US Army Corps of Engineers®
Portland District

Engineering Documentation Report

Bonneville Second Powerhouse Orifice Improvements Study

Columbia River, Oregon-Washington

March 2012

90% Review

EXECUTIVE SUMMARY

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PROJECT DESCRIPTION

Stream	Columbia River (river mile 146.1)
Location	Bonneville, Oregon
Owner	U.S. Army Corps of Engineers
Project Authorization	Rivers and Harbors Act of 1935
Authorized Purposes	Power, Navigation
Other Uses	Fisheries, Recreation

LAKE/RIVER ELEVATIONS (elevation above sea level in feet)

Maximum Controlled Flood Pool	90.0
Maximum Spillway Design Operating Pool	82.5
Maximum Regulated Pool	77.0
Minimum Pool	69.5
Normal Operating Range	71.5 - 76.5
Maximum 24-Hour Fluctuation at Stevenson Gage	4.0
Maximum Flood Tailwater (spillway design flood)	51.5
Maximum Operating Tailwater	33.1
Standard Project Flood Tailwater	48.9
Minimum Tailwater	7.0
Base (100-year) Flood El. (at project site tailwater)	39.8

POWERHOUSES

First Powerhouse (Oregon)	
Length	1,027 feet
Number of Main Units	10
Nameplate Capacity [2 @ 43 megawatts (MW), 8 @ 54 MW]	518 MW
Overload Capacity (2 @ 47 MW, 8 @ 60 MW)	574 MW
Station Service Units (1 @ 4 MW)	4 MW
Hydraulic Capacity	136,000 cfs

Second Powerhouse (Washington)	
Length (including service bay & erection bay)	985.5 feet
Number of Main Units	8
Nameplate Capacity (8 @ 66.5 MW)	532 MW
Overload Capacity (8 @ 76.5 MW)	612 MW
Fish Water Units (2 @ 13.1 MW)	26.2 MW
Hydraulic Capacity	152,000 cfs

SPILLWAY

Capacity at Pool Elevation (El. 87.5)	1,600,000 cfs

FISH PASSAGE FACILITIES

Fish Ladders
Washington Shore
Cascades Island
Bradford Island
Juvenile Bypass System – First Powerhouse
Downstream Migrant System – Second Powerhouse
Upstream Migrant System

ACRONYMS AND ABBREVIATIONS

cfm	cubic feet (foot) per minute
cfs	cubic feet (foot) per second
DSM	downstream migrant
EDR	Engineering Documentation Report
El.	elevation
ERC	emergency relief conduit
FFDRWG	Fish Facilities Design and Review Work Group
FGE	fish guidance efficiency
fps	feet (foot) per second
ft.	feet (foot)
ft-c	foot-candle(s)
HDC	Hydraulic Design Center
HDC	Corps of Engineers Hydraulic Design Criteria
HMI	human-machine interface
I.D.	inside diameter
LED	light-emitting diode
NMFS	National Marine Fisheries Service
O.D.	outside diameter
O&M	operation and maintenance
PDT	Product Development Team
PIT	Passive Integrated Transponder
PLC	programmable logic controller
PNNL	Pacific Northwest National Laboratory
psi	pounds per square inch
RM	river mile(s)
STS	submersible traveling screen
USACE	U.S. Army Corps of Engineers
VBS	vertical barrier screen

1. INTRODUCTION

1.1. PURPOSE AND SCOPE

The purpose of this Engineering Documentation Report (EDR) is to document engineering investigations and evaluations to provide a recommended design to improve Bonneville second powerhouse juvenile fish passage from the powerhouse bulkhead slot orifice entrance to the downstream channel entering the dewatering system. Goals are focused on improvements to the collection system that will reduce injury and delay to migrating fish species to include:

- Improve the ability for the project operators to detect debris plugs in the orifice;
- Reduce the likelihood of fish impingement due to alignment of orifice flow, and
- Improve gatewell egress times with improved lighting.

The scope of this EDR is to identify and recommend modifications to pertinent downstream migrant (DSM) system features, such as the bulkhead slot orifice plates, horizontal pipe through the bulkhead slot wall, light tubes, and downstream gate system to provide biologically acceptable passage to the DSM channel as part of the overall DSM system. Additional biological improvements are concurrently being studied for the Fish Guidance Efficiency (FGE) features, located upstream of the scope of this project.

1.2. PROJECT AUTHORIZATION

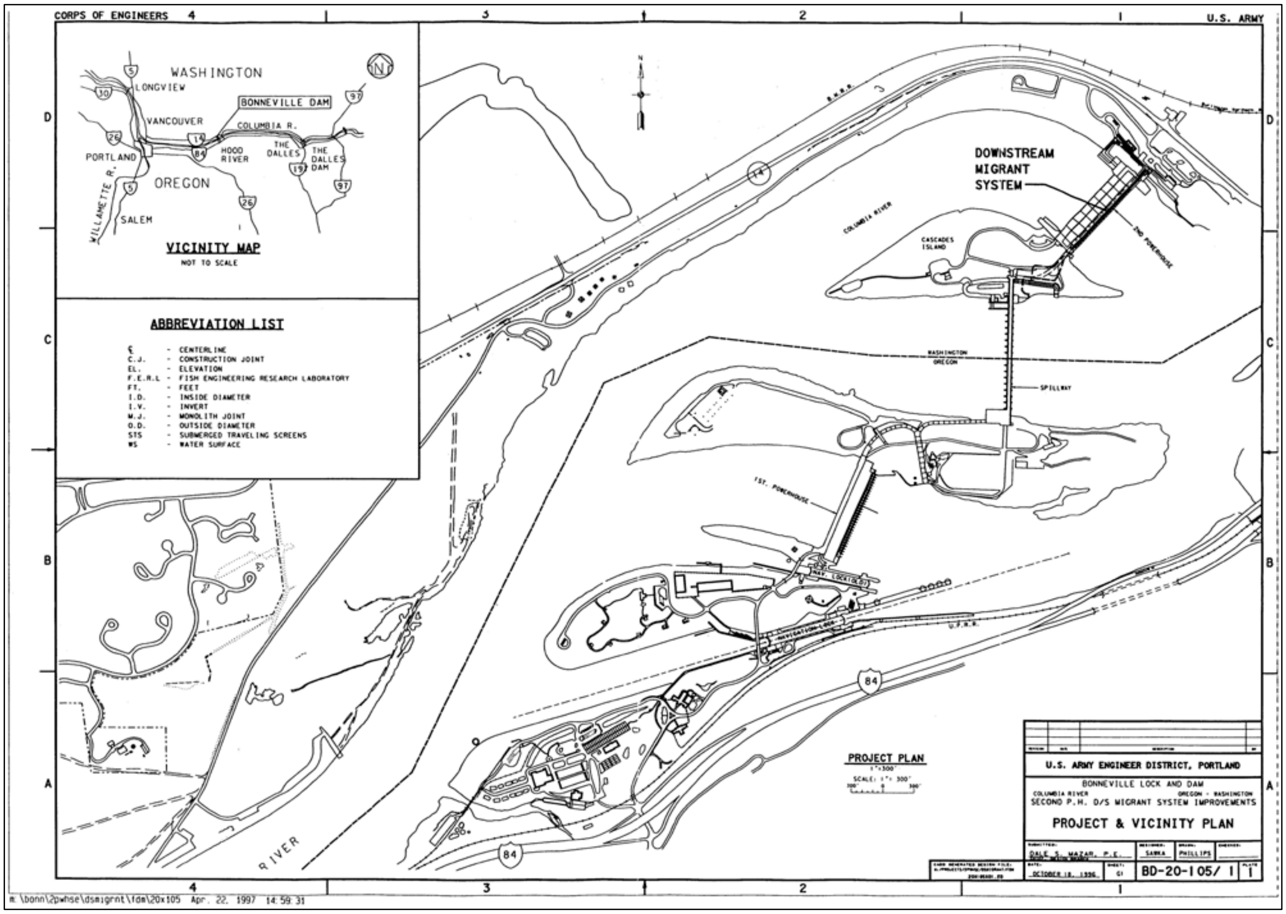
The Bonneville Project began with the National Recovery Act, 30 September 1933 and was formally authorized by Congress in the River and Harbor Act of 30 August 1935. Authority for the completion, maintenance, and operations of Bonneville Dam was provided in Public Law 329, 75th Congress, 20 August 1937. This act provided the authority for the construction of additional hydroelectric generation facilities (Bonneville second powerhouse) when requested by the Administrator of Bonneville Power Administration. Letters dated 21 January 1965 and 2 February 1965 from the Administrator developed the need for the construction of Bonneville second powerhouse. Construction started on the second powerhouse in 1974 with units 11 through 18 and two fishway units, and was completed in 1982.

The Energy and Water Development Appropriation Bill, 1995, directs the U.S. Army Corps of Engineers (USACE) to use additional appropriations to aggressively improve effectiveness and efficiency of the bypass systems, reduce predator mortality, and enhance passage conditions.

1.3. PROJECT LOCATION

The Bonneville Project is located on the Columbia River approximately 42 miles east of Portland, Oregon at river mile (RM) 146. The Bonneville second powerhouse is located between Cascades Island and the river’s north shore in the State of Washington (Figure 1-1).

Figure 1-1. Bonneville Project and Vicinity



2. DESCRIPTION OF PROJECT FEATURES

The components being studied are contained within the existing DSM system. The main features of the DSM system are the bulkhead slot orifices, the DSM collection channel, the dewatering facility, the discharge well and conduit, the emergency relief conduit, and the DSM sampler and sorter. Provided below is a discussion of pertinent project features as designed in 1982 (Figure 2-1), as well as pertinent modifications to date.

2.1. ORIGINAL PROJECT FEATURES

2.1.1. Bulkhead Slot Orifices

The original facility (1983) had 28 operating and 28 blind flanged (sealed) orifices at centerline elevation (El.) 65.5 feet. There are 18 turbine units each with three bulkhead slots. In addition, there are two fish units each with two bulkhead slots. There are two orifices in each bulkhead slot, originally with one operating (north side) and one blind flanged (south side). Light wells are present at each orifice (Figures 2-2 and 2-3). Each orifice originally had a 12-inch diameter replaceable orifice plate bolted into a 16-inch outside diameter (O.D.) and 15 inch inside diameter (I.D.) steel pipe extending through the bulkhead slot wall. The orifices provide a free discharging jet into the downstream collection channel. The observed quality of the jet from the downstream end was used to determine potentially harmful obstructions at the orifice entrance. The head, and therefore, flow from the orifice is dependent on the elevation of the forebay, head across the trashracks, debris accumulation, and orifice blockages. The originally designed 12-inch orifice plate velocity ranged from 11.3 feet per second (fps) to 16 fps (forebay El. 71.5 and 76.5 feet, respectively). The orifice flow rate was 8.9 cubic feet per second (cfs) to 12.6 cfs (forebay El. 71.5 and 76.5 feet, respectively). The orifices are illuminated for fish attraction purposes. Each operating orifice has a pneumatically operated gate and pneumatically operated back flush system that cycles automatically and can be manually operated to remove debris (Figure 2-4).

The DSM collection channel extends from the service bay (downstream end), through generator bays 11 to 18, and into the erection bay and evaluator monoliths (upstream end). The original channel was a 9-foot-wide rectangular channel that was sized to accommodate inflows from fifty-six 12-inch orifices, totaling 500 cfs to 700 cfs (forebay El. 71.5 and 76.5 feet, respectively). The flow in the channel increases in the downstream direction, as each orifice discharges into the channel. Originally operation was limited to 28 orifices, providing 250 cfs to 350 cfs (forebay elevation 71.5 and 76.5 feet, respectively). The operation was limited to comply with the revised allowable velocity of 0.4 fps through the dewatering screens. The channel velocity increased from 0.1 fps in unit 11 to 2.1 fps in the erection bay at a forebay El. 71.5 feet. The channel velocity increased from 0.2 fps in unit 11 to 3.0 fps in the erection bay at a forebay El. 76.5 feet. The channel invert sloped at a steady grade from El. 51.0 feet at the downstream end of the fishway units to El. 57.0 feet in unit 12 (station 11+99.81). The channel was flat in the remainder of units 12 and 11. The water depth at the downstream end was 13.2 feet. A steel grated walkway running the full length and width of the collection channel allows for orifice inspection and maintenance.

Figure 2-1. Original DSM System Design Sectional Plan

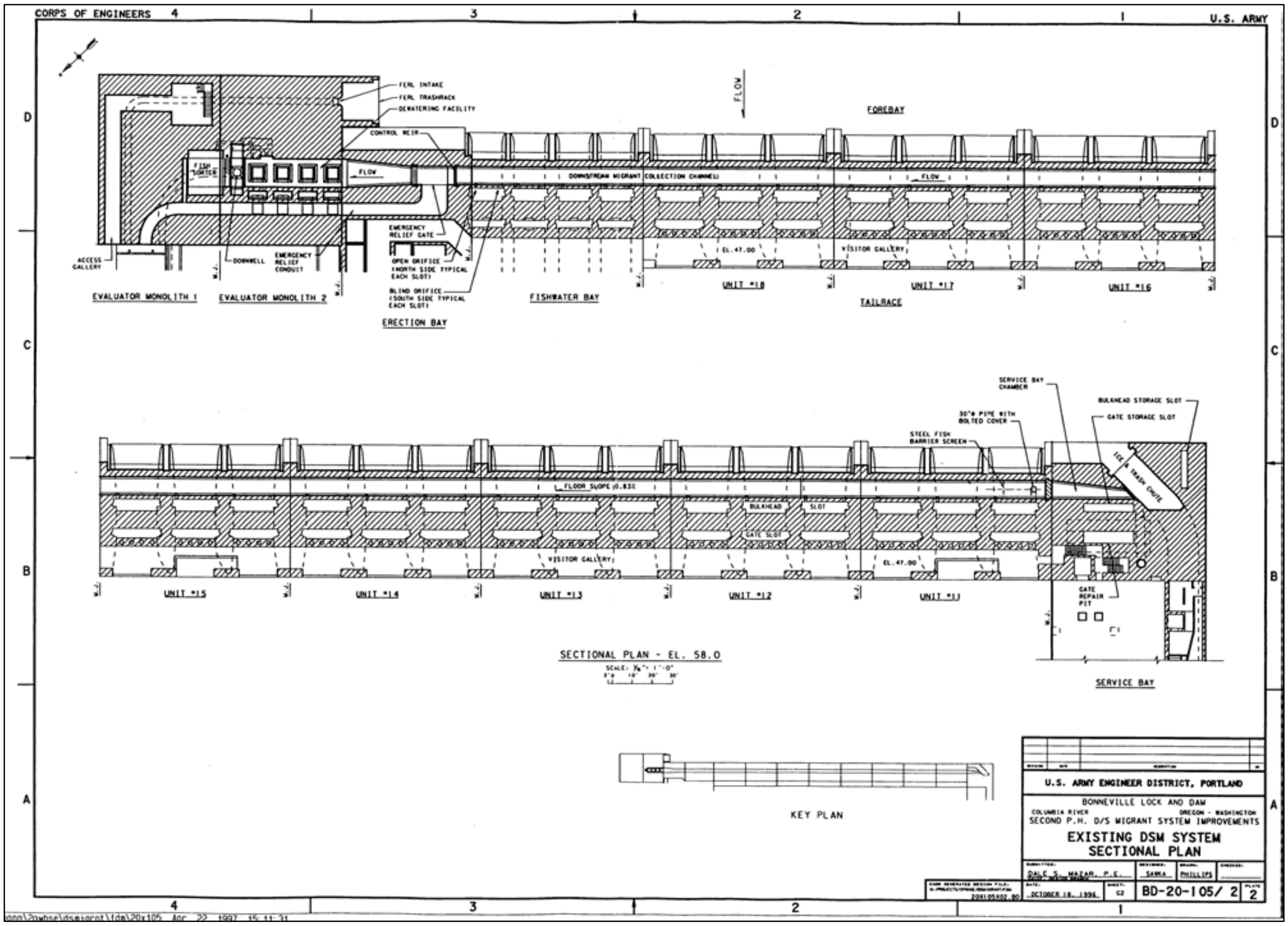


Figure 2-2. Light Well Section View

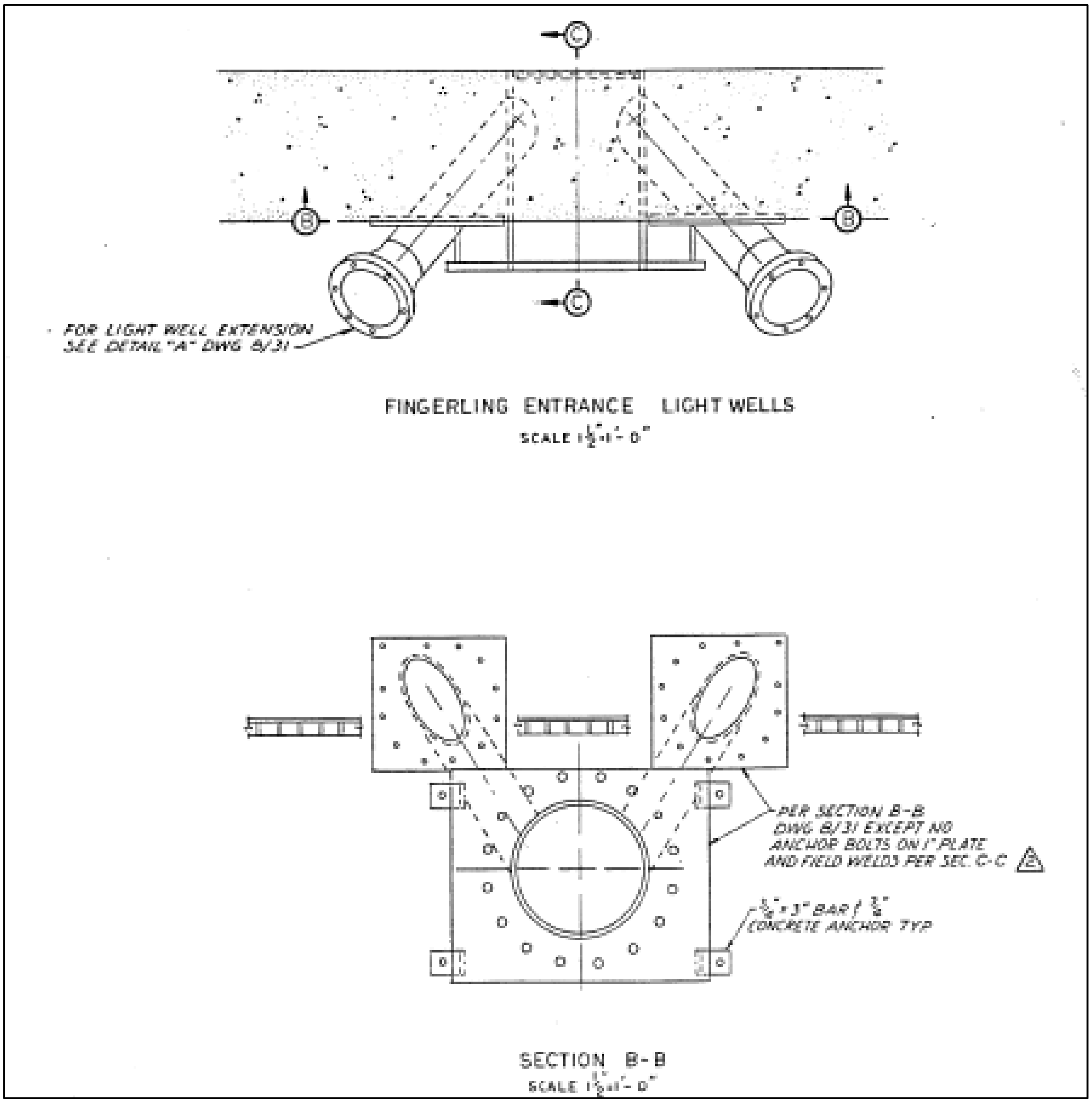


Figure 2-3. Light Well Section View

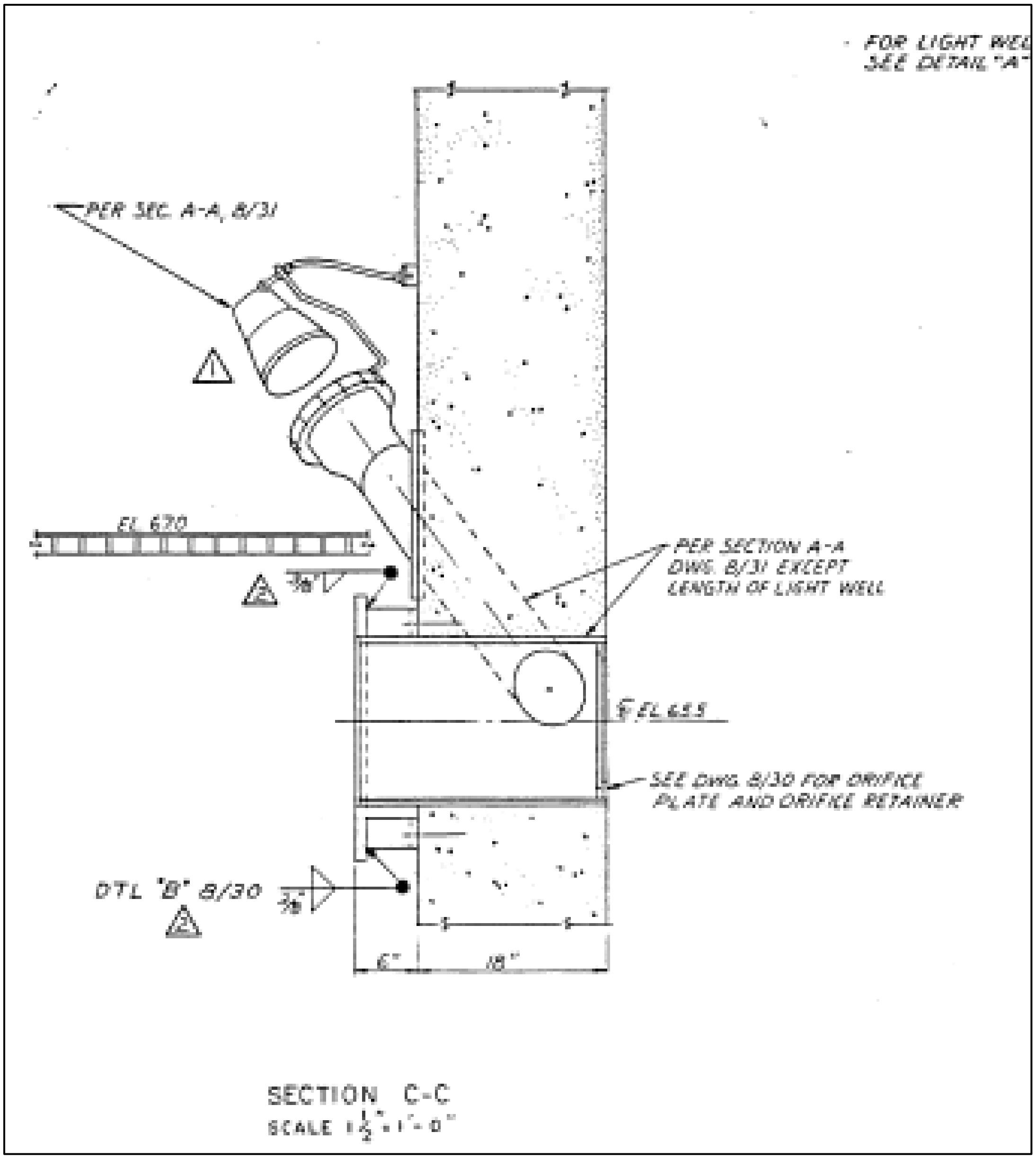
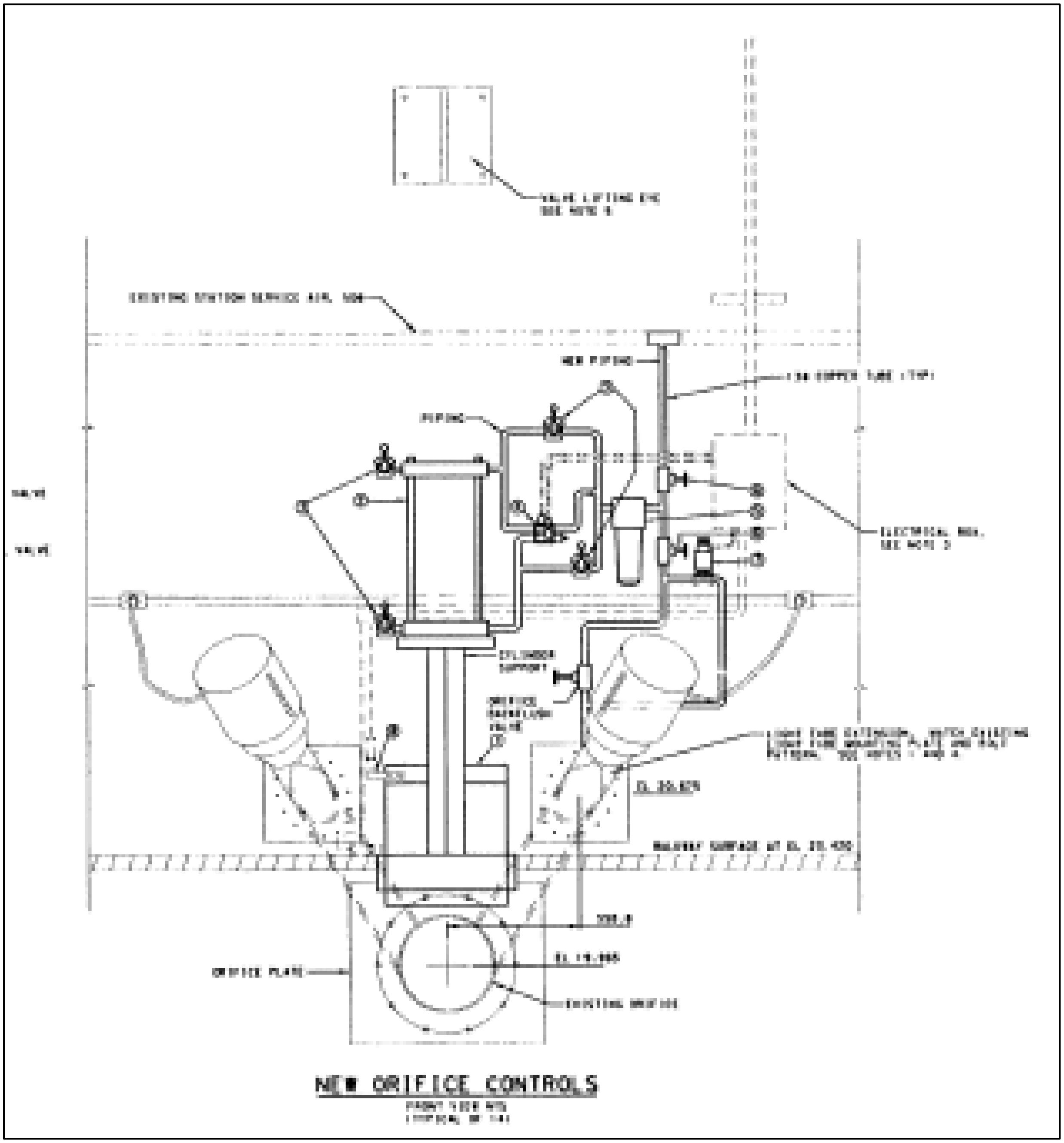


Figure 2-4. Existing Orifice Controls



2.1.2. Control Weir

The control weir was located at station 19+21 in the erection bay. The control weir regulated the water surface elevation in the collection channel.

2.1.3. Dewatering Facility

The dewatering facility consisted of an inclined screen that was 14-feet-wide by 50-feet-long and is inclined by 6.84 degrees from horizontal. The area of the screen was 700 square feet, representing a maximum use of floor screen area within the operating confines. The original design allowed for a velocity of 1.0 fps through the screen. This has been revised to 0.4 fps. Below the screen were four discharge outlets and gates that released water into the emergency relief conduit (ERC). Only the two downstream discharge gates were in operation. The water passing through the dewatering screens flowed through the ERC and ultimately to the tailrace. The remaining water flowed over the 14-foot-wide control weir into the discharge well. The dewatering screen is cleaned with a brush system.

2.1.4. Operation

The design of the Bonneville second powerhouse included provisions for a DSM system. The purpose of the DSM system is to provide passage for juvenile fish from the forebay to the tailwater without having them pass through the turbines. The juveniles bypass the turbines by being directed into the bulkhead slots by submersible traveling screens (STS). The juveniles pass through the lighted orifices into the DSM collection channel, past the originally inclined dewatering floor screen (Figures 2-5 and 2-6).

Figure 2-5. Transverse View Gate Well and Slots

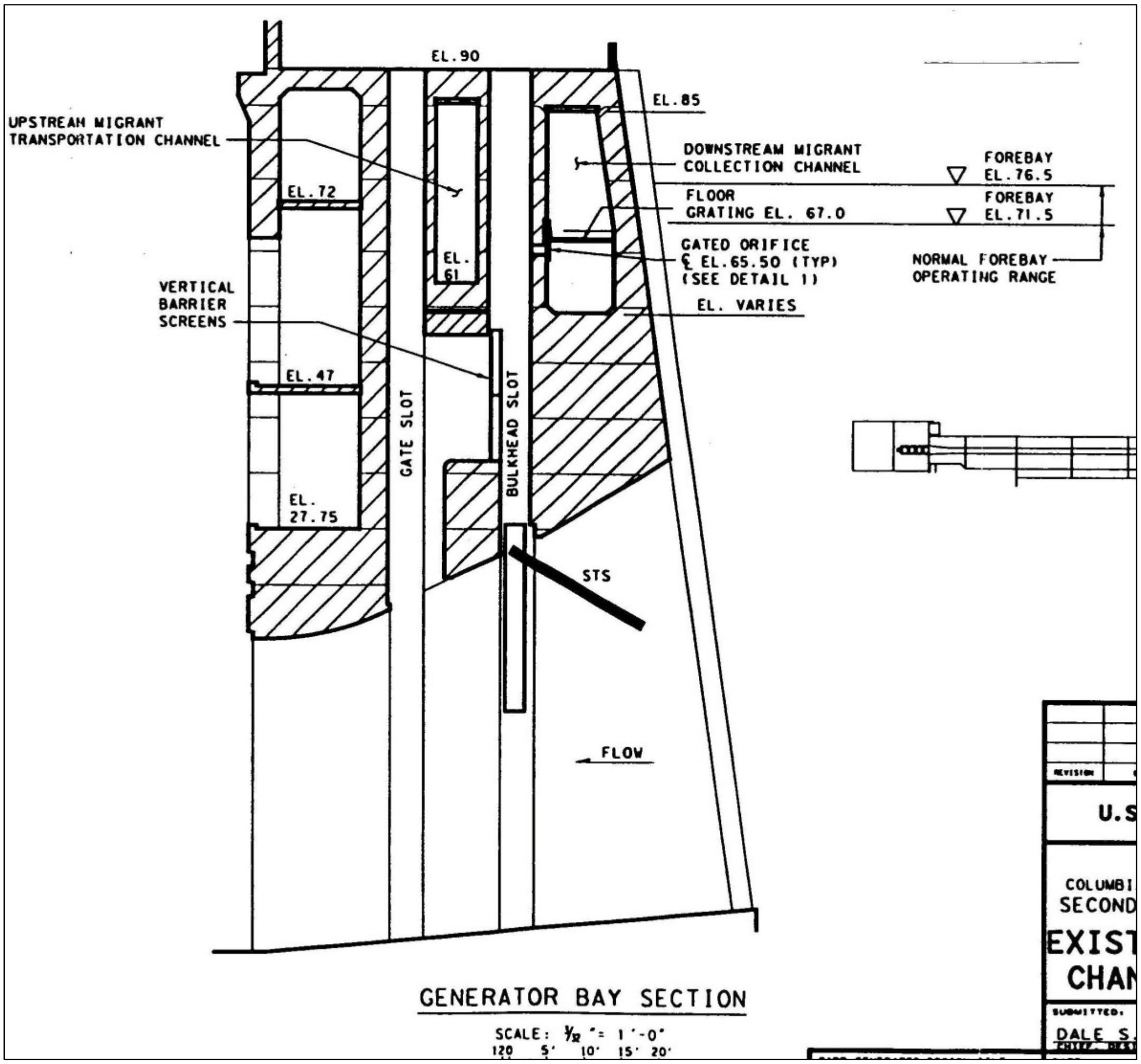
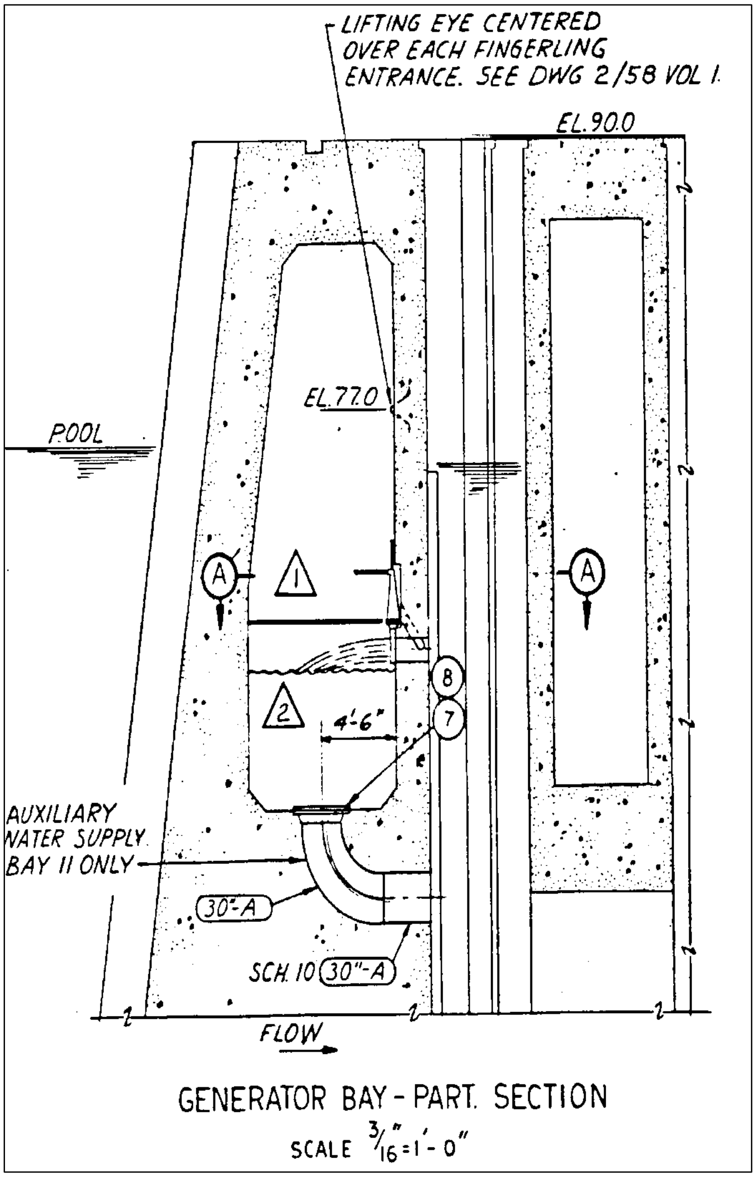


Figure 2-6. Erection Bay Section View – Original Design



2.2. DSM IMPROVEMENTS IN 1999

2.2.1. Bulkhead Slot Orifices

The 1999 DSM system improvements included unsealing and gating 12 of 28 previously sealed orifices (units 11-14) to provide constant flow in the channel for a full range of forebay elevation operations (El. 71.5 to 76.5 feet). The orifice ring diameter was also increased from 12 to 13 inches increasing flow and allowing higher velocities in the collection channel. It should be noted that these new gates have larger actuators resulting in gates and seals extending further downstream from the orifice entrance than the 28 originally gated orifices. This effectively increases the distance that the arc of the jet must travel to clear the gate housing as it exits into the collection channel.

2.2.2. DSM Collection Channel

Add-in water was included in the collection channel entrance and the channel geometry was modified to improve channel velocities that encourage fish passage and reduced stall and delay of juvenile fish.

2.2.3. Control Weir

The control weir was removed to eliminate an observed fish holding area and improve flow conditions.

2.2.4. Dewatering Facility

The dewatering facility was replaced with wall screens to provide more uniform velocities and to maintain criteria for velocity normal to screens.

2.2.5. Operation

Operation was modified to provide constant flow for all design forebay elevations and operating conditions without the need for weir adjustments within the dewatering facility. A constant water surface elevation is maintained over the range of forebays by adding or subtracting the number of orifices in use. Currently, the orifice slide-gates at units 11-18 are controlled automatically via a programmable logic controller (PLC), which is essentially a rugged industrial computer with a main processor that scans inputs and outputs and executes internal logic stored in memory. In auto mode, the regulating orifices at units 11-14 are operated based on water level readings at the DSM channel exit to the dewatering system. The entire system of orifice slide gates for units 11-18 are periodically operated to flush out potential debris buildup in the system. And additional mode of operation allows each slide gate to be operated from the control room touchscreen human machine interface (HMI) or locally near the slide-gate itself. The PLC is a Square-D SyMax and is located in the electrical building on the elevation 90 intake deck on the Washington-side of powerhouse 2.

Current biological practice has been to inspect the condition of the jets at least daily to determine whether debris buildup at the orifice entrance is indicated. If the jet is not clear, it is assumed that debris is likely at the entrance which is known to harm fish. The gate is immediately closed, flushed with compressed air thereby clearing debris and reducing the probability of fish injury.

2.3. Additional Modifications

2.3.1. Bulkhead Slot Orifice Rings

In 2002, the size of orifice rings was reduced from 13 inches to 12 5/8 inches in order to provide the intended 1999 design flow (see Section 3.3.1).

The table below lists the individual orifices and their operational configurations from the original project in 1983 to the current operation.

Table 2-1. Orifice Arrangement and Operation from 1983 to Current

Orifice	Current Actuator Type	Original 1983 Design	1983 Operation After Allowable Velocity Through Dewatering Screens was Revised to V=0.4 fps	1999 Added 14 Operable Orifices to 28 Orifices That Remain Open
		Fifty-Six (12 inch) Orifices Built for ~ 500-700cfs	Only Twenty-Eight (12 inch) Orifices in use ~250-350cfs	Twenty-Eight (13 inch) Orifices Open + Fourteen (13 inch) Orifices Operable to Maintain Q
			A = Always Open	O/C = Open/Close with Forebay
11 A (S)	Blue	X	(Blind-Flanged)	O/C
11 A (N)	Silver	X	A	A
11 B (S)	Blue	X	(Blind-Flanged)	O/C
11 B (N)	Silver	X	A	A
11 C (S)	Blue	X	(Blind-Flanged)	O/C
11 C (N)	Silver	X	A	A
12 A (S)	Blue	X	(Blind-Flanged)	O/C
12 A (N)	Silver-Recessed	X	A	A
12 B (S)	Blue	X	(Blind-Flanged)	O/C
12 B (N)	Silver-Recessed	X	A	A
12 C (S)	Blue	X	(Blind-Flanged)	O/C
12 C (N)	Silver-Recessed	X	A	A
13 A (S)	Blue	X	(Blind-Flanged)	O/C
13 A (N)	Silver-Recessed	X	A	A
13 B (S)	Blue	X	(Blind-Flanged)	O/C
13 B (N)	Silver-Recessed	X	A	A
13 C (S)	Blue	X	(Blind-Flanged)	O/C
13 C (N)	Silver-Recessed	X	A	A
14 A (S)	Blue	X	(Blind-Flanged)	O/C
14 A (N)	Silver	X	A	A
14 B (S)	Blue	X	(Blind-Flanged)	O/C
14 B (N)	Silver	X	A	A
14 C (S)	Blue	X	(Blind-Flanged)	O/C
14 C (N)	Silver	X	A	A
15 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 A (N)	Silver-Recessed	X	A	A
15 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 B (N)	Silver-Recessed	X	A	A
15 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 C (N)	Silver-Recessed	X	A	A
16 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 A (N)	Silver	X	A	A
16 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 B (N)	Silver	X	A	A
16 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 C (N)	Silver	X	A	A
17 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 A (N)	Silver	X	A	A
17 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 B (N)	Silver	X	A	A
17 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 C (N)	Silver	X	A	A
18 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 A (N)	Silver	X	A	A
18 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 B (N)	Silver	X	A	A
18 BC(N)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 C (N)	Silver	X	A	A
F1 A (N)	Silver	X	A	A
F1 B (N)	Silver	X	A	A
F2 A (S)	Blue	X	(Blind-Flanged)	O/C
F2 A (N)	Black/Silver	X	A	A
F2 B (S)	Blue	X	(Blind-Flanged)	O/C
F2 B (N)	Black	X	A	A
Total No. Orifices		**56**	**28**	**42**

3. PROBLEM STATEMENT

The current operation of the DSM system does not provide adequate monitoring of debris blockage at the orifice entrance in the bulkhead slot for the full range of design forebay elevations (El. 71.5 to 76.5 feet). As originally designed, the observance of a clear consolidated jet exiting the downstream pipe indicated unobstructed safe fish passage. In contrast, a spreading jet filling the pipe indicated an obstructed entrance that would be harmful to juveniles. This monitoring allowed personnel to correct the situation, as needed.

Currently, the character of the DSM system orifice jets are inconsistent and predominately spreading throughout the range of forebay operations due to a combination of jet impingement (at lower forebay elevations) and lack of adequate air supply to support the jet (at higher forebay elevations). In addition, lightwell studies at the Bonneville second powerhouse indicated that existing light sources are inadequate for attraction of juvenile salmonids.

The goals of this study are focused on improvements to the collection system that will reduce injury and delay to migrating fish species:

- Improve the ability for the project operators to detect debris plugs in the orifice;
- Reduce the likelihood of fish impingement due to alignment of orifice flow, and
- Improve gatewell egress times with improved lighting.

The sections below outline the history of studies and modifications to the DSM system at the Bonneville second powerhouse leading to the conclusions expressed in the problem statement above.

3.1. History of DSM System Studies and Subsequent Modifications

The DSM system at the Bonneville second powerhouse has undergone several modifications over the last 29 years in an effort to provide a safe, efficient passage route for juvenile salmonids. The information below describes the chronology of pertinent issues with the DSM system, and improvements for the system, since its construction in 1982.

Since construction in 1982, there have been a number of modifications made to improve the operation of the DSM system, with extensive changes being completed in 1999. These modifications were recommended after studies from 1987 to 1991 had shown that the fish using the bypass system were stressed and fatigued, particularly at low tailwater elevations, which likely contributed to the apparent high rate of tailrace predation. Poor survival appeared to be related to low water velocities in the collection channel, high turbulence in the channel from orifice jets, high turbulence over the dewatering screen due to energy dissipation over the channel control weir, air entrainment in the downwell, and negative pressures in the first elbow of the closed pipe (Design Memorandum Supplement #6).

According to Project personnel, one of the aspects of the design that worked well was the hydraulic characteristics of the free-discharging jets. They were described as consistent and clean and functioned well as indicators of potentially harmful upstream debris blockage at the orifice entrance. Typically during this time, debris blockage checks occurred multiple times a day to detect and eliminate any blockage as these conditions are known to be harmful for fish.

3.2. MODIFICATIONS 1999

The modifications described in Section 2.2 were completed in 1999. Studies done after the 1999 improvements indicated that the once clean jets (1982 design) were now disturbed and spreading jets. It was observed that the jet spreading was even worse for those orifices that had previously been sealed and been made operational in 1999 (south blind flanged orifices – See Table 2-1). Most of the jets often hit the downstream gate housing (potentially harming fish) especially at lower forebays. Collectively, there was more flow in the system than predicted, causing the dewatering system to be out of criteria. It was suggested that the lack of a fully contracting jet was causing the discharge coefficient to be higher and more variable than designed, which resulted in flow in excess of design.

3.3. FURTHER MODIFICATIONS AND STUDIES

3.3.1. Hydraulic Field Testing 2002

Field observation/testing in 2002 at a turbine unit not in service recommended decreasing the orifice plate diameter to 12 5/8 inches to effectively decrease the individual orifice flows, thereby bringing the dewatering system back into criteria. It was suspected that the difference between the 1999 orifice diameter (13 inches versus the 12 inch orifices of 1983) and inner pipe diameter (15 inches) was insufficient to maintain the continual air flow needed to produce a cohesive jet. Project operators noted that immediate and temporary improvement of the jets could be produced by releasing bursts of compressed air into the pipes. It was also noted that the orifice rings and support rings (with same diameter I.D.) were not aligned when installed, causing a discontinuity that disturbed the outside of the jet and further exacerbating jet instability and reduced air flow back into the pipe.

When disturbed, jets spread to fill the pipe and air is prevented from entering the pipe to vent the base of the orifice. This causes the orifice jet to be subjected to vacuum within the transport pipe, and consequently, the head differential (the gatewell head minus the pressure head in the orifice pipe) tends to be higher. This results in higher discharge through the orifice and pipe than when properly vented. Basically, the orifice flow becomes full pipe flow with a minor constriction caused by the orifice. Venting, on the other hand, would deliver air to the base of the orifice at the upstream end of the pipe so that the orifice jet would contract downstream of the orifice and stay separated from the inner pipe walls.

The reduction in orifice size to 12 5/8 inches was a relatively easy way to improve air movement somewhat and ultimately solve the excess flow problems but this did not however fix the disturbed jets. Field biologists and regional fishery agencies were still concerned that the continuously disturbed jets made it impossible to monitor potential upstream orifice obstructions thereby endangering the fish utilizing the DSM system.

3.3.2. Hydraulic Field Testing 2006

Further field testing in 2006 (see Appendix A, *Hydraulic Design*) using a working turbine unit indicated that using smaller diameter orifice rings (in relation to the existing inside diameter of the steel pipe) consistently produced cleaner jets. However, the additional 12 previously sealed orifices located on the south side of each bulkhead (made functional in 1999) were consistently more disturbed and more likely to impact the downstream end (pipe end and gate housing) than the original orifices located on the north side of each bulkhead. This was assumed to be related to the larger actuators and gate housing installed during the 1999 modifications that essentially elongated the jet path. It was also surmised that testing with the turbine units off (2002 testing) versus unit on (2006) does affect jet quality.

The 2006 field testing utilized several orifice ring sizes and the smallest (11 inches) appeared to have the most consistent and clean jet. It was deduced that the 11 inch orifice ring was superior due to increased space between the outer circumference of the jet and the inside of the pipe (15 inches I.D.) allowing for adequate air supply to feed the jet. As the jet moves through the bulkhead wall, it entrains air into the jet. If that air is not sufficiently replaced, a low pressure zone develops in the vent tube area from the orifice ring to the downstream side of the gate. A properly vented orifice jet would continue to contract downstream of the orifice, but due to the low pressure in the vent tube, the orifice jet is "pulled" apart as it passes through the bulkhead wall and may even impact the gate structure. The low pressure could also change the orifice efficiency, allowing more flow into the DSM collection channel than anticipated.

The field study concluded that a properly sized orifice in relation to pipe diameter would alleviate the jet spread and hydraulic capacity issues. It was recommended that for a 13-inch diameter orifice ring (as originally designed for the 1997 DSM improvements), the appropriate inside diameter of the steel pipe should be about 17.75 inches (I.D.) to allow the adequate air supply needed for a clean jet. The field study occurred during an average forebay operation at El. 73.6 feet (mean = El. 74 feet) and it should be noted that it is likely that less air would be needed at lower forebays as the flow and velocity would be reduced. Based on preliminary air demand calculations (see Appendix A), the 11-inch orifice ring with a 15-inch (I.D.) pipe would result in an air demand of 1.8 cfs versus the existing orifice ring (12 5/8 inches) with 2.2 cfs air demand.

3.3.3. Light Study at Bonneville

In 2011, research was conducted by the Pacific Northwest National Laboratory (PNNL) to provide USACE biologists and engineers with general design guidelines for using artificial lighting to enhance the passage of juvenile salmonids into the collection channel at the Bonneville second powerhouse. There were three primary objectives of the research: (1) review and synthesize all relevant studies where artificial light was evaluated in a field or laboratory setting for the potential to guide fish at passage barriers within juvenile salmonid outmigration corridors; (2) conduct a field study at the Bonneville second powerhouse to evaluate the output levels of two artificial light sources at one orifice entrance within gatewell 12; and (3) compare, in a laboratory setting, the performance of three light sources in terms of light intensity values.

The PNNL reviewed 36 sources in the published gray and peer-reviewed literature and prepared a synopsis that included study objectives, species and life stage, experimental conditions, type of lighting used, and a summary of results. It was found that artificial lighting has been used in two general applications: (1) as a means to induce avoidance behavior by altering the fishes' swimming pathway, and (2) as a guidance or attraction avenue to assist fish in locating safe passage routes. The literature review indicated that several factors play a combined role in the fishes' ability to safely navigate passage barriers. These factors included genetic makeup (species and subspecies), life stage, season, time of day, light levels, presence of predators, distance to cover, water temperature, group size, noise regime, and water current.

The review by PNNL determined that juvenile salmonids can be attracted to illuminated regions during nocturnal periods and can perceive light levels down to approximately 0.25 lux or 10-2 foot-candles (ft-c), equivalent to the light produced by moonlight. At the other end of the spectrum, we found that juvenile salmonids generally avoid or are startled when exposed to more intense light levels that correspond to daylight conditions or near 400 lux (10-1.5 ft-c). To guide fish through manufactured structures using artificial lights requires an understanding of the types of illumination and the nature of salmonid light perception. To respond to a light source, the fish visual system must be able to respond to the appropriate wavelengths that correspond to peaks in the spectral response of the photo receptors in the eye. Studies that have examined the use of artificial light to guide salmonids safely through migration barriers such as hydroelectric dams show measurable differences in juvenile responses to both the quantity and quality of the light stimulus. The literature review concluded that any fish passage guidance structure must be based on an understanding of fish behavior and environmental and hydraulic conditions at the specific location.

The field study at the Bonneville second powerhouse found the existing lighting conditions at the orifice tubes in the downstream migration channel to be less than ideal to illuminate the entrance of the orifice. Based on review of the lighting studies, a minimum luminance value of approximately 200-300 lux is needed at the orifice entrance. While some studies, in controlled laboratory experiments, have shown that this light intensity could possibly startle test fish (if exposure is sudden), light intensity values are expected to decrease rapidly within a short distance from the orifice. High water turbidity present for much of the spring outmigration period in the Columbia River also would play a role in decreasing light intensity at the orifice.

Field measurements of light intensity from light-emitting diode (LED) light bulbs at a single orifice in gatewell 12 were low, at approximately 0.1 lux with a water-scaled lens. Light output for a 90-watt halogen light with a water-scaled lens was 0.25 lux at the opening. When the water-scaled lens was exchanged for a new lens, the readings increased to 0.6 lux for the LEDs and 3.25 lux for the halogen light. For comparison, 1 lux is the amount of light produced by moonlight at high altitude and 10 lux is the intensity of a candle at a distance of 1 foot. The halogen lights were far more effective at producing illumination near the orifice regions and outward to approximately 16 inches on axis with the opening, where the values were similar to the ambient light background measurements. The LEDs were less effective at illuminating the region; this was especially evident when the water-scaled lens was used. Both light sources produced light levels below effective minimum luminance values noted in the literature.

The laboratory tests were conducted at PNNL’s Aquatic Research Laboratory in Richland, Washington. Researchers measured the light output from halogen spotlights and mercury vapor lamps, as well as the LED lamps currently in use at the Bonneville second powerhouse. The results using a water-scaled glass lens showed that the light loss for the halogen and the aqua green LED lamp was 5-6 times higher than the loss with a clean lens. Output from a mercury vapor lamp, when the water-scaled lens cap was placed at the light face, was reduced by only a factor of two. The drawback to using mercury vapor and halogen lamps is the amount of heat produced by the lens (250°F for mercury vapor and 143°F for halogen) and the reduced bulb life as compared to the LEDs.

Based on the study, some options for improving the lighting at the orifice entrances at the Bonneville second powerhouse include the following:

- Incorporate a ring of LEDs that would be recessed into the orifice opening, thus eliminating the need for the light tubes. An automated cleaning system also would be required.
- Incorporate the light source into the lens cap so that the cap and light housing is one waterproof unit. This would allow for all of the light to be directed into the light tube and eliminate the water scaling and debris-buildup issue, although water buildup still could pose a problem due to the splashing of water upward into the light tubes. Cleaning of the light and cap assembly also would be simplified.

- Use a white-emitted light source that has a minimum luminance value of approximately 200-300 lux near the immediate orifice entrance.
- Incorporate higher-intensity LED lamps. Several manufacturers have developed high-output LEDs that have been used in a variety of applications, including automobiles, flashlights, and residential and industrial interior and exterior lighting. These relatively new LEDs provide almost 50% more light (some up to 250 lux) than a standard 5-watt LED bulb. Models of the cool white version have an expected 50,000-hour lifespan and have peak wavelengths of 440 and 550 nanometers.

To evaluate the effectiveness of any modification to the existing system, tests could be conducted in which tagged fish are released in the gatewell with a light-on/light-off scenario and the orifice passage efficiency evaluated. Different lighting sources could be tested to determine if white light or light emitted within the peak action spectra of juvenile salmonids (blue-green region) is best for attracting fish near the orifice where the flow component is sufficient for entrainment into the collection channel.

3.3.4. 2010 Light Attraction Studies at McNary Dam

Artificial lighting is currently being used in varying applications and intensities for illumination of gatewell exits at USACE hydroelectric projects to decrease delays for bypassed fish on the Snake and Columbia Rivers. While previous studies have shown a variable response to light across salmonid species, the literature suggests that improvements can often be made in fish passage if light intensity, wavelength, and/or directionality are optimized.

In 2010, PNNL designed a light ring system for illuminating the orifice entrance in a gatewell. Staff from the Pasco Research Station of the National Marine Fisheries Service (NMFS) collaborated with PNNL on the design, fabrication, and installation of a track system for the light. The track system was used to lower, retrieve, and positions the light ring over the orifice entrance. The light ring was deployed and tested during 2010 on an existing 30.5-centimeter orifice in gatewell 6B (south orifice) at McNary Dam.

Three levels of light intensity were evaluated, 50 lux, 300 lux, and reference (light off with <1 lux), to determine whether there was a difference in gatewell egress associated with each treatment. The light ring directed most of the light inward and produced a glow that projected outward into the gatewell. Intensity could be adjusted by an external control module. Prior to each test, a light meter was used to measure luminance and adjust output to meet the designated treatment schedule. Changing turbidity levels required adjustment of light output to meet the required treatment conditions.

Using a hose, groups of PIT-tagged fish were released behind the trash rack for entrainment into the gatewell of turbine unit 6B. During each light treatment, tagged fish moved volitionally out of the gatewell, passing through the orifice and into a flume, where two in-line PIT-tag detectors recorded their passage. Researchers released fish for one light treatment per day, during both day and night diel periods, and monitored detections for each group over a 12-hour period.

For each release group, mean passage time (gatewell egress) was estimated from release until first detection at the PIT-tag monitors on the downstream side of the test orifice. Passage distribution was modeled using time-to-event methods. The models included three factors: *week* (1-6), *diel period* (day/night), and *light treatment* (300 lux, 50 lux, and reference or light off); and three covariates (*fork length*, *turbidity*, and turbine unit *flow*). Akaike's information criterion (AIC) was used to determine which set of iv factors and covariates were best supported by the data. Prediction of 50% passage was estimated for each cohort from the model-averaged individual estimates.

Both orifice light treatments decreased delay in the gatewell and improved egress for yearling and subyearling Chinook salmon, sockeye salmon, and juvenile steelhead under most conditions. Sample sizes for coho salmon were insufficient for analysis. Differences in passage-time distribution between the two light treatments (50 lux and 300 lux) were minimal. The magnitude of delay between the 50-lux and 300-lux treatments and the reference (light off) treatment was greater for fish released in the evening than for those released in the morning, indicating that the orifice light was less effective during daytime due to ambient light. By covering the gatewells, egress for illuminated orifices during the daytime could be improved. The 50-lux and 300-lux treatments also provided a significant reduction in passage delay during periods of high turbidity, which occurred during the end of May and early June.

3.3.5. Site Visits and Further Observations (2011)

Several observations have been made during this study to augment the conclusions that have been made in previous field observations. A definite correlation can be seen between the particular gate assembly and its placement versus jet quality.

There are two different sizes of actuators used on the orifice gate valves. The smaller of the two is used on orifices such as 12A-N. On orifices like 12A-N the concrete has been chipped away allowing room for the actuator to be recessed into the concrete. This also allows the gate valve to be mounted flush with the mounting plate giving an overall distance of 0.6 inches from DSM wall to upstream face of the gate (Photo 3-1).

Although the smaller actuators were used on many of the orifices, orifices such as 14A-N did not have the concrete removed so the gate valve had to be mounted offset from the wall using spacer rings to allow clearance for the actuator. This results in an overall distance of 4.2 inches from DSM wall to upstream face of the gate (Photo 3-2).

The larger actuators are used on orifices such as 14A-S. The concrete was not removed at any these orifices and to provide clearance for the larger actuators the gate valves were offset further resulting in an overall distance of 7.2 inches from DSM wall to upstream face of the gate (Photo 3-3).

Table 3-1 demonstrates the correlation between jet quality and gate type/placement. The gates with the largest offset (7.2 inches) tend to consistently present a poor quality jet. The gates with the medium offset (4.2 inches) were observed to have somewhat better performance related to a cohesive free jet. The Grey actuators that have the gates flush with the wall (0.6 inch offset) routinely present a better jet. This is likely caused by the jet trajectory especially for the lower forebays where jets will have less discharge and lower velocities. If jet impingement occurs there is deterioration around the exit of the jet which also reduces the air available to sustain the continuity of the jet. The combination of the impact itself and reduced air access to the jet causes poor jet quality. Observations at a higher forebay indicate a reduction in jet quality as discharge and velocities increase requiring more air to support the jet. This reduction in jet quality is most likely caused by lack of sufficient air supply to the jet. For both conditions the Grey actuators with the least offset from the wall fair better with regards to jet quality.

Other situations that may cause variation in jet quality during observations include turbine unit operation (on/off) and fish screens (in/out). The concurrent study for Bonneville Second Powerhouse Fish Guidance Efficiency is looking at various alternatives to increase efficiency and decrease mortality. Alternatives that are being considered include modification of the gatewell to reduce turbulence as well as alternatives that modify the design of the current orifice design. These two programs are proceeding concurrently with frequent coordination and with the expectation that any recommendations will be further explored jointly.

Photo 3-1. Grey Actuators with Concrete Chipped Away (Offset = 0.6 inches)

Photo 3-2. Grey Actuators with No Concrete Chipped Away (Offset = 4.2 inches)

Photo 3-3. Blue Actuators with No Concrete Chipped Away (Offset =7.2 inches)

Table 3-1. Field Observations Citing Relative Jet Quality

Orifice	Current Actuator Type	Field Observations - for 12 5/8 Inch Orifice Rings		Existing Gap Between Gatewell Wall (Orifice Entrance) and Gate (inches)
			7-Jul-11	
		Forebay=72.7	Forebay=74.4	
		Jet Condition	Jet Condition	
11 A (S)	Blue	poor	poor	7.2
11 A (N)	Silver	poor	poor	4.2
11 B (S)	Blue	closed	closed	7.2
11 B (N)	Silver	closed	closed	4.2
11 C (S)	Blue	poor	poor	7.2
11 C (N)	Silver	good	poor	4.2
12 A (S)	Blue	poor	poor	7.2
12 A (N)	Silver-Recessed	good	poor	0.6
12 B (S)	Blue	poor	closed	7.2
12 B (N)	Silver-Recessed	good	good	0.6
12 C (S)	Blue	poor	closed	7.2
12 C (N)	Silver-Recessed	good	good	0.6
13 A (S)	Blue	poor	closed	7.2
13 A (N)	Silver-Recessed	good	poor	0.6
13 B (S)	Blue	poor	closed	7.2
13 B (N)	Silver-Recessed	good	good	0.6
13 C (S)	Blue	closed	closed	7.2
13 C (N)	Silver-Recessed	good	good	0.6
14 A (S)	Blue	closed	closed	7.2
14 A (N)	Silver	good	poor	4.2
14 B (S)	Blue	closed	closed	7.2
14 B (N)	Silver	poor	poor	4.2
14 C (S)	Blue	closed	closed	7.2
14 C (N)	Silver	poor	poor	4.2
15 A (S)	Blind-Flanged			
15 A (N)	Silver-Recessed	good	good	0.6
15 B (S)	Blind-Flanged			
15 B (N)	Silver-Recessed	good	good	0.6
15 C (S)	Blind-Flanged			
15 C (N)	Silver-Recessed	good	good	0.6
16 A (S)	Blind-Flanged			
16 A (N)	Silver	poor	poor	4.2
16 B (S)	Blind-Flanged			
16 B (N)	Silver	poor	poor	4.2
16 C (S)	Blind-Flanged			
16 C (N)	Silver	poor	poor	4.2
17 A (S)	Blind-Flanged			
17 A (N)	Silver	poor	poor	4.2
17 B (S)	Blind-Flanged			
17 B (N)	Silver	poor	poor	4.2
17 C (S)	Blind-Flanged			
17 C (N)	Silver	poor	good	4.2
18 A (S)	Blind-Flanged			
18 A (N)	Silver	poor	poor	4.2
18 B (S)	Blind-Flanged			
18 B (N)	Silver	good	poor	4.2
18 BC(N)	Blind-Flanged			
18 C (N)	Silver	good	poor	4.2
F1 A (N)	Silver	poor	poor	4.2
F1 B (N)	Silver	good	good	4.2
F2 A (S)	Blue	poor	poor	7.2
F2 A (N)	Black/Silver	closed	closed	4.2
F2 B (S)	Blue	poor	poor	7.2
F2 B (N)	Black	closed	closed	4.2

4. ALTERNATIVES DEVELOPMENT

4.1. BIOLOGICAL CONSIDERATIONS

4.1.1. Biological Criteria

Biological criteria for current and existing systems will adhere to the most current NMFS design criteria for passage systems. The most pertinent criteria driving the design are as follows:

- Through dewatering screen criteria of ≤ 0.4 fps at the screen face.
- DSM channel velocities of 3-5 fps over the entire length of channel.
- Depths with the main channel will be greater than 2 feet at all times.

4.1.2. Biological Considerations

Since orifice modifications in 1999, regional fish representatives and USACE fish biologists have been critical of the Bonneville second powerhouse orifice system because of the inability to ascertain whether or not the orifice is being affected by debris due to the physical and new hydraulic conditions that resulted from the new orifice ring size. In years prior to modifications, inspectors could view the condition of the jet exiting the wall and determine if the orifice had a blockage due to a change in the jet's characteristics. Under the new operation, the disturbed jet does not allow the inspector to determine whether or not there is debris. The goal of this program is to return the orifices to their clean jet status with minimal modifications and to also incorporate a new orifice lighting system under the same modification contract.

4.2. HYDRAULIC CONSIDERATIONS

4.2.1. Hydraulic Design Criteria

4.2.1.1. General

Hydraulic design of the DSM system is driven by hydraulic criteria for safe passage of downstream migrating juvenile salmon. The primary objective of the criteria is to minimize injury or delay to fish. Criteria for forebay range, orifices, collection channel, dewatering structure and exit section were provided by NMFS during design of the 1999 improvements (Sections 4.2.1.2 to 4.2.1.5). Additional standards desired for juvenile fish safety and hydraulic integrity of the system operation pertain to the orifice jet characteristics (Section 4.2.1.6) and dewatering system operation (Section 4.2.1.7).

4.2.1.2. Design Forebay Operating Ranges

Design forebay elevation range for DSM system constant flow operation is El. 71.5-76.5 feet.

4.2.1.3. Orifices (1999 Improvements)

- Plate velocity ≥ 10 fps.
- Orifice discharge ≥ 11 cfs.
- Centerline trajectory of the orifice jets should enter the collection channel water surface at least 4 feet from the opposite wall.

4.2.1.4. Collection Channel

- Channel velocity minimum ≥ 2 fps (acceptable for unit 11 per NMFS discussion).
- Channel velocity 3-5 fps.
- Channel water depth ≥ 4 feet.

4.2.1.5. Dewatering Facility

- Channel velocity between 3-5 fps.
- Average gross velocity entering dewatering screens ≤ 0.4 fps.
- Bypass outflow rate = 30 fps.
- Channel water depth ≥ 2 feet.

4.2.1.6. Orifice Jet Characteristics

- Provide clean free jet suitable for monitoring debris and obstructions at orifice entrance.
- Adequately aerate jet to reduce fluctuations in discharge due to air deprivation and vacuum conditions (especially for higher forebay elevations).
- Reduce current jet impingement at the downstream exit of orifice pipe and gate housing for lower forebay elevations to reduce risk of fish impingement and avoid compounding air deprivation of the jet.

4.2.1.7. Dewatering System Operations

Water surface elevation downstream of the collection channel must remain at a constant elevation for dewatering system to remain in criteria for 0.4 fps screen velocity (fry criteria). Orifices must be opened or closed to maintain the correct total flow (~465-477 cfs) for full range of forebays to maintain a depth of 13.2 feet at the downstream end of the collection channel.

4.2.2. Alternative Hydraulic Concepts

There are four main categories of alternatives that were developed by the Product Delivery Team (PDT) during a brainstorming session: (1) aerate jet to provide means of discerning upstream debris blockage through observation of orifice exit; (2) provide means of discerning upstream debris blockage through observation of orifice entrance; (3) reduce or prevent jet trajectory impingement for lesser flows; and (4) decrease fish passage retention time through attraction lighting.

4.2.2.1. Aerate Jet to Provide Means of Discerning Upstream Debris Blockage Through Observation of Orifice Exit (Alternatives 1-5)

This concept is based on field assessments made from 2000 to present. Often, adding a short influx of compressed air clears up the jet temporarily, but not in all cases. The inconsistency is likely due to the forebay elevation and the associated controlling mechanism affecting the jet characteristics. For higher forebay elevations, the controlling factor appears to be the higher flow, higher velocities and more air demand. For lower forebay elevations, the controlling factor appears to be related more to jet trajectory impingement. The 2006 testing (forebay El. 73.6 feet) compared various size orifice rings and clearly, the "best" jet hydraulics occurred when the ratio of pipe I.D. to orifice ring I.D. was greatest.

Alternatives to introduce air to the jet include both adding air externally, and increasing the ratio between the pipe I.D. and the orifice ring I.D. With a fully aerated jet, obstructions at the orifice entrance could be seen by inspection of the jet and actions could be taken to remove the debris. In addition, a more consistent discharge would likely result with this concept along with a more confined jet less likely to impact the downstream pipe and gate housing. See Appendix A for table showing air demand calculations for previous field testing and alternative comparisons.

4.2.2.2. Provide Means of Discerning Upstream Debris Blockage Through Observation of Orifice Entrance (Alternatives 6-8 and 9-10)

This concept focuses on alternative means of monitoring debris buildup than inspecting the jet characteristics. These alternatives include the use of cameras in the bulkhead for visual observation, as well as pressure transducers or sonic/acoustic sensors placed across the orifice plate. In conjunction with the upstream modifications, inserts to partially support the jet, rounded entrances for full flow and realignment of the orifice ring and gates housing could be used to enhance safe fish passage.

4.2.2.3. Reduce or Prevent Jet Trajectory Impingement for Lower Forebays and Reduced Flow

Field testing and observations indicate that for lower forebay elevations within the operating range, jet disturbances are more likely caused by jet trajectory impact than air demand. Lower forebays result in less discharge per orifice with commensurate reduction in velocities. This results in less air demand and issues with vacuum conditions but decreases the trajectory distance to impact. Field observations indicate three different gate valve offset distances from the DSM system wall:

- Grey actuators with concrete chipped away have an offset of 0.05 feet (0.6 inches; Photo 3-1).
- Grey actuators with no concrete chipped away have an offset of 0.35 feet (4.2 inches; Photo 3-2).
- Blue actuators with no concrete chipped away have an offset of 0.6 feet (7.2 inches; Photo 3-3).

The larger the offset, the more likely it is that the orifice jet will impact the downstream gate housing before it reaches the collection channel. This effect is amplified by lower forebays and resulting lower orifice discharge velocities.

4.2.2.4. Decrease Fish Passage Retention Time Through Attraction Lighting

Field testing at McNary Dam in 2010 showed that a light ring system for illuminating the orifice entrance in the bulkhead provided a reduction in fish passage retention time for the 50 lux and 300 lux light levels, as compared to lights turned off for the spring and summer migrants tested (see Section 3.3.2).

5. ALTERNATIVES

Twelve alternatives were identified as potential solutions to the current DSM system from the downstream bulkhead slot to the dewatering system and are described in the following sections.

5.1. Alternative A1 – Add Compressed Air to Orifice Pipe (uses 13-inch Orifice Ring)

5.1.1. General Description

Introducing compressed air to the area surrounding the jet should supply some relief for the required air demand of the jet. Preliminary air demand calculations were based on Hydraulic Design Criteria (HDC) charts 050-1 and 050-2 for the design of air vents in regulated outlet works. The air demand is caused by the drag force between the water surface and the air above. This results in an air demand for a 13-inch orifice ring with existing pipe I.D. of 15 inches of approximately 2.3 cfs (see Appendix A). Compressed air would be injected through air supply lines periodically during regularly scheduled inspection. This should allow for a more cohesive jet character that can be used as an indicator for orifice blockage. This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13 inch orifice ring flows.

5.1.2. Mechanical Design Components

The calculated air demand for each orifice is 139 cubic feet per minute (cfm). The current copper air supply lines have a 0.5-inch I.D.; at 100 pounds per square inch (psi) nominal station service air, they do not have adequate airflow capacity. The air supply lines would need to be at least 1-inch I.D. (Figure 5-1). The most economical use of the compressed air would be manually injecting the air individually at the time of inspection to support the jet and allow for inspection personnel to observe a clean jet if no blockage is present. The existing 2-inch I.D. air supply header would have adequate airflow capacity for this use. This use is recommended over continuous injection of air, which for 42 orifices would require almost 6,000 cfm of air supply. This would require the air supply header from the air receiver to be increased to 8-inch I.D. and a dedicated air compressor and receiver system just for the DSM. Either way, using compressed air more frequently is expensive. This will cause the air compressors to run more frequently and incur additional operation and maintenance (O&M) costs.

Assuming that the air-on-demand method is used for inspection, the existing 2-inch I.D. air supply header would remain in service and the individual orifice supply lines and valves would be increased to 1-inch pipe. It is apparent that a considerable increase in O&M costs would result with this alternative due to increased usage of the powerhouse station service air compressors.

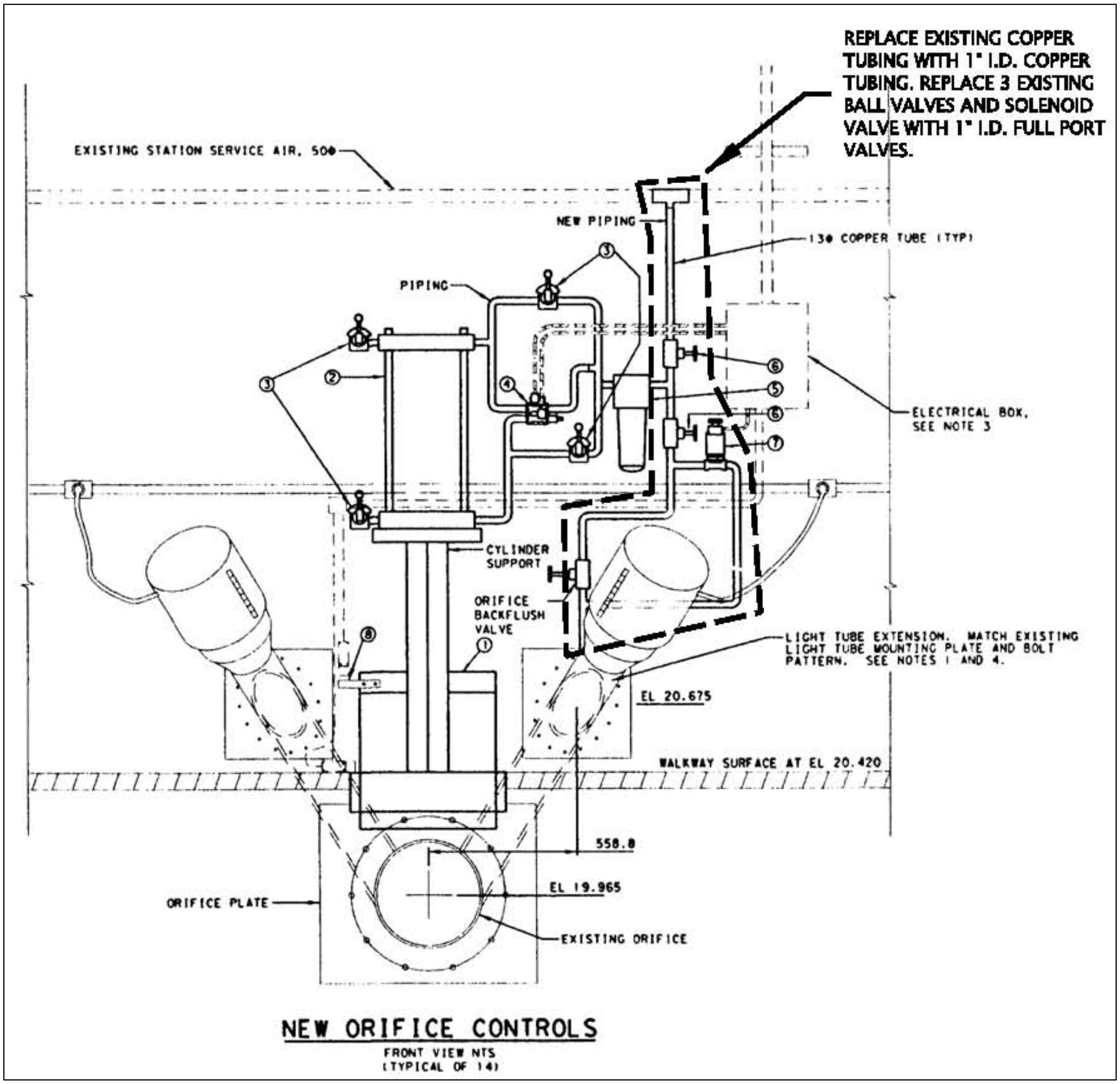
5.1.3. Electrical Design Components

No electrical work required.

5.1.4. Structural Design Components

The pneumatic piping from the compressor will need new brackets and anchorage. The new piping off the main line will need new anchorage.

Figure 5-1. Alternative A1 – Add Compressed Air to Orifice Tube



5.2. Alternative A2 – Vent Orifice Pipe with the Existing Light Tube (Uses 13-inch Orifice Ring)

5.2.1. General Description

Similar to Alternative A1, introducing air to the area surrounding the jet through the existing light tubes should supply some relief for the required air demand of the jet. This should allow for a more cohesive jet character that can be used as an indicator for orifice blockage. Similar to Alternative A1, air demand for a 13-inch orifice ring with existing pipe I.D. of 15 inches would be approximately 2.3 cfs (see Appendix A). The existing light tube covers would be removed to allow air to flow unobstructed into the pipe just downstream of the orifice opening. However, based on preliminary field observations, it does not appear likely that there will be enough air to satisfy the deficit. Opening the light tubes in the field during lower forebays did not show a marked difference in jet characteristics and any improvement was transitory. It could potentially help the jet cohesion for higher forebays somewhat. This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13 inch orifice ring flows

5.2.2. Mechanical Design Components

This design would include a combination of 6-inch galvanized pipe fittings to convert the light tubes into one way air vents and redirect any leakage back down into the DSM. A check valve would be added so that water cannot exit the air vents when the gate valve is closed. A swing check valve modified to minimal cracking pressure would maximize the naturally entrained airflow. The existing light tube lens covers would be removed and new custom match-drilled flanges would be used to make the connection (Figure 5-2). Fasteners would be 300 series stainless steel. Flange gaskets would be buna-N or EPDM.

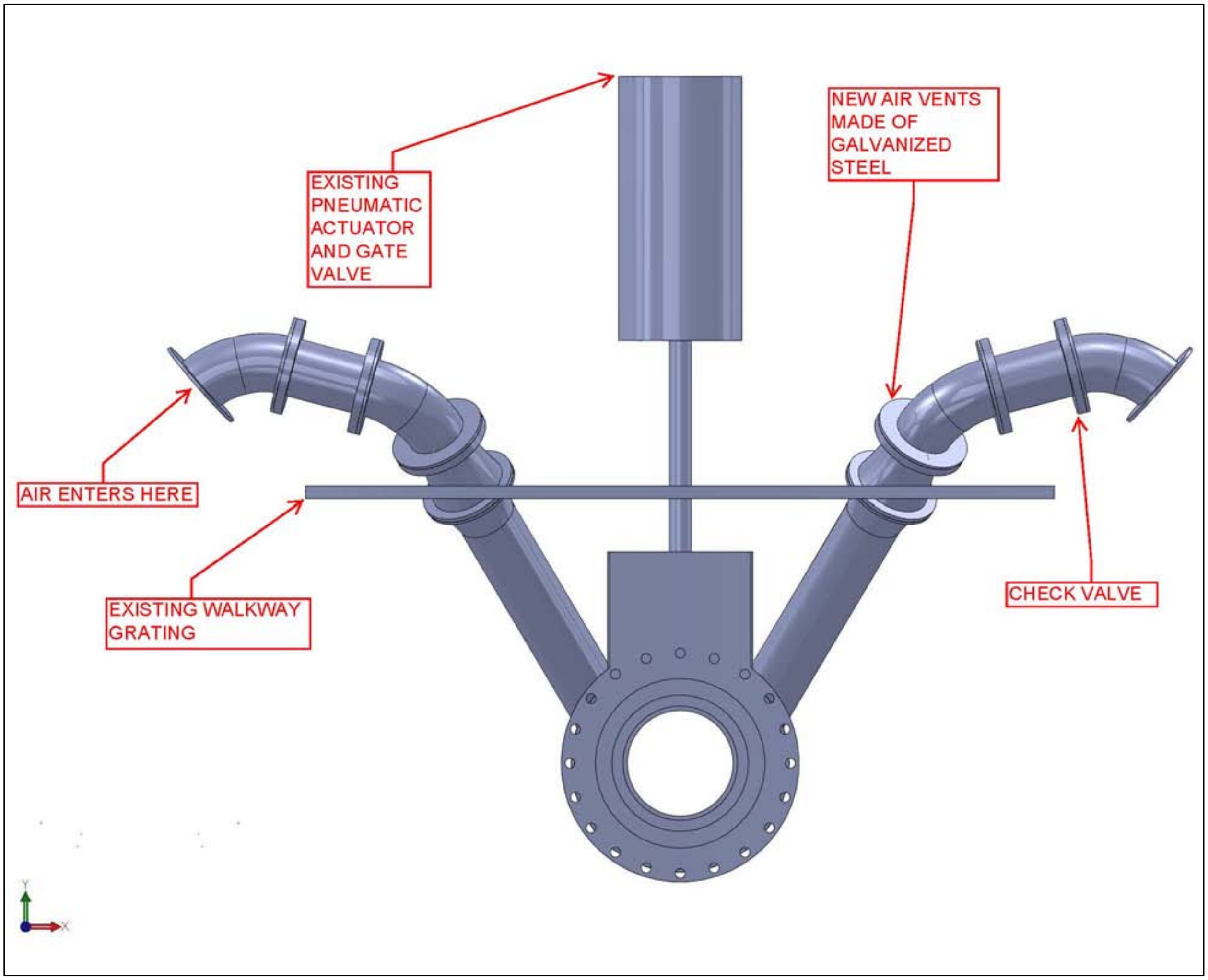
5.2.3. Electrical Design Components

No electrical work required.

5.2.4. Structural Design Components

Vent orifice pipe through existing light tubes that will no longer be used. Will need a check valve and will be directed into DSM channel in the event of check valve failure and backflow. Flow should be comparable to existing due to the elimination of vacuum conditions which will offset the increase due to a larger orifice ring. The check valve will need anchorage. It could be possible to anchor to the existing bolts used for the lens. It is possible that some of the grating for the walkway will need to be modified.

Figure 5-2. Alternative A2 – Vent Orifice Tube with Existing Light Tube



5.3. ALTERNATIVE A3 – ENLARGE OUTER CORE AND INCREASE INTERIOR PIPE DIAMETER (USES 13-INCH ORIFICE RING)

5.3.1. General Description

Enlarging the diameter of the concrete core and replacing the existing pipe with a larger diameter one should improve the air circulation and supply to the jet providing a jet character suitable for debris blockage observation. Increasing the available air space surrounding the jet by increasing the ratio of pipe diameter to orifice ring diameter, will allow more air entrainment to feed the jet and reduce the tendency for jet expansion and fragmentation. Preliminary air demand calculations for a 13-inch orifice ring with a larger steel pipe I.D. of 17.75 inches would be approximately 2.3 cfs (see Appendix A). This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13 inch orifice ring flows.

5.3.2. Mechanical Design Components

If the jet pipe diameters are increased, then the gate valve size will need to be increased as well to allow more room for the jet to clear them before entering the DSM, in addition to allowing more air to enter the pipe. If the gate valves do get larger, then the pneumatic actuators will need to be replaced with actuators that have a higher force output. This is due to the increased weight of the larger valve and the increased friction force developed by having a larger surface area subject to upstream pressure. Additionally, the larger valves will require a longer stroke to open and close completely. The recommended valve size for a 17.75-inch I.D. pipe is 18-inches I.D. (Figure 5-3). Additionally, the new 17.75-inch I.D. pipe sleeve will need to be added. New 13 inch diameter orifice rings would need to be manufactured. In order to reattach the orifice ring and gate valve, a new orifice retainer and gate valve mounting plate will need to be added to the new pipe assembly (see Figure 5-3). The pneumatic piping will need to be reconfigured slightly to attach to the new actuators.

5.3.3. Electrical Design Components

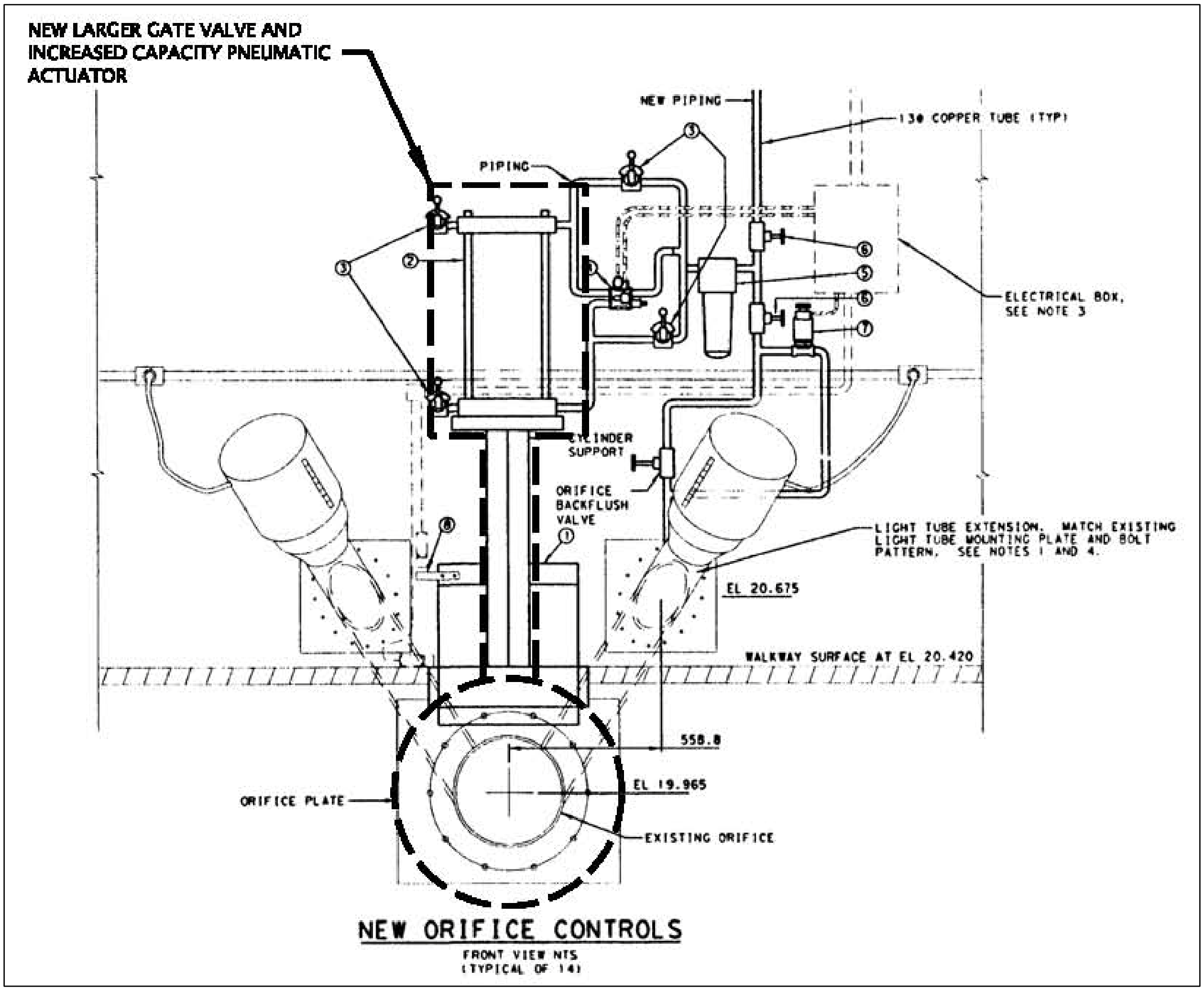
No electrical work required.

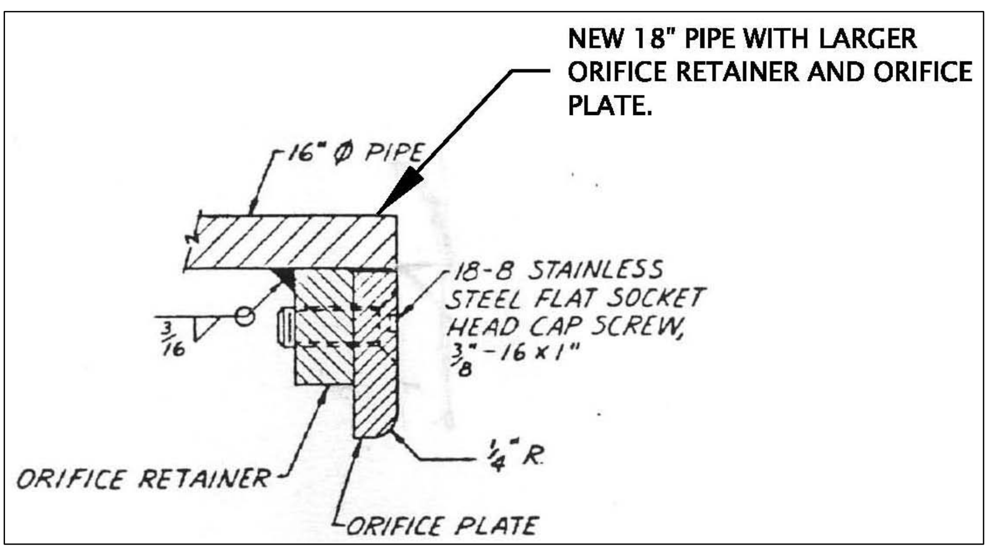
5.3.4. Structural Design Components

The current out-to-out diameter of the bore holes is 15.75 inches. The structural focus will be on coring, anchoring, and reinforcement. Re-core the orifice to larger diameter ≥ 19 inches (existing about 16 inches) to allow for ≥ 17.75-inch I.D. inner sleeve (pipe) while increasing the upstream orifice ring size from about 12 5/8 to 13 inches. This should provide enough area surrounding the jet to allow sufficient air to maintain a clean jet for higher forebay elevations. Flow should be comparable to existing due to the elimination of vacuum conditions which will offset the increase due to a larger orifice ring. Actual size of inner sleeve will depend somewhat on the anticipated jet trajectory and the balance between increased length due to gate housing and the added clearance provided by the increase in pipe diameter.

Concrete coring will require over excavation and grouting back concrete cover in order to provide adequate protection of the reinforcement in accordance with EM-1110-2-2104. The over excavation will require 3-inch grout. This requires the first cut to be at least 20 inches and the second cut line is located 22 inches from the center line of the core. Coring will be limited to a maximum 36-inch core with a 30-inch conduit. Anchorage to the concrete wall of any new fixtures will require post installed bolts. Given the location, age, and quality of concrete, undercut anchors will be used at a minimum for anchorage.

Figure 5-3. Alternative A3 – Re-core Orifice Tube to Larger Size





5.4. ALTERNATIVE A4 – REDUCE ORIFICE RING SIZE TO 12 INCHES IN DIAMETER AND OPEN ADDITIONAL ORIFICES AS NEEDED

5.4.1. General Description

Reducing the orifice ring size, while maintaining the existing inner diameter of the pipe, will increase the volume of air space surrounding the jet. This should alleviate some of the air demand and produce a cohesive jet. Field testing in 2006 indicated that the 11-inch diameter jet appeared better than the 12-inch diameter jet; however, both were considered better than the existing 12 5/8-inch diameter jet. Preliminary air demand calculations indicate approximately 2.1 cfs for a 12-inch diameter orifice and a 15-inch steel pipe I.D. Reducing the current orifice ring size from 12 5/8 inches will reduce the flow. This can be compensated for by opening seven additional orifices (that were originally cored but not gated) to maintain the design flow (49 orifices total). This will also impact the existing collection channel velocities (see Appendix A for comparison of channel velocities for 13-inch versus 12-inch orifice rings).

5.4.2. Mechanical Design Components

New 12-inch diameter orifice rings would need to be manufactured. The new rings could easily be installed using the existing orifice retainer. New 300 series stainless steel fasteners would be installed. Additional gate systems would need to be added to seven of the existing cored but blanked-off south orifices that were included in the original design. This includes 15A, 15B, 15C, 16A, 16B, 16C, and 17A.

5.4.3. Electrical Design Components

New orifice control cabinets will need to be installed for each of the 7 new gate systems. Each control cabinet will be equipped with terminal strips, control switches, conduit and control wiring to the new solenoid valves and back to the existing PLC located in the electrical room on the elevation 90 intake deck on the Washington side of powerhouse 2. Although there are 18 spare inputs and 14 spare outputs on the existing PLC system, the processor and I/O modules are antiquated and availability of spare parts is dwindling. Consequently, there may be a need to use newer PLC technology from such manufacturers as Opto 22 or an Opto 22/Allen-Bradley combination which is used in other systems at Bonneville. The DSM air burst system and VBS both use Opto 22 hardware and then newer domestic water system uses Opto 22/Allen Bradley technology. Using the existing SyMax PLC would be less expensive than using all new hardware but its life expectancy and technical support from the manufacturer could be limited. PLC and HMI programming would need to be performed for either option.

5.4.4. Structural Design Components

Assume using new inner diameter and keeping the old outside diameter and existing bolts.

5.5. ALTERNATIVE A5 – REDUCE ORIFICE RING SIZE TO 12 INCHES IN DIAMETER AND SEASONALLY MODIFY OPERATION OF DSM SYSTEM

5.5.1. General Description

The maximum allowable velocity through the dewatering screens for the existing system is 0.4 fps (fry criteria). This limits the amount of flow that the dewatering system can handle. Currently, orifices are opened/closed to maintain a downstream collection channel depth of 13.2 feet for full range of forebays. This alternative proposes a modification to the maximum screen velocity to 0.6 fps (fingerling criteria) for a portion of the fish passage season for which fry have already passed downstream. This criteria change would allow approximately 100 cfs of additional flow into the system. Approximately 14 new orifices (56 total) could be operated by modifying the all of the south orifices that have been cored and blind flanged. Four additional orifices (60 total) in units 11 and 12 could be cored and gated and still remain within the 100 cfs additional flow gained by the change in criteria. However, there is not a significant biological gain for the extra cost of coring 4 new orifices so the maximum of 56 orifices would be made operative for this alternative. Hydraulic challenges for this alternative include re-setting the dewatering gates mid-season for fry criteria. This will likely be a difficult task and success of this alternative is contingent on adequate drainage downstream of the weirs.

Similar to Alternative A4, preliminary air demand calculations indicate approximately 2.1 cfs for a 12-inch diameter orifice and a 15-inch steel pipe I.D. This will also impact the existing collection channel velocities (see Appendix A for comparison of channel velocities for 13-inch versus 12-inch orifice rings).

5.5.2. Mechanical Design Components

In addition to the work covered under Section 5.4.2, five additional gate valve systems would be added to existing south orifice cores 17B, 17C, 18A, 18B, and 18C.

5.5.3. Electrical Design Components

Similar electrical equipment and wiring as discussed in Section 5.4.3 will need to be installed to support the additional 14 gate valve systems.

5.5.4. Structural Design Components

See Section 5.4.4.

5.6. ALTERNATIVE A6 – CAMERA IN BULKHEAD FOR VISUAL INSPECTION

5.6.1. General Description

This alternative provides a different means of monitoring the orifice entrance for potential debris blockage using submersible cameras in the bulkhead slot for viewing. This would allow other downstream options to include bottom supported jet flow (Alternative A9) alleviating potential jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems and can be combined with Alternative A9.

5.6.2. Mechanical Design Components

Due to space limitations in the bulkhead slot, a submersible camera would require a steel frame for deployment, similar to the frame used to inspect the vertical barrier screen (VBS) and STS (Figure 5-4). The frame would be left in place until that slot needed to be accessed. This alternative assumes that the water is clear enough for adequate visibility. It is assumed that the lights from the new light rings would provide adequate light to provide a silhouette of the debris blocking the orifice. This visual indication of debris would be used to determine if an orifice should be manually cleaned or not. If the amount of light is not adequate, then it may not be possible to add additional lights to the frame since it could possibly distract the fish in the gatewell from noticing the orifice light rings. The frame would allow for easy extraction of the cameras for maintenance and could simplify the install. The camera frame would need to be extracted by the second powerhouse gantry crane or a mobile crane.

5.6.3. Electrical Design Components

The cameras would require submersible fiber optic data cable, power cable, fiber optic/coax receivers for each camera feed, a central processor/matrix switcher receiver, and at least one monitor for control room viewing. Moreover, each camera would require an ac/dc converter to provide the necessary 12VDC in which case dedicated 120VAC power from a nearby panelboard in the gallery would be required.

5.6.4. Structural Design Components

This assumes the camera is deployed using a steel frame similar to the current camera frame used to inspect the VBS and STS. This additional camera will utilize the VBS slot (see frame in Figure 5-4).

Figure 5-4 Alternative A6 – Camera in Bulkhead for Visual Inspection

5.7. ALTERNATIVE A7 – PRESSURE TRANSDUCER ACROSS ORIFICE OPENING

5.7.1. General Description

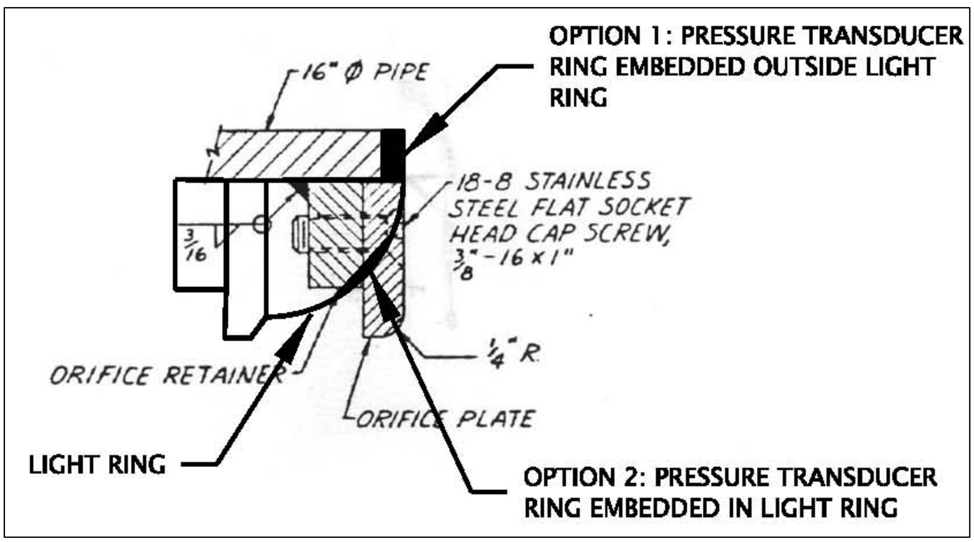
This alternative provides a different means of monitoring orifice entrance for potential debris blockage using pressure transducers across the orifice opening in the bulkhead slot to sense blockage. This would allow an alternative downstream option to the free jet such as a bottom supported jet (Alternative A9), alleviating potential for jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems.

5.7.2. Mechanical Design Components

There are two options for this alternative.

- Option 1: The pressure transducer ring could be incorporated into the light ring. When debris is present, it would get lodged across the light ring and create a rise in pressure on the pressure ring. This increase in pressure would be signaled to the operators and the orifice could then be manually cleaned. To accomplish this, a local monitoring device which accepts a 4-20 mA signal from the transducer and closes an output contact if the input signal falls outside of an acceptable range—a clogged condition. The output contact could be tied to a discrete input point of the existing PLC.
- Option 2: The transducer could be mounted just outside the light ring embedded in the wall. The ring's function would be the same as Option 1 but would be used in case the pressure transducer ring was too large to fit inside the light ring (Figure 5-5).

Figure 5-5. Alternative A7 – Pressure Transducer Across Orifice Opening



5.7.3. Electrical Design Components

Materials would include a local pressure monitoring device for each orifice, submersible signal cable, conduit, and wiring between the output contact and a digital input on the existing SyMax PLC and submersible signal cable. The SyMax PLC has 18 spare inputs which would not be enough for 42 orifice transducers thus an additional two 16-point digital input modules would need to be installed in the PLC rack. Furthermore, the transducers would require one or multiple 24 VDC power supplies for loop power. However, as discussed in Alternative A4 (5.4.3) if the Bonneville project personnel expressed a desire to move away from using the existing PLC system then this alternative would also include new PLC hardware as mentioned in Alternative A4.

5.7.4. Structural Design Components

Assume using existing light tube for electrical cable and conduit routing with the pressure transducer power and signal cable being rated for submersible use.

5.8. Alternative A8 – Sonic/Acoustic Sensor Across Orifice

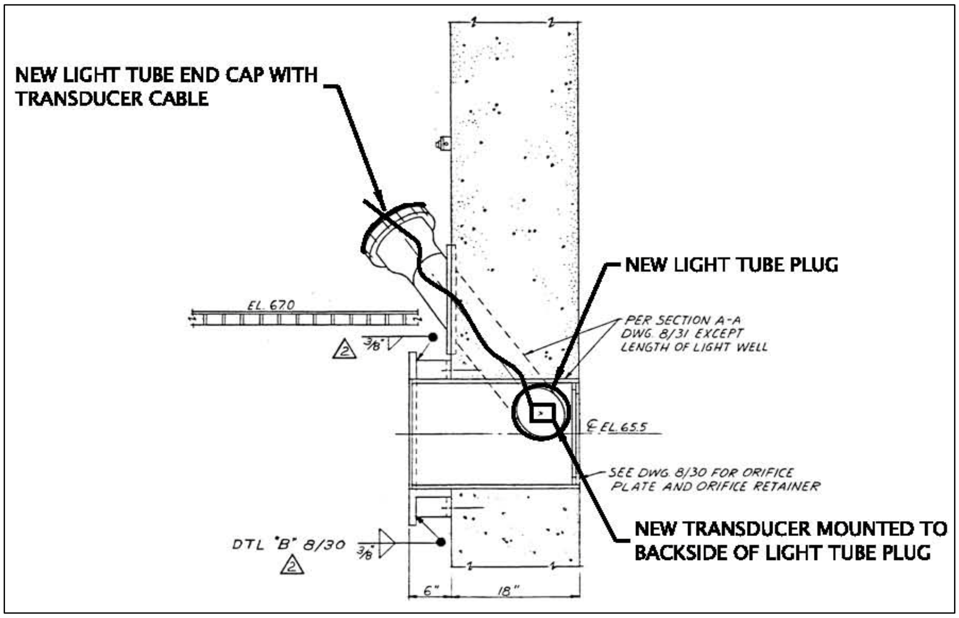
5.8.1. General Description

This alternative provides a different means of monitoring orifice entrance for potential debris blockage using sonic/acoustic sensors across orifice openings. This would also allow the pipe to flow full (Alternative A10) eliminating potential jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems.

5.8.2. Mechanical Design Components

This alternative uses a sonic sensor to measure turbulence in the pipe and compare it to turbulence observed with a clean orifice. When the orifice is blocked, flow becomes more turbulent and thus, the operators would know that the orifice was blocked based on the output of the sonic sensor. The operators could initiate a cleaning cycle from the control room specifically for that blocked orifice instead of cleaning all of them. A sensor would need to be installed in each orifice pipe sleeve and connected to a PLC for reporting. The existing light tubes and pipe sleeve would need to be modified to accommodate the transducer. A steel plate plug would be installed in the existing light tube opening and the transducer would be mounted to the backside of the plate inside the light tube space. The signal cable from the transducer would run up through a new cap that would seal the light tube in place of the lens (Figure 5-6).

Figure 5-6. Alternative A8 – Sonic/Acoustic Sensor Across Orifice



5.8.3. Electrical Design Components

Electrical requirements would be similar to that described in 5.7.3.

5.8.4. Structural Design Components

No structural effort noted.

5.9. ALTERNATIVE A9 – PIPE INSERT TO ACT AS TROUGH

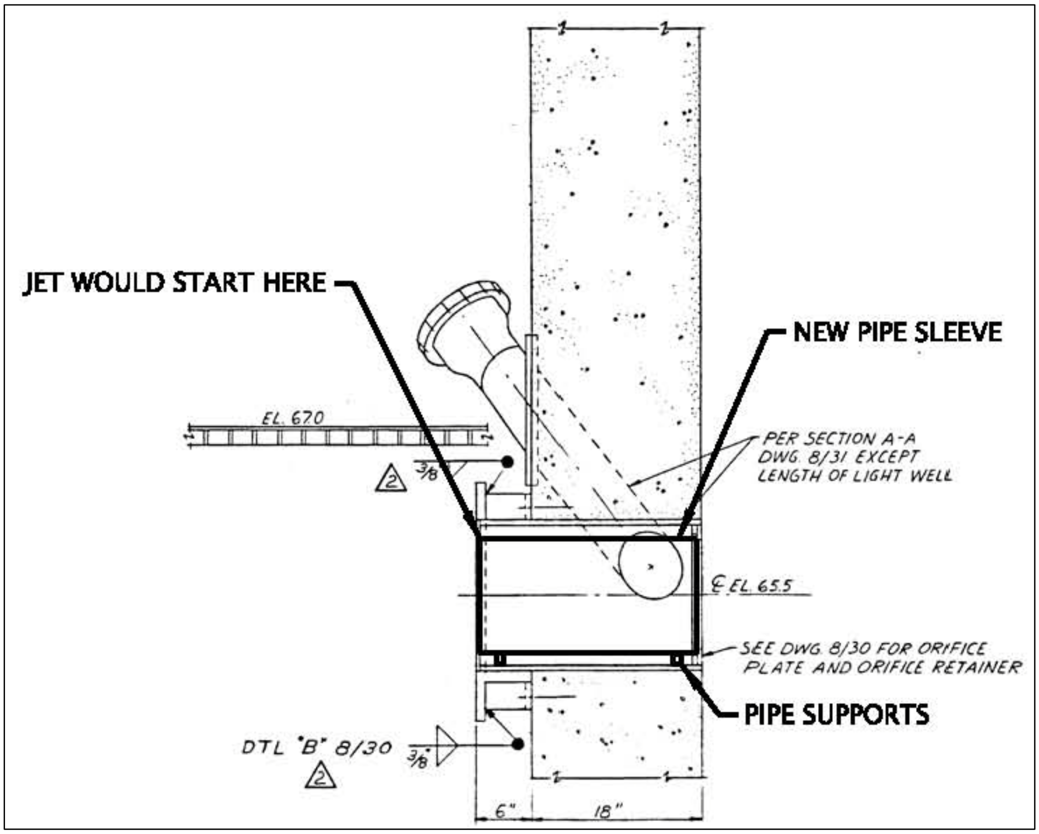
5.9.1. General Description

This alternative could be combined with Alternatives A6 and A7. The insert would support the underside of the jet, eliminating opportunity for impingement at the orifice exit. This alternative would apply to the 42 existing gated orifice systems.

5.9.2. Mechanical Design Components

A painted or stainless steel pipe with the same I.D. as the orifice would be installed in the existing pipe sleeve and be sealed against the back side of the orifice ring (Figure 5-7).

Figure 5-7. Alternative A9 – Tube Insert to Act as Trough



5.9.3. Electrical Design Components

No electrical work required.

5.9.4. Structural Design Components

No structural effort noted.

5.10. ALTERNATIVE A10 – ROUND ENTRANCE PIPE INSERT

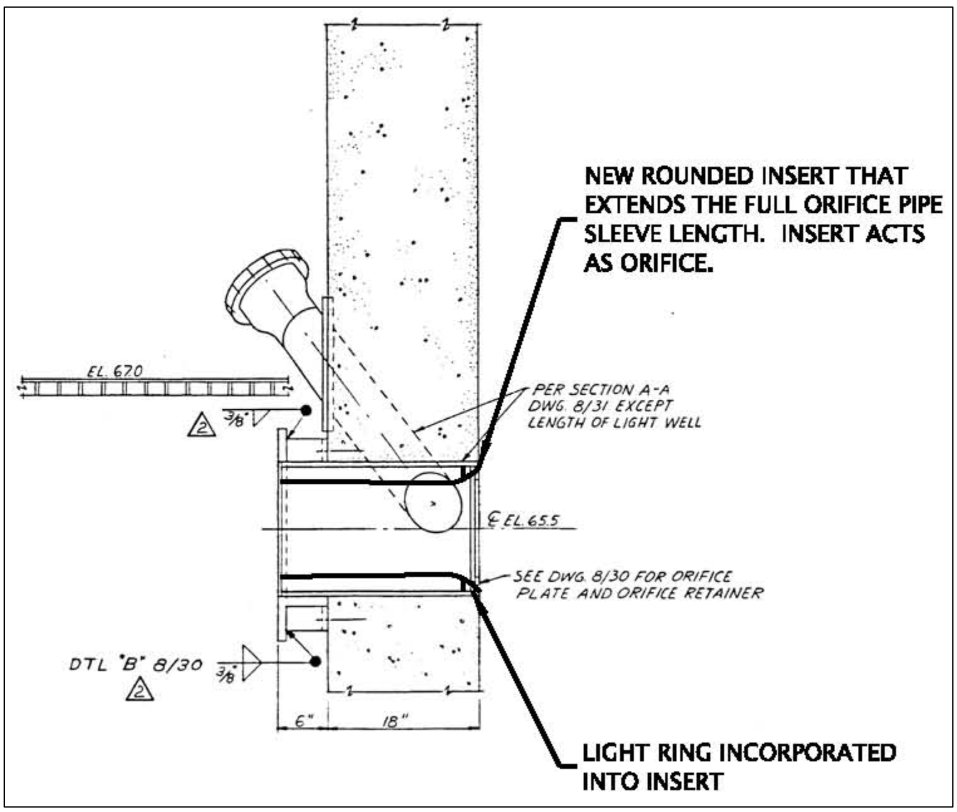
5.10.1. General Description

This alternative could be combined with Alternative A8. The rounded entrance tube insert would support the full flow jet, eliminating opportunity for impingement at the orifice exit. This alternative would apply to the 42 existing gated orifice systems.

5.10.2. Mechanical Design Components

The insert would most likely be a casting to make sure that the correct profile is achieved. The casting would be anchored to the existing pipe sleeve and/or orifice retainer (Figure 5-8).

Figure 5-8. Alternative A10 – Round Entrance Tube Insert



5.10.3. Electrical Design Components

No electrical work required.

5.10.4. Structural Design Components

Provide a full flow jet supported all of the way to the gate housing by adding an insert likely with rounded entrance and potentially expanding diameter downstream. Insert would be sized to provide comparable flow to existing.

5.11. Alternative A11 – Minimize Overall Length of Pipe and Mounting Flange

5.11.1. General Description

Several field observations have indicated that the quality of the jet tends to be better for those orifices where the concrete was chipped away at the exit to allow the gate to align as closely as possible with the downstream wall (Table 3-1). This occurs on nine of the existing working orifices. This alternative would be combined with Alternatives A1-A5 to reduce opportunity for jet trajectory impingement and further reduce the air deficit. This alternative would apply to approximately 33 of the 42 existing gated orifice systems and all newly opened orifices depending on the alternative.

5.11.2. Mechanical Design Components

There are two different sizes of actuators used on the orifice gate valves. The smaller of the two is used on orifices such as 12A-N. On orifices like 12A-N the concrete has been chipped away to allowing room for the actuator to be recessed into the concrete. This also allows the gate valve to be mounted flush with the mounting plate giving an overall distance of 0.6 inches from DSM wall to upstream face of the gate.

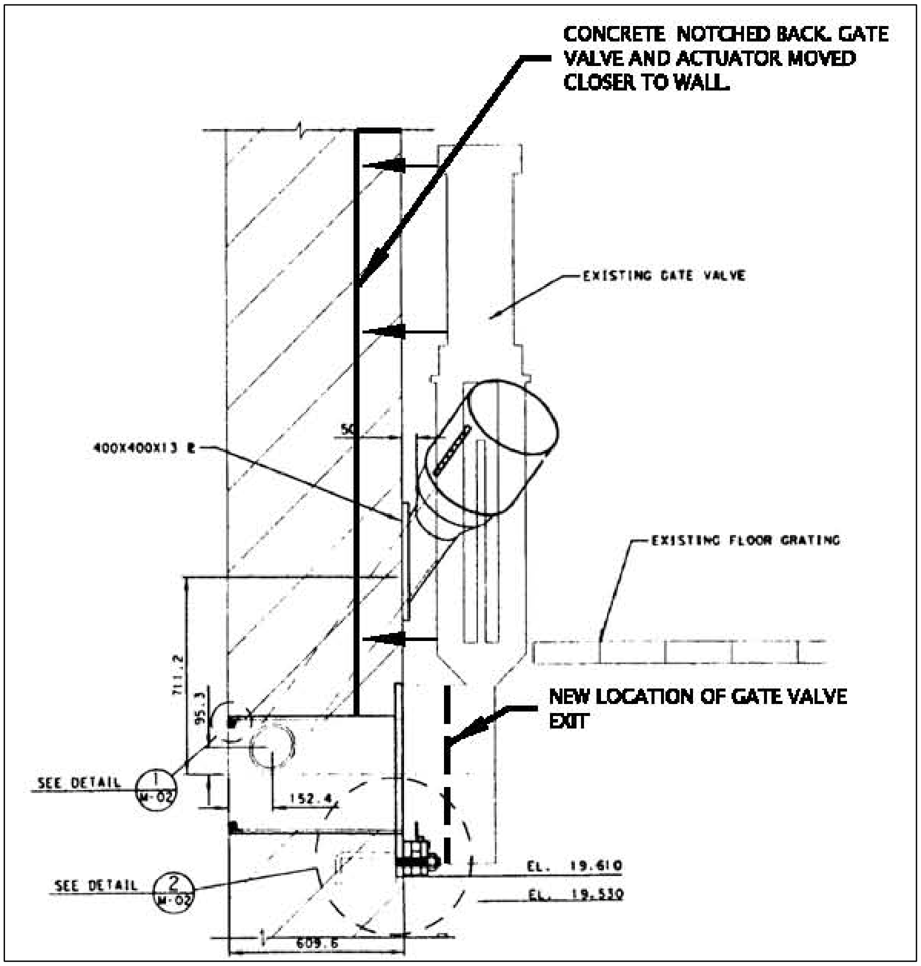
Although the smaller actuators were used on many of the orifices, orifices such as 14A-N did not have the concrete removed so the gate valve had to be mounted offset from the wall using spacer rings to allows clearance for the actuator. This results in an overall distance of 4.2 inches from DSM wall to upstream face of the gate.

The larger actuators are used on orifices such as 14A-S. The concrete was not removed at any these orifices and to provide clearance for the larger actuators the gate valves were offset further resulting in an overall distance of 7.2 inches from DSM wall to upstream face of the gate.

This alternative would remove the concrete as needed to allow all of the gate valves to be mounted flush on the mounting plate resulting in a uniform 0.6 inch offset between valve gate and DSM wall. This reduces the distance required for the jet to clear the gate valve housing and also reduces the distance required for the air to reach and support the jet.

The majority of the existing mechanical components would be reused for this option. The pneumatic piping would need to be modified at the end connections to match the slightly relocated pneumatic actuators (Figure 5-9). Each valve would be recessed according to the size of the pneumatic actuator.

Figure 5-9. Alternative A11 – Minimize Length of Pipe and Mounting Flange



5.11.3. Electrical Design Components

No electrical work required.

5.11.4. Structural Design Components

This will require mining out the concrete surrounding the actuator and installing a galvanized steel frame around the excavation. The affected area of concrete would be about 3 cubic feet of mining. The frame would be roughly 8 feet of 8 x 2 x ¼-inch pipe that is steel grouted and anchored into the concrete.

5.12. ALTERNATIVE A12 – REPLACE EXISTING ORIFICE RING WITH LIGHTED ORIFICE RING

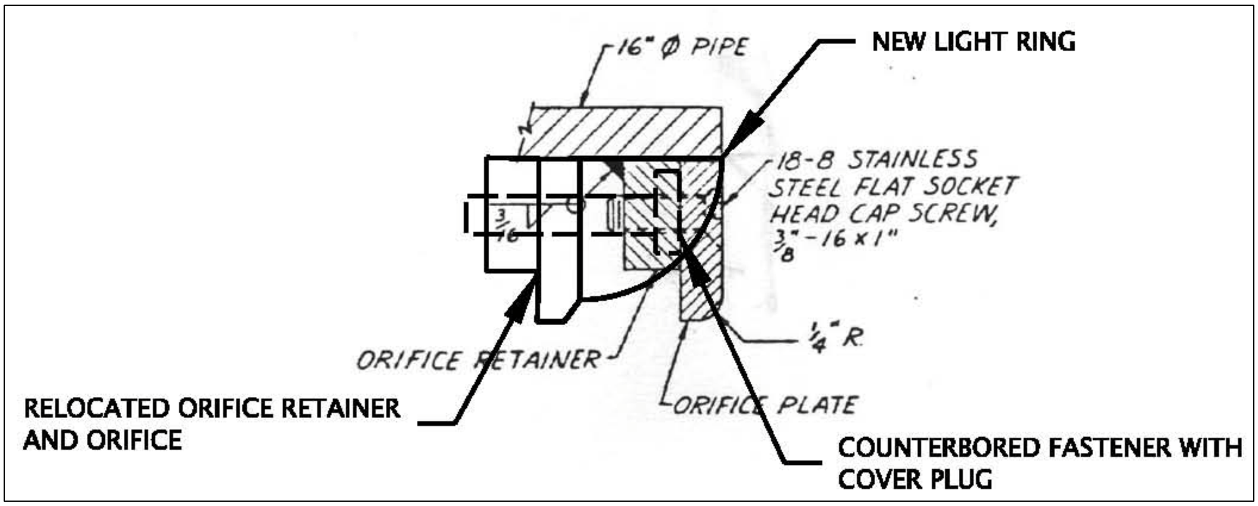
5.12.1. General Description

This alternative will be undertaken in conjunction with any chosen alternative. Number of lighted orifice rings will be determined by alternative chosen.

5.12.2. Mechanical Design Components

The new light ring can be mounted inside the existing orifice pipe sleeve. The outside of the light ring would be flush with the wall inside the gatewell. In order to accommodate the light ring, the orifice retainer would need to be relocated further back inside the pipe sleeve. The light ring would be mounted using the same fasteners as the orifice ring. A new retainer ring and fasteners would be required since the existing components will most likely be destroyed during removal (Figure 5-10).

Figure 5-10. Alternative A12 – Replace Orifice with Lighted Orifice Ring



5.12.3. Electrical Design Components

The lighted orifice ring would be comprised of LED lights encased in clear epoxy, similar to acrylic. The light ring would emit 27-28 foot-candles, equivalent to 300 lux. Each ring would include a power supply transformer that plugs into an existing 120V receptacle that is currently used for the existing incandescent orifice lights. These existing lights will be removed and an abandoned light tube can be used to route the power cable from the new LED light to the 120V receptacle. Multiple light segments can be contained in the ring to serve as switchable backup lighting should an active light segment fail thereby maintaining the necessary illumination. As a means of indication if a light segment fails, a photocell could be used to detect light emitted from the LED ring and turn on an indicator light in the gallery to signal if a light has failed and requires replacement.

5.12.4. Structural Design Components

Possibly mining out the existing concrete where the light tube and ring anchor. Grout back the new orifice ring and install new anchors.

6. ALTERNATIVES EVALUATION

6.1. ALTERNATIVES MATRIX

An alternative matrix (Table 6-1) was used to evaluate and compare the 12 alternatives developed in this study. The alternatives were grouped together by concept and rated for the following seven attributes (without weighting factors):

- Observable passage route
- Fish condition with modification
- Alignment with DSM criteria
- Technical viability
- O&M cost
- Ease of testing proof of concept
- Construction timing

Scoring ranged from 1 to 4 (poor to excellent) for all but the O&M cost category, which ranged from 0 to 4 (high to low). Comments related to the alternatives during the matrix evaluation are in black type in Table 6-1. Additional comments from Fish Facilities Design and Review Work Group (FFDRWG) members at the 17 August 2011 special FFDRWG meeting are included in red in the table.

First-round scoring did not include construction cost considerations, nor weighting factors. Based on the seven attributes shown above, the top six alternatives included:

1. A1: Add compressed air to orifice tube (13-inch orifice rings).
2. A2: Vent orifice tube using existing light tube ports (13-inch orifice rings).
3. A3: Re-core orifice tube to larger size (13-inch orifice rings).
4. A4: Reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.
5. A5: Seasonally increase capacity of DSM, reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.
6. A6: Install cameras in gatewell for visual inspection upstream in conjunction with Alternative A9 (tube insert).

Second-round scoring included construction cost as an additional rated item to the top-rated alternatives previously chosen, along with weighting factors that were applied to each rated item (in parenthesis below):

- Observable passage route (3)
- Fish condition with modification (2.5)
- Alignment with DSM criteria (2)
- Technical viability (1)
- O&M cost (1)
- Ease of testing proof of concept (1)
- Construction timing (1)
- Construction cost (1)

Table 6-1. Alternatives Matrix

B2 Orifice Improvements - Alternatives Matrix (17 August 2011 FFDRWG comments included in red)

Concept	No.	Description	Orifice Ring Size	Observable Passage Route	Fish Condition With Modification	Alignment With DSM Criteria	Technical Viability	O & M Cost	Ease of Testing Proof of Concept	Construction Timing	Comments	Total Score for all Alternatives - No Weighting	Construction Cost -- (Added to top 5 scored alternatives only)	Top 5 Total Scores With Construction Cost Added and Weighting Factors Applied
	Weighting Factors - Used on Top 5 of Initial Scores =			3	2.5	2	1	1	1	1		Top 6 Alternatives	Additional Rated Item - Weighting = 1	Top 3 Alternatives
	Alternatives			Rated Item	Rated Item	Rated Item	Rated Item	Rated Item	Rated Item	Rated Item			Rated Item	
Alternatives That Allow Observable Passage Route														
Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice	1	Add Compressed Air to Orifice Tube	13"	3	3	3	2	0	3	3	Ability to provide and maintain necessary air would be impractical due to space requirements, O&M costs & risk of compressor outage	17	1	31.5
	2	Vent Orifice Tube Using Existing Light Tube Ports	13"	2	2	3	2	3	3	3	Not likely enough air could be pulled in through light tubes based on field tests	18	3	31
	3	Re-Core Orifice Tube to Larger Size	13"	3	4	3	3	3	3	1	Larger orifice ring size with larger diameter tube preferred by several members of FFDRWG - more similar to original design ring to tube diameter ratio and less potential for debris blockage	20	0	35
Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice + Add More Opportunity for Exposure With Additional Orifices	4	Reduce Orifice Ring Size <= 12" & Open Additional Orifices as Needed	<= 12"	3	3	2	4	2	3	3	Possibly more debris blockage; Concern with increased adult fallback injury with smaller orifice rings	20	2	34.5
	5	Increase Capacity of DSM, Reduce Orifice Ring Size <= 12" & Open Additional Orifices as Needed and/or Add Gates/Rings to Additional S. Entrances	<= 12"	3	3	2	3	2	3	3	Possibly more debris blockage; Concern with increased adult fallback injury with smaller orifice rings	19	2	33.5
Provide Observable Passage Route Upstream of Orifice	6	Cameras in Gatewell for Visual Inspection Upstream In Conjunction With Alt. # 9	13"	4	3	3	1	1	3	2	Large O&M cost and interference with existing fish operations, therefore not included in top 5	17	x	x
	7	Pressure Transducers Across Orifice Openings In Conjunction With Alt. #9	13"	3	3	3	1	1	2	2	Interest in full flow option, but concern with debris jamming inside and whether debris blockage at entrance could be "seen"	15	x	x
	8	Sonic/Acoustic Sensors Across Orifice Openings in Conjunction With Alt. # 10	13"	3	2	3	1	1	2	2	Would require full pipe/tube flow in conjunction with Alt #10	14	x	x
Alternatives That Reduce jet Impingement in Conjunction With Alternatives 6-8														
Reduce Jet Impingement in Conjunction With Alts #6-7	9	Tube Insert in Bottom to Support Bottom of Jet to the full length of Tube	-	x	x	x	x	x	x	x	As Alts 6-8 have lowest Ratings - These add-on alternatives are not ranked.	x	x	x
Reduce Jet Impingement in Conjunction With Alt. # 8	10	Rounded Entrance Tube Insert Flowing Full in conjunction w/ Alt. # 8 only	-	x	x	x	x	x	x	x	As Alt #8 has lowest Rating - This add-on alternative is not ranked. Interest in full flow option, but concern with debris jamming inside and whether a debris blockage at entrance could be "seen"	x	x	x
Alternatives That will be Included With any Chosen Alternative														
Reduce Potential for Jet Impingement in Conjunction With Chosen Alternative	11	Reduce Effective Orifice Tube Length by Removing Wall Concrete at Exit For ~17 N. Orifices in Units 12-15 as well as all working S. Orifices.	-	No Ranking - Assumed to be Ancillary to any Alternative.							Field assessments indicate existing orifice exits with this installation provide better jet hydraulics in S. Orifices especially for low TW. Assumed repositioning existing gates would be extension of current as built design and ancillary to chosen alternative.	x	x	x
Increase Fish Attraction in Conjunction With Chosen Alternative	12	Replace Orifice Rings with Light Emitting Orifice Rings	-								Testing at McNary Dam in 2010 showed high potential for attraction and deemed ancillary to chosen alternative.	x	x	x

NOTES:

(stippled) 22	Alternatives 9-10 not considered viable alternatives as they would only be used in conjunction with alternatives 6-8 that had the lowest ratings.
x	No ratings for these alternatives as they are paired with alternatives 6 - 8 which were ranked low.
(tan)	Top 6 Scores for 7 rating categories (no weighting or construction cost)
(green)	Of the Top 6 Scores: Top 3 Scores for 8 rating categories and weighting (added construction cost)
(light blue)	Ancillary features to be included in chosen alternative
Concern with injury	Comments from FFDRWG, 17 August 2011

Criteria for Ranking:

General Scoring:	Cost Scoring:
	high = 0
Poor = 1	Medium-High = 1
Fair = 2	Medium = 2
Good = 3	Low-Medium = 3
Excellent = 4	Low = 4

The second-round scoring resulted in the following top three alternatives:

1. A3: Re-core orifice tube to larger size (13-inch orifice rings).
2. A4: Reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.
3. A5: Seasonally increase capacity of DSM, reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.

Below is a summary of the number of orifices that will need to be modified by Alternatives 3, 4 and 5.

Table 6-2. Orifice Modifications by Powerhouse Unit Groupings & Top Three Alternatives

					Alt 3	Alt 4	Alt 5
Orifice Groupings	Number Operating Orifices/Bay	Number of Bays per Unit	Number of Units	Available Pre-Drilled Holes Without Gates	Replace Existing Working Orifices With 18" Pipe & 13" Orifice Ring	Additional Orifices With 12" Ring That Would be Added To Maintain Current Channel Flow	Additional Orifices With 12" Ring That can be Added by Increasing Flow by ~100 cfs Using Existing Pre-Cored Holes
Units 11-14	2	3	4	0	24	0	0
Units 15-18	1	3	4	12	12	7	5
Fish Unit #1	1	2	1	2	2	0	2
Fish Unit #2	2	2	1	0	4	0	0
Subtotal of Orifices			10	14	42	7	7
Total Number of Orifices by Alternative					42	49	56

6.2. PRELIMINARY COST ESTIMATES FOR TOP THREE ALTERNATIVES

Table 6-3 summarizes the preliminary costs for the top three alternatives. A breakdown of the costs is located in Appendix B, *Cost Estimate.*

Table 6-3. Preliminary Alternative Costs for Top Three Alternatives

B2 Orifice Improvements 2012					
Preliminary Cost Estimate (Rounded to 100,000$)					
Prepared by: RLR					
10/25/2011					
Modified by: KAK 11/23/11					
Physical Description	Re-core opening for 18" ID pipe; Minimize overall pipe length; Replace 12 5/8" orifice rings With 13" LED orifice rings.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Operate with additional orifices to maintain current channel operation/flow.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Modify screen velocity criteria for part of fish passage season to operate with additional flow allowing additional orifices to open.	Minimize overall pipe length.	Replace 12 5/8" orifice ring with LED orifice ring.
(costs rounded to $100k)	**Alt 3 (42 Orifices Modified)**	**Alt 4 (49 Orifices Modified)**	**Alt 5 (56 Orifices Modified)**	**Alt 11 only (42 Orifices Modified)**	**Alt 12 only (42 Orifices Modified)**
Direct Costs	$4,000,000	$2,100,000	$3,000,000	$900,000	$1,500,000
Markups (Overhead, Profits, Bond, tax, OT)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
SUBTOTAL COSTS	$6,200,000	$3,200,000	$4,600,000	$1,400,000	$2,300,000
CONTINGENCY (35%)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
TOTAL ESTIMATE CONSTRUCTION COST	**$8,400,000**	**$4,300,000**	**$6,200,000**	**$1,900,000**	**$3,100,000**
NOTES					
Escalation & Inflation NOT included					
Engineering, Supervision, Admin, etc costs NOT included					
Alternative 3: Utilizes the 42 existing gated orifices; Provides aerated jets, maintains similar jet flows, reduces opportunity for impingement, increases attraction through light ring.					
Alternative 4: Utilizes the 42 existing gated orifices; Requires 7 additional gate systems for currently blind flanged orifices; Provides aerated jet maintaining current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower flows, increases attraction through light ring.					
Alternative 5: Utilizes the 42 existing gated orifices; Requires 14 additional gate systems for currently blind flanged orifices; Increases DSM system flow with seasonally modified criteria at dewatering screens; Provides aerated jet increasing current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower forebays, increases attraction through light ring.					
Alternative 11: Utilizes the 42 existing gated orifices; Reduces probability for jet impingement at lower forebays.					
Alternative 12: Utilizes the 42 existing gated orifices; Increases attraction through light ring.					
Cost of Alt 11 & Alt 12 cannot be subtracted from the Other alternatives due to work not being mutually exclusive					
Cost of "Alt 11" only cannot be added to "Alt 12 only" due to overlapping costs/tasks.					
Nine Orifice lengths have already have been shortened by concrete mining. Costs in this spreadsheet do not reflect the reduction in cost for these orifices.					

6.3. REGIONAL COORDINATION

Regional review of this EDR has been conducted through the FFDRWG. This body made up of federal, state and tribal partners who work closely with the USACE to provide input and comment on major improvements at Columbia River Fish Mitigation projects. FFDRWG has been briefed of progress throughout the study. Comments received from the 60% EDR are included in Appendix C. Responses to these comments will be discussed at the scheduled April FFDRWG meeting. Responses to comments and pertinent discussions will be included in the 100% report.

7. RECOMMENDATION

7.1. FOR ALL MAJOR ALTERNATIVES CONSIDERED, ALTERNATIVES A11 AND A12 WERE ASSUMED TO BE INCLUDED:

- A11 – Minimize Overall Length of Pipe and Mounting Flange
- A12 – Replace Existing Orifice Ring with Lighted Orifice Ring

7.2. ALTERNATIVE A5 – SEASONALLY INCREASE CAPACITY OF DSM, REDUCE ORIFICE RING SIZE TO 12" AND OPEN ADDITIONAL ORIFICES AS NEEDED TO MAINTAIN CHANNEL DESIGN FLOW AND VELOCITIES

Based on strong environmental Agency concerns for relaxing the dewatering screen velocity criteria for part of the fish passage season, Alternative A5 is no longer being considered.

7.3. ALTERNATIVE A3 – RE-CORE ORIFICE TUBE TO LARGER SIZE, INSTALL LARGER I.D. TRANSPORT PIPE OF 18", REPLACE 12 5/8" ORIFICE RING WITH 13"ORIFICE RING

Based on large cost of $8.4M (compared to $4.3M for A4), Alternative A3 is no longer being considered.

7.4. ALTERNATIVE A4 – REDUCE ORIFICE RING SIZE TO 12" AND OPEN ADDITIONAL ORIFICES AS NEEDED TO MAINTAIN CHANNEL DESIGN FLOW AND VELOCITIES

Alternative A4 in conjunction with Alternative A11 and A12 was chosen as the recommended alternative due to its ability to meet all goals outlined in the study:

- Improve the ability for the project operators to detect debris plugs in the orifice;
- Reduce the likelihood of fish impingement due to alignment of orifice flow, and
- Improve gatewell egress times with improved lighting.

The major components of this alternative are the following:

- Replace 12 5/8 inch orifice rings with 12 inch lighted orifice rings to:
  - Bring hydraulics back to a cohesive jet that can be used to detect debris plugs at the orifice entrance;
  - Reduce residence time in gatewell by increasing probability of fish locating and entering orifice opening through light attraction.
- Mine out concrete on collection channel side of gatewell wall to inset the larger actuators allowing slide gates to be closer to the entrance of the orifice pipe. This will effectively decrease the distance the jet will need to travel to clear the gate housing preventing impingement. Table 7-1 shows the locations of the major components of A4.

Table 7-1. Major Components of Alternative A4 by Orifice

Orifice	Current Actuator Type	Recommended Alternative (Alt 4)		
		Mine Concrete to Reduce Gap Btn Wall & Gate	Flanged Cores/Tubes to be Gated	12" Lighted Orifice Rings
11 A (S)	Blue	X		X
11 A (N)	Silver	X		X
11 B (S)	Blue	X		X
11 B (N)	Silver	X		X
11 C (S)	Blue	X		X
11 C (N)	Silver	X		X
12 A (S)	Blue	X		X
12 A (N)	Silver-Recessed	NA		X
12 B (S)	Blue	X		X
12 B (N)	Silver-Recessed	NA		X
12 C (S)	Blue	X		X
12 C (N)	Silver-Recessed	NA		X
13 A (S)	Blue	X		X
13 A (N)	Silver-Recessed	NA		X
13 B (S)	Blue	X		X
13 B (N)	Silver-Recessed	NA		X
13 C (S)	Blue	X		X
13 C (N)	Silver-Recessed	NA		X
14 A (S)	Blue	X		X
14 A (N)	Silver	X		X
14 B (S)	Blue	X		X
14 B (N)	Silver	X		X
14 C (S)	Blue	X		X
14 C (N)	Silver	X		X
15 A (S)	Blind-Flanged	X	X	X
15 A (N)	Silver-Recessed	NA		X
15 B (S)	Blind-Flanged	X	X	X
15 B (N)	Silver-Recessed	NA		X
15 C (S)	Blind-Flanged	X	X	X
15 C (N)	Silver-Recessed	NA		X
16 A (S)	Blind-Flanged	X	X	X
16 A (N)	Silver	X		X
16 B (S)	Blind-Flanged	X	X	X
16 B (N)	Silver	X		X
16 C (S)	Blind-Flanged	X	X	X
16 C (N)	Silver	X		X
17 A (S)	Blind-Flanged	X	X	X
17 A (N)	Silver	X		X
17 B (S)	Blind-Flanged			
17 B (N)	Silver	X		X
17 C (S)	Blind-Flanged			
17 C (N)	Silver	X		X
18 A (S)	Blind-Flanged			
18 A (N)	Silver	X		X
18 B (S)	Blind-Flanged			
18 B (N)	Silver	X		X
18 BC(N)	Blind-Flanged			
18 C (N)	Silver	X		X
		X		X
F1 A (N)	Silver	X		X
F1 B (N)	Silver	X		X
F2 A (S)	Blue	X		X
F2 A (N)	Black/Silver	X		X
F2 B (S)	Blue	X		X
F2 B (N)	Black	X		X
Total No. Orifices		**40**	**7**	**49**

- Table 7-2 shows a preliminary comparison of channel velocities between the 1997 design flows/velocities and the proposed Alternative A4 flows/velocities.

Table 7-2. Preliminary Comparison of Channel Velocities Between the 1997 Design Flows/Velocities and the Proposed Alternative A4 Flows/Velocities

Estimated Change in Collection Channel Hydraulics Between 1997 Design and Alternative A4

Channel Discharge Increases Down Page S to N	FB 71.5 ft				FB 74.5 ft				FB 76.5 ft			
	Orifice Discharge (cfs)		Channel Velocity (fps)		Orifice Discharge (cfs)		Channel Velocity (fps)		Orifice Discharge (cfs)		Channel Velocity (fps)	
	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice
↓												
11 A	10.4	8.9	2.0	2.0	13.2	11.2	2.1	2.0		12.6	2.1	2.1
	10.4	8.9			13.2	11.2			14.7	12.6		
11 B	10.4	8.9	3.0	2.8	13.2	11.2	3.4	3.1		12.6	2.7	3.3
	10.4	8.9			13.2	11.2			14.7	12.6		
11 C	10.4	8.9	3.3	3.0	13.2	11.2	3.9	3.5		12.6	2.9	3.7
	10.4	8.9			13.2	11.2			14.7	12.6		
12 A	10.4	8.9	3.4	3.1		11.2	3.8	3.7		12.6	2.9	3.9
	10.4	8.9			13.2	11.2			14.7	12.6		
12B	10.4	8.9	3.6	3.3		11.2	3.8	3.9		12.6	3.0	4.2
	10.4	8.9			13.2	11.2			14.7	12.6		
12 C	10.4	8.9	3.8	3.4		11.2	3.7	4.1			3.1	4.1
	10.4	8.9			13.2	11.2			14.7	12.6		
13 A	10.4	8.9	3.9	3.5		11.2	3.6	4.1			3.1	4.0
	10.4	8.9			13.2	11.2			14.7	12.6		
13 B	10.4	8.9	4.0	3.5		11.2	3.6	4.2			3.1	3.9
	10.4	8.9			13.2	11.2			14.7	12.6		
13 C	10.4	8.9	4.0	3.6			3.6	4.1			3.1	3.8
	10.4	8.9			13.2	11.2			14.7	12.6		
14 A	10.4	8.9	4.0	3.6			3.5	3.9			3.1	3.7
	10.4	8.9			13.2	11.2			14.7	12.6		
14 B	10.4	8.9	4.1	3.6			3.4	3.8			3.1	3.6
	10.4	8.9			13.2	11.2			14.7	12.6		
14 C	10.4	8.9	4.1	3.6			3.4	3.7			3.1	3.6
	10.4	8.9			13.2	11.2			14.7	12.6		
15 A		8.9										
	10.4	8.9	3.9	3.5	13.2	11.2	3.3	3.6	14.7	12.6	3.0	3.4
15 B		8.9										
	10.4	8.9	3.8	3.5	13.2	11.2	3.2	3.5	14.7	12.6	3.0	3.4
15 C		8.9										
	10.4	8.9	3.7	3.5	13.2	11.2	3.2	3.4	14.7	12.6	3.0	3.3
16 A		8.9										
	10.4	8.9	3.7	3.6	13.2	11.2	3.2	3.4	14.7	12.6	3.1	3.4
16 B		8.9										
	10.4	8.9	3.7	3.7	13.2	11.2	3.3	3.5	14.7	12.6	3.2	3.4
16 C		8.9										
	10.4	8.9	3.7	3.8	13.2	11.2	3.4	3.5	14.7	12.6	3.2	3.5
17 A		8.9										
	10.4	8.9	3.7	3.9	13.2	11.2	3.4	3.5	14.7	12.6	3.3	3.5
17 B	10.4	8.9	3.8	3.9	13.2	11.2	3.5	3.6	14.7	12.6	3.4	3.6
17 C	10.4	8.9	3.8	3.9	13.2	11.2	3.5	3.6	14.7	12.6	3.5	3.6
18 A	10.4	8.9	3.8	3.9	13.2	11.2	3.6	3.6	14.7	12.6	3.5	3.7
18 B	10.4	8.9	3.8	3.9	13.2	11.2	3.6	3.7	14.7	12.6	3.6	3.7
18 C	10.4	8.9	3.9	3.9	13.2	11.2	3.7	3.7	14.7	12.6	3.7	3.8
F1 A	10.4	8.9	3.9	3.9	13.2	11.2	3.7	3.8	14.7	12.6	3.7	3.8
F1 B	10.4	8.9	3.9	4.0	13.2	11.2	3.8	3.8	14.7	12.6	3.8	3.9
F2 A	10.4	8.9	4.0	4.0	13.2	11.2	3.9	3.9	14.7	12.6	3.9	3.9
F2 B	10.4	8.9	4.0	4.0	13.2	11.2	3.9	3.9	14.7	12.6	4.0	4.0
(cfs)	**476.7**	**477.6**			**468.5**	**464.5**			**472.7**	**474.7**		

Dashed Lines Indicate Bays With 2 Orifices

7.5. RECOMMENDED ALTERNATIVE DRAFT TOTAL PROJECT COST

**** **TOTAL PROJECT COST SUMMARY** ****

Printed:3/7/2012
Page 1 of 2

PROJECT: B2 Orifice Improvement Report
LOCATION: Bonneville Dam PwrHse 2

DISTRICT: NWP Portland PREPARED: 3/6/2012
POC: CHIEF, COST ENGINEERING, Michael R. Moran

This Estimate reflects the scope and schedule in report: Bonneville 2nd Powerhouse Orifice Improvements Study EDR March 2012

						Program Year (Budget EC): 2013 Effective Price Level Date: 1 OCT 12				TOTAL PROJECT COST (FULLY FUNDED)				
		ESTIMATED COST				PROJECT FIRST COST				Spent Thru:				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	1-Mar-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
03	RESERVOIRS		-			-								
04	DAMS		-			-								
05	LOCKS		-			-								
06	FISH & WILDLIFE FACILITIES	$3,200	$1,120	35%	$4,320	1.6%	$3,252	$1,138	$4,390			$3,349	$1,172	$4,521
07	POWER PLANT		-			-								
	CONSTRUCTION ESTIMATE TOTALS:	$3,200	$1,120		$4,320	1.6%	$3,252	$1,138	$4,390			$3,349	$1,172	$4,521
01	LANDS AND DAMAGES		-			-								
30	PLANNING, ENGINEERING & DESIGN	$960	$336	35%	$1,296	2.9%	$988	$346	$1,334			$996	$348	$1,344
31	CONSTRUCTION MANAGEMENT	$320	$112	35%	$432	2.9%	$329	$115	$445			$354	$124	$478
	PROJECT COST TOTALS:	$4,480	$1,568	35%	$6,048	2.0%	$4,569	$1,599	$6,168			$4,698	$1,644	$6,343

_______________ CHIEF, COST ENGINEERING, Michael R. Moran

_______________ PROJECT MANAGER, George J. Medina

_______________ CHIEF, REAL ESTATE, xxx

_______________ CHIEF, PLANNING,xxx

_______________ CHIEF, ENGINEERING, Lance A. Helwig

_______________ CHIEF, OPERATIONS, xxx

_______________ CHIEF, CONSTRUCTION, Karen L. Garmire

_______________ CHIEF, CONTRACTING, Ralph Banse-Fay

_______________ CHIEF, PM-PB, xxxx

_______________ CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	100%	**$6,343**
ESTIMATED NON-FEDERAL COST:		
ESTIMATED TOTAL PROJECT COST:		**$6,343**

O&M OUTSIDE OF TOTAL PROJECT COST:

Filename: TPCS_B2orifice90.xlsx
TPCS

****** TOTAL PROJECT COST SUMMARY ******

Printed:3/7/2012
Page 2 of 2

****** CONTRACT COST SUMMARY ******

PROJECT: B2 Orifice Improvement Report
LOCATION: Bonneville Dam PwrHse 2
This Estimate reflects the scope & schedule in report; Bonneville 2nd Powerhouse Orifice Improvements Study EDR March 2012

DISTRICT: NWP Portland
POC: CHIEF, COST ENGINEERING, Michael R. Moran
PREPARED: 3/6/2012

Estimate Prepared: 6-Mar-12
Effective Price Level: 1-Mar-12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

				RISK BASED						FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
03	RESERVOIRS													
04	DAMS													
05	LOCKS													
06	FISH & WILDLIFE FACILITIES	$3,200	$1,120	35%	$4,320	1.6%	$3,252	$1,138	$4,390	2015Q1	3.0%	$3,349	$1,172	$4,521
07	POWER PLANT													
	CONSTRUCTION ESTIMATE TOTALS:	$3,200	$1,120	35%	**$4,320**		$3,252	$1,138	$4,390			$3,349	$1,172	$4,521
01	LANDS AND DAMAGES			35%										
30	PLANNING, ENGINEERING & DESIGN													
4.0%	Project Management	$128	$45	35%	$173	2.9%	$132	$46	$178	2013Q2		$132	$45	$178
	Planning & Environmental Compliance			35%										
19.0%	Engineering & Design	$608	$213	35%	$821	2.9%	$626	$219	$845	2013Q2		$626	$219	$845
2.0%	Engineering Tech Review ITR & VE	$64	$22	35%	$86	2.9%	$66	$23	$89	2013Q2		$66	$23	$89
2.0%	Contracting & Reprographics	$64	$22	35%	$86	2.9%	$66	$23	$89	2013Q2		$66	$23	$89
3.0%	Engineering During Construction	$96	$34	35%	$130	2.9%	$99	$35	$133	2015Q1	7.6%	$106	$37	$143
	Planning During Construction			35%										
	Project Operations			35%										
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$256	$90	35%	$346	2.9%	$263	$92	$356	2015Q1	7.6%	$283	$99	$383
	Project Operation:			35%										
2.0%	Project Management	$64	$22	35%	$86	2.9%	$66	$23	$89	2015Q1	7.6%	$71	$25	$96
	CONTRACT COST TOTALS:	$4,480	$1,568		**$6,048**		$4,569	$1,599	$6,168			$4,698	$1,644	**$6,343**

Filename: TPCS_B2orifice90.xlsx
TPCS

APPENDICES

APPENDIX A – HYDRAULIC DESIGN

APPENDIX B – COST ESTIMATE

APPENDIX C – REGIONAL COORDINATION

APPENDIX A – HYDRAULIC DESIGN

SEE ATTACHED PDF

DRAFT Calculations for air demand (Q and V) for Field test conditions and proposed design geometry to improve jet performance

Coefficient of Discharge CD	0.65											
Orifice Centerline EL	65.5		gatewell drawdown:		0.33	0.9						
			forebay elevation:		71.5	76.5						

	Orifice Diam in	Tube Diam in	Orifice Area (ft²)	Tube Area (ft²)	Open Area (ft²)	Flow (min) cfs	Flow (max) cfs	Velocity min ft/sec	Velocity max ft/sec	Froude Number	Beta Qa/Qw	Qa =B*Qw	Va
5/31/2006	12.25	15.00	0.818	1.227	0.409	10.2	13.6	12.4	16.6	5.78	0.158	2.138	5.23
5/31/2006	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71
5/31/2006	11.75	15.00	0.753	1.227	0.474	9.4	12.5	12.4	16.6	5.90	0.162	2.021	4.26
5/31/2006	11.50	15.00	0.721	1.227	0.506	9.0	12.0	12.4	16.6	5.97	0.164	1.962	3.88
5/31/2006	11.25	15.00	0.690	1.227	0.537	8.6	11.4	12.4	16.6	6.03	0.166	1.904	3.55
5/31/2006	11.00	15.00	0.660	1.227	0.567	8.2	10.9	12.4	16.6	6.10	0.169	1.847	3.26
Existing	12.63	15.00	0.869	1.227	0.358	10.8	14.4	12.4	16.6	5.70	0.155	2.228	6.23
Alternative 4	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71
Alternative 3	13.00	17.75	0.922	1.718	0.797	11.4	15.3	12.4	16.6	5.61	0.152	2.318	2.910

Assumptions: 0.33 ft. drawdown at low forebay= 71.5 ft; 0.9 ft drawdown at high forebay=76.5 ft

References: HDC chart 050-1/1 Show two maxima for air demand, roughly at 5% and 80% gate opening
HDC chart 050-2 'Air demand - regulated outlet works

APPENDIX B – COST ESTIMATE

SEE ATTACHED PDF

APPENDIX C – REGIONAL COORDINATION

COMMENTS 60% EDR FROM NOAA 1 FEB 2012

February 1, 2012 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks, Ed Meyer and Trevor Conder

SUBJECT: Comments on the 60% Orifice Improvements Report

These comments are regarding the Bonneville Second Powerhouse Orifice Improvements Study Engineering Documentation 60% Draft Report – November 2011.

1. The goals of this project should be clearly stated as improvements to the collection system that will reduce injury and delay to migrating fish species. These improvements should address three specific issues:
   a. Improve the ability for the project operators to detect debris plugs in the orifice,
   b. Reduce the likelihood of fish impingement due to misalignment of orifice flow, and
   c. Improve gatewell egress times with improved orifice lighting.

2. As we mentioned in our recent memo regarding the FGE Alternatives Report, we do not support alternatives (e.g., A4) that alter the original design goals of this collection channel as outlined in sections 6.1 and 6.2. Nor do we support alternatives that relax NOAA screen criteria (e.g., Alt A5) for any portion of the fish passage season.

3. Additionally, we do not support reducing the orifice ring size (Alt A4) from the current size due to concerns for injury to fallback adult salmon and steelhead.

4. Acceptable alternatives should allow for daily (or more frequent) inspection of the orifice to assure against debris plugging. Alternative A6 would be impractical for this inspection frequency.

5. Alternative A7 has been tried in the past (at PH1) with poor results. The electronic pressure sensors just didn't do well in this gatewell environment. How would these be tested on a daily basis and would the project know if they have failed? Reliability and O&M may be a serious impediment to this design.

6. Alternative A8 has similar reliability and O&M concerns as alternative A7.

7. We support alternative A12 (and elimination of the current incandescent lights and light tubes), however, there should be some provision for determining when these lights are working correctly (lit or not).

8. Summary Comment. Of the alternatives selected as final by the Corps Development Team, we would not support A4 and A5 for reasons mentioned above. Alternative A3,

while acceptable, is likely cost prohibitive as written, given the region's current appetite for bypass systems. We recommend looking closely at steps to reduce the costs for Alternative A3 while maintaining its intent of maintaining minimum orifice dimensions and eliminating jet impingement. We suggest further investigation into a cost effective alternative that works to increase the size and or shape of the exit orifice ring so impingement is not possible under any forebay level. This alternative in addition to either alternatives A1 and A2 may provide enough air to support the jet, and possibly eliminate obstruction to the jet that could potentially injure fish. We would appreciate further discussion of these issues in the next Portland District FFDRWG meeting.

CENWP-EC-HD 31 May 2006

MEMORANDUM FOR RECORD

SUBJECT: B2 DSM Orifice Plates – Site Visit

1. On 15 May 2006 subject trip was made to view the hydraulics of 6 new juvenile fish passage orifice rings with variable diameters installed at Unit 12 and to select the orifice that provides a consistently clean jet. Using the selected orifice we will determine the corresponding core to use. Attending from NWP where Rick Mettler EC-DM, Steve Schlenker and Randy Lee EC-HD.

A contractor removed the 6 existing fish passage orifice rings from Unit 12's intake gate slots. There are two orifice rings per gate slot and there are three slots per unit. The new orifice rings vary in opening dimensions from 12 ¼" to 11" in ¼" increments and installed in the locations shown below.

Intake Gate Slot	Orifice Ring ID
12 A-South	12 ¼"
12 A-North	12"
12 B-South	11 ¾"
12 B-North	11 ½"
12 C-South	11 ¼"
12 C-North	11"

2. Background. In 1997, Design Memorandum 9, supplement 6 for DSM improvements called for 13-inch orifices in order to increase the flow rates and channel velocities in the DSM collection channel. The same discharge coefficient was assumed for the new 13-inch orifice that had been measured in the DSM channel in 1996 with the original 12-inch orifices. Unfortunately, the cores and the steel pipe liner were left the same. After construction in 1999, HD realized that two things were apparent during testing for the initial water-up:

- Many of the jets were no longer clean jets--where there is clear separation between the jet and tube walls--but instead were disturbed with spreading, splattering flow filling the entire tube opening.
- The discharge coefficients were higher and more variable because the jets were not fully contracted passing from the orifices as intended, used the entire tube flow area, and operated under an increased vacuum on the downstream end that effectively raised the overall the head differential across the orifice.

The reason all this occurred was that difference between diameters of the orifice (13-inches) and the inside diameter of the tube (about 15.25") was insufficient to properly vent the orifice. Specifically, the conveyance area that allows air flow to move from the downstream opening of the tube to the location immediately downstream of the orifice lip at the upstream end of the tube is too restricted. Factor in the fact that there must be a layer of air at the jet perimeter that is pulled outwardly with the jet and the air inflow must work against the friction that this layer causes. The lesser the opening dimension, the greater the amount friction between air moving upstream (inflow) and downstream (along periphery of jet). So the thinner the gap between jet and tube, the more constriction occurs to air inflow. This is further aggravated by the fact that the orifice jets are often partly submerged at the upstream end of the collection channel--which further restricts air flow capacity.

In 2001, HD tested smaller orifices and settled on 12 5/8 inch to fix the excessive flow problem and hopefully reduce the disturbed jet problem. Unfortunately, the evaluation for jet condition for different sized orifice was incomplete since the unit with the test orifices was never operated during the evaluation. The high flow problem was fixed but only marginal improvements were found with the disturbed jet problem.

3. Observations. Project Conditions: Unit 12 operating at 18.5 kcfs, forebay elevation 73.6 ft and tailwater elevation 23 ft.

Unit 12 A – South

General observation: This orifice did not show separation between the jet and tube. This is considered no good. See following photos.

Unit 12 A – North

General observation(s): Marginal jet separation from top and sides. There is some splatter of the jet. This is considered okay. See following photos.

Unit 12 B – South

General observation(s): No separation of the jet. Water was splashing through the walkway grating. This orifice is considered no good. See following photos.

Unit 12 B – North

General observation(s): This jet at time looked good, but, did not always have separation. This orifice is considered no good. See following photos.

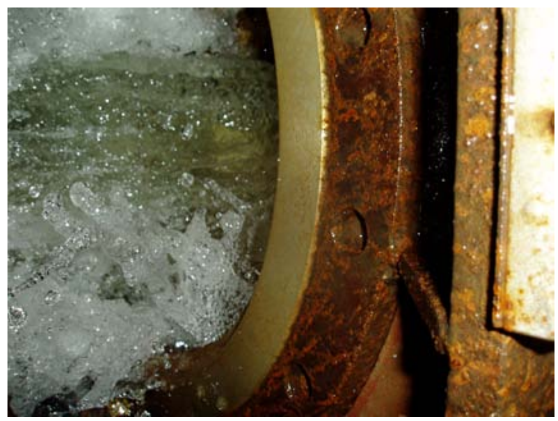
Unit 12 C – South

General observation(s): This orifice did have separation at times. This orifice was considered no good. See following photos.

Unit 12 C – North

General observation(s): This orifice had complete separation and considered good. See following photos.



Conclusions:

5. Upon visual observations by the attendees and the primary criteria of complete separation of the orifice jet, we ranked the orifices from 1 to 6 (1 being best, 6 being worst).

Ranking	Orifice Location
1.	12C-North
2.	12A-North
3.	12B-North
4.	12C-South
5.	12A-South
6.	12B-South

Another observation was that orifices on the north side of the bays produced consistently higher quality jets than those on the south side. In fact none of the south bay jets were acceptable even when the orifices were smaller than an adjacent north side orifice that was acceptable. Rick Mettler, EC-DM, noted that the valves on the south side were the new gates installed with the DSM improvements in 1999. The new (south) gates have cylinders that are about 4 inches wider than the old gate cylinders on the north side. This places the opening of the new valves comparatively 4-inches downstream of the old valves and causes the tube length to be 4 inches longer. The extended tube length or distance of gate from orifice apparently reduces the conveyance of air into tube. More importantly, the extra distances causes the jet to flare to the point that it impacts the gate housing (either at the bottom of on the sides) and thus disrupts or effectively blocks the intake opening for air into the tube. Thus the recommended orifice size only applies to either a gate with an equal or smaller cylinder than the old gate, or with tube lengths that are equal or smaller than the old tube lengths. There may be some room for refinement given that the orifice size is proportioned upwards; however, it also important to remember that the centerline arc of the jet trajectory will not change with orifice enlargement.

Recommendations:

6. Based on the above conclusions it is recommended a minimum inside core diameter of 17.75 inches (I.D.) be used. (The inside core diameter is the inside diameter of the pipe tube inserted and grouted into core for orifice and valve connection.) The recommended inside core diameter is based on the following relationship:

$$C_n = (O_n/O_e) \times Ce$$

Where

C_n = New Core Diameter (I.D.)
O_e = Existing Orifice Diameter = 11”
O_n = New Orifice Diameter = 13”
C_e = Existing Core Diameter (I.D.) = 15”[1]

Randy Lee, Steve Schlenker
EC-HD

CF:
EC-DM (Mettler)
PM-E (Schwartz)

[1] Existing inside core was provided by Ron Wridge, EC-DM, as required to piping for the valve. Existing outside diameter of core, or drill hole diameter is 16 inches.

DRAFT Calculations for air demand (Q and V) for Field test conditions and proposed design geometry to improve jet performance

Coefficient of Discharge

CD	0.65				
Orifice Centerline EL	65.5	Gatewell Drawdown:	0.33	0.9	
		Forebay Elevation:	71.5	76.5	

	Orifice Diam in	Tube Diam in	Orifice Area (ft²)	Tube Area (ft²)	Open Area (ft²)	Flow (min) cfs	Flow (max) cfs	Velocity min ft/sec	Velocity max ft/sec	Froude Number	Beta Qa/Qw	Qa =B*Qw	Va
5/31/2006	12.25	15.00	0.818	1.227	0.409	10.2	13.6	12.4	16.6	5.78	0.158	2.138	5.23
5/31/2006	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71
5/31/2006	11.75	15.00	0.753	1.227	0.474	9.4	12.5	12.4	16.6	5.90	0.162	2.021	4.26
5/31/2006	11.50	15.00	0.721	1.227	0.506	9.0	12.0	12.4	16.6	5.97	0.164	1.962	3.88
5/31/2006	11.25	15.00	0.690	1.227	0.537	8.6	11.4	12.4	16.6	6.03	0.166	1.904	3.55
5/31/2006	11.00	15.00	0.660	1.227	0.567	8.2	10.9	12.4	16.6	6.10	0.169	1.847	3.26
Existing	12.63	15.00	0.869	1.227	0.358	10.8	14.4	12.4	16.6	5.70	0.155	2.228	6.23
Alternatives 1 & 2	13.00	15.00	0.922	1.227	0.305	11.4	15.3	12.4	16.6	5.61	0.152	2.318	7.59
Alternative 3	13.00	17.75	0.922	1.718	0.797	11.4	15.3	12.4	16.6	5.61	0.152	2.318	2.910
Alternative 4 & 5	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71

Assumptions: 0.33 ft. drawdown at low forebay= 71.5 ft; 0.9 ft drawdown at high forebay=76.5 ft

References: HDC chart 050-1/1 : Air Demand; Regulated Outlet Works - Primary and Secondary Maxima

HDC chart 050-2 : Air Demand; Regulated Outlet Works - Sample Computation

APPENDIX B – COST ESTIMATING

- Preliminary Cost Estimate for 60% EDR

October 20, 2011
November 28, 2011 [updated KK]

B2 ORIFICE IMPROVEMENT ALTERNATIVE STUDY

BONNEVILLE 2 POWERHOUSE
NORTH BONNEVILLE, SKAMANIA COUNTY WASHINGTON

SHORT NARRATIVE OF ASSUMPTION FOR COST ESTIMATES AT 60%

1. Project Description:
At Bonneville 2nd Power, orifices connect the intake gatewell slots to the downstream migrant channel (DSM). These are part of the Juvenile Bypass System (JBS) at B2. The orifice jet hydraulics are considered biologically undesirable since the orifice jet spreads at many of the orifices. A matrix to rank the possible improvement alternatives considered, showed the top three alternatives to have cost estimates at the 60% review phase. The other alternatives were determined to have unfavorable results/performance which likely eliminate them from further consideration. The top 3 are:

Alternative 3: Re-core Orifice for 13" Dia Tubes
Alternative 4: Reduce Orifice Ring to 12" Dia.
Alternative 5: Increase DSM Flow with more open orfices with Seasonally Modified criteria at the D/W structure.

Additionally, the recommended alternative from above would also include both:
Alternative 11 to minimize overall tube length and
Alternative 12: Replace Orifice Ring with LED Orifice Ring.

2. Basis of Design and Estimate:
Draft 60% report and information from the design engineers.

General Assumptions for the cost estimates are as follows:

a) Use an excel spreadsheet with the same rows of task for all the alternatives.
b) Add Alt 11 & 12 to the bottom of each of the main alternatives.
c) Similar crews and task would perform similar tasks for each of the alternatives.
d) Due to the requirements of attaching the light ring orifice, the gate slot must be dewatered.
e) The main units will be dewatered with the existing intake bulkheads, rather than using a caisson.
f) Each Main Unit will be dewatered to tail water.
g) Bonneville project personnel & equipment will place and remove the intake bulkheads.
h) Work on the orifice is limited to the IWWP since the DSM must be dewatered therefore the JBS is shutdown.
i) Only one Main Unit can be dewatered at a time due to number of bulkheads and project operating requirements.

j) Only 3 units maximum can be dewatered per IWWP due to the duration of work on the orifices, length of time required to dewater each, and system wide coordination of unit outages.
k) For cost comparison among the alternatives on a like to like basis general assumption and adjustments will be used rather than detailing the specifics of overtime, subcontracting, detailed labor rates, etc. To recognize Overtime assume 6-10s and labor is about 45% of direct costs for 70 hr paid per week for 60 Mhr worked ((70/60) *.45)-.45 = 7.5% of direct costs is OT cost
k) All Markups are assumed from the rule of thumb of JOOH 15%, HOOH 10%, Profit 10%, Bond, Sales tax, B&O tax 3%. and OT of 7.5% for a total markup (running) of 54%
l) Material costs from engineers UNO.
m) See notes in spreadsheets for production assumptions and other considerations.
n) For Alternative Comparison purposes assume 35% contingency until a risk based analysis is performed to determine a more detailed contingency.

CREWS

GENERAL WORK CREW (GenCrew)
Performs: Dewatering support, Scaffolding install, Demolition, General Deck Support
Includes:
40 T crane
Misc Power Tools
Flat Bed Truck
2 Equipment Operators
3 Laborers
1 Foreman

CORING CREW (Core)
Performs: Coring new orifices
Includes:
2 Laborers
Core Drill

STRUCTURAL INSTALLERS (StruCr)
Performs: Installing Orifice Tubes, Grouting (tubes, old light tubes, new orifice rings., Chipping/removing concrete.
Includes:
3 Laborers
2 pickup trucks
Misc Power Tools
Small Tools

MECHANICAL ELECTRICAL INSTALLERS (MechElCr) Assumes same cost for millwright and electrician and same cost for their required equipment.
Performs: Installing Valves, Actuators, Light Rings, Redo Piping, sensors, power. Modify Dewatering Structure
Includes:

2 Millwright
2 pickup trucks
Misc Power Tools
Small Tools

CONTROLS (Ctrl)
Performs: Changing programming of controls.
Includes:
Elec Engineer
Small Tools

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 100,000$)

Prepared by: RLR

10/25/2011

Modified by: KAK 11/23/11

Physical Description	Re-core opening for 18" ID pipe; Minimize overall pipe length; Replace 12 5/8" orifice rings With 13" LED orifice rings.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Operate with additional orifices to maintain current channel operation/flow.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Modify screen velocity criteria for part of fish passage season to operate with additional flow allowing additional orifices to open.	Minimize overall pipe length.	Replace 12 5/8" orifice ring with LED orifice ring.
(costs rounded to $100k)	**Alt 3 (42 Orifices Modified)**	**Alt 4 (49 Orifices Modified)**	**Alt 5 (56 Orifices Modified)**	**Alt 11 only (42 Orifices Modified)**	**Alt 12 only (42 Orifices Modified)**
Direct Costs	$4,000,000	$2,100,000	$3,000,000	$900,000	$1,500,000
Markups (Overhead, Profits, Bond, tax, OT)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
SUBTOTAL COSTS	$6,200,000	$3,200,000	$4,600,000	$1,400,000	$2,300,000
CONTINGENCY (35%)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
TOTAL ESTIMATE CONSTRUCTION COST	**$8,400,000**	**$4,300,000**	**$6,200,000**	**$1,900,000**	**$3,100,000**

NOTES

1 Escalation & Inflation NOT included

2 Engineering, Supervision, Admin, etc costs NOT included

3 Alternative 3: Utilizes the 42 existing gated orifices; Provides aerated jets, maintains similar jet flows, reduces opportunity for impingement, increases attraction through light ring.

4 Alternative 4: Utilizes the 42 existing gated orifices; Requires 7 additional gate systems for currently blind flanged orifices; Provides aerated jet maintaining current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower flows, increases attraction through light ring.

5 Alternative 5: Utilizes the 42 existing gated orifices; Requires 14 additional gate systems for currently blind flanged orifices; Increases DSM system flow with seasonally modified criteria at dewatering screens; Provides aerated jet increasing current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower forebays, increases attraction through light ring.

6 Alternative 11: Utilizes the 42 existing gated orifices; Reduces probability for jet impingement at lower forebays.

7 Alternative 12: Utilizes the 42 existing gated orifices; Increases attraction through light ring.

8 Cost of Alt 11 & Alt 12 cannot be subtracted from the Other alternatives due to work not being mutually exclusive

9 Cost of "Alt 11" only cannot be added to "Alt 12 only" due to overlapping costs/tasks.

10 Nine Orifice lengths have already have been shortened by concrete mining. Costs in this spreadsheet do not reflect the reduction in cost for these orifices.

Assumptions for costs
B2 Orifice Improvements 2012
Preliminary Cost Estimate
RLR 10/20/2011

V1 Start worksheet based on Lamprey grating cost estimate worksheet

Only Alt 3, 4, & 5 studied for cost. (each of these alternative will include Alt 11 and 12) Other Alternatives not studied for cost due to unfavorable results and performance likely eliminate those alternatives from further consideration.

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews: GenCrew, Core

Green Cells are link/formula

V1 — **Direct Costs Alt A3 Recore for Larger Tubes & 13" dia Orifices**

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 3 Recore for 13" diameter	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	In addition to Light Ring Below Assume 16 hrs per orifice to accnt for extra for coring & grouting need extra room on schafolding ASSUME 42 orifices	Hrs	672.0	1	GenCrew	$367	$247,000		$0		16	42				672	
	3	Scaffolding Main units	See Calcs for Cost p. 60-10 & 60-11 Is needed at each slot. 8 units with 3 slots per unit plus 4 slots at fish units	ea	24.0	1	See calc.	$7,000	$168,000		$0		8	3				24	
	4	scaffolding at fish units	ditto	ea	4.0	1	See calc	$7,000	$28,000		$0		2	2				4	
	5	Demo existing orifice tube	Assume 3 days (10hrs) each orifice (42) to remove orifice ring, light tube stuff, misc items to access wall to core drill	hr	1,260.0	1	StruCr	$147	$186,000		$0		3	10	42			1260	
	6	Core drill for 13" dia Tube	See Calc 60-12. 6 hrs ea orifice	hr	252.0	1	Core	$1,093	$276,000		$0		6	42				252	
	7	Install 13" Tube	Assume 2 days (10hrs) to install & grout new tubes in. Total of 42	hr	840.0	1	StruCr	$147	$124,000		$0		2	10	42			840	
	8	Matl costs for new tubes	from Struc text in report $100,000/28 is about $3600 ea	ea	42.0	1	n/a		$0	$ 3,600	$152,000		42					42	
	9	Install New Gate	Assume 1 day (10 hrs) ea	hrs	420.0	1	MechElCr	$128	$54,000		$0		1	10	42			420	
	10	Install New Actuator	Assume 12 hrs ea (crew hrs)	hr	504.0	1	MechElCr	$128	$65,000		$0		1	12	42			504	
	11	Matl Cost for Mech	From Mech Text in report	ea	42.0	1	n/a		$0	$ 10,000.00	$420,000		42					42	
	12	Modifiy DSM Grating	Assume 8 hrs ea (crew hrs)	hr	336.0	1	StruCr	$147	$50,000		$0		8	42				336	
	13	Redo Orifice Opening Controls HMI	assume 80 hours to reprogram, test, commission, etc.	hr	80.0	1	Ctrl	$51	$5,000		$0		80					80	
	14	Redo Air Flush System Controls	assume 24 hours to reprogram, test, commission, etc.	hr	24.0	1	Ctrl	$51	$2,000		$0		24					24	
	15	New SS Retainer Ring (alt 4)			-	1			$0		$0							0	
	16				-	1			$0		$0							0	
	17				-	1			$0		$0							0	
	18				-	1			$0		$0							0	
ht Ring	19	*** Light Ring**	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + StruCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew
Core

Green Cells are link/formula

V1 **Direct Costs Alt A3 Recore for Larger Tubes & 13" dia Orifices**

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 12 Lig	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	42.0	1	n/a		$0	$ 650.00	$28,000		42					42	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	27	Matl costs mech Elec	From text report	ea	42.0	1			$0	$ 1,500.00	$63,000		42					42	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	100.8	1			$0	$ 150.00	$16,000		42	2.4				100.8	
	29					1			$0		$0							0	
Alt 11 Reduce Orifice Tube Length	30	**** Reduce Orifice Tube Length**			-	1			$0		$0							0	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	420.0	1	StruCr	$147	$62,000		$0		42	10				420	
	32	Install Structural Frame	Assume 20 hrs ea	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	33	Matl cost for frame	from rpt text	ea	42.0	1	na/		$0	$ 700.00	$30,000		42					42	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	168.0	1	MechElCr	$128	$22,000		$0		42	4				168	
	36	Install Atuator Valve	Assume 12 hrs each	hr	504.0	1	MechElCr	$128	$65,000		$0		42	12				504	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	42.0	1	StruCr	$147	$7,000	$ 500.00	$21,000		42					42	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	146,000.0	1		$0	$0	$ 1.00	$146,000		730,000	0.2				146000	
	43	Misc Labor etc	Say 20%	%	515,400.0	1		$1	$516,000	$ -	$0		2,577,000	0.2				515400	
		Subtotal Direct Cost	**$3,969,000**						$3,093,000		$876,000								

Notes: This alternative modifies only those orifice units currently in use: 42 orifice units

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew

Green Cells are link/formula

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
V1		**Direct Costs Alt A4 Reduce Orifice Ring to 12" Dia and Operate Additional C**																	
Alt 4 Reduce Orifice Ring to 12" diameter	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo existing orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	70.0	1	MechElCr	$128	$9,000		$0		1	10	7			70	
	10	Install New Actuator	Ditto	hr	84.0	1	MechElCr	$128	$11,000		$0		1	12	7			84	
	11	Matl Cost for Mech	Ditto	ea	7.0	1	n/a		$0	$ 10,000.00	$70,000		7					7	
	12	Modifiy DSM Grating	Ditto	hr	56.0	1	StruCr	$147	$9,000		$0		8	7				56	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	49.0	1			$0	$ 400.00	$20,000		49					49	
	16				-	1			$0	$ 401.00	$0							0	
	17				-	1			$0	$ 402.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	*** Light Ring**	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + StruCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	980.0	1	StruCr	$147	$145,000		$0		49	20				980	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	49.0	1	n/a		$0	$ 650.00	$32,000		49					49	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	980.0	1	MechElCr	$128	$126,000		$0		49	20				980	
	27	Matl costs mech Elec	From text report	ea	49.0	1			$0	$ 1,500.00	$74,000		49					49	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	117.6	1			$0	$ 150.00	$18,000		49	2.4				117.6	
	29					1			$0		$0		49					49	
th	30	**** Reduce Orifice Tube Length**			49.0	1			$0		$0		49					49	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew

Green Cells are link/formula

V1 **Direct Costs Alt A4 Reduce Orifice Ring to 12" Dia and Operate Additional C**

						Production	Labor or Crew or Sub-Bid	Rate	L-Cr-SB	Material	Matl	Verified	Quantities per Item						
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 11 Reduce Orifice Tube Leng	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	490.0	1	StruCr	$147	$73,000		$0		49	10				490	
	32	Install Structural Frame	Assume 20 hrs ea	hr	980.0	1	StruCr	$147	$145,000		$0		49	20				980	
	33	Matl cost for frame	from rpt text	ea	49.0	1	na/		$0	$ 700.00	$35,000		49					49	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	980.0	1	MechElCr	$128	$126,000		$0		49	20				980	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	196.0	1	MechElCr	$128	$26,000		$0		49	4				196	
	36	Install Atuator Valve	Assume 12 hrs each	hr	588.0	1	MechElCr	$128	$76,000		$0		49	12				588	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	49.0	1	StruCr	$147	$8,000	$ 500.00	$25,000		49					49	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	54,800.0	1		$0	$0	$ 1.00	$55,000		274,000	0.2				54800	
	43	Misc Labor etc	Say 20%	%	301,200.0	1		$1	$302,000	$ -	$0		1,506,000	0.2				301200	
		Subtotal Direct Cost	**$2,137,000**						$1,808,000		$329,000								

Note: This alternative modifies orifice units currently in use (42) plus additional units that have been drilled but not gated (7) for a total of 49 working orifices maintaining the current operating flow in the collection channel and dewatering system.

Values in red depict the items that are affected by the additional orifice units included and/or the total quantity of orifice units.

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew

Green Cells are link/formula

Direct Costs Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
V1																			
Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0		0	0				0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo existing orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0		0	0				0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0		0	0	0			0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0		0					0	
	9	Install New Gate	Ditto	hrs	140.0	1	MechElCr	$128	$18,000		$0		1	10	14			140	
	10	Install New Actuator	Ditto	hr	168.0	1	MechElCr	$128	$22,000		$0		1	12	14			168	
	11	Matl Cost for Mech	Ditto	ea	18.0	1	n/a		$0	$ 10,000.00	$180,000		18					18	
	12	Modifiy DSM Grating	Ditto	hr	112.0	1	StruCr	$147	$17,000		$0		8	14				112	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	180.0	1	GenCrew, Core, StruCr, MechElCr, Ctrl	$1,786	$322,000		$0		3	60				180	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		3.0	1			$0	$ 50,000.00	$150,000		3					3	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	*** Light Ring**	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + StruCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	1,120.0	1	StruCr	$147	$165,000		$0		56	20				1120	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	56.0	1	n/a		$0	$ 650.00	$37,000		56					56	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	1,120.0	1	MechElCr	$128	$144,000		$0		56	20				1120	
	27	Matl costs mech Elec	From text report	ea	56.0	1			$0	$ 1,500.00	$84,000		56					56	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

Prepared by: RLR 10/21/2011

V1 **Direct Costs Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria**

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	134.4	1			$0	$ 150.00	$21,000		56	2.4				134.4	
	29					1			$0		$0		56					56	
Alt 11 Reduce Orifice Tube Length	30	**** Reduce Orifice Tube Length**			56.0	1			$0		$0		56					56	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	560.0	1	StruCr	$147	$83,000		$0		56	10				560	
	32	Install Structural Frame	Assume 20 hrs ea	hr	1,120.0	1	StruCr	$147	$165,000		$0		56	20				1120	
	33	Matl cost for frame	from rpt text	ea	56.0	1	na/		$0	$ 700.00	$40,000		56					56	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	1,120.0	1	MechElCr	$128	$144,000		$0		56	20				1120	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	224.0	1	MechElCr	$128	$29,000		$0		56	4				224	
	36	Install Atuator Valve	Assume 12 hrs each	hr	672.0	1	MechElCr	$128	$87,000		$0		56	12				672	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	56.0	1	StruCr	$147	$9,000	$ 500.00	$28,000		56					56	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	108,000.0	1		$0	$0	$ 1.00	$108,000		540,000	0.2				108000	
	43	Misc Labor etc	Say 20%	%	391,400.0	1		$1	$392,000	$ -	$0		1,957,000	0.2				391400	
		Subtotal Direct Cost	**$2,997,000**						$2,349,000		$648,000								

Note: This alternative modifies orifice units currently in use (42), plus the maximum number of additional orifice units that have been drilled but not gated (18), plus additional units that need to be drilled and gated for a total of 60 working orifices to operate with an increase in flow of ~100 cfs due to operational changes and increase in allowable screen velocity during a portion of the fish passage season.

Values in red depict the items that are affected by the additional orifice units included and/or the total quantity of orifice units.

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew

Green Cells are link/formula

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid: Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item: X	Y	Z	T	S	Q (product xyzts)	NOTE
V1		**Direct Costs Alt A11 minimize overall tube length**																	
N/A	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo exiting orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	-	1	MechElCr	$128	$0		$0							0	
	10	Install New Actuator	Ditto	hr	-	1	MechElCr	$128	$0		$0							0	
	11	Matl Cost for Mech	Ditto	ea	-	1	n/a		$0	$ 10,000.00	$0							0	
	12	Modifiy DSM Grating	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	-	1	GenCrew, Core, StruCr, MechElCr, Ctrl	$1,786	$0		$0							0	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		-	1			$0	$ 50,000.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	*** Light Ring**	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	-	1	See calcs	$4,730	$0	$ -	$0								*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	-	1	Gen Crew + SturCr	$514	$0		$0								
	23	scaffolding at fish units	ditto	hr	-	1	ditto	$514	$0		$0								
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	-	1	StruCr	$147	$0		$0								
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	-	1	n/a		$0	$ 650.00	$0								
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	-	1	MechElCr	$128	$0		$0								
	27	Matl costs mech Elec	From text report	ea	-	1			$0	$ 1,500.00	$0								

Crews
GenCrew

Green Cells are link/formula

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
V1		**Direct Costs Alt A11 minimize overall tube length**																	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	-	1			$0	$ 150.00	$0								
	29					1			$0		$0							0	
Alt 11 Reduce Orifice Tube Length	30	**** Reduce Orifice Tube Length**			-	1			$0		$0							0	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	420.0	1	StruCr	$147	$62,000		$0		42	10				420	
	32	Install Structural Frame	Assume 20 hrs ea	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	33	Matl cost for frame	from rpt text	ea	42.0	1	na/		$0	$ 700.00	$30,000		42					42	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	168.0	1	MechElCr	$128	$22,000		$0		42	4				168	
	36	Install Atuator Valve	Assume 12 hrs each	hr	504.0	1	MechElCr	$128	$65,000		$0		42	12				504	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	42.0	1	StruCr	$147	$7,000	$ 500.00	$21,000		42					42	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	10,200.0	1		$0	$0	$ 1.00	$11,000		51,000	0.2				10200	
	43	Misc Labor etc	Say 20%	%	141,400.0	1		$1	$142,000	$ -	$0		707,000	0.2				141400	
		Subtotal Direct Cost	**$911,000**						$849,000		$62,000								

Note: This workseet assumes that Alt 11 -only is <u>not</u> attached to any other Alternatives and would be implemented only on the existing working orifice units (42).

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

Prepared by: RLR 10/21/2011

V1 **Direct Costs Alt 12 Replace Orifice Ring w/ LED Orifice Ring**

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo exiting orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	-	1	MechElCr	$128	$0		$0							0	
	10	Install New Actuator	Ditto	hr	-	1	MechElCr	$128	$0		$0							0	
	11	Matl Cost for Mech	Ditto	ea	-	1	n/a		$0	$ 10,000.00	$0							0	
	12	Modifiy DSM Grating	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	-	1	GenCrew, Core, StruCr, MechElCr, Ctrl	$1,786	$0		$0							0	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		-	1			$0	$ 50,000.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	*** Light Ring**	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + SturCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	42.0	1	n/a		$0	$ 650.00	$28,000		42					42	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	27	Matl costs mech Elec	From text report	ea	42.0	1			$0	$ 1,500.00	$63,000		42					42	

	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	100.8	1			$0	$ 150.00	$16,000	42	2.4	100.8	
	29					1			$0		$0			0	
Alt 11 Reduce Orifice Tube Length	30	**** Reduce Orifice Tube Length**			-	1			$0		$0			0	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	-	1	StruCr	$147	$0		$0			0	
	32	Install Structural Frame	Assume 20 hrs ea	hr	-	1	StruCr	$147	$0		$0			0	
	33	Matl cost for frame	from rpt text	ea	-	1	na/		$0	$ 700.00	$0			0	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	-	1	MechElCr	$128	$0		$0			0	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	-	1	MechElCr	$128	$0		$0			0	
	36	Install Atuator Valve	Assume 12 hrs each	hr	-	1	MechElCr	$128	$0		$0			0	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	-	1	StruCr	$147	$0	$ 500.00	$0			0	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	-	1	Ctrl	$51	$0		$0			0	
	39	Mob Demob if not other alts done	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0	9	3	27	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0				
	41				-	1			$0		$0			0	
	42	Misc Matl	Say 20% ea Matl	%	21,400.0	1		$0	$0	$ 1.00	$22,000	107,000	0.2	21400	
	43	Misc Labor etc	Say 20%	%	221,000.0	1		$1	$221,000	$ -	$0	1,105,000	0.2	221000	
		Subtotal Direct Cost	**$1,455,000**						$1,326,000		$129,000				

Note: This workseet assumes that Alt 12 -only is <u>not</u> attached to any other Alternatives and would be implemented only on the existing working orifice units (42).

Assumptions for costs				
B2 Orifice Improvments 2012				
Preliminary Cost Estimate				
RLR 10/20/2011				
	Crews_	$/hr	Cellname	NOTE
	GenCrew			GenCrew to perfom Dewatering support, Scaffolding install, Demolition, General Deck Support see calc p. 60-4
	Labor	244		
	Equip	123		
	Total	367	**GenCrew**	
	Coring Crew			Performs: Coring new orifices see calc p. 60-5
	Labor	84		
	Equip	9		
	Wear	1000		
	Total	1093	Core	
	Structural Installers Crew			Performs: Installing Orifice Tubes, Grouting (tubes, old light tubes, new orifice rings., Chipping/removing concrete. See calc p. 60-6
	Labor	114		
	Equip	33		
	Total	147	StruCr	
	MECH ELECTRICAL INSTALLERS			MechElCr) Assumes same cost for millwright and electrician and same cost for their required equipment. Performs: Installing Valves, Actuators, Light Rings, Redo Piping, sensors, power. Modify Dewatering Structure See Calc p. 60-7
	Labor	95		
	Equip	33		
	Total	128	MechElCr	
	Controllers			Performs: Changing programming of controls. See Calc p. 60-8
	Labor	49		
	Equip	2		
	Total	51	Ctrl	