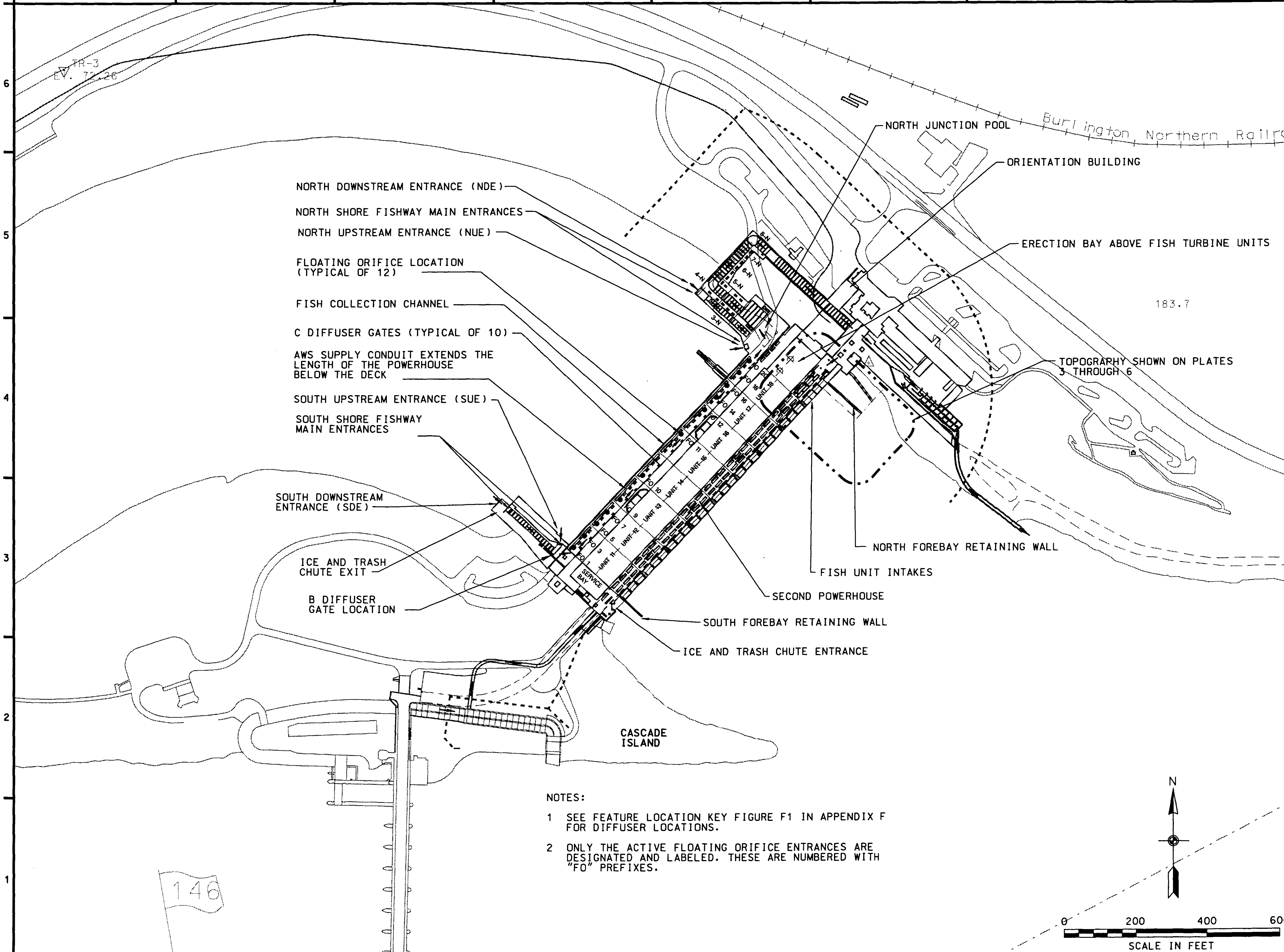
CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

LOCATION MAP, VICINITY MAP
AND SITE PLAN

DRAWING STATUS:
FINAL

DRAWING NO.
PLATE
1




NOTES:

1 SEE FEATURE LOCATION KEY FIGURE F1 IN APPENDIX F FOR DIFFUSER LOCATIONS.

2 ONLY THE ACTIVE FLOATING ORIFICE ENTRANCES ARE DESIGNATED AND LABELED. THESE ARE NUMBERED WITH "FO" PREFIXES.

US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
| --- | --- | --- | --- |
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Designed by: POSTLEWAITE
Date: 26 SEP 01
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CADD File Name: WO23PLATE02.DGN
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Technical Manager:
Submitted by:

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CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

# SITE PLAN EXISTING FACILITIES

DRAWING STATUS: FINAL

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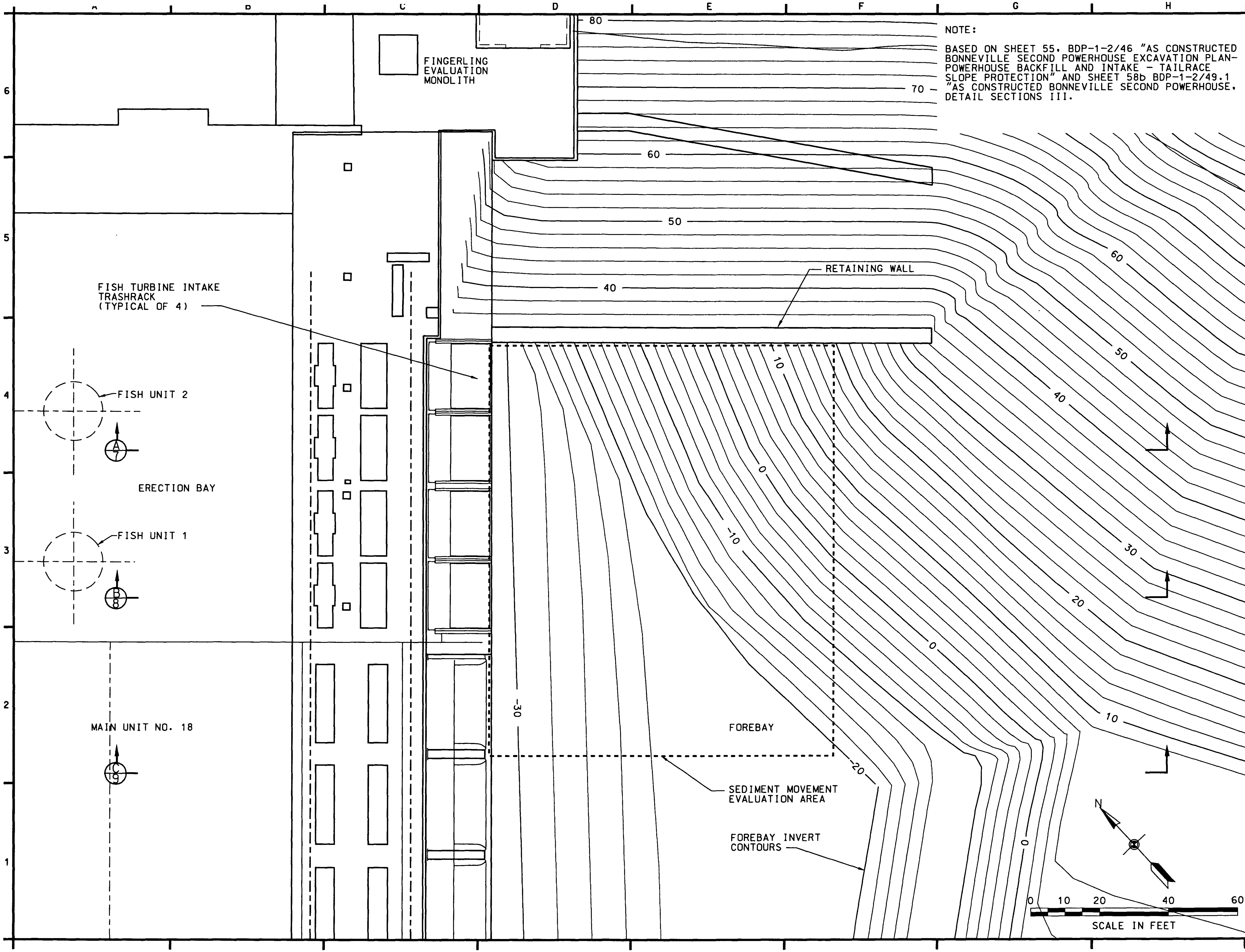


US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
|---|---|---|---|

Designed by: POSTLEWAITE
Drawn by: PATRICK
Checked by:
Submitted by:
Date: 26 SEP 01
CADD File Name: WO23PLATE03.DGN
Technical Manager:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

1986 BACKFILL GRADE

DRAWING STATUS:
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DRAWING NO.
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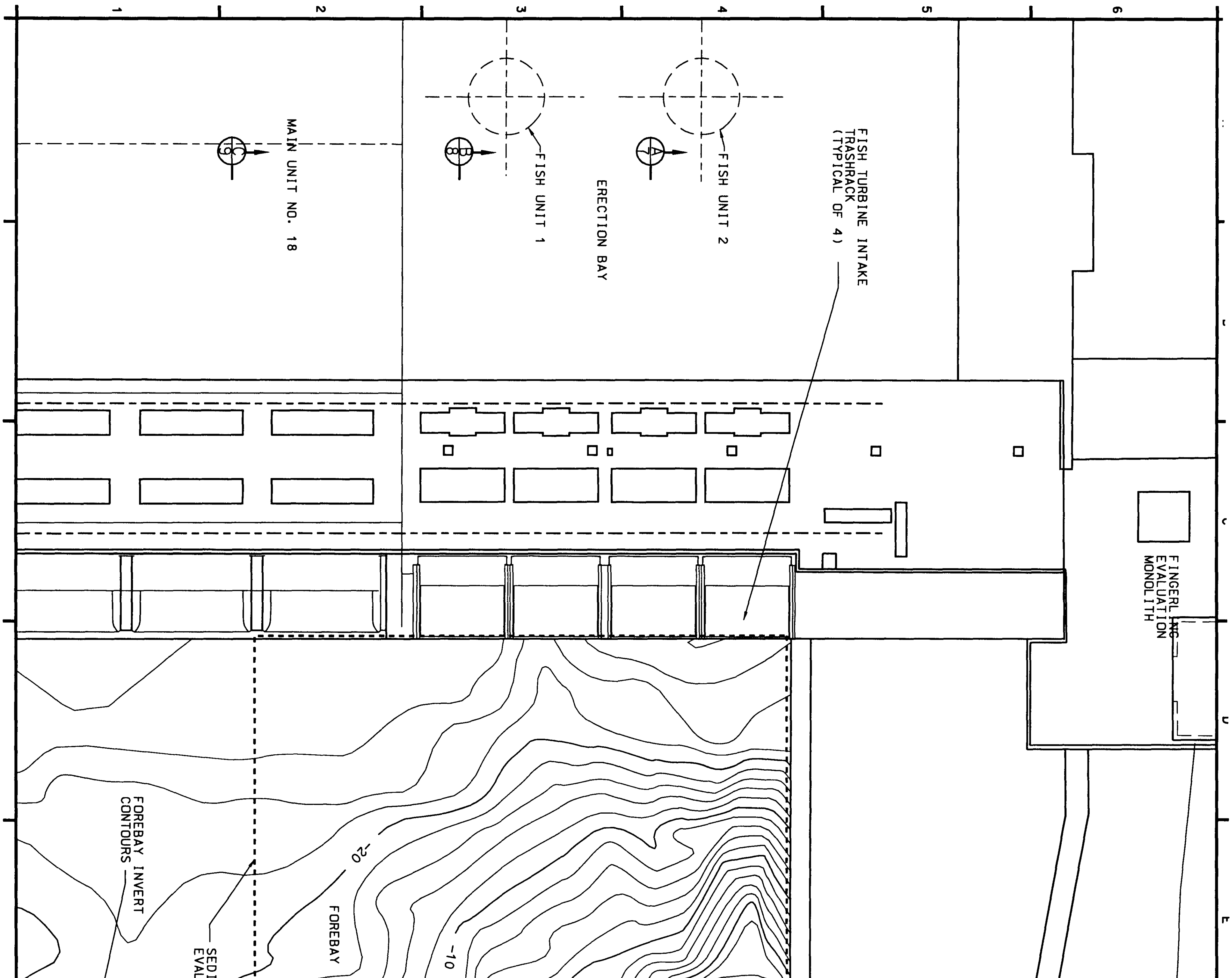


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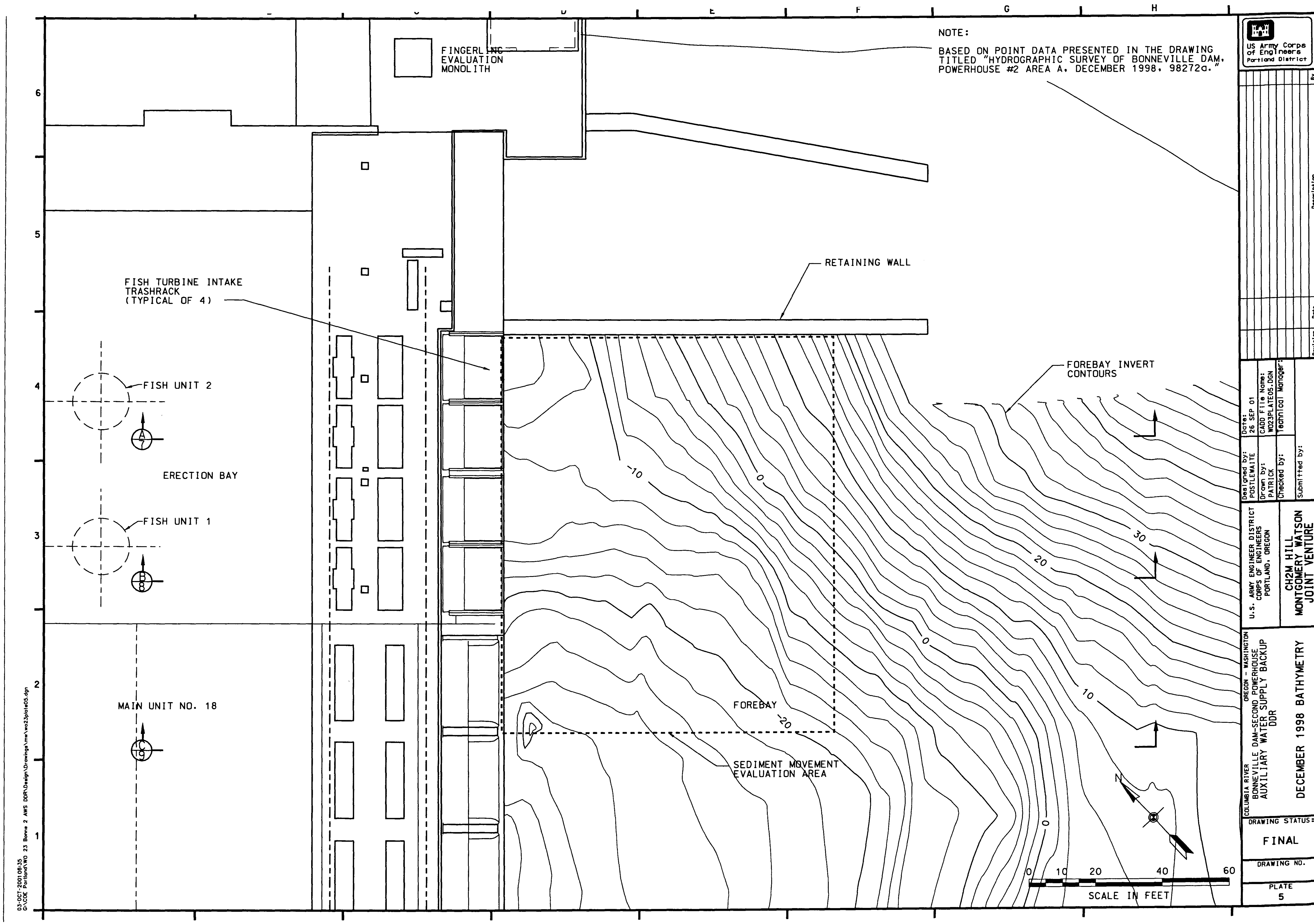
|---|---|---|---|---|
| COLUMBIA RIVER OREGON - WASHINGTON<br>BONNEVILLE DAM-SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY BACKUP<br>DDR<br>1997 POST-DREDGE SOUNDINGS | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: POSTLEWAITE<br>Drawn by: PATRICK<br>Checked by:<br>Submitted by: | Date: 26 SEP 01<br>CADD File Name: WO23PLATE04.DGN<br>Technical Manager: | US Army Corps of Engineers Portland District |

DRAWING STATUS: FINAL

DRAWING NO. PLATE 4

| Revision | Date | Description | By |
|---|---|---|---|
| | | | |


NOTE:
BASED ON POINT DATA PRESENTED IN THE DRAWING TITLED "HYDROGRAPHIC SURVEY OF BONNEVILLE DAM, POWERHOUSE #2 AREA A, DECEMBER 1998, 98272a."
FINGERLING EVALUATION MONOLITH
RETAINING WALL
FISH TURBINE INTAKE TRASHRACK (TYPICAL OF 4)
FISH UNIT 2
FISH UNIT 1
ERECTION BAY
MAIN UNIT NO. 18
FOREBAY INVERT CONTOURS
FOREBAY
SEDIMENT MOVEMENT EVALUATION AREA
-10
0
-20
30
20
10
N
0 10 20 40 60
SCALE IN FEET
US Army Corps of Engineers Portland District
Revision Date Description By
Designed by: POSTLEWAITE
Drawn by: PATRICK
Checked by:
Submitted by:
Date: 26 SEP 01
CADD File Name: W023PLATE05.DGN
Technical Manager:
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON
CH2M HILL MONTGOMERY WATSON JOINT VENTURE
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP DDR
DECEMBER 1998 BATHYMETRY
DRAWING STATUS: FINAL
DRAWING NO. PLATE 5
03-OCT-2001 08:35
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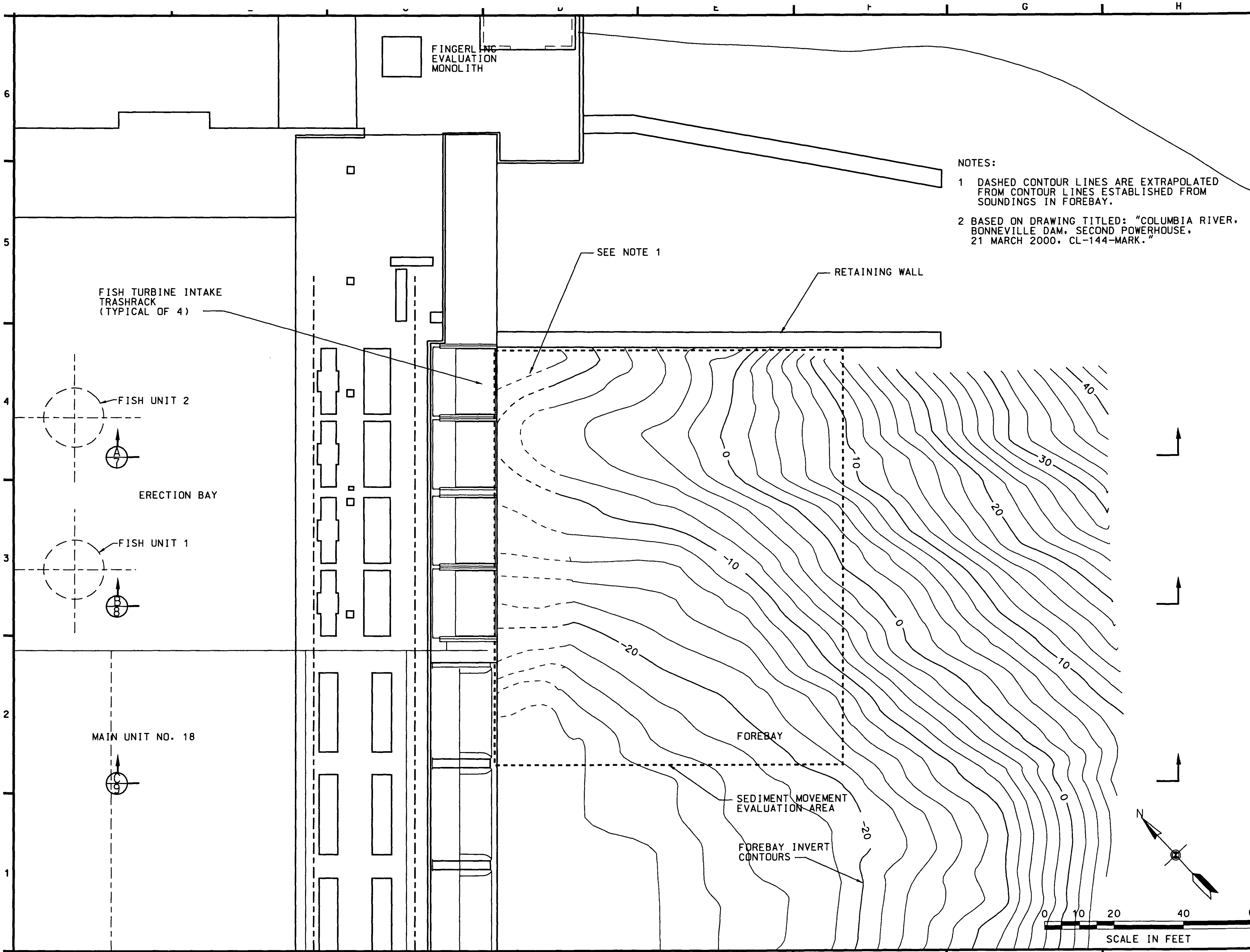


NOTES:

1 DASHED CONTOUR LINES ARE EXTRAPOLATED FROM CONTOUR LINES ESTABLISHED FROM SOUNDINGS IN FOREBAY.

2 BASED ON DRAWING TITLED: "COLUMBIA RIVER, BONNEVILLE DAM, SECOND POWERHOUSE, 21 MARCH 2000, CL-144-MARK."

US Army Corps of Engineers
Portland District

Revision | Date | Description | By

Designed by: POSTLEWAITE
Drawn by: PATRICK
Checked by:
Submitted by:
Date: 26 SEP 01
CADD File Name: WO23PLATE06.DGN
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JOINT VENTURE

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

MARCH, 2000 SOUNDINGS

DRAWING STATUS:
FINAL

DRAWING NO.
PLATE
6

03-OCT-2001 06:35
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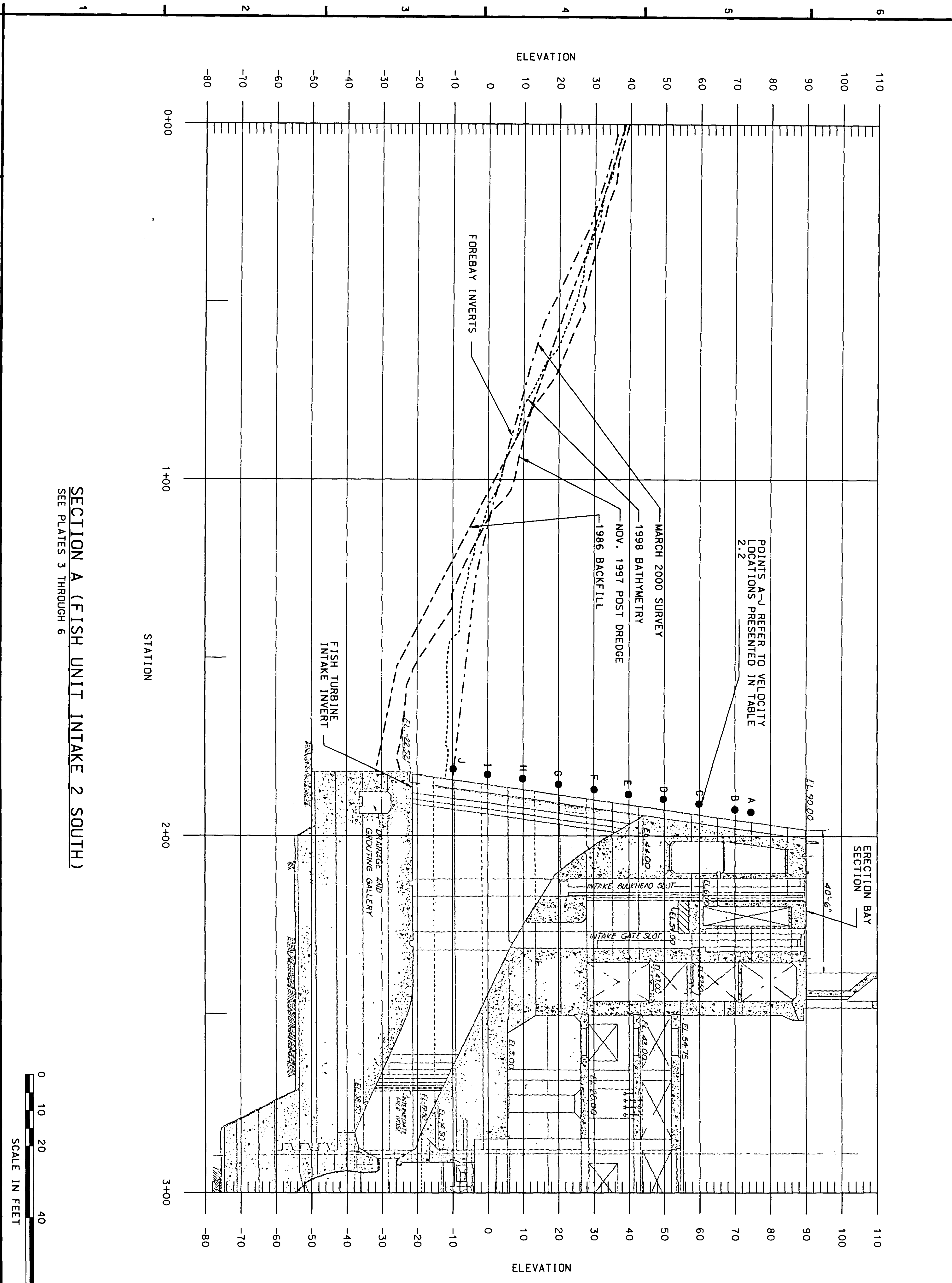


| | | | |
|---|---|---|---|
| COLUMBIA RIVER — OREGON - WASHINGTON<br>BONNEVILLE DAM-SECOND POWERHOUSE<br>AUXILIARY WATER SUPPLY BACKUP<br>DDR<br>FOREBAY AND B2 POWERHOUSE<br>SECTION A | U.S. ARMY ENGINEER DISTRICT<br>CORPS OF ENGINEERS<br>PORTLAND, OREGON<br>CH2M HILL<br>MONTGOMERY WATSON<br>JOINT VENTURE | Designed by: POSTLEWAITE<br>Drawn by: PATRICK<br>Checked by:<br>Submitted by: | Date: 26 SEP 01<br>CADD File Name: WO23PLATE07.DGN<br>Technical Manager: |

DRAWING STATUS: FINAL

DRAWING NO. PLATE 7

US Army Corps of Engineers Portland District

| Revision | Date | Description | By |
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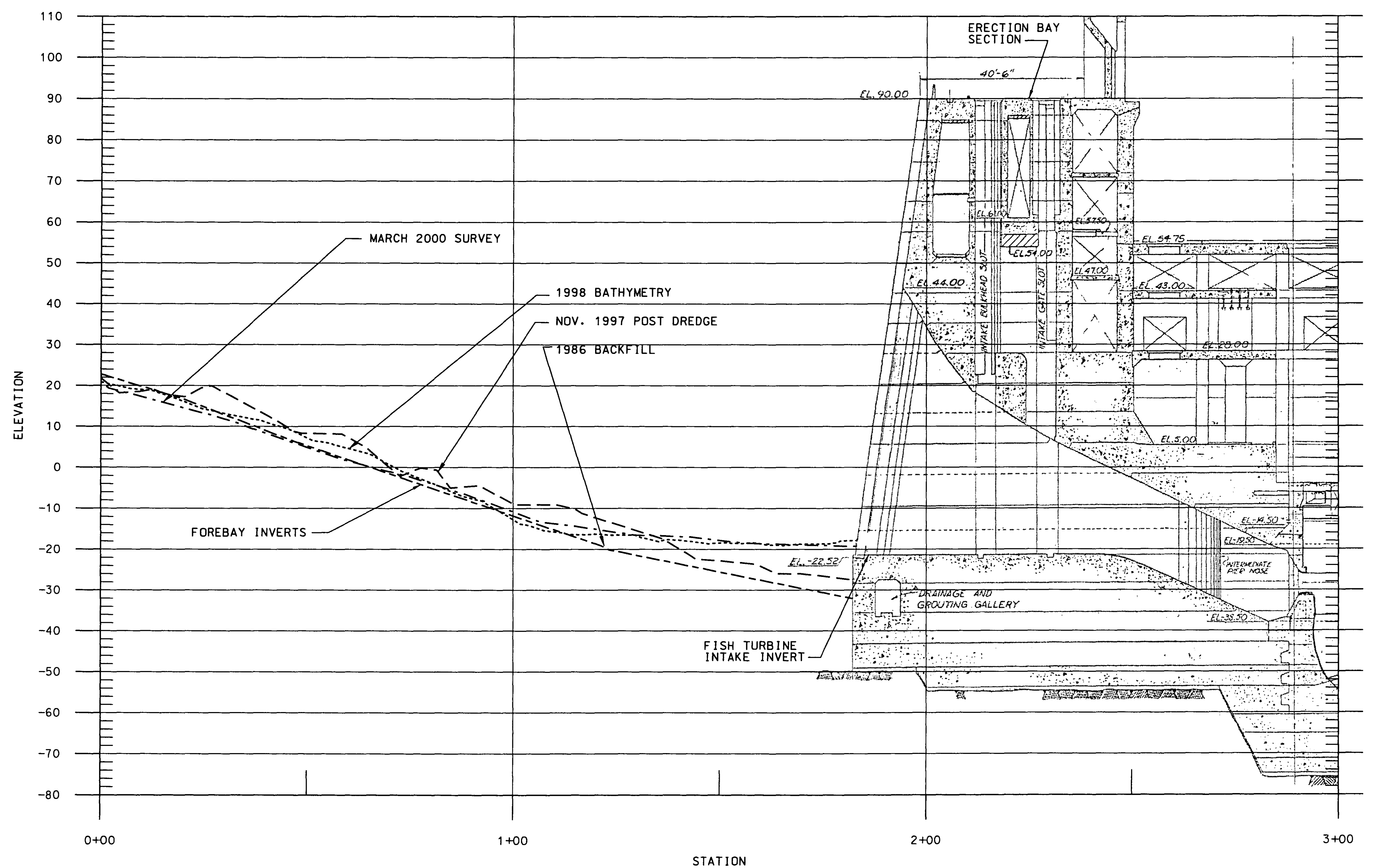



## SECTION B (FISH UNIT INTAKE 1 SOUTH)

SEE PLATES 3 THROUGH 6

0 10 20 40 60
SCALE IN FEET



US Army Corps of Engineers Portland District

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

FOREBAY AND B2 POWERHOUSE
SECTION B

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

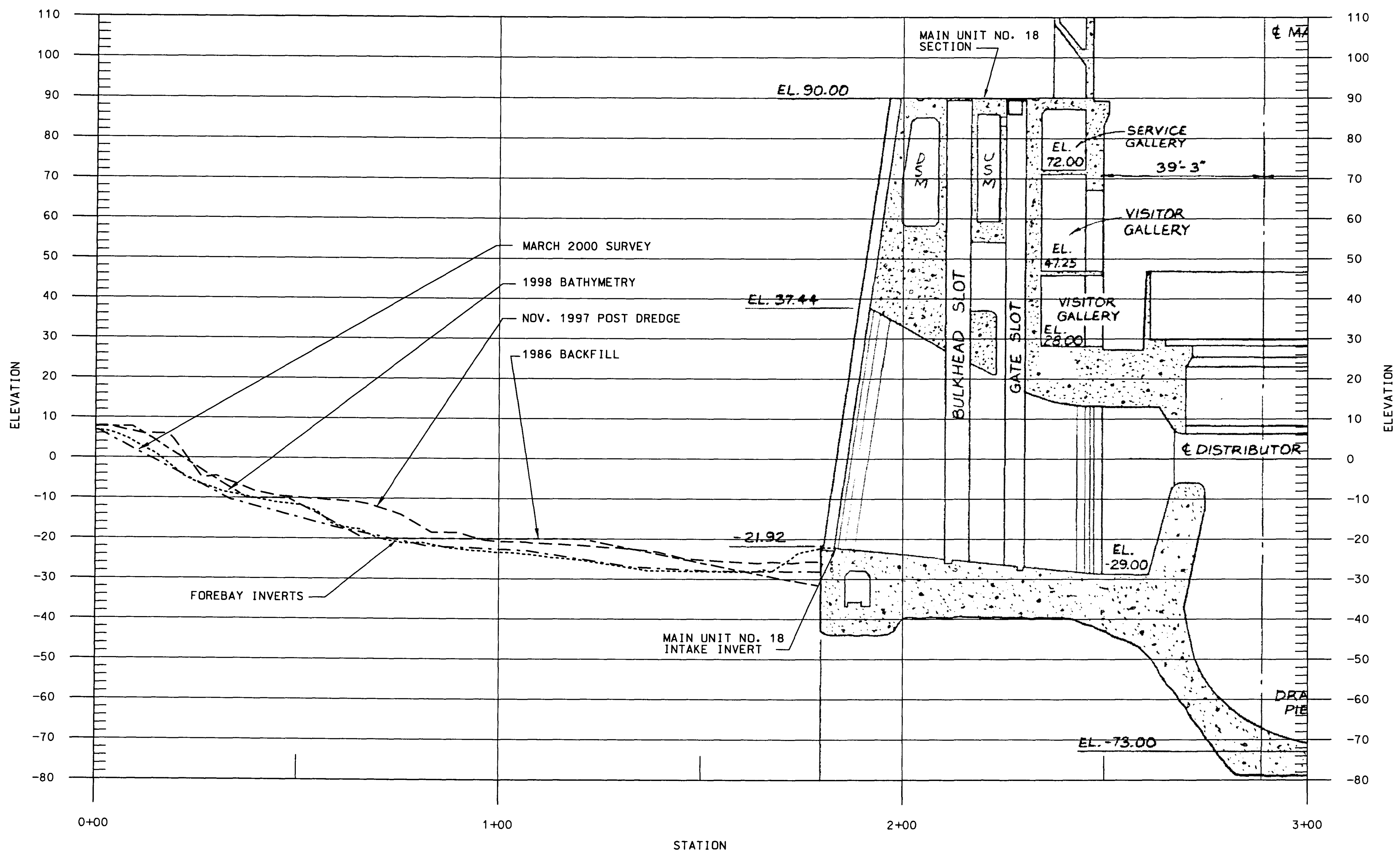
| | |
|---|---|
| Designed by: POSTLEWAITE | Date: 26 SEP 01 |
| Drawn by: PATRICK | CADD File Name: WO23PLATE08.DGN |
| Checked by: | Technical Manager: |
| Submitted by: | |

| Revision | Date | Description | By |
|---|---|---|---|

DRAWING STATUS: FINAL

DRAWING NO.

PLATE 8




# SECTION C (MAIN UNIT NO. 18 NORTH)

SEE PLATES 3 THROUGH 6

0 10 20 40 60
SCALE IN FEET

US Army Corps of Engineers Portland District

Date: 26 SEP 01
CADD File Name: W023PLATE09.DGN
Designed by: POSTLEWAITE
Drawn by: PATRICK

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON

CH2M HILL MONTGOMERY WATSON JOINT VENTURE

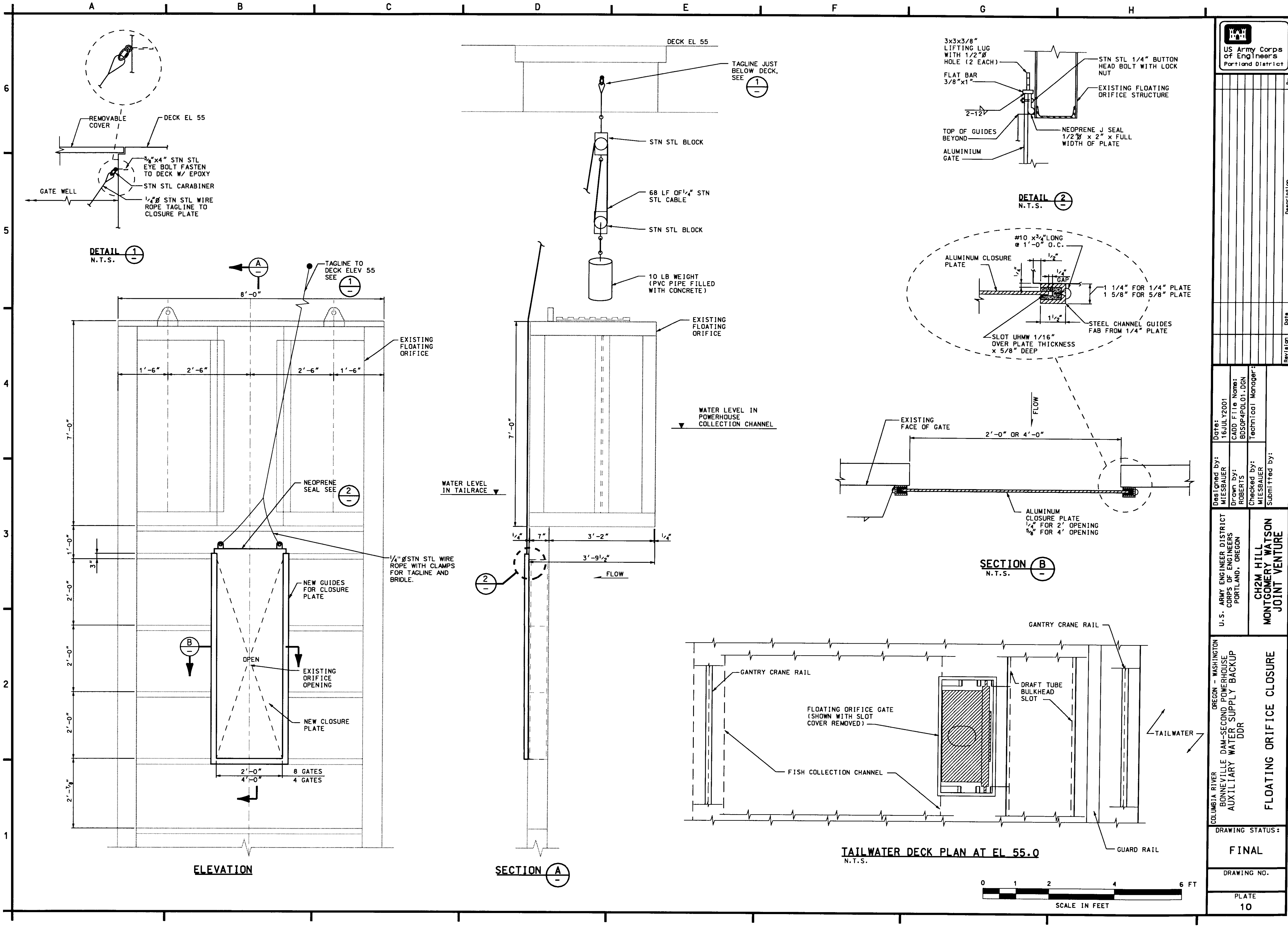
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP DDR

FOREBAY AND B2 POWERHOUSE SECTION C

DRAWING STATUS: FINAL

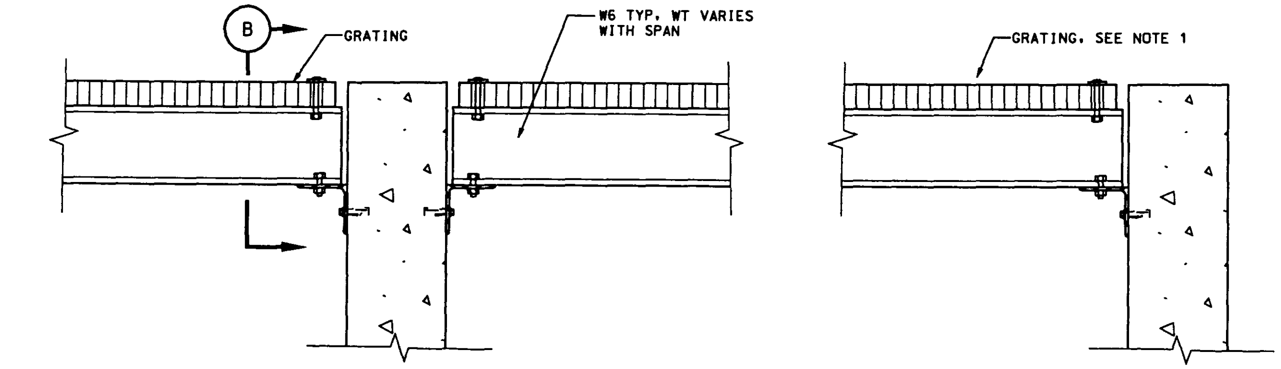
PLATE 9

03-OCT-2001 06:37

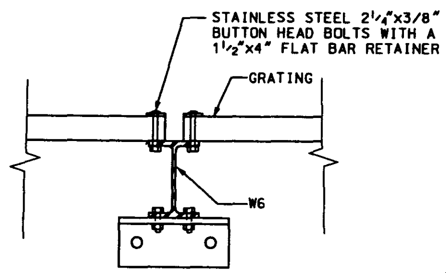

A B C D E F G H
1 2 3 4 5 6
REMOVABLE COVER
DECK EL 55
3/8"x4" STN STL EYE BOLT FASTEN TO DECK W/ EPOXY
STN STL CARABINER
1/4"Ø STN STL WIRE ROPE TAGLINE TO CLOSURE PLATE
GATE WELL
DETAIL 1
N.T.S.
DECK EL 55
TAGLINE JUST BELOW DECK, SEE 1
STN STL BLOCK
68 LF OF 1/4" STN STL CABLE
STN STL BLOCK
10 LB WEIGHT (PVC PIPE FILLED WITH CONCRETE)
EXISTING FLOATING ORIFICE
WATER LEVEL IN POWERHOUSE COLLECTION CHANNEL
WATER LEVEL IN TAILRACE
7'-0"
1/4" 7" 3'-2" 1/4"
3'-9 1/2"
FLOW
SECTION A
TAGLINE TO DECK ELEV 55 SEE 1
8'-0"
EXISTING FLOATING ORIFICE
1'-6" 2'-6" 2'-6" 1'-6"
7'-0"
1'-0"
3"
2'-0"
2'-0"
2'-0"
2'-7 7/8"
NEOPRENE SEAL SEE 2
1/4"ØSTN STL WIRE ROPE WITH CLAMPS FOR TAGLINE AND BRIDLE.
NEW GUIDES FOR CLOSURE PLATE
OPEN
EXISTING ORIFICE OPENING
NEW CLOSURE PLATE
2'-0" 8 GATES
4'-0" 4 GATES
ELEVATION
3x3x3/8" LIFTING LUG WITH 1/2"Ø HOLE (2 EACH)
FLAT BAR 3/8"x1"
2-12
STN STL 1/4" BUTTON HEAD BOLT WITH LOCK NUT
EXISTING FLOATING ORIFICE STRUCTURE
TOP OF GUIDES BEYOND
NEOPRENE J SEAL 1/2"Ø x 2" x FULL WIDTH OF PLATE
ALUMINIUM GATE
DETAIL 2
N.T.S.
#10 x 3/4" LONG @ 1'-0" O.C.
ALUMINUM CLOSURE PLATE
1/2"
1/4"
1/4" GAP
1 1/4" FOR 1/4" PLATE
1 5/8" FOR 5/8" PLATE
1 1/2"
STEEL CHANNEL GUIDES FAB FROM 1/4" PLATE
SLOT UHMW 1/16" OVER PLATE THICKNESS x 5/8" DEEP
FLOW
EXISTING FACE OF GATE
2'-0" OR 4'-0"
ALUMINUM CLOSURE PLATE 1/4" FOR 2' OPENING 5/8" FOR 4' OPENING
SECTION B
N.T.S.
GANTRY CRANE RAIL
GANTRY CRANE RAIL
DRAFT TUBE BULKHEAD SLOT
FLOATING ORIFICE GATE (SHOWN WITH SLOT COVER REMOVED)
TAILWATER
FISH COLLECTION CHANNEL
GUARD RAIL
TAILWATER DECK PLAN AT EL 55.0
N.T.S.
0 1 2 4 6 FT
SCALE IN FEET
US Army Corps of Engineers Portland District
Revision Date Description By
Designed by: MIESBAUER
Drawn by: ROBERTS
Checked by: MIESBAUER
Submitted by:
Date: 16JULY2001
CADD File Name: BDSOP4POL01.DGN
Technical Manager:
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS PORTLAND, OREGON
CH2M HILL MONTGOMERY WATSON JOINT VENTURE
COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE AUXILIARY WATER SUPPLY BACKUP DDR
FLOATING ORIFICE CLOSURE
DRAWING STATUS: FINAL
DRAWING NO.
PLATE 10

NOTES:

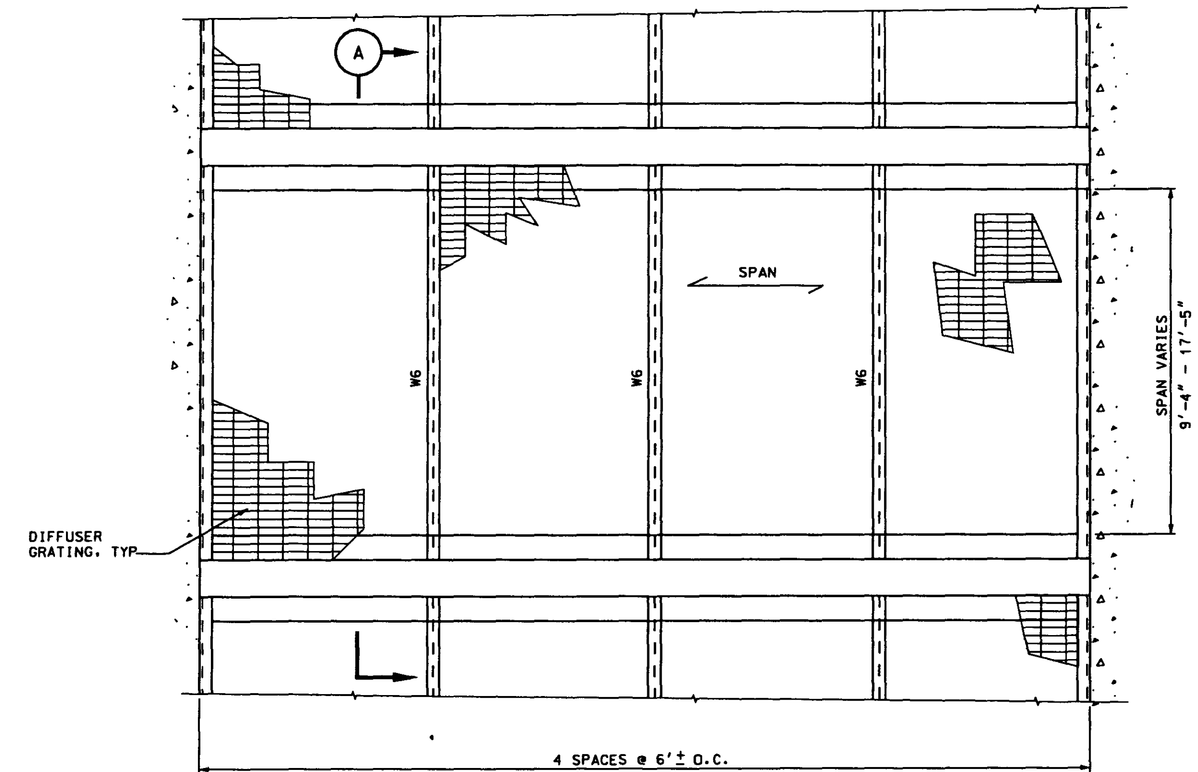
1 DIFFUSER GRATING:
BEARING BARS - 3/16" x 1/4" AT 1 3/16" ON CENTER
CROSS BARS - 1/4" DIAMETER AT 4" ON CENTER.



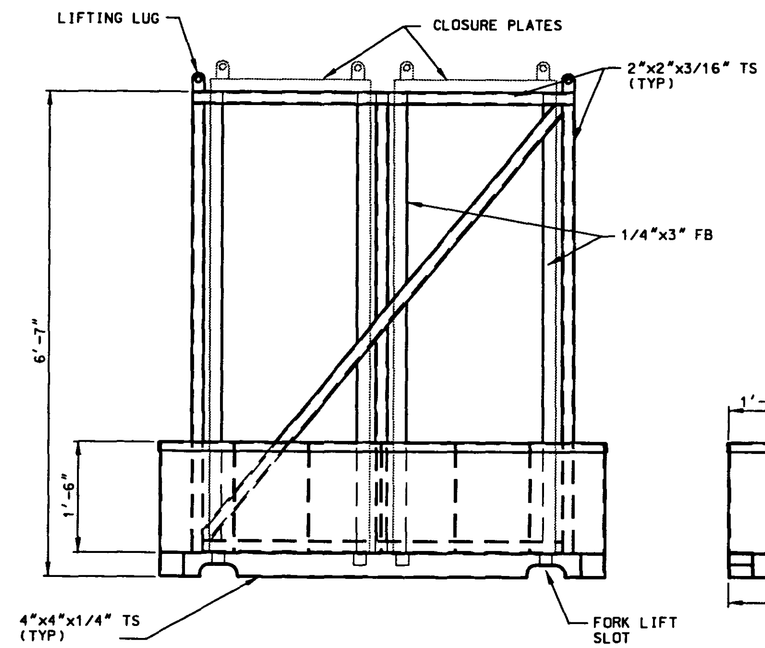

SECTION A



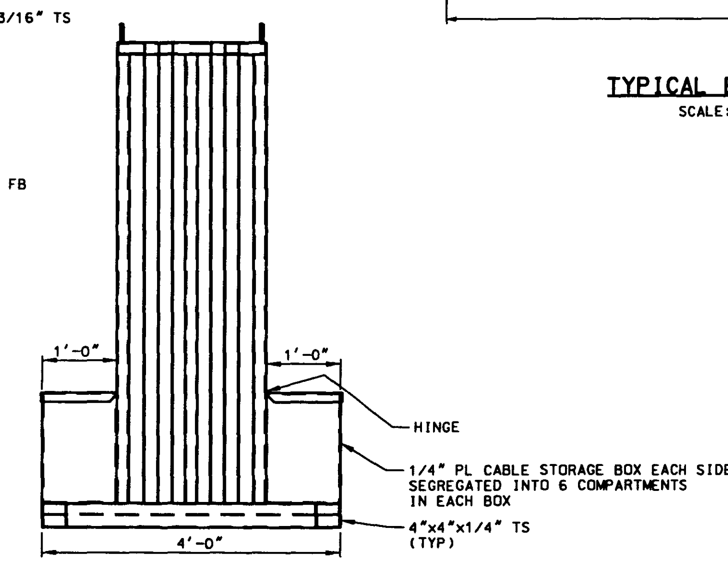

SECTION B




TYPICAL EXISTING DIFFUSER GRATING FRAMING PLAN
SCALE: 1/4" = 1'-0"

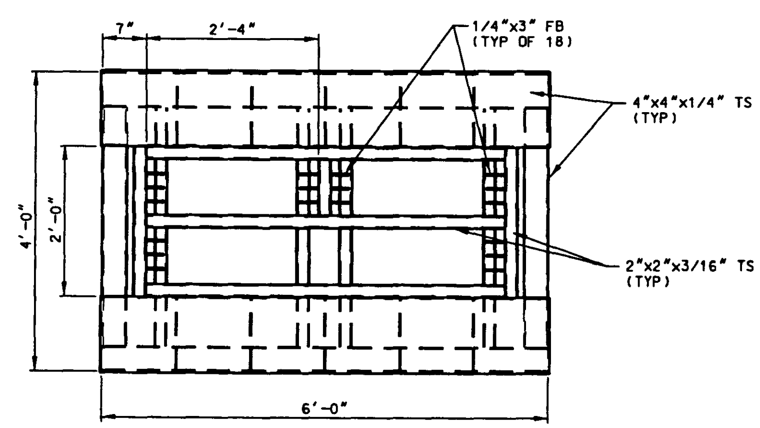



SIDE ELEVATION




END ELEVATION

NOTES:
1 GALVANIZE RACK ASSEMBLY AFTER FABRICATION
2 LINE SLOT GUIDES WITH 1/4" UHMW PLASTIC PANELS FASTEN WITH #12 MACHINE SCREWS




PLAN

SLIDE GATE STORAGE RACK
SCALE: 1/2"=1'-0"

0 2 4 8 12 FT
SCALE IN FEET

US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
|---|---|---|---|

Designed by: MIESBAUER
Drawn by: ROBERTS
Checked by: MIESBAUER
Submitted by:
Date: 16JULY2001
CADD File Name: BD50P5PoL01.DGN
Technical Manager:

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MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

DIFUSER GRATINGS (& FRAMES) AND SLIDE GATE RACK

DRAWING STATUS: FINAL

DRAWING NO.

PLATE 11

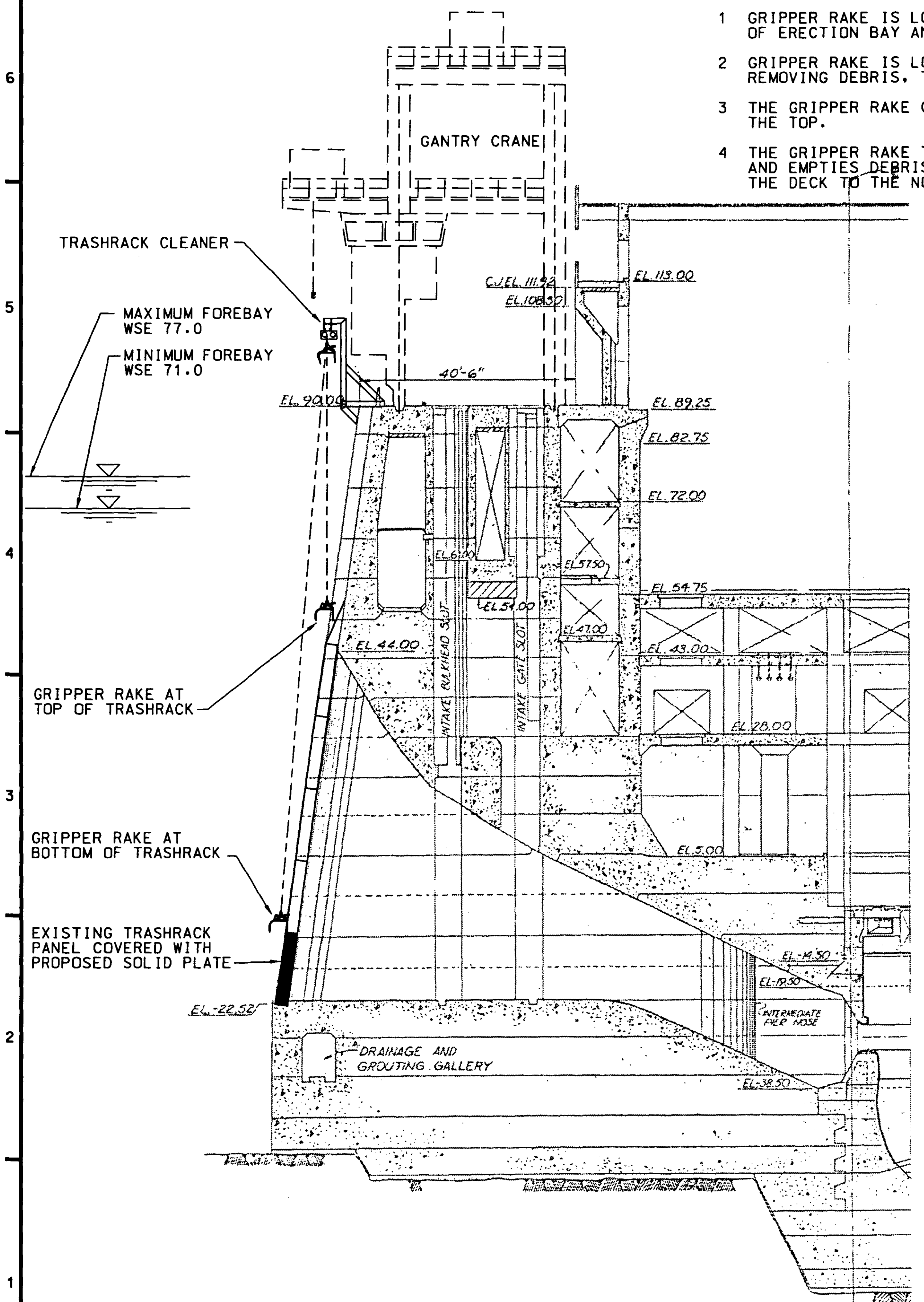
TRASH RAKE OPERATION:

1 GRIPPER RAKE IS LOWERED ON CABLES DOWN THE FACE OF ERECTION BAY AND ENGAGES IN THE TRASHRACK.

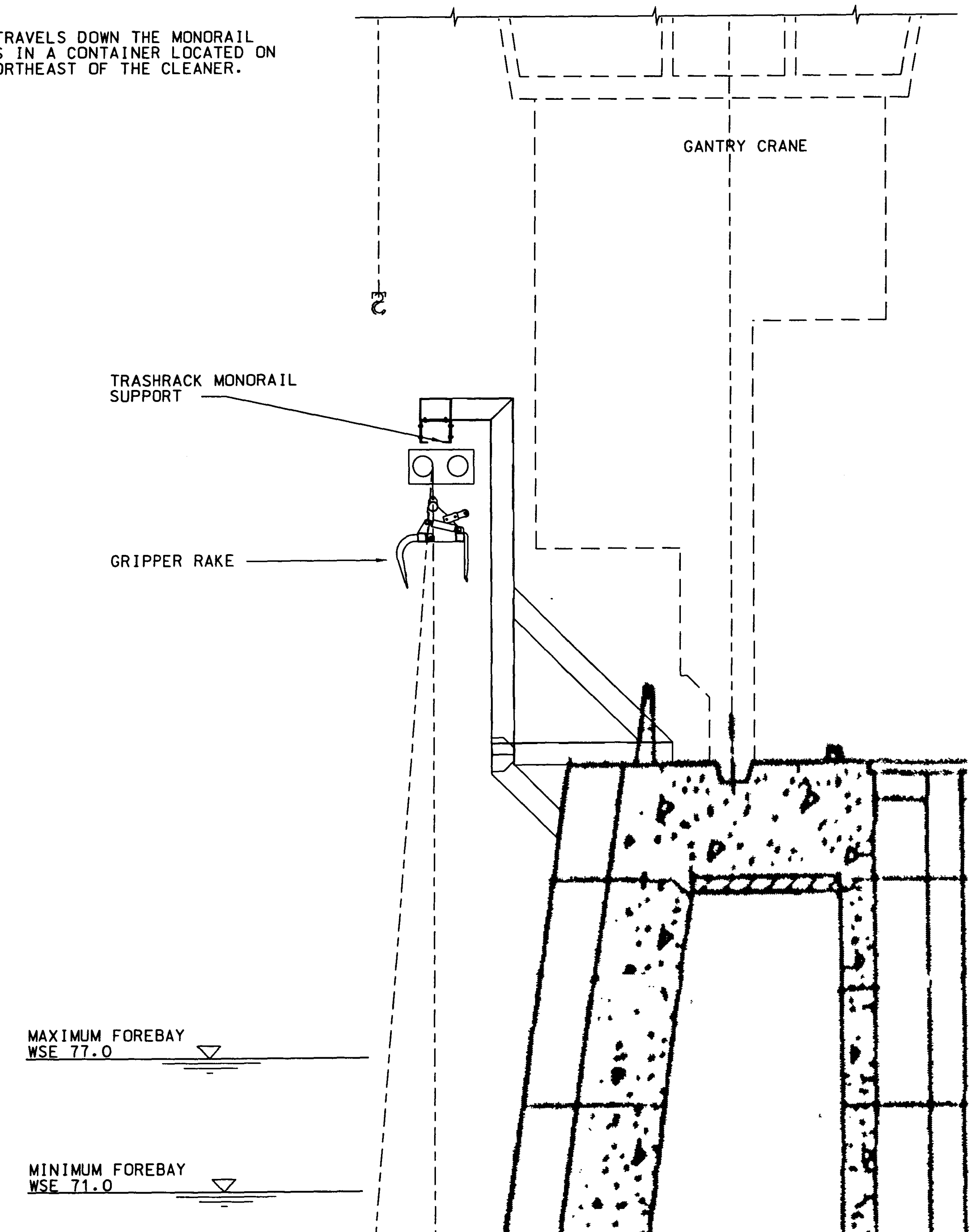
2 GRIPPER RAKE IS LOWERED DOWN THE TRASHRACK, REMOVING DEBRIS, TO THE BOTTOM.

3 THE GRIPPER RAKE CLOSES AND IS DRAWN BACK TO THE TOP.

4 THE GRIPPER RAKE TRAVELS DOWN THE MONORAIL AND EMPTIES DEBRIS IN A CONTAINER LOCATED ON THE DECK TO THE NORTHEAST OF THE CLEANER.




ERECTION BAY SECTION




DETAIL SECTION

US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
|---|---|---|---|

Designed by: POSTLEWAITE
Drawn by: PATRICK
Checked by:
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Date: 26 SEP 01
CADD File Name: WO23PLATE14.DGN
Technical Manager:

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PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER · OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

TRASHRACK CLEANER SECTION
GRIPPER RAKE ALTERNATIVE

DRAWING STATUS:
FINAL

DRAWING NO.

PLATE
12

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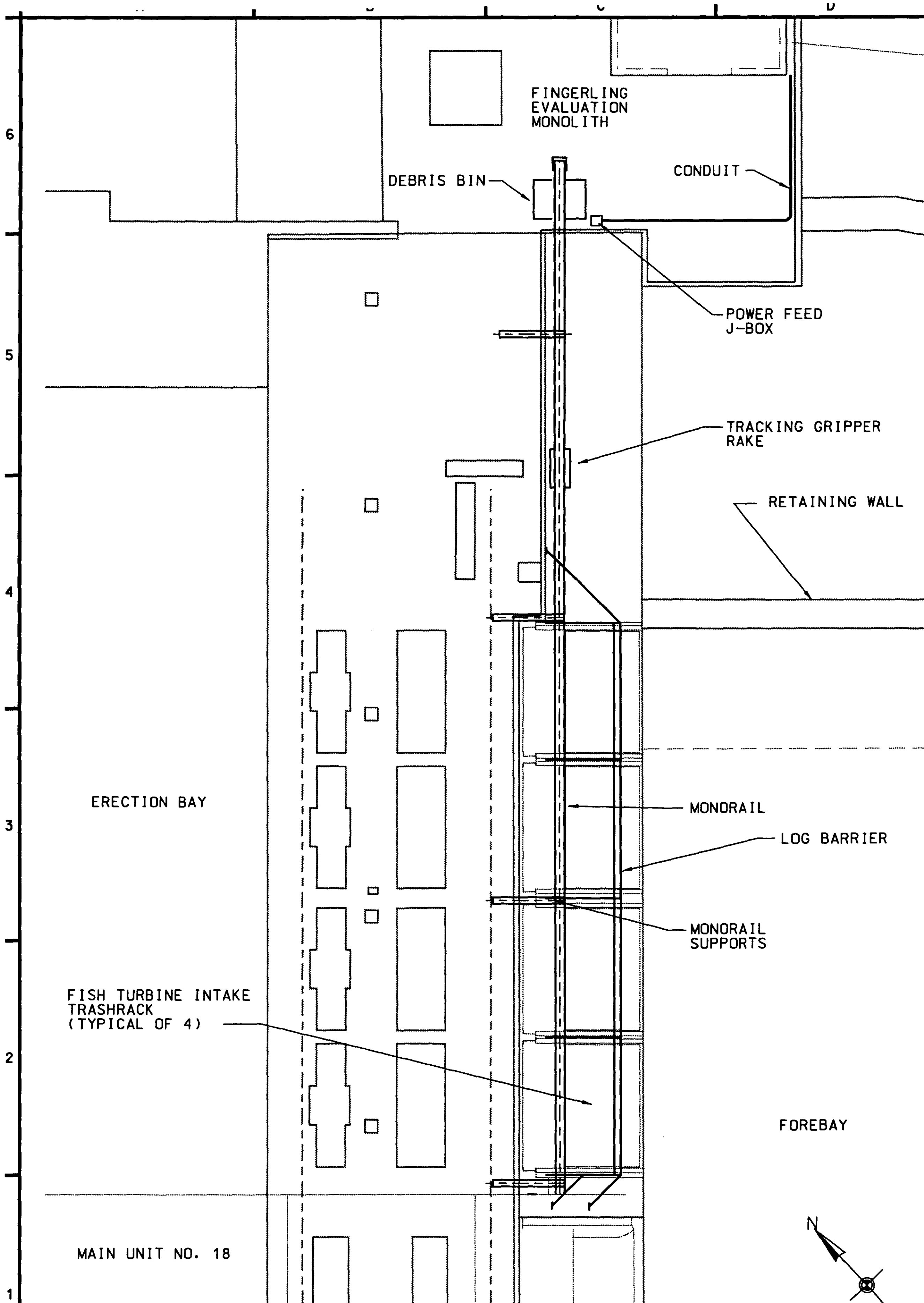
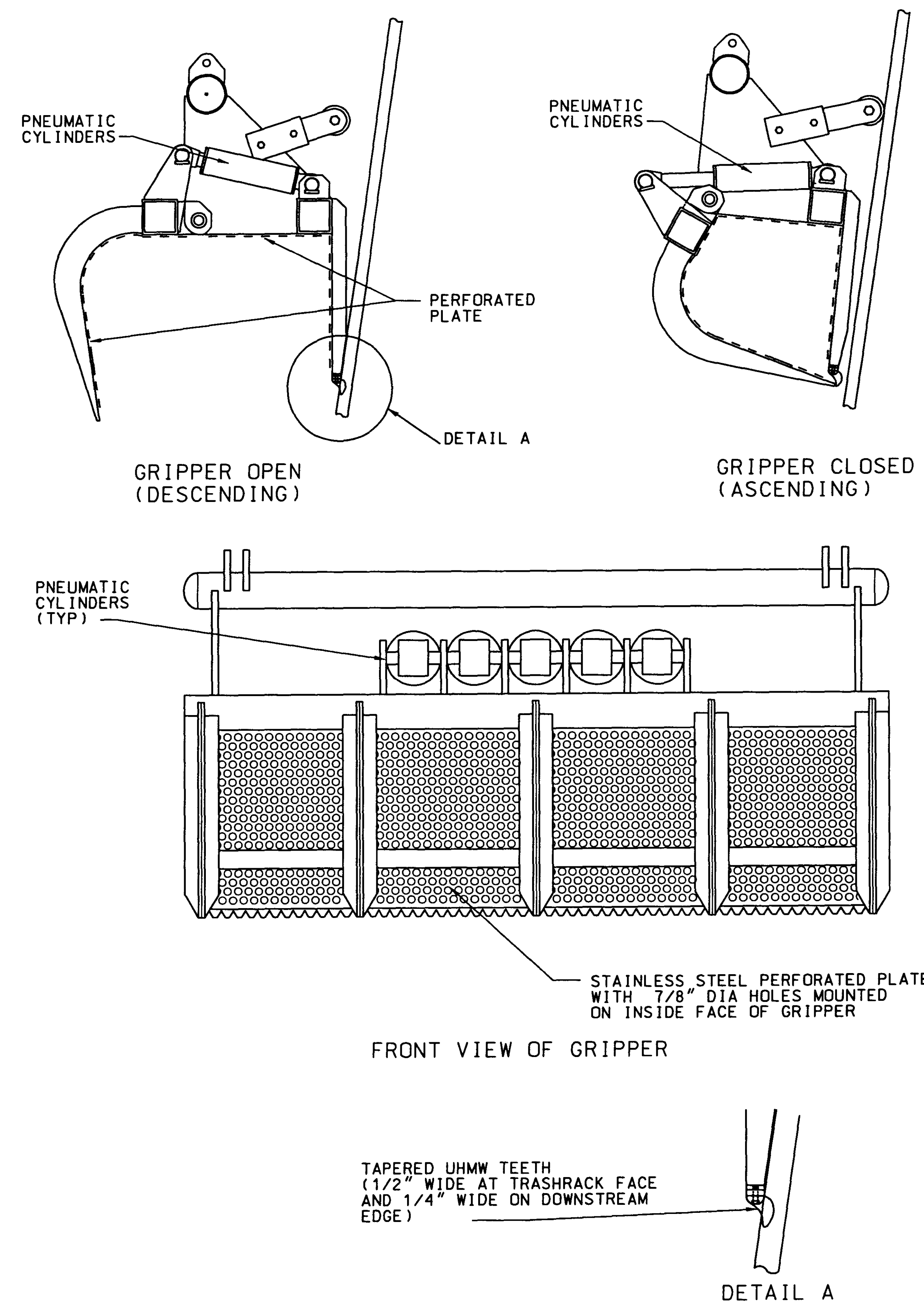



TRASHRACK CLEANER PLAN
MONORAIL TRAVELING GRIPPER RAKE ALTERNATIVE




GRIPPER RAKE DETAILS
NOT TO SCALE

US Army Corps of Engineers
Portland District

Revision | Date | Description | By

Designed by: POSTLEWAITE
Drawn by: PATRICK
Checked by:
Submitted by:
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PORTLAND, OREGON

CH2M HILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

TRASHRACK CLEANER PLAN
GRIPPER RAKE ALTERNATIVE

DRAWING STATUS:
FINAL

DRAWING NO.
PLATE
13

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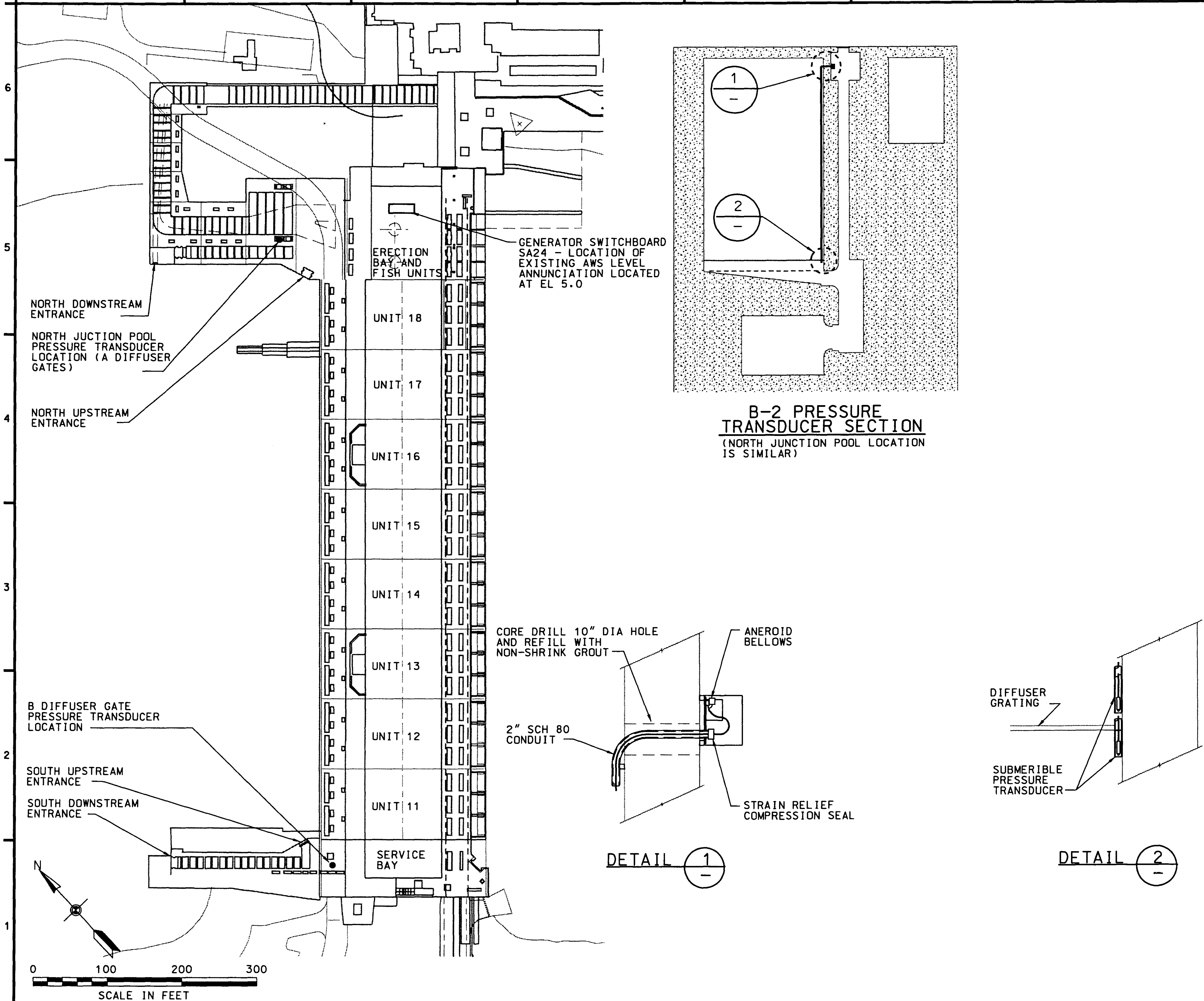


US Army Corps of Engineers Portland District

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Designed by: POSTLEWAITE
Date: 26 SEP 01
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Submitted by:

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COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

PRESSURE TRANSMITTER PLANS AND SECTIONS

DRAWING STATUS: FINAL

DRAWING NO.

PLATE 14

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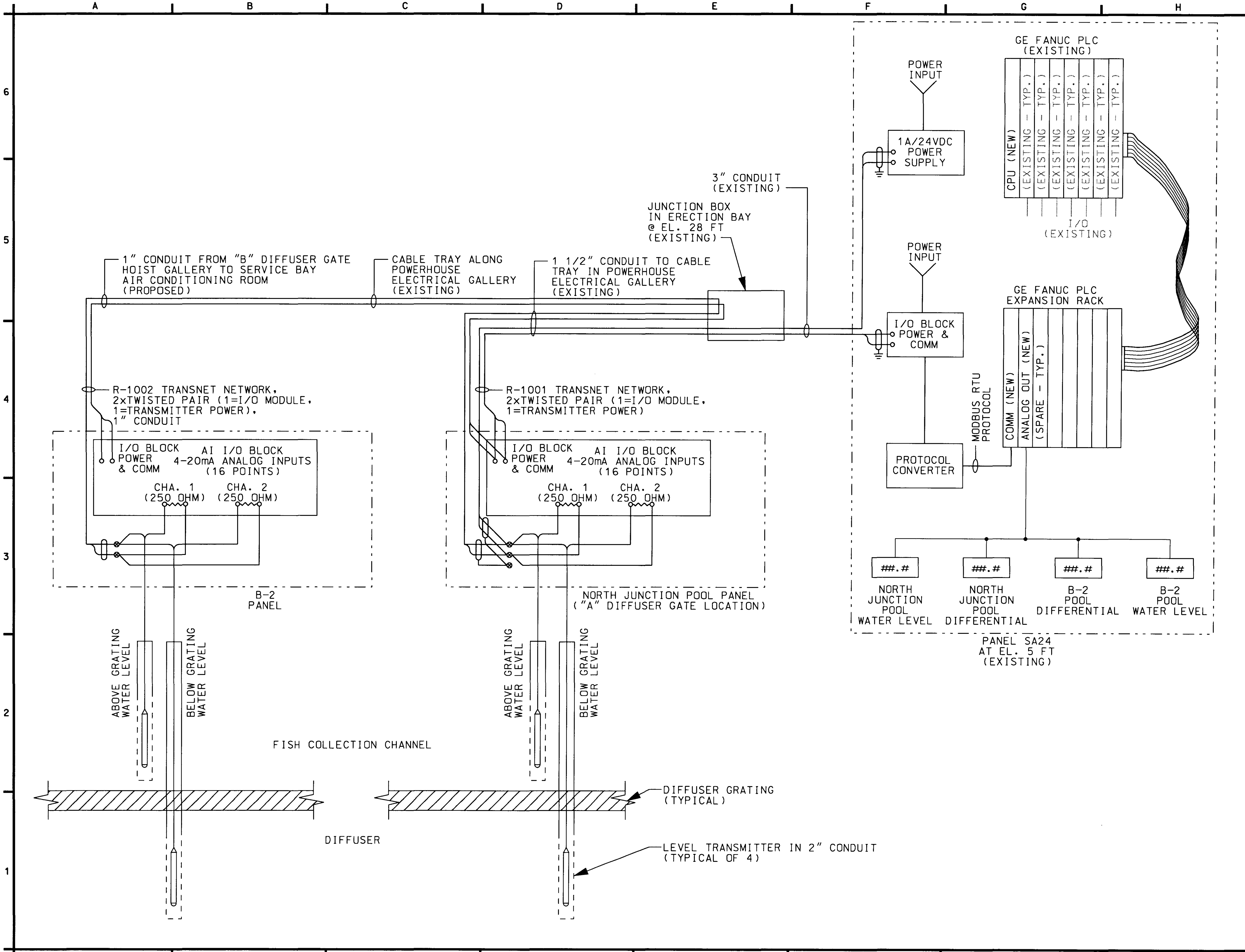


US Army Corps of Engineers
Portland District

| Revision | Date | Description | By |
|---|---|---|---|

Designed by: POSTLEWAITE
Drawn by: J.C. DEERKOP
Checked by:
Submitted by:
Date: 30 JUL 01
CADD File Name: WO23PLATE15.DGN
Technical Manager:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OREGON

CH2MHILL
MONTGOMERY WATSON
JOINT VENTURE

COLUMBIA RIVER OREGON - WASHINGTON
BONNEVILLE DAM-SECOND POWERHOUSE
AUXILIARY WATER SUPPLY BACKUP
DDR

ELECTRICAL
DIFFUSER GRATING MONITORING
SYSTEM SCHEMATIC

DRAWING STATUS:
FINAL

DRAWING NO.
PLATE
15

05-NOV-2001 11:10
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# APPENDIX I

# GANTRY CRANE DATA

**Gantry #7 Crane Log Data**

| 2013 | | | |
|---|---|---|---|
| **Date** | **Key Word** | **Work Performed** | **Hours Operated** |
| 9-Mar-13 | rake | STS/Rake | 10 |
| 10-Mar-13 | rake | Rake 15,16,17,18/STS repair | |
| 11-Mar-13 | slots | de-bark slots | |
| 20-Mar-13 | rack | STS/Trash rack | 3 |
| 25-Mar-13 | rack | trash racks 14 | 5 |
| 4-Apr-13 | rack | unit 14, trash rack | |
| 10-Apr-13 | rake | rake fish units | |
| 6-May-13 | fish | move fish screen | |
| 7-May-13 | screen | screen repairs | |
| 14-May-13 | rake | rake | 10 |

| 2012 | | | |
|---|---|---|---|
| **Date** | **Key Word** | **Work Performed** | **Hours Operated** |
| 8-Feb-12 | fish unit | Pull F1 B Bulkhead | |
| 9-Feb-12 | rack | F1 A trash rack | 1.5 |
| 13-Feb-12 | rake | Rake PH2 All units | |
| 14-Feb-12 | rake | Rake fish unit | 10 |
| 15-Feb-12 | rack | Pull F1 B top trash rack | |
| 21-Feb-12 | rack | fish unit trash racks | 10 |
| 28-Feb-12 | rack | fish unit trash racks | 10 |
| 12-Mar-12 | headgate | headgate rehab | |
| 12-Jun-12 | rake | rake F2 | 3 |
| 20-Jun-12 | rake | rake/STS #11 | 10 |
| 26-Jun-12 | rake | Rake F1&2 | 6 |
| 4-Jul-12 | headgate | STS/Headgate | 4 |
| 10-Jul-12 | headgate | headgate | 8 |
| 11-Jul-12 | headgate | headgate | 8 |
| 12-Jul-12 | headgate | headgate/VBS's | 10 |
| 16-Jul-12 | headgate | headgate/VBS's | 6 |
| 17-Jul-12 | headgate | headgate | 4 |

| 2011 | | | |
|---|---|---|---|
| **Date** | **Key Word** | **Work Performed** | **Hours Operated** |
| 22-Mar-11 | headgate | headgate overhaul | 2 |
| 30-May-11 | headgate | Headgate | 4 |
| 31-May-11 | rake | Rake F1&2 | |
| 14-Jun-11 | fish unit | fish units | 2 |
| 15-Jun-11 | fish unit | STS - Fish Unit | 5 |
| 27-Jun-11 | headgate | unit #18 headgate swap | |
| 28-Jun-11 | headgate | headgate | 10 |
| 12-Oct-11 | headgate | Move Bulkhead and Headgate | 4 |
| 14-Oct-11 | headgate | Fish Unit Headgate | 2 |
| 17-Oct-11 | headgate | Headgate | 10 |

# APPENDIX J

# CALCULATIONS

*Project: Bonneville B2 AWS*
*Subject: Plate Drag Force*

Mathcad notes: This worksheet is formatted in U.S. units (BGS). To change units, go to options on the math menu and select the unit system tab.

**Problem:** Proposed trashrake modifications include a perforated plate that will be subjet to flow and occlusion. A drag force estimate is needed to determine if additional structural support is needed to prevent plate failure or distortion.

**Assumptions:**
-Perforated plate will be treated as fully occluded for calculations
-Drag force coefficent is 1.28 (flat plate perpendicular to flow)

**Variables:**

Drag force coefficent $\quad Cd := 1.28$

Plate Area $\quad Ap := 28.8 \cdot ft^2$

Density of working fluid $\quad \rho := 1.94 \cdot \frac{slug}{ft^3}$

Velocity of working fluid $\quad v := 0.33 \cdot \frac{ft}{sec}$

**Solution:**

Drag force applied to a flat plate in perpendicular flow

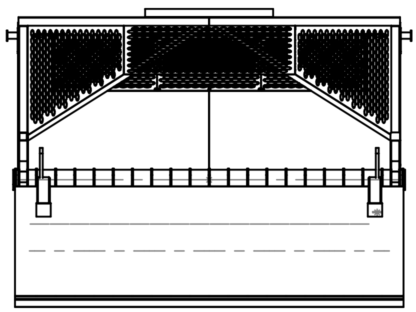
$$Df := Cd \cdot \rho \cdot Ap \cdot \left(\frac{v^2}{2}\right)$$

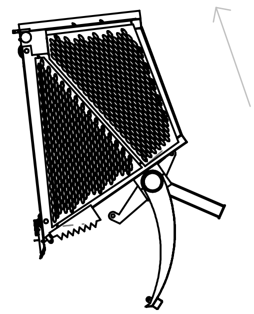
$$Df = 3.894\, lbf$$

**Conclusion:**

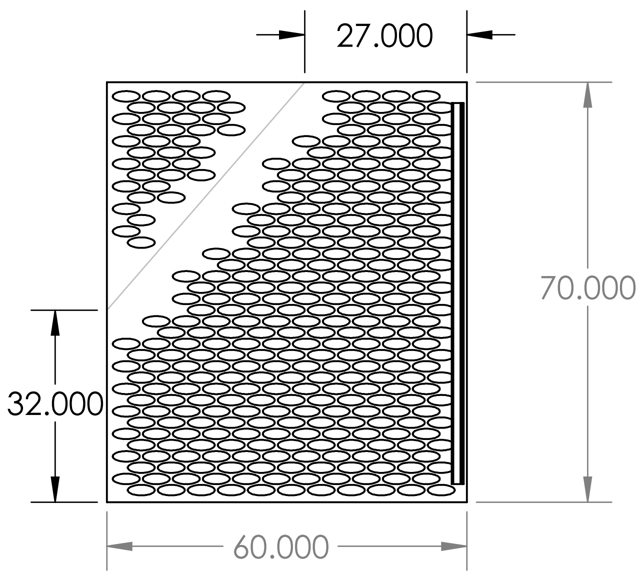
Force on the fully occluded plate is not significant.

FLOW DIRECTION
RATE 0.33FT/S





DIRECTION OF TRAVEL




OCCLUDED PLATE

OCCLUDED PLATE AREA=28.83 ft^2
55% POROCITY
CRANE LIFTING VELOCITY=20 ft/mins



NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:

SIZE A | DWG. NO. PLATE FORCE SKETCH | REV.

SCALE:1:96 | WEIGHT: | SHEET 1 OF 1

(2) Lower limit of travel not higher than Elevation...19

1.4.4 Main Trolley

a. Rated Trolley Travel Speed, Feet per Minute...........15

b. Trolley Travel, Feet.................................22

1.4.5 Auxiliary Hoist

a. Rated Capacity Upstream Auxiliary Hoist, Tons.........15

b. Rated Capacity Downstream Auxiliary Hoist, Tons.......15

c. Rated Hoisting Speed (Rated Load), Feet per Minute....20 0.33 ft/sec

d. Center of Load Block Pin travel, Feet.................140

(1) Upper limit of travel not lower than Elevation....126

(2) Lower limit of travel not higher than Elevation...-14

1.4.6 Auxiliary Trolley

a. Rated Trolley Travel Speed, Feet per Minute...........24

b. Trolley Travel, Feet.................................35.5

1.4.7 Monorail Hoist

a. Rated Capacity Monorail Hoist, Tons...................5

b. Rated Hoisting Speed (Rated Load), Feet per Minute....8

c. Center of Load Block Pin travel, Feet.................86

(1) Upper limit of travel not lower than Elevation....122

(2) Lower limit of travel not higher than Elevation...36

1.5 QUALIFICATIONS

Data showing that crane inspectors, craftsmen, crane electricians, and crane operators meet the following qualifications shall be submitted for approval:

1.5.1 Qualified Crane Inspectors

Crane inspectors shall possess the following:

a. Have experience and knowledge in performing inspection on gantry cranes of similar size and capacity as the Bonneville Powerhouse 2 intake gantry crane.

b. Certifications showing they have attended crane inspection training seminars provided by established training institutions such as Morris Material Institute (866-821-4006) and CraneTech (800-290-0007). Certifications issued by the Contractor do not meet this requirement.

U.S. ARMY CORPS OF ENGINEERS OFFICE SYMBOL:

| PROJECT: B2 TRASH RAKE | COMPUTED BY: Reimer | DATE: 1/23/14 |
|---|---|---|
| SUBJECT: Lifting Load Check | CHECKED BY: | SHT. OF |
| | | PART: |

Assuming max lifting load is crane capacity. (15 ton = 30,000 lbs)

Lifting connection is comprised of:

4 plates - 4" long, 1" thick with a ½ fillet on one side of each plate

Determine stress on weld:

Weld area: 0.707(.5")(4") × 4 plates

Weld area = 5.66 in²

LOAD ON WELD = 30 kips

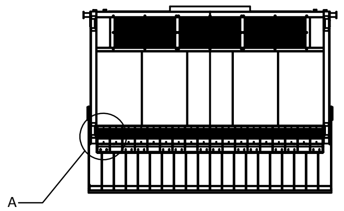
Stress on weld = $\frac{P}{A} = \frac{30 \text{ kips}}{5.66 \text{ in}^2}$ = 5.3 ksi

WHAT IS THE CAPACITY OF THE WELD? (Assume 60 ksi weld)

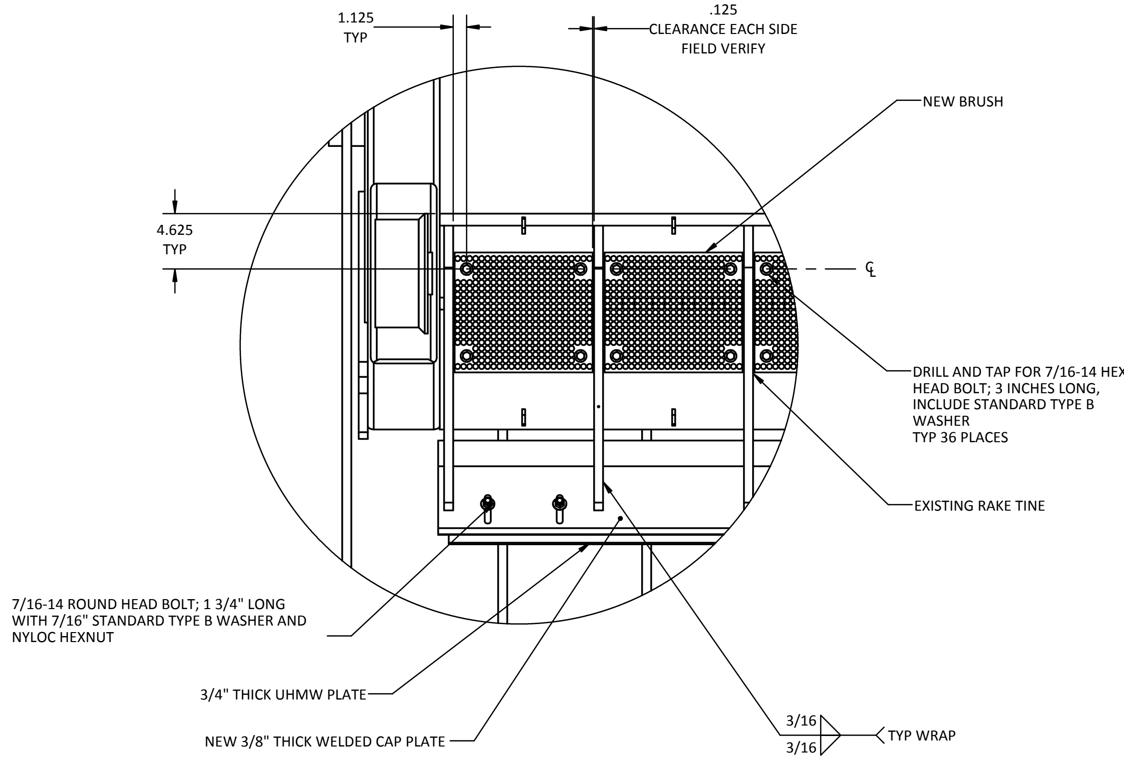
0.3(60 ksi)(.707)(0.5")(4")(4)

$P_u$ = 101.8 k

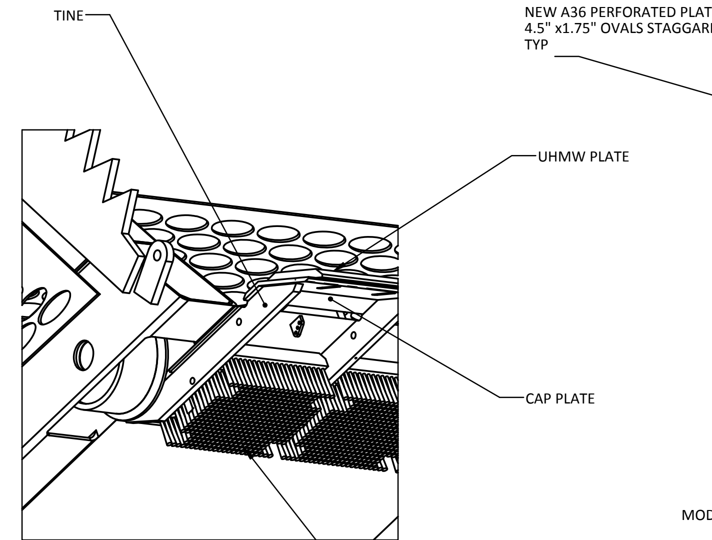
$\frac{101.8 \text{ k}}{30 \text{ k}}$ = **3.4 FS** ✓ OK



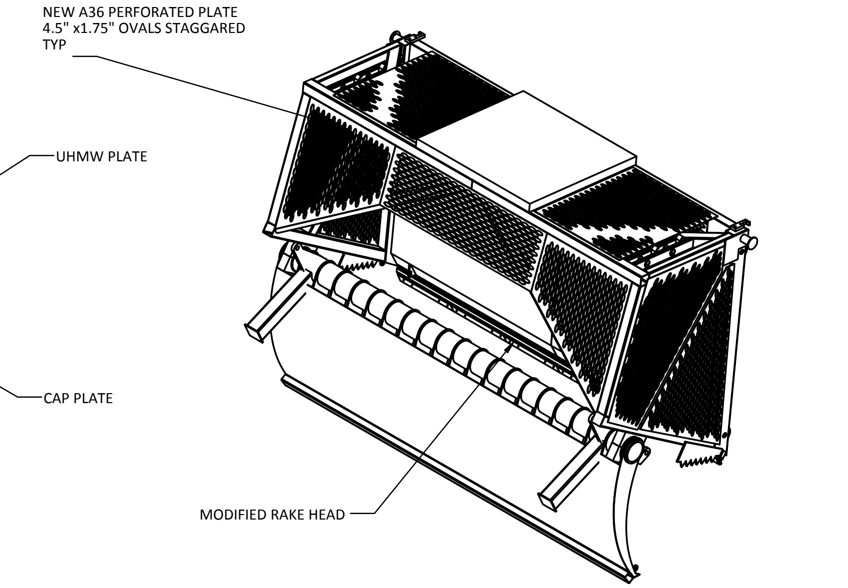

EXISTING RAKE
SCALE 1:96



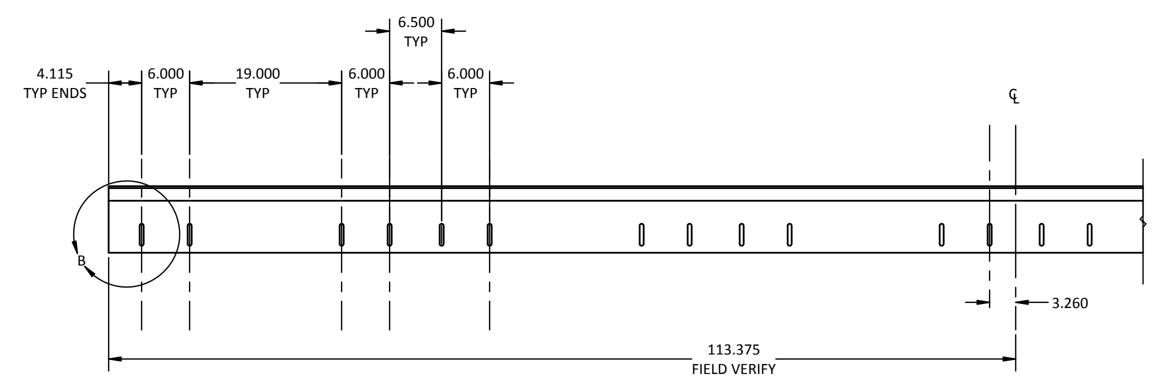

DETAIL A
SCALE 1 : 8



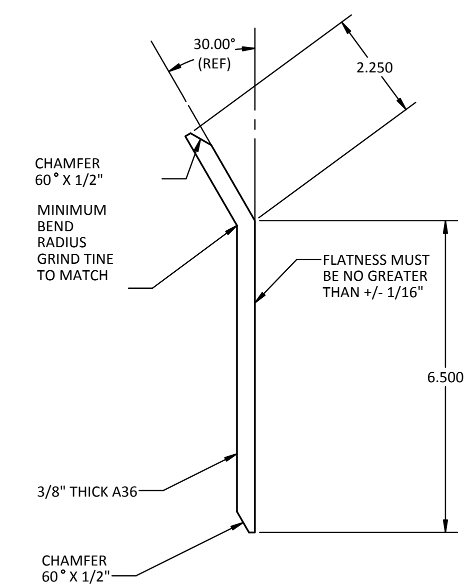

EXISTING RAKE
BOTTOM ISO VIEW
SCALE 1:12



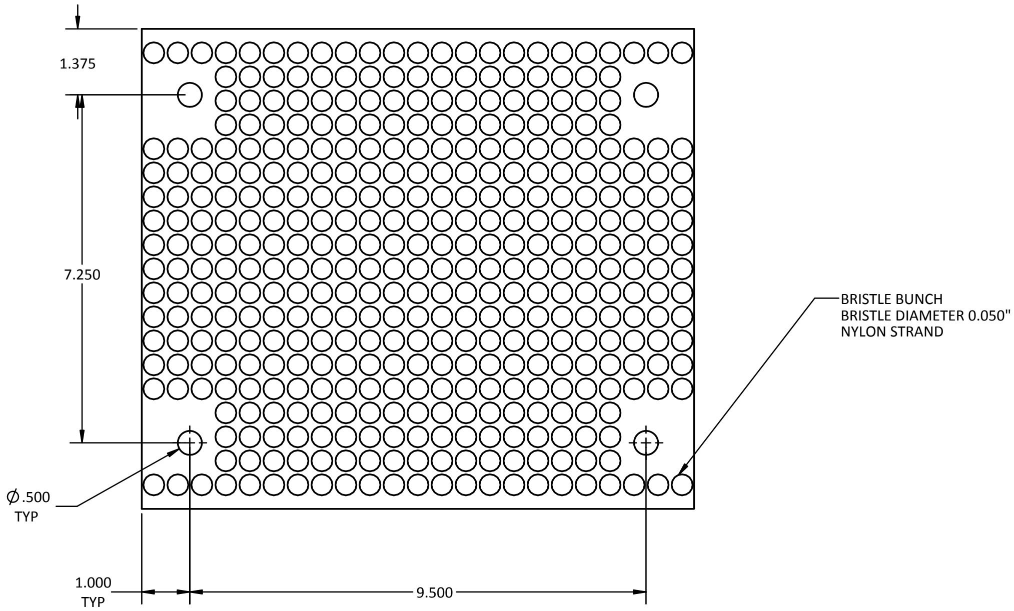

EXISTING RAKE
SCALE 1:48

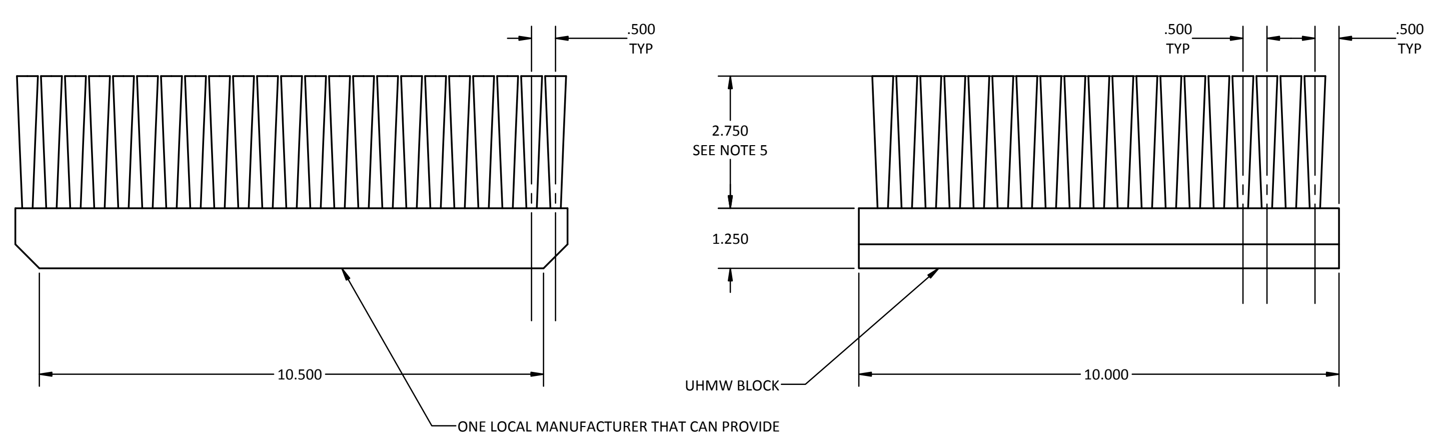



CAP PLATE
SCALE 1:12
QTY: 1

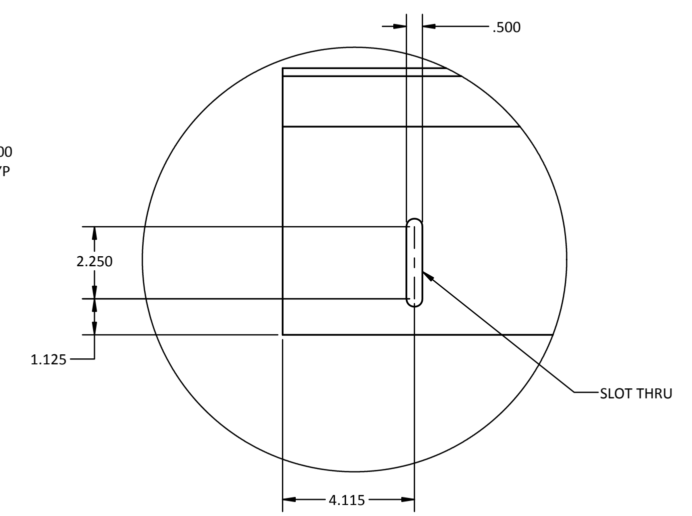



SCALE 1:2




NEW BRUSH
SCALE 1:2
SEE NOTE 6
QTY: 18




DETAIL B
SCALE 1 : 3

NOTES:

1. FASTENERS SHALL BE 300 SERIES STAINLESS STEEL; INSTALLED USING ANTI-GALLING COMPOUND.
2. EXISTING RAKE DIMENSIONS MAY VARY; FIELD VERIFY DIMENSIONS TO ENSURE PROPER FIT.
3. PAINT CARBON STEEL USING VINYL PAINT SYSTEM 5-A-Z
4. FABRICATION TOLERANCE IS +/- 0.125"
5. PRIOR TO ORDERING BRUSHES; USE DISTANCE RODS TO DETERIMINE RACK TO RACK CLEARANCE. ORDER BRUSH LENGTH TO ENGAGE RACK BY 1".
6. PROVIDE TWO SPARE BRUSHES
7. SUBMIT FOR APPROVAL WELD PROCEEDURE AND WIRE TYPE
8. WELDING SHALL BE PERFORMED PER AWS D1.1

US Army Corps of Engineers
Portland District

REV. | DATE: | DESCRIPTION: | BY:

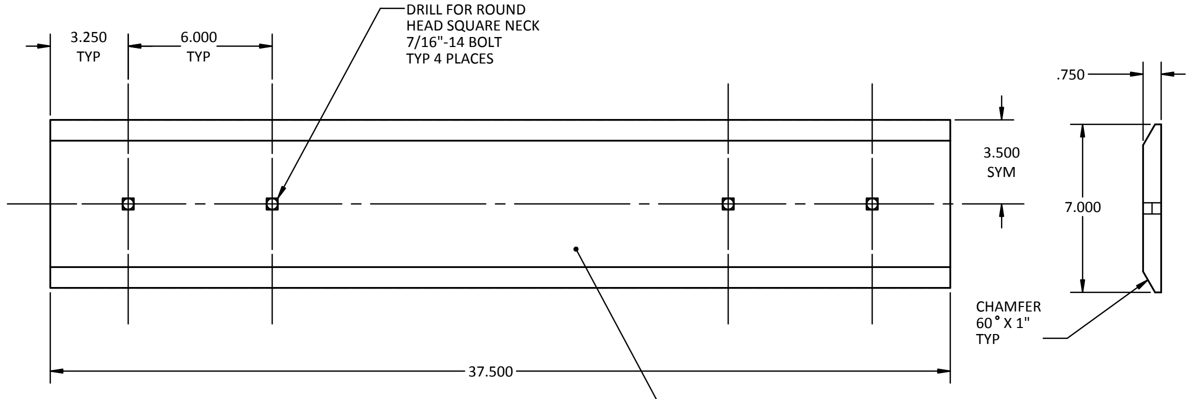
DATE: 25FEB14
CADD FILE NAME:
DESIGNED BY: BEN FILAN
DRAWN BY: BEN FILAN
CHECKED BY:
SUBMITTED BY:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OR

MECHANICAL
DESIGN SECTION

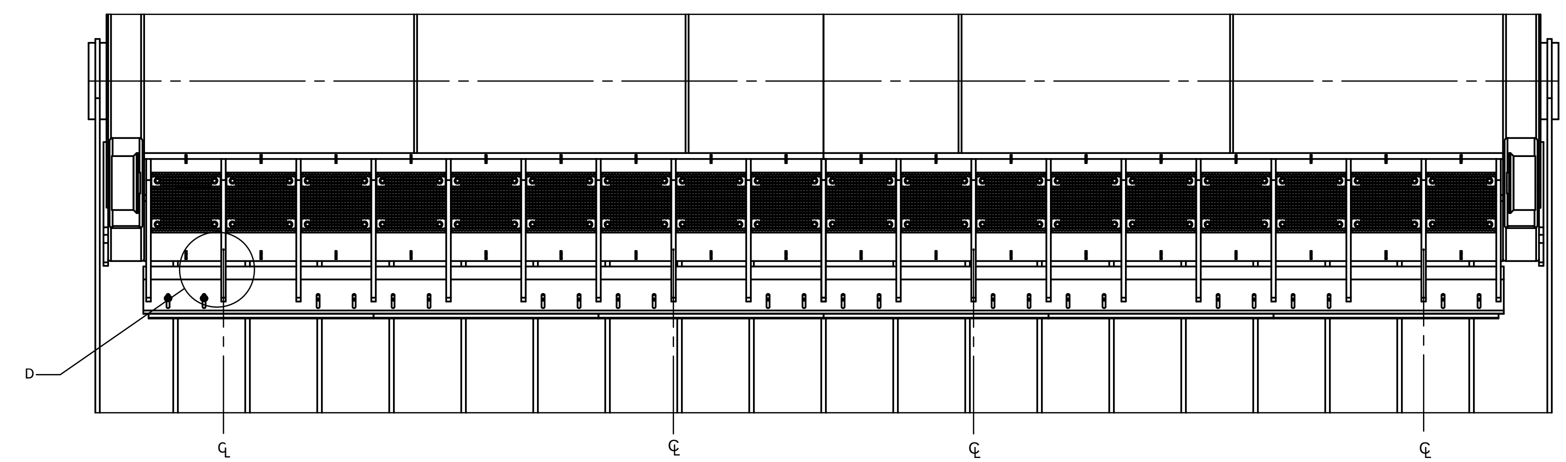
OREGON - WASHINGTON
COLUMBIA RIVER
BONNEVILLE DAM SECOND POWERHOUSE
AUXILIARY WATER SUPPLY TRASHRAKE
MECHANICAL
EXISTING TRASHRAKE
MODIFICATIONS

DRAWING NO.
PLATE
1



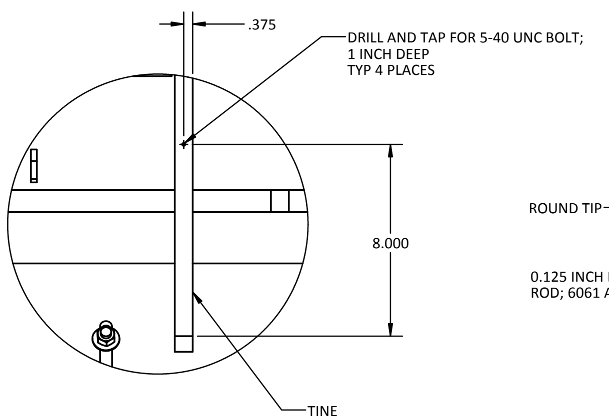

UHMW PLATE

SCALE 1:4



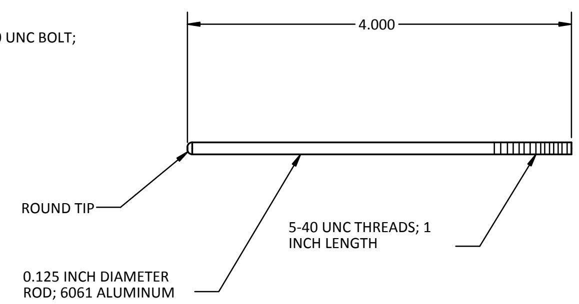

RAKE BOTTOM

SCALE 1:16



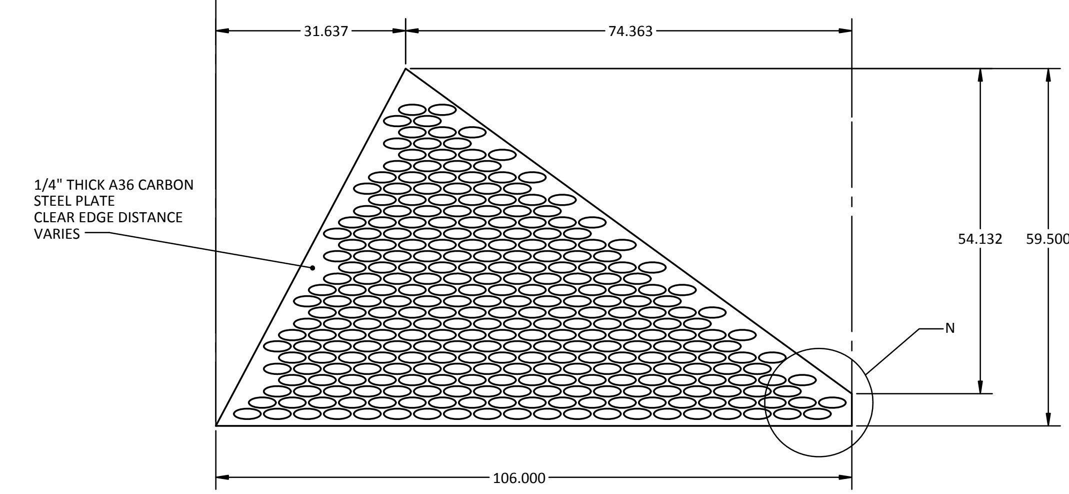

DETAIL D

SCALE 1:4



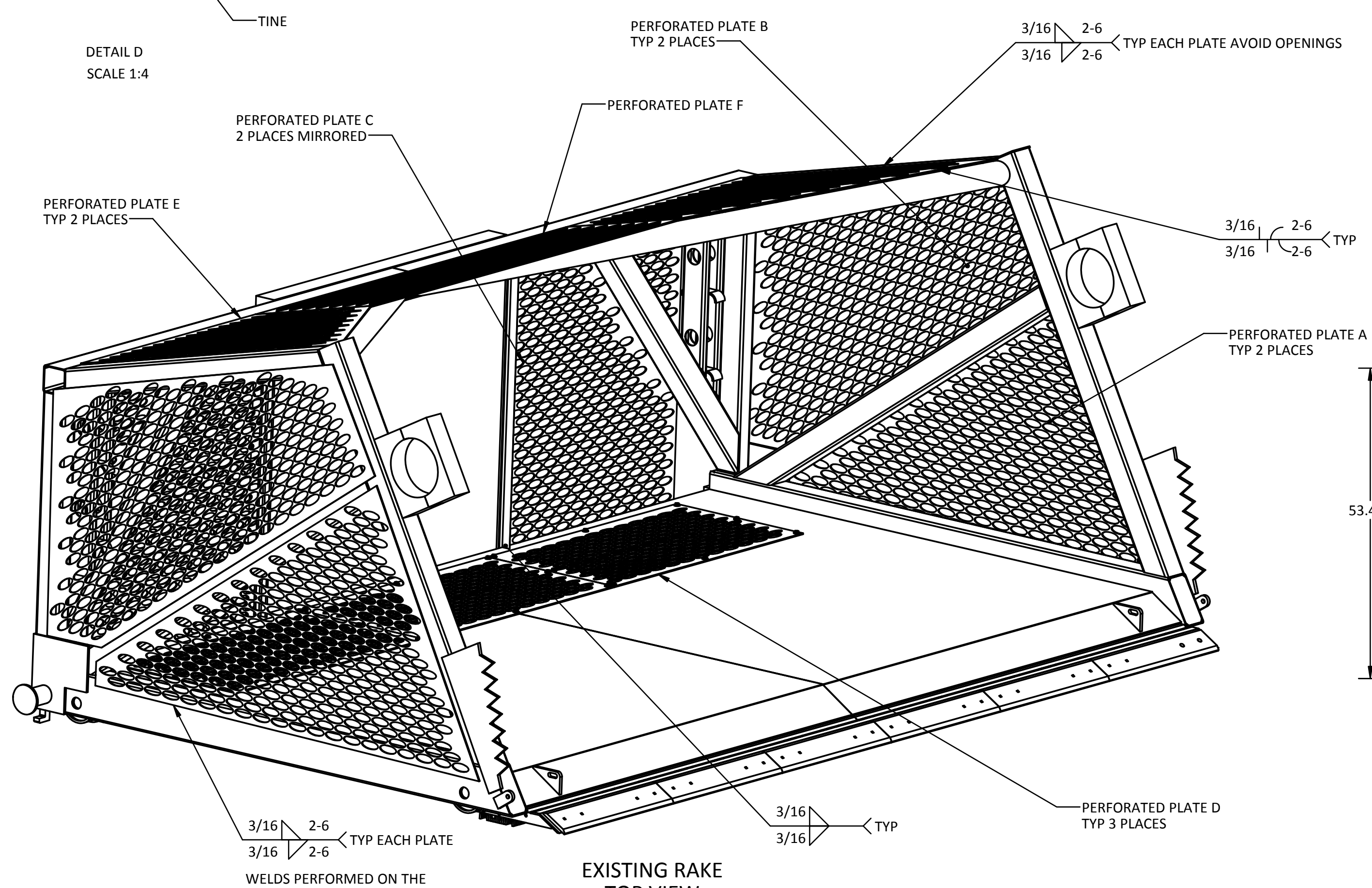

DISTANCE ROD

SCALE 1:1



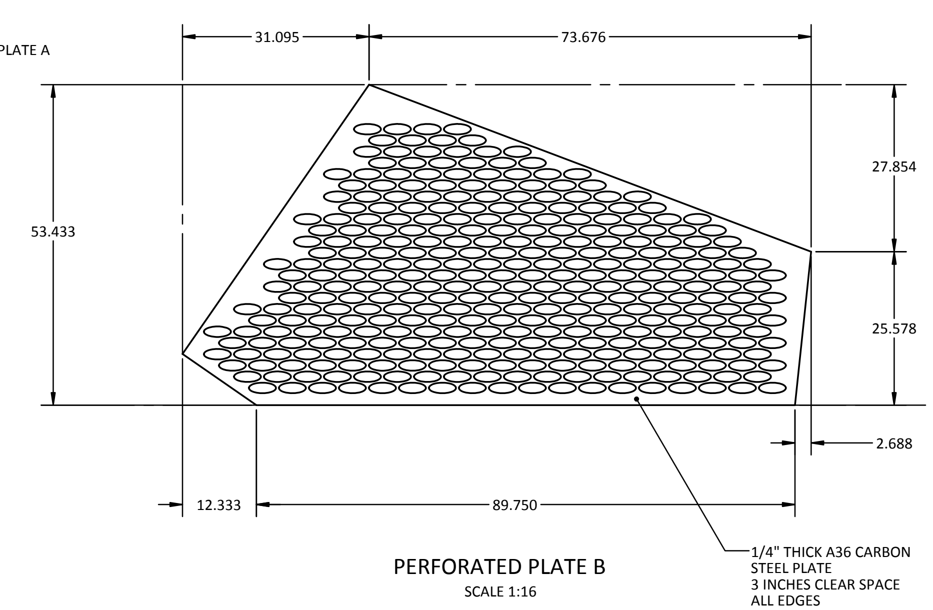

PERFORATED PLATE A

SCALE 1:16



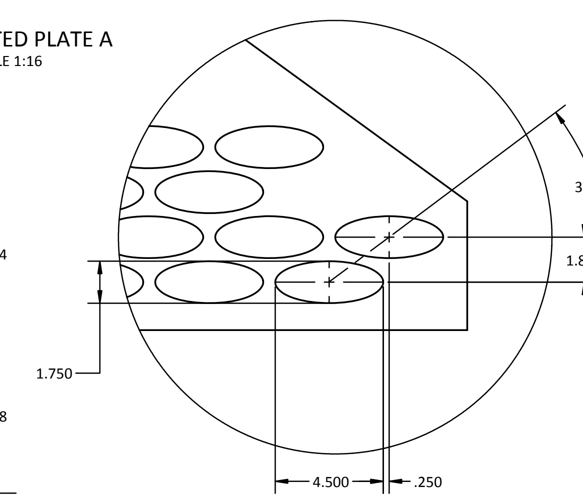

EXISTING RAKE TOP VIEW

SCALE 1:20




PERFORATED PLATE B

SCALE 1:16




DETAIL N

TYPICAL PERFORATION PATTERN

NOTES:

1. FASTENERS SHALL BE 300 SERIES STAINLESS STEEL; INSTALLED USING ANTI-GALLING COMPOUND.
2. EXISTING RAKE DIMENSIONS VARY; FIELD VERIFY DIMENSIONS TO ENSURE PROPER FIT.
3. PAINT CARBON STEEL USING VINYL PAINT SYSTEM 5-A-Z
4. FABRICATION TOLERANCE IS +/- 0.125"
5. WELDING PERFORMED PER AWS D1.1
6. SUBMIT FOR APPROVAL WELD PROCEEDURE AND WIRE TYPE

US Army Corps of Engineers
Portland District

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DRAWN BY: BEN FILAN

CHECKED BY:

SUBMITTED BY:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
PORTLAND, OR

MECHANICAL DESIGN SECTION

COLUMBIA RIVER — OREGON - WASHINGTON
BONNEVILLE DAM SECOND POWERHOUSE
AUXILIARY WATER SUPPLY TRASHRAKE
MECHANICAL

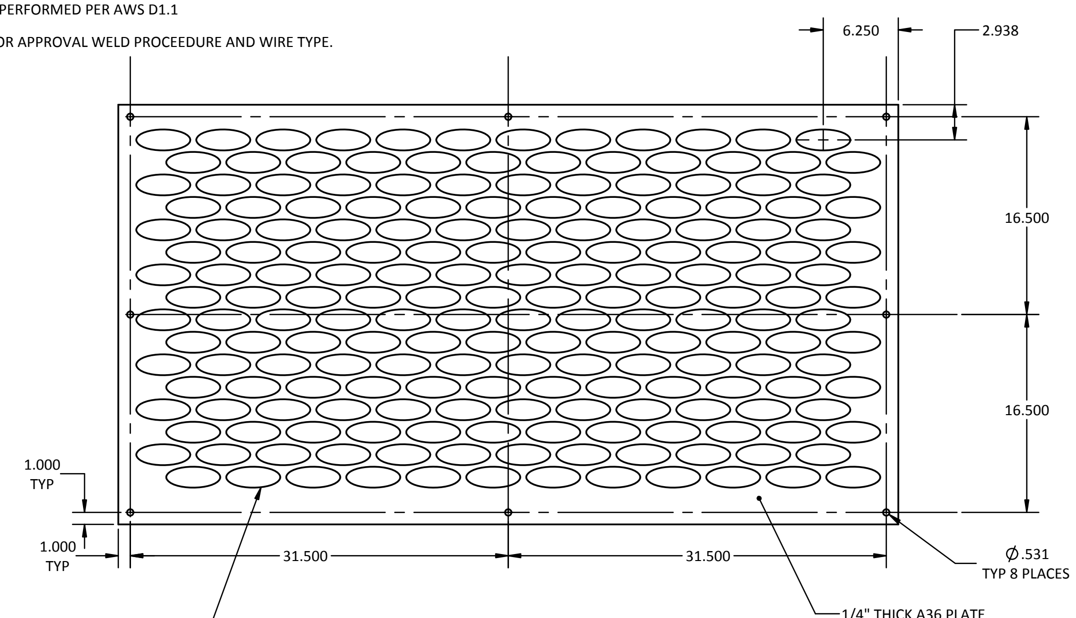
EXISTING TRASHRAKE MODIFICATIONS

DRAWING NO.

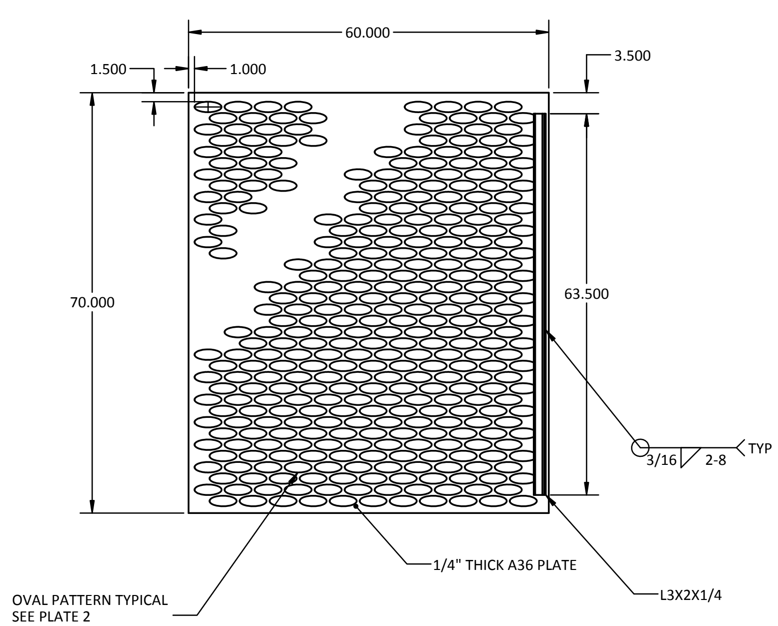
PLATE 2

GENERAL
INSTALLATION NOTES:

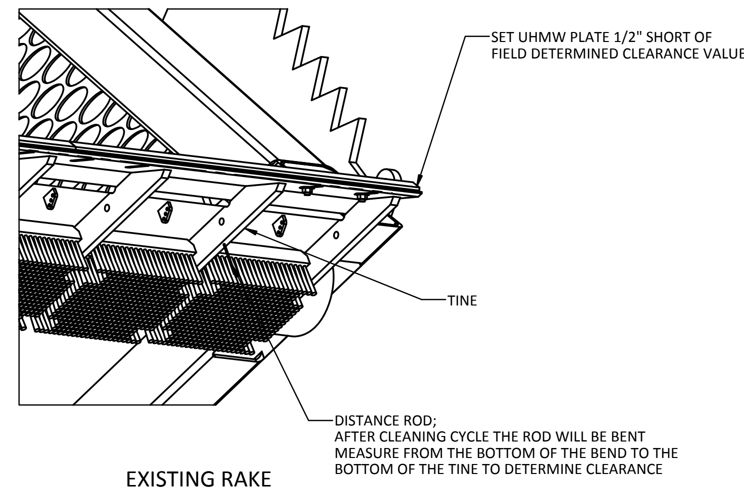
1. FASTENERS SHALL BE 300 SERIES STAINLESS STEEL; INSTALLED USING ANTI-GALLING COMPOUND.
2. EXISTING RAKE DIMENSIONS VARY; FIELD VERIFY DIMENSIONS TO ENSURE PROPER FIT.
3. PAINT CARBON STEEL USING VINYL PAINT SYSTEM 5-A-Z
4. FABRICATION TOLERANCE IS +/- 0.125"
5. INSTALL DISTANCE RODS PRIOR TO PERFORMING ANY OTHER WORK; CYCLE THE RAKE TO FIELD VERIFY THE RAKE TO RACK CLEARANCE. BRUSH BRISSLE LENGTH AND UHMW PLATE INSTALLATION POSITION DEPEND ON THIS MEASUREMENT.
6. WELDING PERFORMED PER AWS D1.1
7. SUBMIT FOR APPROVAL WELD PROCEEDURE AND WIRE TYPE.



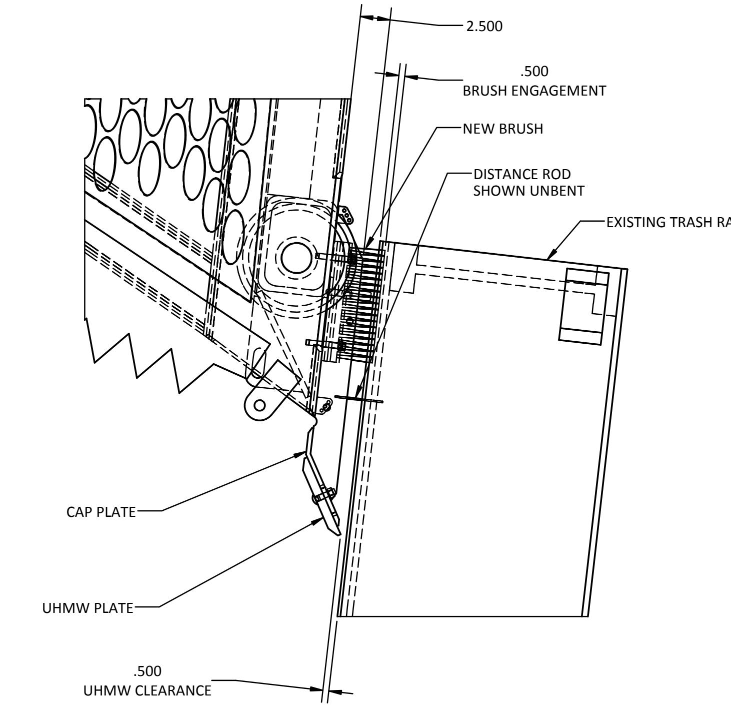

PERFORATED PLATE D
SCALE 1:8
QTY. 3 PCS



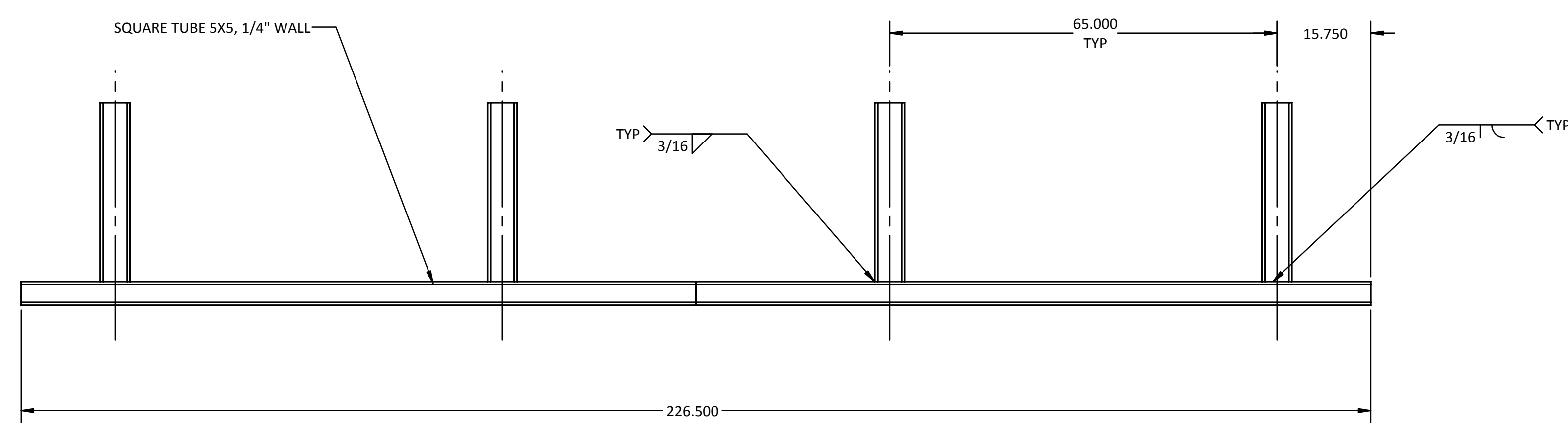

PERFORATED PLATE C
SCALE 1:8
QTY. 2 PCS
SECOND PLATE IS MIRRORED ACROSS RAKE CENTERLINE



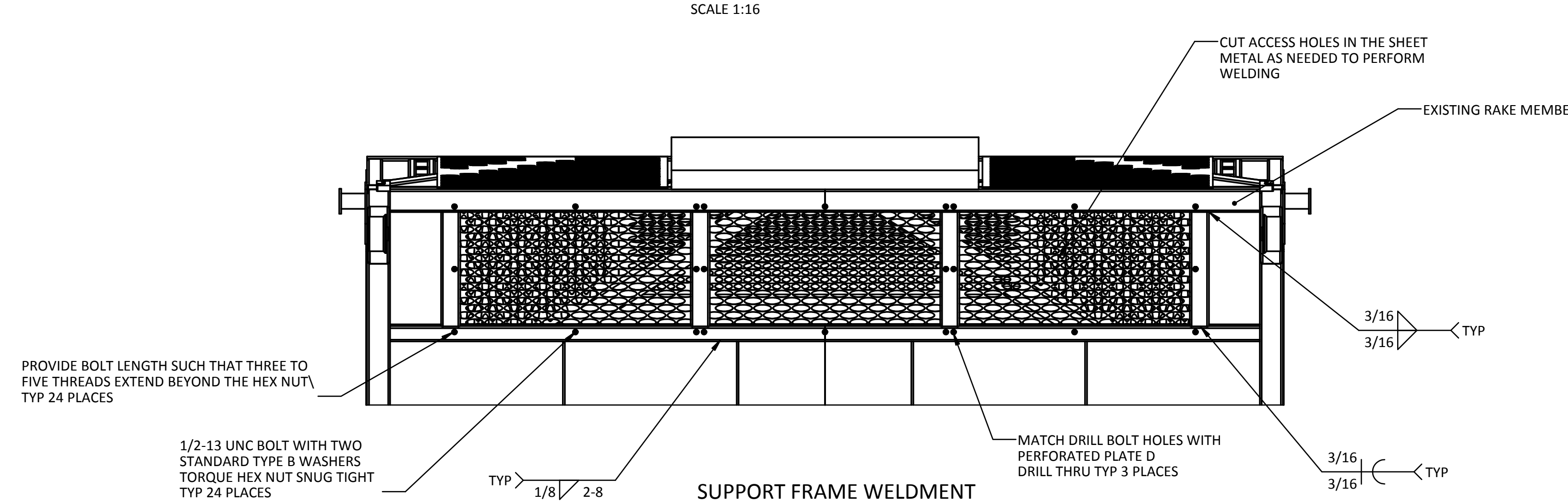

EXISTING RAKE
BOTTOM ISO VIEW
SCALE 1:12




EXISTING RAKE AND INTAKE RACK
SIDE VIEW
SCALE 1:8




PERFORATED PLATE D SUPPORT FRAME
PLAN VIEW
SCALE 1:16




SUPPORT FRAME WELDMENT
SCALE 1:24

US Army Corps
of Engineers
Portland District

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MECHANICAL
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OREGON - WASHINGTON
BONNEVILLE DAM SECOND POWERHOUSE
AUXILIARY WATER SUPPLY TRASHRAKE
MECHANICAL
EXISTING TRASHRAKE
MODIFICATIONS

DRAWING NO.
PLATE
3

GENERAL
INSTALLATION NOTES:

1. FASTENERS SHALL BE 300 SERIES STAINLESS STEEL; INSTALLED USING ANTI-GALLING COMPOUND.

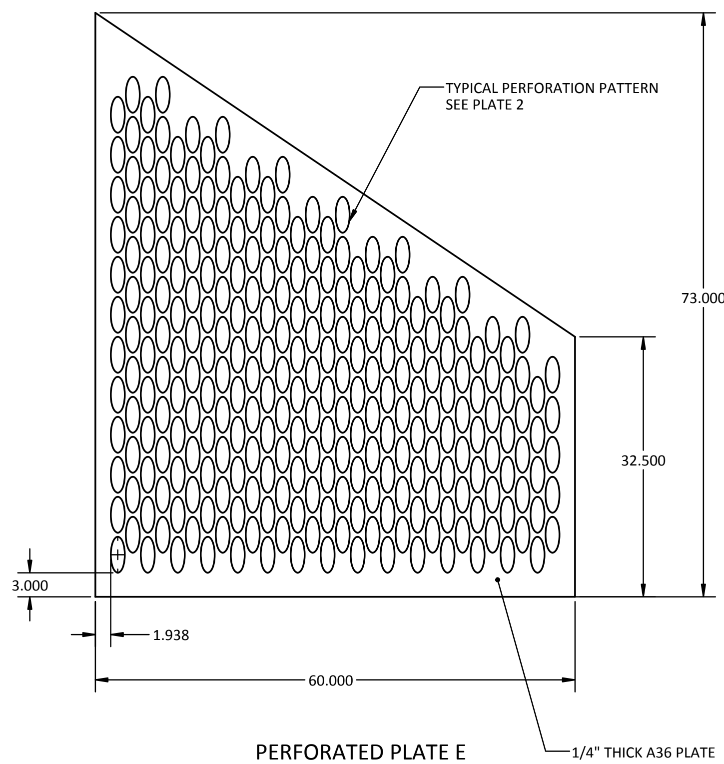
2. EXISTING RAKE DIMENSIONS VARY; FIELD VERIFY DIMENSIONS TO ENSURE PROPER FIT.

3. PAINT CARBON STEEL USING VINYL PAINT SYSTEM 5-A-Z

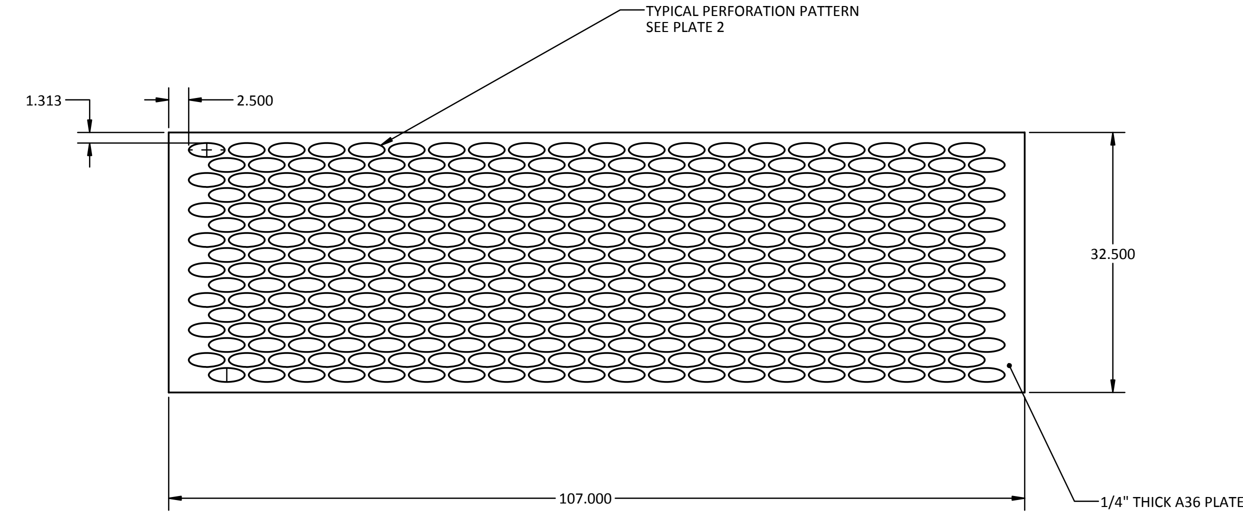
4. FABRICATION TOLERANCE IS +/- 0.125"

5. INSTALL DISTANCE RODS PRIOR TO PERFORMING ANY OTHER WORK; CYCLE THE RAKE TO FIELD VERIFY THE RAKE TO RACK CLEARANCE. BRUSH BRISSLE LENGTH AND UHMW PLATE INSTALLATION POSITION DEPEND ON THIS MEASUREMENT.

6. EXISTING RAKE COATING SYSTEM MAY CONTAIN LEAD; TEST AND ABATE AS NEEDED




PERFORATED PLATE E
SCALE 1:12




PERFORATED PLATE F
SCALE 1:12

US Army Corps of Engineers
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COLUMBIA RIVER
OREGON - WASHINGTON
BONNEVILLE DAM SECOND POWERHOUSE
AUXILIARY WATER SUPPLY TRASHRAKE
MECHANICAL
EXISTING TRASHRAKE
MODIFICATIONS

DRAWING NO.

PLATE
4