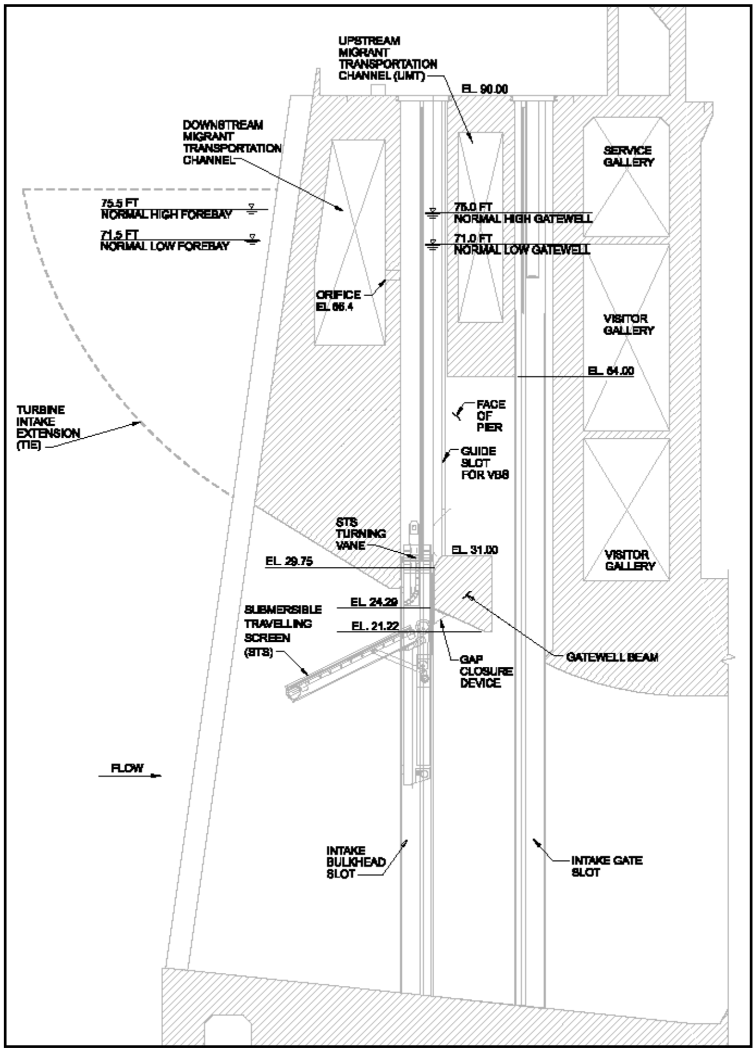
US Army Corps of Engineers®
Portland District

Alternatives Report

Bonneville Second Powerhouse Fish Guidance Efficiency (FGE) Program Post Construction



February 2013

90% Review

EXECUTIVE SUMMARY

This report documents the investigation and development of alternatives to improve fish guidance efficiency (FGE) for subyearling and juvenile fish survival at the Bonneville second powerhouse. Alternatives to investigate were identified and chosen via collaborative discussions with regional state and federal agencies. The initial premise was that high subyearling mortality in the second powerhouse gatewells was directly attributed to high flow conditions feeding into the gatewells. It was reasoned that if flow conditions were reduced or adjusted, subyearling mortality would similarly drop.

Three types of operational and structural alternatives were recommended for investigation: flow control alternatives, operational alternatives, and a flow pattern change alternative.

Flow control alternatives:

- A1 – Adjustable Louver Flow Control Device: Construct a device to control the flow up the gatewell. The device would be placed downstream of the vertical barrier screen (VBS).
- A2 – Sliding Plate Flow Control Device: Construct a sliding plate flow control device attached to the top of the gatewell beam.
- A3 – Modify VBS Perforated Plates.
- A4 – Modify Turning Vane and/or Gap Closure Device.

Operational alternatives:

- B1 – Operate Main Units Off 1% Peak Range: Operate the main turbine units at the lower to mid 1% peak operating range during juvenile fish release.
- B2 – Open Second DSM Orifices: Open the second downstream migrant system (DSM) gatewell orifice to decrease fish retention time in the gatewell.
- B3 – Horizontal Slot for DSM: Construct a horizontal slot in place of the existing orifices to decrease fish retention time in the gatewell.

Flow pattern change alternative:

- C – Gate Slot Fillers: Install gate slot fillers in the slots above the turning vane and submerged traveling screen supports to reduce turbulence in the gatewell and streamline sweeping velocities up the VBS.

Using computational fluid dynamics modeling of the gatewell environment, it became apparent that flow conditions in the gatewell were far from streamline and optimum. The modeling revealed notable levels of turbulence that increased relative to flow volume and pattern. The Product Development Team reasoned that there likely was a correlation between the levels of turbulence and subyearling mortality. It was further reasoned that the origin of the gatewell turbulence stemmed from hydraulic expansion into the VBS slots. Thus, the team introduced the flow pattern change alternative (Alternative C) that focused on methods for filling the VBS slots to reduce turbulence of flow up the gatewell.

Each alternative was evaluated using a point-based matrix approach for the following evaluation factors: biological benefits, construction costs, construction time, operation and maintenance costs, operational effectiveness, reliability, impacts to power revenues, and environmental factors. Alternative B3 (Horizontal Slot for DSM) and Alternative C (Gate Slot Fillers), received the highest scores. Alternative C is recommended for further investigation.

Hydraulic model results indicate that Alternative C can significantly reduce the level of turbulence inside the gatewell potentially improving the hydraulic conditions for fish passage. Of the alternatives presented, Alternative C should not impact FGE since the turbine unit can be operated in its current operating range and discharge into the gate slot would not change.

Prior to implementation on a full powerhouse scale, it is recommended that the gate slot fillers concept (Alternative C) be installed in a limited number of gate slots. Hydraulic and biological tests are also recommended to evaluate the effectiveness of the gate slot filler on fish survival.

The hydraulics and juvenile fish passage at Bonneville are interrelated and complex. Should the evaluation of Alternative C be unfavorable, it is recommended that the other alternatives identified in this report be readdressed.

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PERTINENT PROJECT DATA

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 Elev. (at project site tailwater)	39.8

POWERHOUSES

First Powerhouse (Oregon)	
Length	1,027 feet
Number of Main Units	10
Nameplate Capacity (2 @ 43 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 ft^3/s
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 ft^3/s

SPILLWAY

Capacity at Pool Elevation (Elev. 87.5)	1,600,000 ft^3/s

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

BPA	Bonneville Power Administration
CFD	computational fluid dynamics
CRFM	Columbia River Fish Mitigation Program
DDR	Design Documentation Report
DSM	downstream migrant system
ERC	emergency relief conduit
FCRPS	Federal Columbia River Power System
FFDRWG	Fish Facility Design Review Work Group
FGE	fish guidance efficiency
FPP	Fish Passage Plan
ft/s	feet (foot) per second
ft^3/s	cubic feet per second
ft^2/s^2	feet squared per second squared
GCD	gap closure device
HDC	Hydroelectric Design Center
HLH	heavy-load hours
HVAC	heating, ventilation and air conditioning
HYSSR	Hydro System Seasonal Regulation (model)
kV	kilovolt(s)
LCC	life cycle costs
LLH	light-load hours
mm	millimeter(s)
MW	megawatt(s)
MWh	megawatt hour(s)
NOAA	National Oceanic and Atmospheric Administration
O&M	operation and maintenance
OPE	orifice passage efficiency
PDT	Product Development Team
PH1	first powerhouse
PH2	second powerhouse
PIT	passive integrated transponder
PLC	programmable logic controller
S&A	supervision and administration
SCNFH	Spring Creek National Fish Hatchery
SP	super-peak (hours)
STS	submerged traveling screen
TEAM	Turbine Energy Analysis Model
TDG	total dissolved gas
TIE	turbine intake extension
UHMW	ultra-high molecular weight
USACE	U.S. Army Corps of Engineers
VBS	vertical barrier screen
WT	wide-tee

1. INTRODUCTION

1.1. PURPOSE

The purpose of this report is to document the evaluation of alternatives developed and recommend an alternative that will help eliminate or reduce subyearling fish mortality in the Bonneville second powerhouse (PH2) gatewell environment. Three types of operational and structural alternatives were considered: flow control alternatives, operational alternatives, and a flow pattern change alternative.

1.2. PROJECT OBJECTIVE

With the recent discovery of poor survival of Spring Creek National Fish Hatchery (SCNFH) subyearling Chinook salmon (*Oncorhynchus tshawytscha)*, the biological objective and goal is to improve hydraulic conditions in the gatewell without compromising the existing fish guidance efficiency (FGE) capability.

1.3. BACKGROUND

In 1999, regional fisheries agencies agreed to pursue a phased approach and focus on improving fish guidance and survival at Bonneville PH2 by maximizing flow up the turbine intake gatewells, a guideline that has been used on similar programs to improve FGE. The modifications, completed in 2008, included an increase in vertical barrier screen (VBS) flow area, installation of turning vanes to increase flow up the gatewell, addition of a gap closure device (GCD) to eliminate fish loss at submerged traveling screen (STS), and installation of interchangeable VBS to allow for screen removal and cleaning without outages or intrusive gatewell dipping. Results of biological studies showed an increase in FGE by 21% for yearling Chinook and 31% for subyearling Chinook. Test fish conditions showed no problems with descaling and gatewell retention time (including fry) in a newly modified unit.

During the 2008 juvenile fish passage season, the SCNFH released hatchery subyearlings in early spring 2008 over a 3-month period (March, April, May). Biological testing conducted by National Oceanic and Atmospheric Administration (NOAA) suggests that SCNFH subyearlings are incurring high mortality and de-scaling when the newly modified units are being operated at the upper 1% range. Evidence suggests a relationship may exist between the operation of the powerhouse units (lower, mid, and upper 1%) and survival of the SCNFH subyearlings. A logical assumption would be that operating turbine units at the upper 1% puts more water up the gatewell, thus producing poor hydraulic conditions within the gatewell.

Biological test data was evaluated by the U.S. Army Corps of Engineers (USACE) and preliminary alternatives were suggested to the region that could potentially regulate and throttle hydraulic conditions in the gatewell. The region agreed with the initial assessment and approved the study to investigate and evaluate flow control and operational alternatives – flow control devices to regulate the volume and direction of flow and operational alternatives using turbine operation as a means to throttle and control flow volume going into the gatewell.

1.4. PROJECT SCOPE

The scope of the project is to provide a comprehensive investigation of the Bonneville PH2 gatewell environment to better understand the hydraulic dynamics as they impact subyearling fish mortality, and to assess and evaluate alternatives that improve passage and survival of subyearling fish through the gatewell environment.

A computational fluid dynamics (CFD) model was developed and utilized in the investigation of the gatewell hydraulic environment and to evaluate alternatives. The alternatives evaluated included flow control device alternatives, operational alternatives, and a flow pattern change alternative. The alternatives were collaboratively developed and approved by regional federal and state agencies (see Appendix A, *Relevant Correspondence*, for the Gatewell Fish Condition Test Results Meeting on October 3, 2008). Flow control alternatives included:

- Construct a device to control the flow up the gatewell. The device would be placed downstream of the VBS. Similar devices have been used at the John Day and McNary dams.
- Construct a sliding plate flow control device attached to the top of the gatewell beam.
- Modify the existing VBS perforated plates, which results in a reduction of gatewell flow.
- Modify the turning vane and GCD.

Operational alternatives included:

- Operate main turbine units at lower to mid 1% peak operating range during juvenile fish release.
- Open the second downstream migrant system gatewell orifice to decrease fish retention time in the gatewell.
- Construct a horizontal slot in place of the existing orifices or additional orifices to decrease fish retention time in the gatewell.

A flow pattern change alternative (gate slot fillers) was developed after modeling data suggested that relative to hydraulic volume and flow, eddy currents were developed at the top of the gatewell that could potentially have negative effects on subyearling fish. It is hypothesized that filling the VBS gate slots will change the flow patterns in the gatewell, reduce turbulent flow, and improve subyearling fish passage and survival.

1.5. 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 completion, maintenance, and operations of Bonneville Dam was provided by Public Law 329, 75th Congress, 20 August 1937. This act provided authority for the construction of additional hydroelectric generation facilities (Bonneville PH2) when requested by the Administrator of Bonneville Power Administration (BPA). Letters dated 21 January 1965 and 2 February 1965 from the Administrator developed the need for construction of Bonneville PH2. Construction started in 1974 and was completed in 1982.

1.6. PROJECT COORDINATION

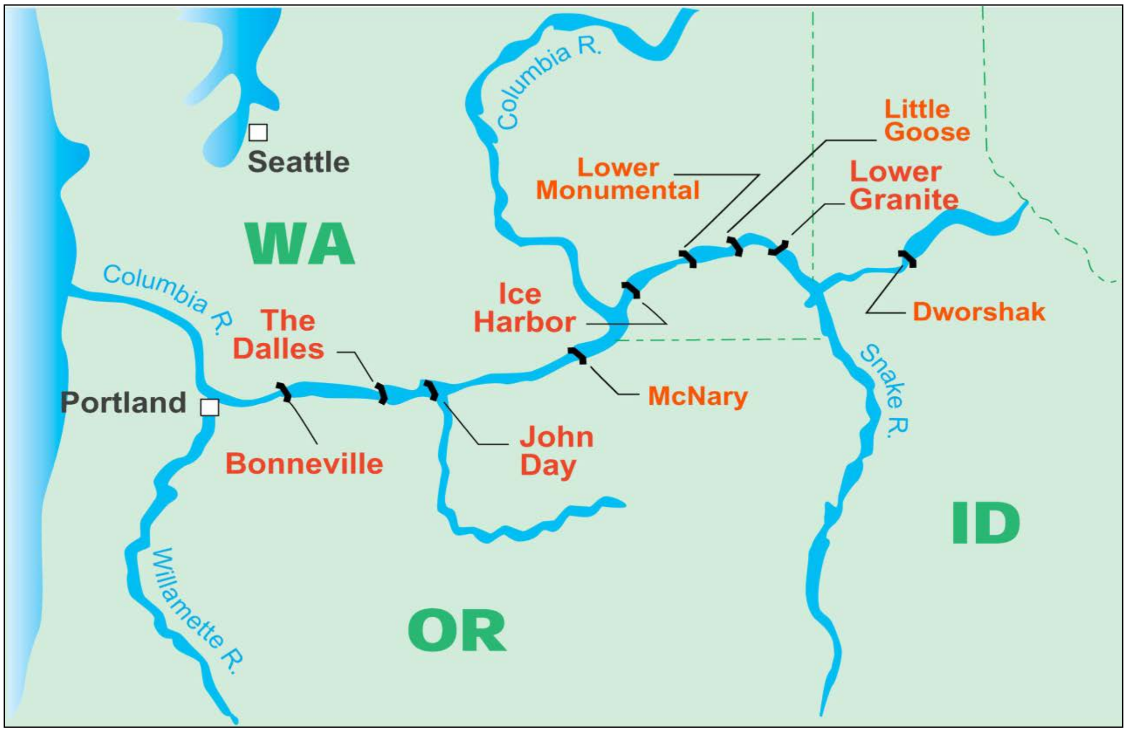
The study and report was coordinated with the regional fisheries agencies and tribes through the Fish Facility Design Review Work Group (FFDRWG).

2. EXISTING PROJECT FEATURES

2.1. PROJECT LOCATION AND FEATURES

The Bonneville Project is located on the Columbia River at river mile (RM) 146, approximately 42 miles east of Portland, Oregon (Figure 2-1). Bonneville PH2 is located between Cascades Island and the river's north shore in the State of Washington (Figure 2-2). It consists of eight 66 megawatt (MW) Kaplan turbine main units and two 13.1 MW turbine units that supply water to the adult fish passage facilities.

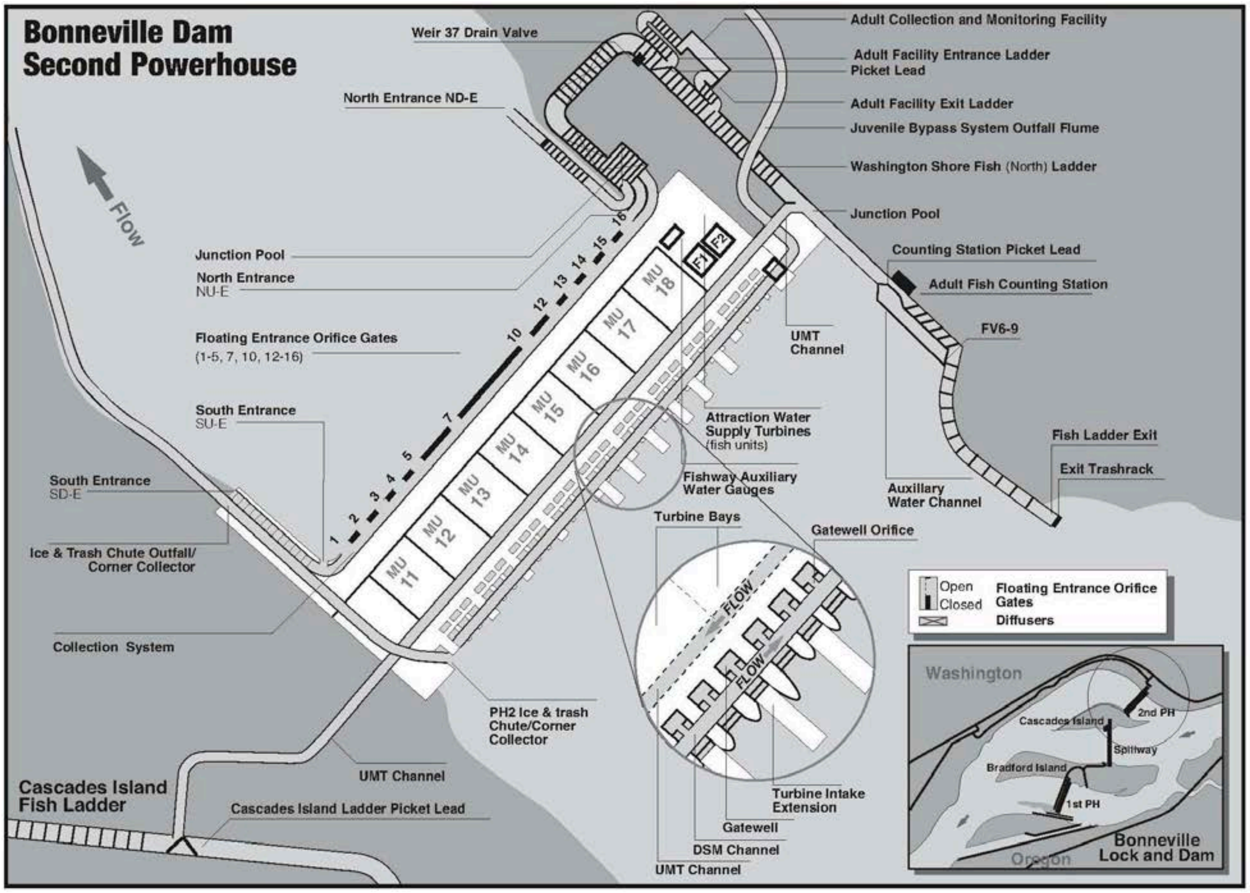
Figure 2-1. Bonneville Project Location



2.2. GATEWELL CONDITION ISSUES POST-FGE IMPROVEMENTS

In 2006 and 2007, SCNFH subyearling Chinook passing Bonneville PH2 DSM showed increased mortalities and descaling (add citation). Physical inspections of the bypass facilities rendered little evidence to indicate that a mechanical system was causing this increased poor condition of fish. Regional fish managers and the USACE believed that gatewell modifications that focused more water up the gatewell area (thus improving FGE) was the cause for the increase numbers of damaged fish. In 2008, increased mortality of SCNFH fish were again noticed during the first releases in early March (add citations). Regional fish managers asked USACE to reduce MW loads (reduced flow up the gatewell slot) on the FGE modified units to the lower end of their 1% operating ranges during both of the spring releases to see if this would reduce mortalities. The reduced load operations were seen to lessen the amount of descaling and mortalities in the daily samples.

Figure 2-2. Bonneville Dam Second Powerhouse



2.2.1. Target Species

The focus of the proposed improvements has been mainly on hatchery reared subyearling Chinook salmon from the SCNFH and run-of-river spring migrants such as yearling Chinook and steelhead (*Oncorhynchus mykiss).* Previous research prompted the USACE to focus on subyearling migrants because of the higher mortality documented by smolt monitoring at the Bonneville PH2 juvenile monitoring facility (add citations). Researchers and the USACE Product Development Team (PDT) believe that the more naïve the fish is to the river system, the higher probability that these fish will be impacted by the current Bonneville PH2 gatewell environment at turbine loads at the upper end of their 1% operating range [17,000 to 19,500 cubic feet per second (ft^3/s)].

2.2.2. Gatewell Orifice Passage Efficiency Testing 2008-2009

In response to the suspected gatewell issues indentified in 2006-2007, the USACE developed research through the Columbia River Fish Mitigation Program (CRFM) with the assistance of NOAA to test the orifice passage efficiency (OPE) effects of varying turbine loads along with opening an additional gatewell orifices (add citations). Test fish were collected, tagged with a passive integrated transponder (PIT tag), and released via a release hose into the top of the turbine intake. Fish then volitionally entered the intake and were directed up the gatewell via the submerged traveling screens. Test fish entered the gatewell environment and then exited the gatewell via orifices. Fish were then detected at PIT tag readers the downstream smolt monitoring facility and timing and passage data collected and compared for varying loads and numbers of orifices open. Research from the 2008 study indicated that SCNFH subyearling test fish were being impacted significantly at turbine operations above 13,900 ft^3/s and were highly impacted at the upper operating ranges (Table 2-1).

Table 2-1. 2008 Recapture Rates and Mortality of Juvenile SCNFH Fish Released in Bypass System Collection Channel or Gatewell 12A

Juvenile SCNFH Chinook salmon released in the bypass system collection channel or gatewell 12A on March 3 and 4, 2008, at Bonneville PH2. Average fork length of fin-clipped test fish was 63 millimeters (mm).

Parameter	Collection Channel	Gatewell 12A Lower 1% 11,600-11,800 ft^3/s	Gatewell 12A Middle 1% 13,900-14,000 ft^3/s	Gatewell 12A Upper 1% 16,800-16,900 ft^3/s
Test blocks (no.)	2	2	2	2
Test duration (h)	4	4	4	4
Fish released (no.)	1,801	799	854	799
Recaptured (%)	98.3	82.7	81.3	66.6
Mortality (%)	0.3	1.9	14.2	32.3
T-test results for comparisons of recapture and mortality percentages: $P<0.01$ for all comparisons except for recapture of lower and middle 1% gatewell releases where $P=0.44$.				

In addition, run-of-river yearling Chinook were also evaluated in late spring and early summer and the same outcome was noted for their test releases (add citations). Under higher turbine operations starting at 13,900 ft^3/s, researchers noted that mortality rose sharply as turbine operations increased (Table 2-2).

Table 2-2. 2009 Data for Yearling Fish from Bonneville Smolt Monitoring Program Released into PH2 Turbine 14A Intake

Recapture rates, observed mortality, passage timing, and descaling data for yearling Chinook salmon from Bonneville Smolt Monitoring Program, PIT tagged and released into the Bonneville PH2 turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish that were descaled ≥20% on at least one side.

Parameter	Collection Channel	Intake 14A Middle 1%, 14,700 ft^3/s	Intake 14A Upper 1%, 17,800 ft^3/s	P^a
Test blocks (no.)	8	8	8	
Test duration (h)	24	24	24	
Fish released (no.)	389	3,229	3,153	
Recaptured (%)	97.7	98.4	97.4	0.05
Mortality (%)	0.3	0.5	4.4	<0.01
Timing (median, h)	0.6	1.7	2.7	<0.01
Descaling (%)	0.3	1.0	11.5	<0.01
[a] ANOVA. P values are for load comparisons.				

Once again in 2009, the USACE conducted research at Bonneville PH2 (add citations). Fish were released in the same fashion as in the 2008 study and once again the trends were identified as the same (Table 2-3). At higher turbine operations (17,800 ft^3/s), test fish showed greater mortality rates than fish that were released at a turbine mid-range operation at 14,700 ft^3/s (Table 2-3).

Table 2-3. 2009 Data for Subyearling Fish from Bonneville Smolt Monitoring Program Released into PH2 Turbine 14A Intake, One Open Gatewell Orifice

Recapture rates, observed mortality, passage timing, and descaling data for subyearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT tagged, and released into the Bonneville PH2 turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish descaled ≥20% on at least one side. Tests conducted with one open gatewell orifice.

Parameter	Collection Channel	Intake 14A Middle 1%, 14,700 ft^3/s	Intake 14A Upper 1%, 17,800 ft^3/s	P[a]
Test blocks (no.)	8	8	5	
Test duration (h)	24	24	24	
Fish released (no.)	400	3,167	2,058	
Recaptured (%)	96.7	97.2	96.5	0.13
Mortality (%)	0.3	2.6	4.5	0.01
Timing (median, h)	0.6	2.6	6.1	0.03
Descaling (%)	0.3	0.5	2.6	<0.01

[a] ANOVA. P values are for load comparisons, one open gatewell orifice.

The USACE also undertook a 2009 gatewell testing protocol that opened an additional gatewell orifice during specific releases to see if this additional open orifice had any impact on OPE or mortality (add citations). Test results indicated that OPE increased from a median time of 6.1 hours with one orifice open to 2.9 hours with two open (Table 2-4). Also descaling dropped from 2.6% to 1.2%. Indications are that providing and additional open orifice had a significant impact on reducing the gatewell retention time as well as descaling associated with these higher OPE times.

Table 2-4. 2009 Data for Subyearling Fish from Bonneville Smolt Monitoring Program Released in PH2 Turbine 14A Intake, One or Two Open Gatewell Orifices

Recapture rates, observed mortality, passage timing, and descaling data for subyearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT tagged, and released into the Bonneville PH2 turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish descaled ≥20% on at least one side. Tests conducted with one or two open gatewell orifices.

Parameter	Collection Channel	Intake 14A Upper 1%, One Orifice	Intake 14A Upper 1%, Two Orifices	P[a]
Test blocks (no.)	8	5	4	
Test duration (h)	24	24	24	
Fish released (no.)	400	2,058	1,641	
Recaptured (%)	96.7	96.5	95.9	0.08
Mortality (%)	0.3	4.5	2.4	0.04
Timing (median, h)	0.6	6.1	2.9	0.06
Descaling (%)	0.3	2.6	1.2	0.10

[a] ANOVA. P values are for load comparisons of one or two open gatewell orifices.

2.3. HYDRAULIC FEATURES

A CFD model of the existing features of Bonneville PH2 was developed to investigate the existing hydraulic conditions and support alternative development for FGE improvement as described in the report, *Bonneville Second Powerhouse Fish Guidance Efficiency Computational Fluid Dynamics Modeling*, dated September 2011 (Appendix C). The following sections summarize model selection, development, and application to existing conditions. Additional detailed information is provided in Appendix C.

2.3.1. Hydraulic Model Selection

An existing forebay CFD model was developed by the Pacific Northwest National Laboratory (2009) using the Star CD software. The forebay CFD model was applied to investigate the relative impacts of forebay configuration on hydraulic conditions approaching and in the intake gatewells. However, this model does not include the current details of improvements to the gatewell geometry, and an updated model was needed to support the alternatives analysis for this study.

During earlier phases of this study, the thought was to build a physical sectional model to investigate FGE improvement alternatives. After reviewing the physical and numerical models developed to date, it was determined that the gatewell hydraulics could be impacted by the physical configuration of the Bonneville PH2 forebay. Therefore, using a CFD model to analyze FGE alternatives would allow for investigation of alternatives in a sectional CFD model with secondary confirmation of selected alternatives over a range of forebay configurations and operations in the full forebay CFD model. A summary of the advantages and limitations of the selected CFD model are summarized below.

Advantages

- The CFD model can be linked to the forebay model to investigate the impacts of forebay configuration and powerhouse operations on gatewell hydraulics. This capability will be important in confirming the performance of FGE improvement alternatives over a range of forebay configurations and powerhouse operations.
- Relevant geometric features in the powerhouse unit that affect gatewell hydraulics can be readily included in the CFD model. These features are described in Section 2.3.2.
- Model results can be queried at any location in the model domain for velocity, pressure, turbulence. Particles seeded into the model results can provide quantifiable information on gatewell residence time and flow patterns.
- Alternatives (operational or functional changes) can be included in the CFD model relatively efficiently.
- CFD models can be maintained on a computer system in backup files. If the model is compatible with future software versions, it can be used for many years with little maintenance.

Limitations

- Significant changes to VBS velocities that require rebalancing of VBS screen porosities will result in the need for a physical model. The CFD model cannot be used to directly identify updated porosity plate configurations for screen balancing as configured. The CFD model represents the VBS as a porous baffle and uses two porosity parameters to represent the pressure change across the screen panels rather than direct porosity.

- The sectional CFD model calibration is adequate to investigate the relative change in gatewell flow between existing conditions and FGE alternatives. If the CFD model is to be used to develop detailed gatewell flow rating curves, additional prototype velocity data is recommended to minimize uncertainty in the rating curves.
- The CFD model is a steady-state representation of hydraulic conditions and the influence of transient conditions needs to be considered when interpreting the results.
- Real time viewing of results in a CFD model is limited to available computing resources.

2.3.2. CFD Model Development

An updated sectional CFD model of a Bonneville PH2 turbine unit was developed to support alternative development and analysis for FGE improvements. The updated sectional CFD model was developed of a single PH2 turbine unit to include the following geometric features in sufficient detail to capture the hydraulic influence of the features:

- Turbine intake extensions (TIEs);
- Trash rack including main horizontal and vertical support members;
- STS including structural members and a with a zero-thickness porous baffle representing the STS screen for each bay;
- Gap closure device (GCD);
- Turning vane;
- Gate slots including overall width and depth of gate slots;
- Modified gatewell beam;
- VBS including structural members and zero-thickness porous baffles representing the nine VBS screen panels in each bay;
- Fish orifice; and
- Emergency gate including horizontal structural members on upstream face of gate.

The updated sectional CFD model was developed by creating a solid geometry of the turbine unit (Figure 2-3) in SolidWorks, a three-dimensional rendering software. The sectional CFD model domain extends from the upstream boundary approximately 100 feet upstream of the trashrack to just upstream of the ends of the piers separating the A, B, and C bays prior to the scroll case.

The computational grid for the model domain was developed using the grid generation program in the Star CCM+ modeling software and consists of approximately 2.4 million polyhedral (or many-sided) cells, as shown in Figures 2-4 and 2-5. The sectional CFD model is of sufficient detail for analyzing relative impacts of FGE improvement alternatives on gatewell hydraulic conditions and flow. The sectional CFD model calibration and validation using VBS normal and sweeping velocity data from previous physical modeling and field studies is described in detail in Appendix C. A grid sensitivity analysis was conducted as described in Appendix C to ensure that the baseline model results are not dependent on the grid resolution.

Figure 2-3. Isometric View (left) and Section View (right) of Turbine Unit

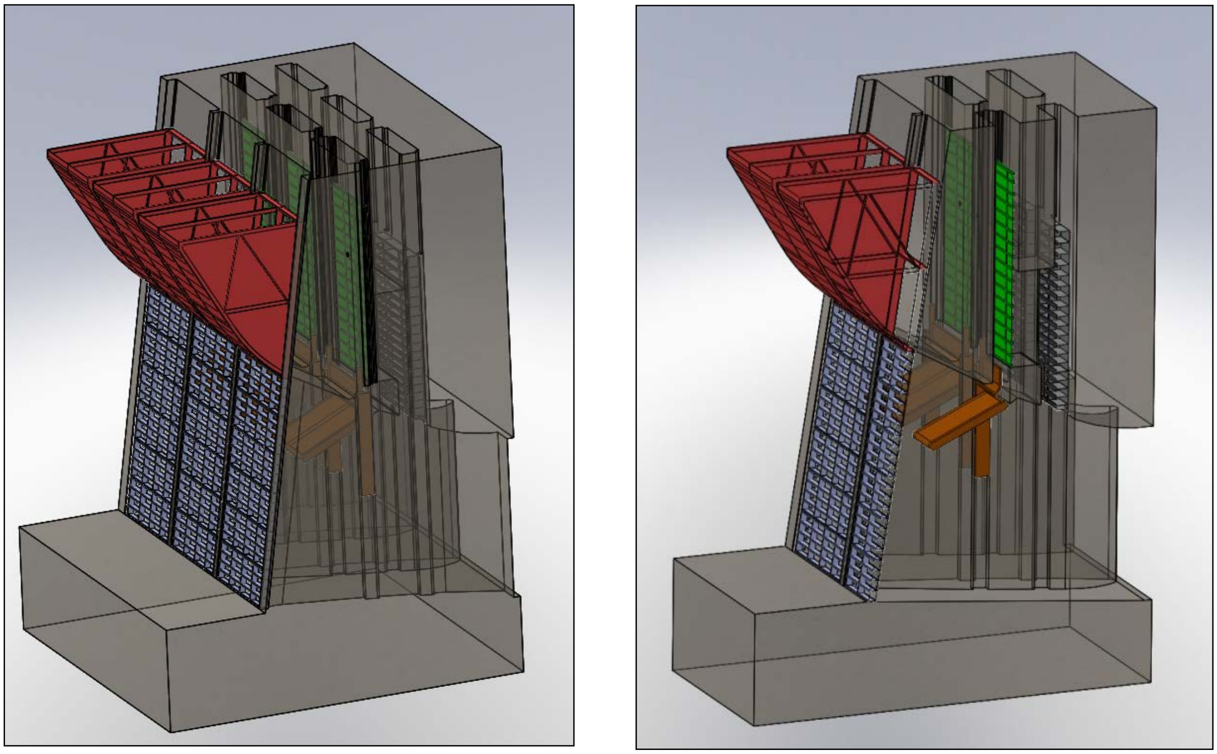


Figure 2-4. CFD Model Grid – Section View

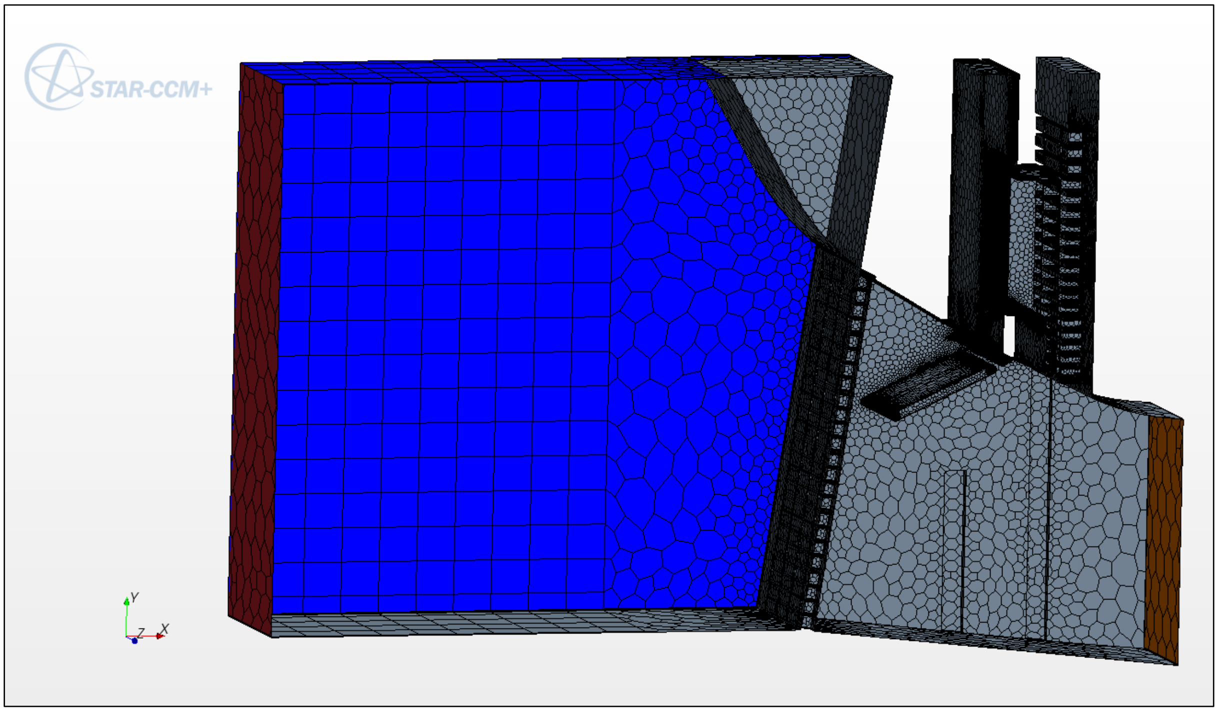
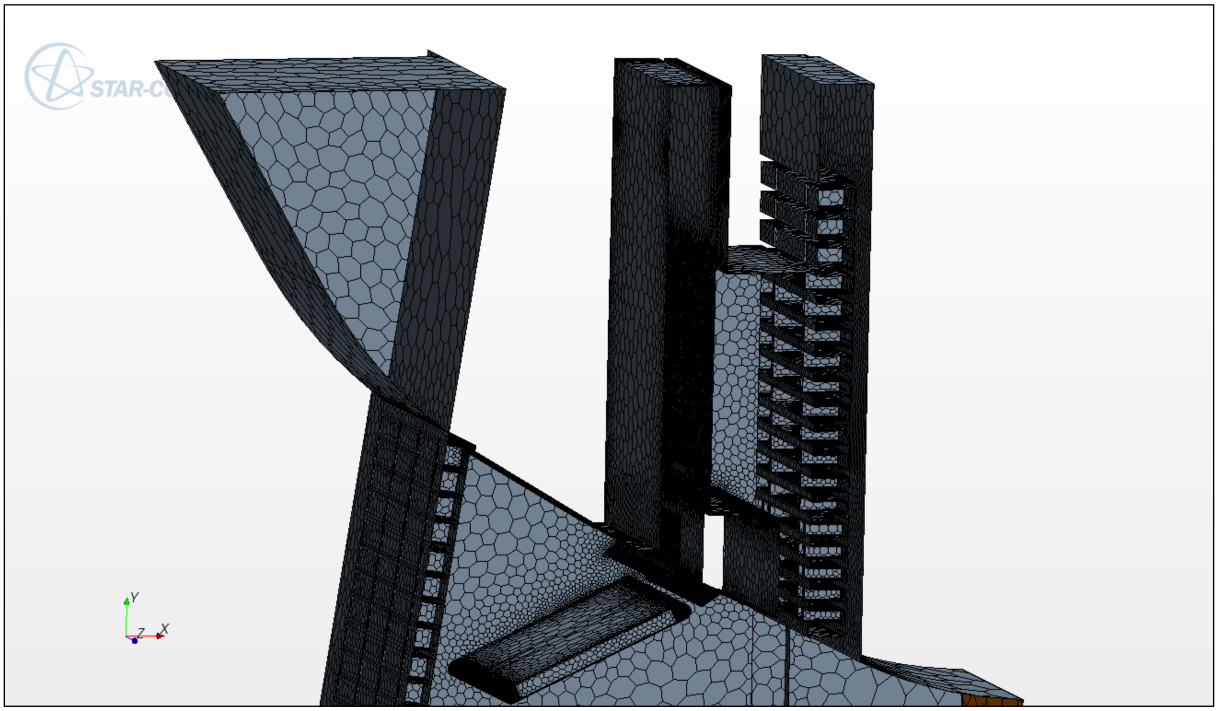


Figure 2-5. CFD Model Grid – Zoomed View



2.3.3. CFD Modeling for Baseline Conditions

Following calibration and validation, the CFD Model was run for unit flow conditions representing the low, medium, and high 1% efficiency unit operation as shown in Table 2-5. The runs were conducted with existing gatewell geometry to establish a hydraulic baseline for evaluation of alternatives.

Table 2-5. Baseline Run Outflow Conditions

Unit Flow (ft^3/s)	Bay A Flow (ft^3/s)	Bay B Flow (ft^3/s)	Bay C Flow (ft^3/s)
12,000	4,536	4,104	3,360
15,000	5,670	5,130	4,200
18,000	6,804	6,156	5,040

The 18,000 ft^3/s unit flow provided a baseline for hydraulic conditions assumed to represent unfavorable flow conditions for fish passage at the high 1% efficiency range, while the 15,000 ft^3/s unit flow provided a baseline for assumed minimally favorable hydraulic conditions for fish passage at the medium 1% efficiency range. The 12,000 ft^3/s provided a low-flow baseline for assumed favorable hydraulic conditions for fish passage at the low 1% efficiency range. Additional details of the sectional CFD model boundary conditions are provided in Appendix C.

2.3.3.1. Low Unit Flow Conditions – 12,000 ft^3/s

With the existing gatewell geometry in place and a unit flow (Unit Q) of 12,000 ft^3/s, the CFD model-predicted VBS flows in bay A are summarized in Table 2-6. Bay A has the highest flow of the three bays in each unit and thus, the highest VBS and gatewell flow. The VBS flow for each bay was calculated from the CFD model results by converting the mass flux (kilograms/second) across the VBS baffle to flow (ft^3/s). The VBS flows for the baseline CFD model runs in Table 2-6 shows increasing VBS flow with increasing unit flow, as expected.

Table 2-6. Baseline Run VBS Flow Summary

Unit Flow (ft^3/s)	Bay A VBS Flow (ft^3/s)
12,000	219
15,000	272
18,000	328

The CFD model results for the low unit flow condition are summarized in Figures 2-6 to 2-11 show flow passing through the trashrack, with a portion of the flow passing up the STS to the gatewell, and the remainder passing into the intake. Flow up the STS accelerates to up to 5-6 ft/s, with a portion of the flow returning to the intake between the GCD and the STS (Figures 2-6 to 2-8). The gatewell flow passes along the turning vane, with some separation downstream of the upstream intake roof and the turning vane, as shown by the low velocity areas in Figure 2-7. As the flow passes above the turning vane, the gate slot width increases abruptly above the turning vane and STS side supports, and the flow cannot immediately expand to fill the volume. An opposing recirculation of flow upward and then downward on either side of each bay results as the flow expands downstream of the abrupt gate slot transition (Figure 2-9). The CFD model results show that the recirculation is more intense on one side (generally the left side, looking upstream), likely as a result of slightly asymmetrical approach conditions generated by the different bay flows for bays A, B, and C.

Figure 2-6. Baseline, Unit Q = 12,000 ft^3/s, Bay A Centerline Velocities

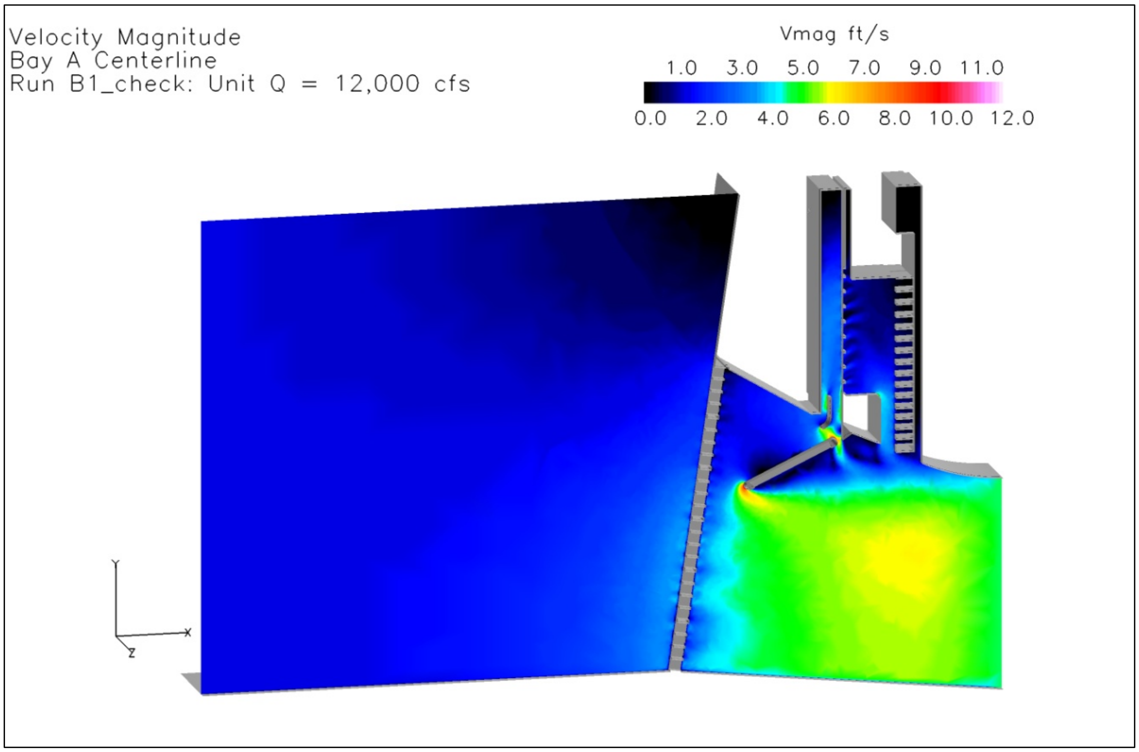


Figure 2-7. Baseline, Unit Q = 12,000 ft³/s, Bay A Centerline Velocities (zoomed)

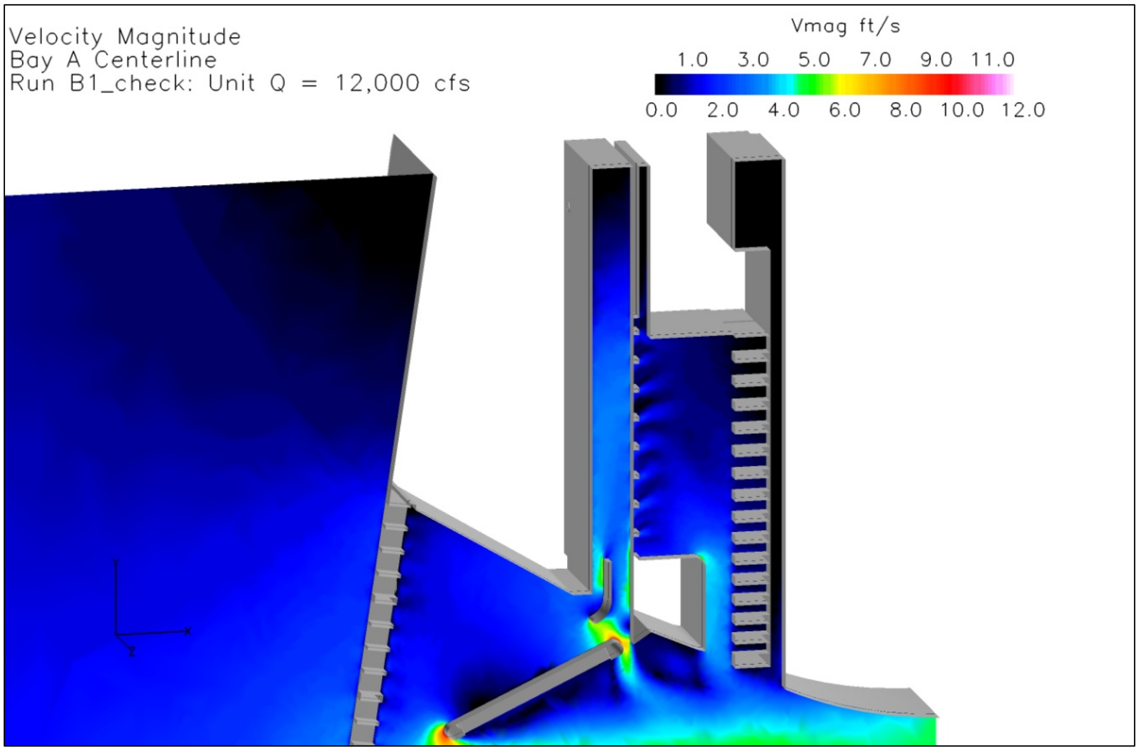


Figure 2-8. Baseline, Unit Q = 12,000 ft³/s, Bay A Fish Orifice Centerline Velocities

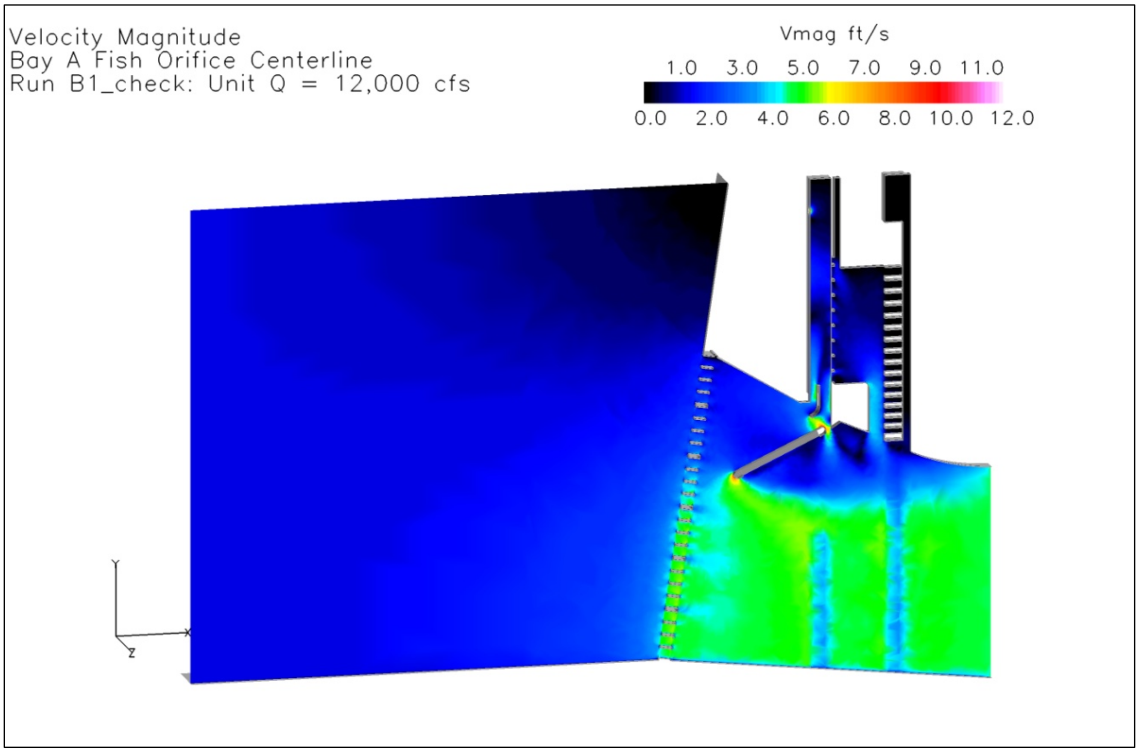
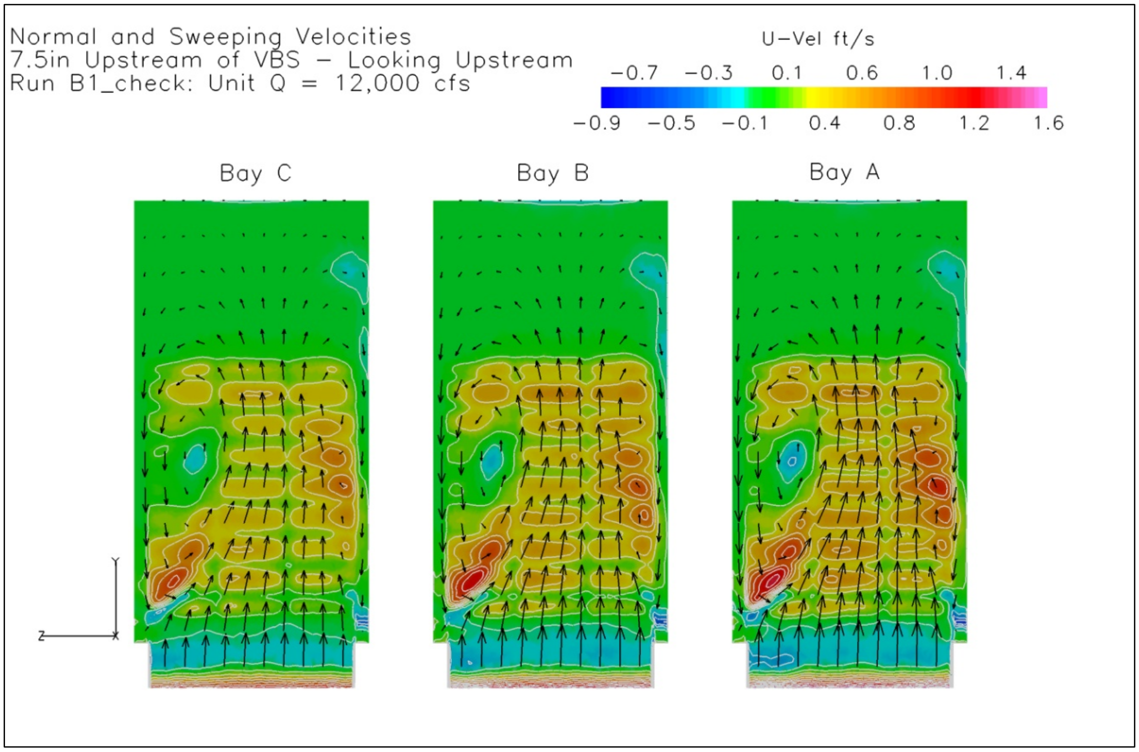


Figure 2-9. Baseline, Unit Q = 12,000 ft^3/s, VBS Normal Velocities and Flow Patterns



Normal velocities just upstream of the VBS are generally less than the 1 ft/s criteria, with some velocities approaching 1 ft/s in the recirculation areas on either side of the VBS (Figure 2-9). Sweeping velocities up the VBS are generally positive (positive upward), but negative in the recirculation on either side of the VBS. The general level of turbulence in the gatewell is characterized by the turbulent kinetic energy isosurface plots in Figures 2-10 and 2-11. In the isosurface plots, regions with a specified level of turbulent kinetic energy [0.25 feet squared per second squared (ft^2/s^2) and 0.5 ft^2/s^2 in Figures 2-11 and 2-12, respectively] are plotted as a three-dimensional surface to indicate location. For low flow conditions, regions of turbulence are present downstream of the intake roof, on the downstream face of the turning vane, and extending along either side of the VBS downstream of the gate slot expansion above the STS side supports.

Figure 2-10. Baseline, Unit Q = 12,000 ft^3/s, Turbulent Kinetic Energy Isosurface (0.25 ft^2/s^2)

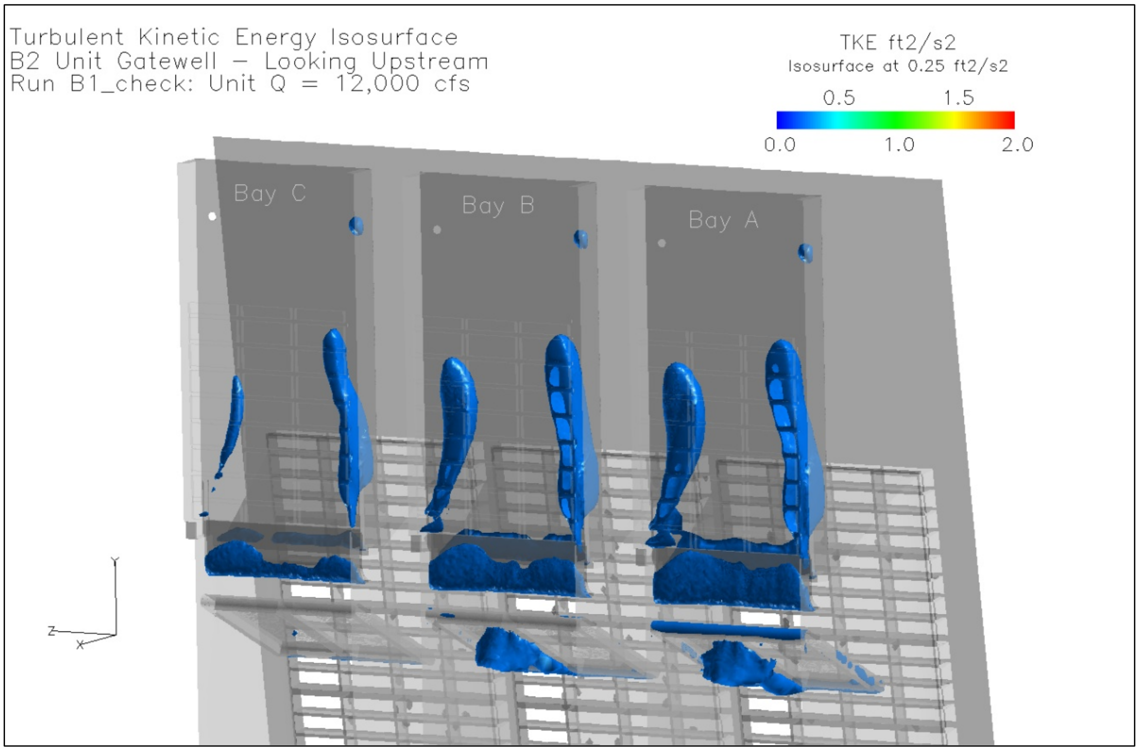
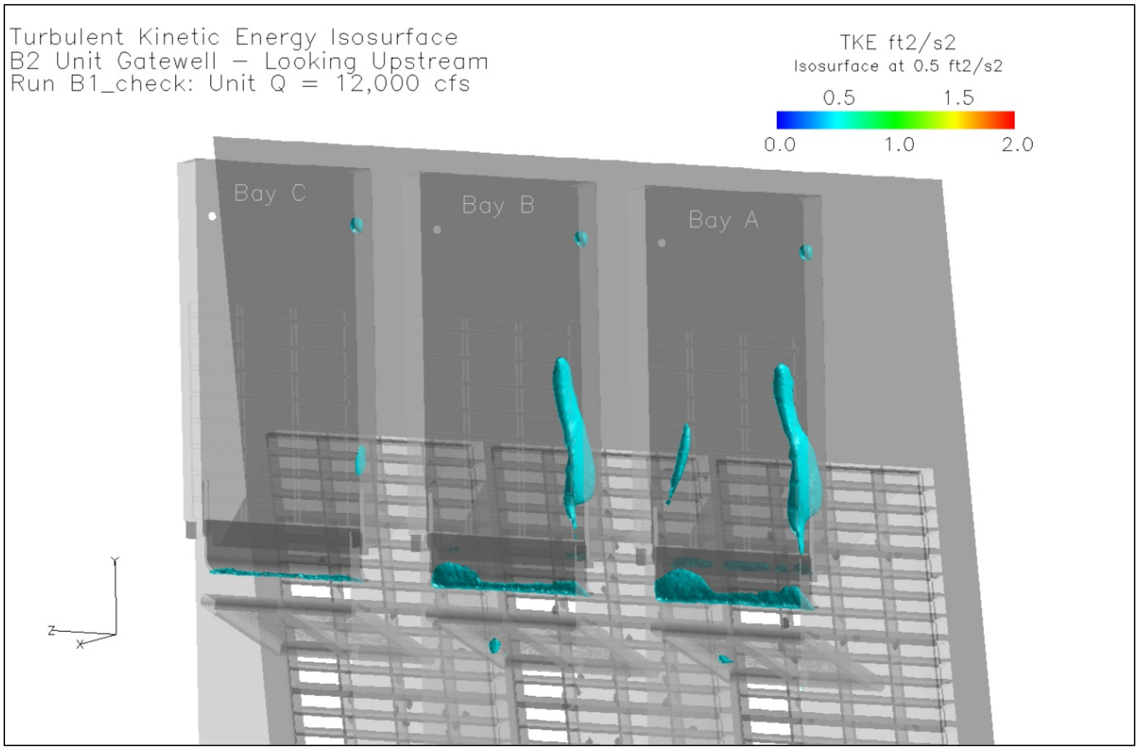


Figure 2-11. Baseline, Unit Q = 12,000 ft^3/s, Turbulent Kinetic Energy Isosurface (0.5 ft^2/s^2)



2.3.3.2. Medium Unit Flow Conditions – 15,000 ft^3/s

The CFD model results for the medium unit flow (Unit Q) condition are summarized in Figures 2-12 to 2-15, with additional plots provided in Appendix C. The VBS flow for the medium unit flow condition (15,000 ft^3/s) is approximately 270 ft^3/s (see Table 2-6). The gatewell flow patterns for the 15,000 ft^3/s unit flow condition are generally similar to those for the low unit flow condition, but the velocity magnitudes and intensity of the turbulence in the gatewell are increased. As flow passes up the STS to the GCD and turning vane, velocities reach 7-8 ft/s (Figure 2-13) as compared to 5-6 ft/s for the low unit flow condition. The plots of VBS normal velocity show increased intensity of the recirculation regions downstream of the gate slot expansion, and VBS normal velocities as high as 1.3-1.5 ft/s in the “hot spots” inside the left and right recirculation zones in bay A (Figure 2-14). The positive sweeping velocities are concentrated to the center portion of the VBS, with negative sweeping velocities on the outer left and right portions of the VBS (Figure 2-14). Turbulent kinetic energy increased in the gatewell with increased unit flow as shown by the larger volume isosurfaces in Figure 2-15.

Figure 2-12. Baseline, Unit Q = 15,000 ft^3/s, Bay A Centerline Velocities

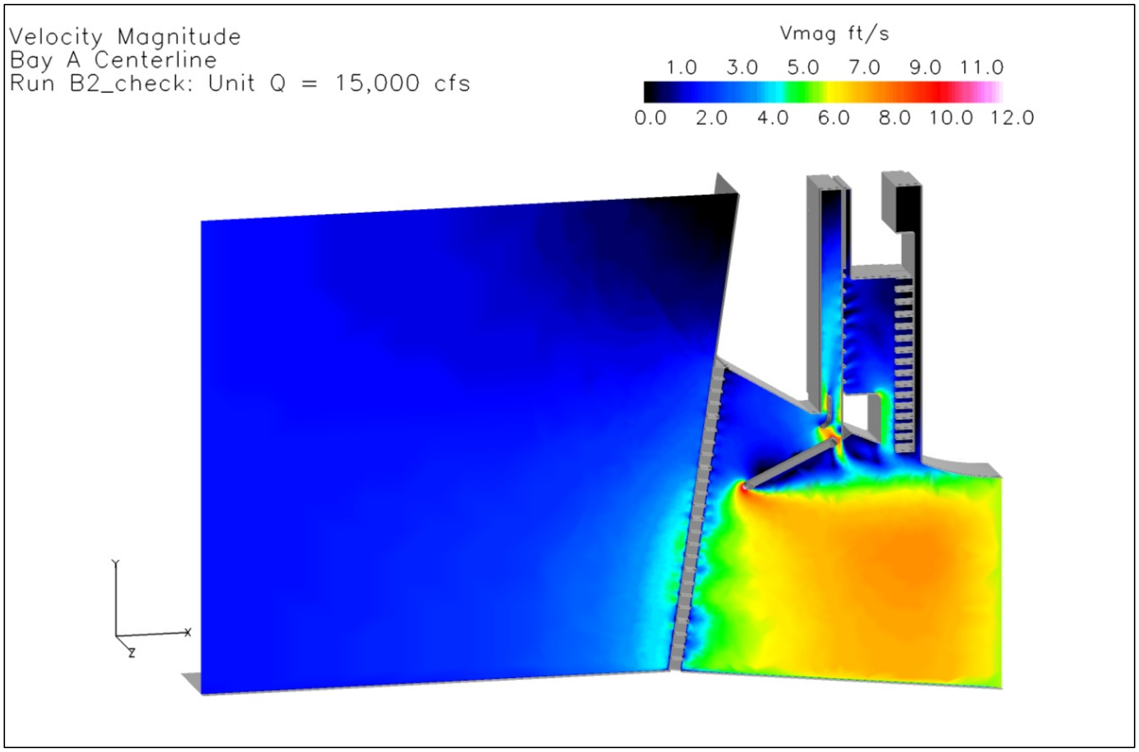


Figure 2-13. Baseline, Unit Q = 15,000 ft³/s, Bay A Centerline Velocities (zoomed)

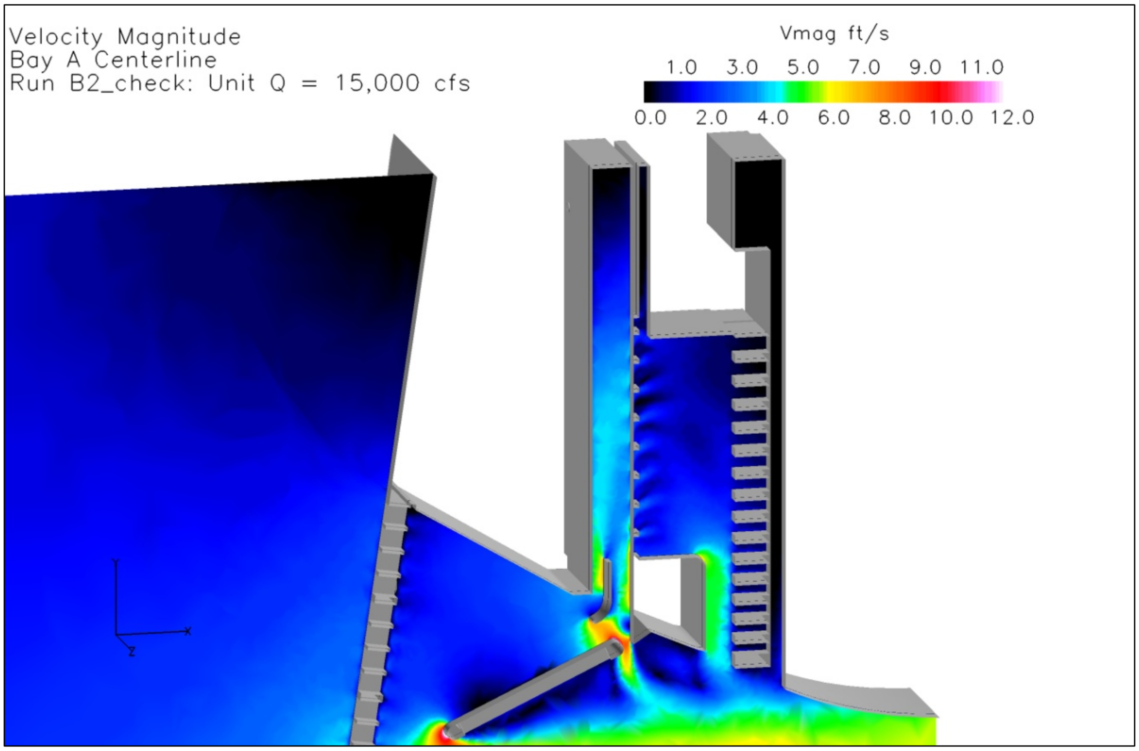


Figure 2-14. Baseline, Unit Q = 15,000 ft³/s, VBS Normal Velocities and Flow Patterns

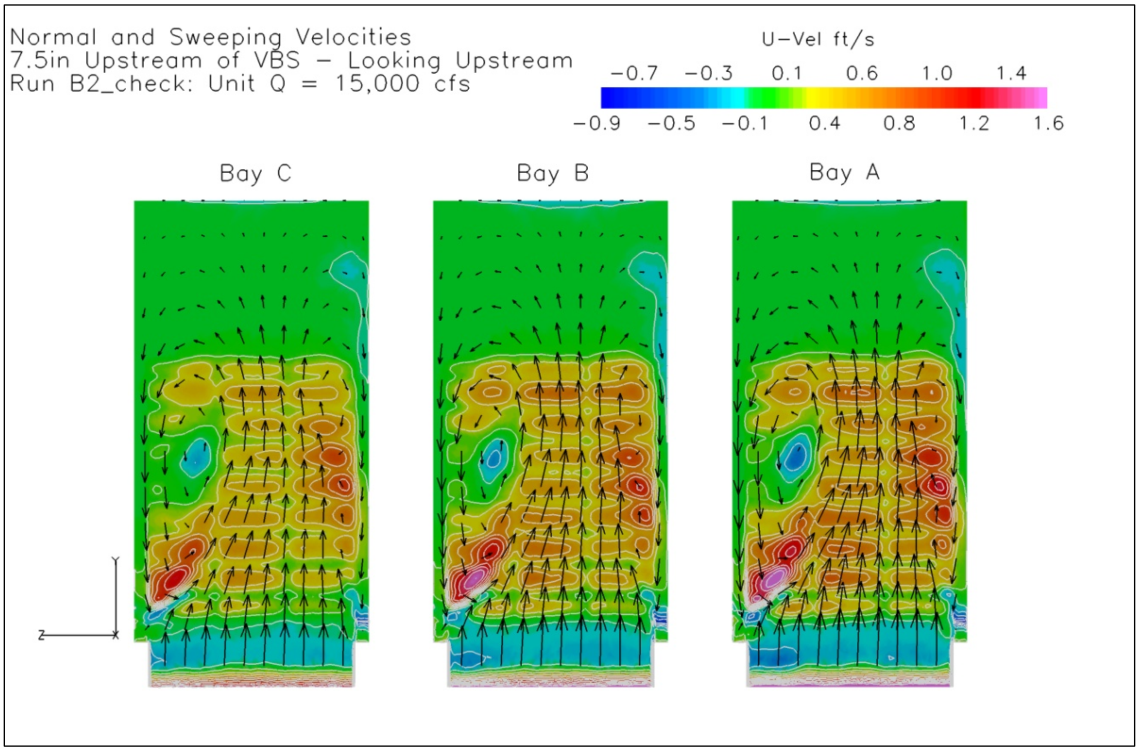
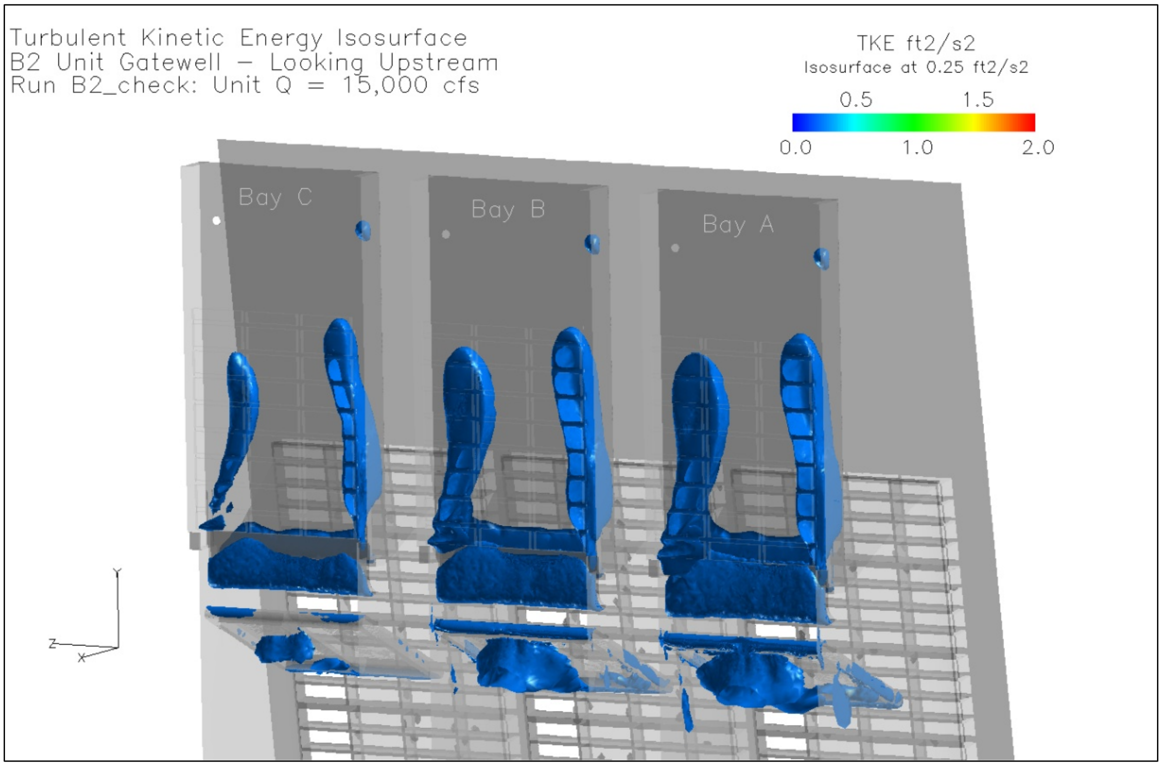


Figure 2-15. Baseline, Unit Q = 15,000 ft^3/s, Turbulent Kinetic Energy Isosurface (0.25 ft^2/s^2)



2.3.3.3. High Unit Flow Conditions – 18,000 ft^3/s

The CFD model results for the high unit flow (Unit Q) condition are summarized in Figures 2-16 to 2-19. The VBS flow for the high unit flow condition (18,000 ft^3/s) is approximately 330 ft^3/s (see Table 2-6). The gatewell flow patterns for the 18,000 ft^3/s unit flow condition are generally similar to those for the low and medium unit flow condition, but the velocity magnitudes and intensity of the turbulence in the gatewell are further increased. As flow passes up the STS to the GCD and turning vane, velocities reach 9-10 ft/s (Figure 2-17) as compared to 5-6 ft/s for the low unit flow condition. The plots of VBS normal velocity show increased intensity of the recirculation regions downstream of the gate slot expansion, and VBS normal velocities as high as 1.4-1.6 ft/s in the “hot spots” inside the left and right recirculation zones in bay A (Figure 2-18). The positive sweeping velocities are concentrated to the center portion of the VBS, with negative sweeping velocities on the outer left and right portions of the VBS (Figure 2-18). Turbulent kinetic energy increased in the gatewell with increased unit flow as shown by the larger volume isosurfaces in Figure 2-19.

It is unknown whether there is a specific threshold for tolerance of turbulence by juveniles, but the increased turbulent kinetic energy coincident with higher recirculation and normal velocities on the VBS may be a significant factor in exhaustion and subsequent injury for juveniles. Therefore, alternatives for improving FGE will consider streamlining the sweeping velocities along the VBS, reducing turbulence in the gatewell, minimizing gatewell residence time, and reducing and evenly distributing normal velocities on the VBS.

Figure 2-16. Baseline, Unit Q = 18,000 ft^3/s, Bay A Centerline Velocities

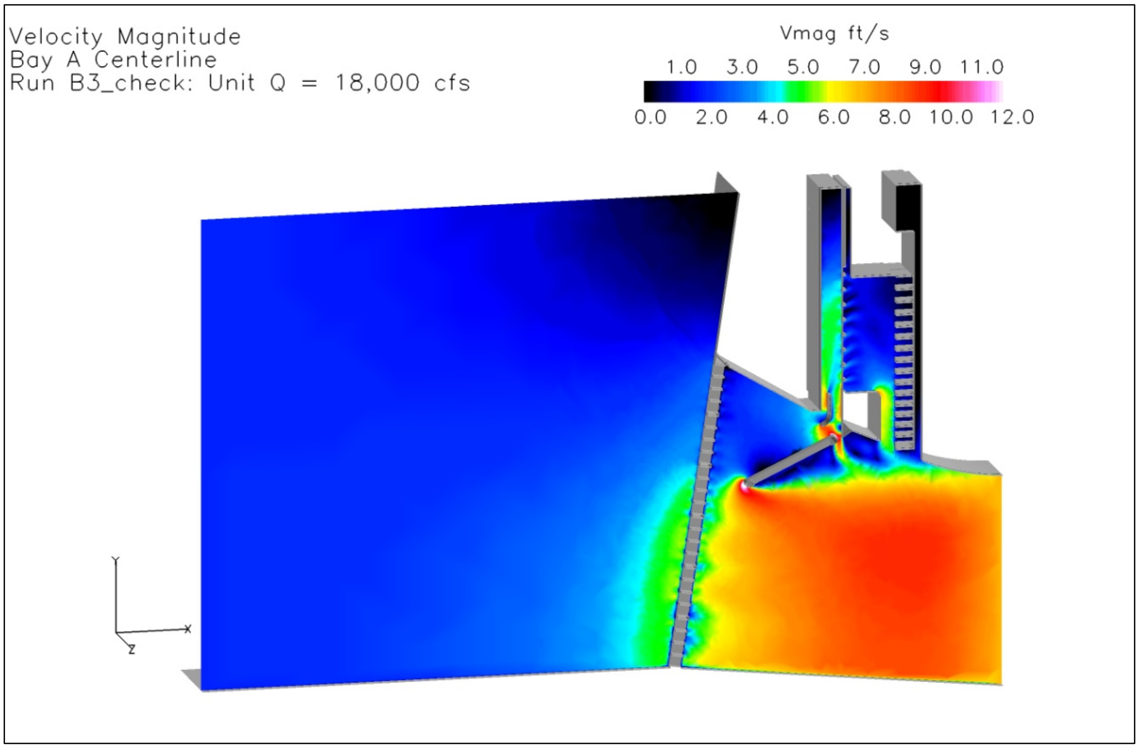


Figure 2-17. Baseline, Unit Q = 18,000 ft^3/s, Bay A Centerline Velocities (zoomed)

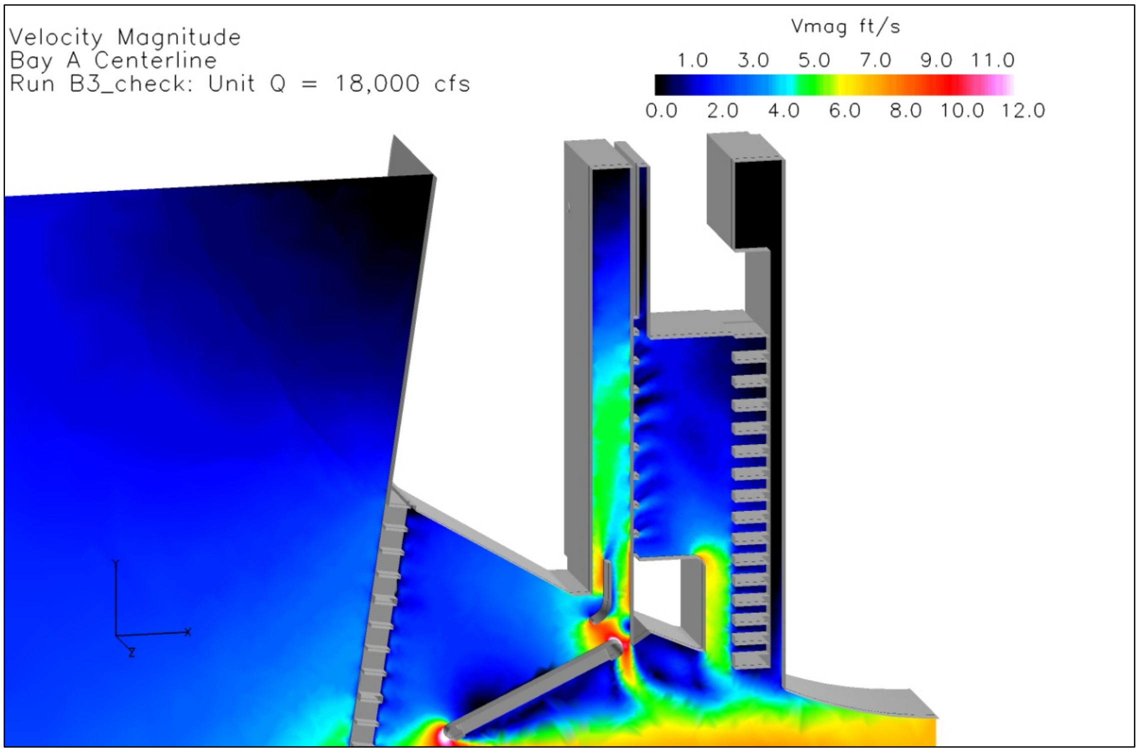


Figure 2-18. Baseline, Unit Q = 18,000 ft^3/s, VBS Normal Velocities and Flow Patterns

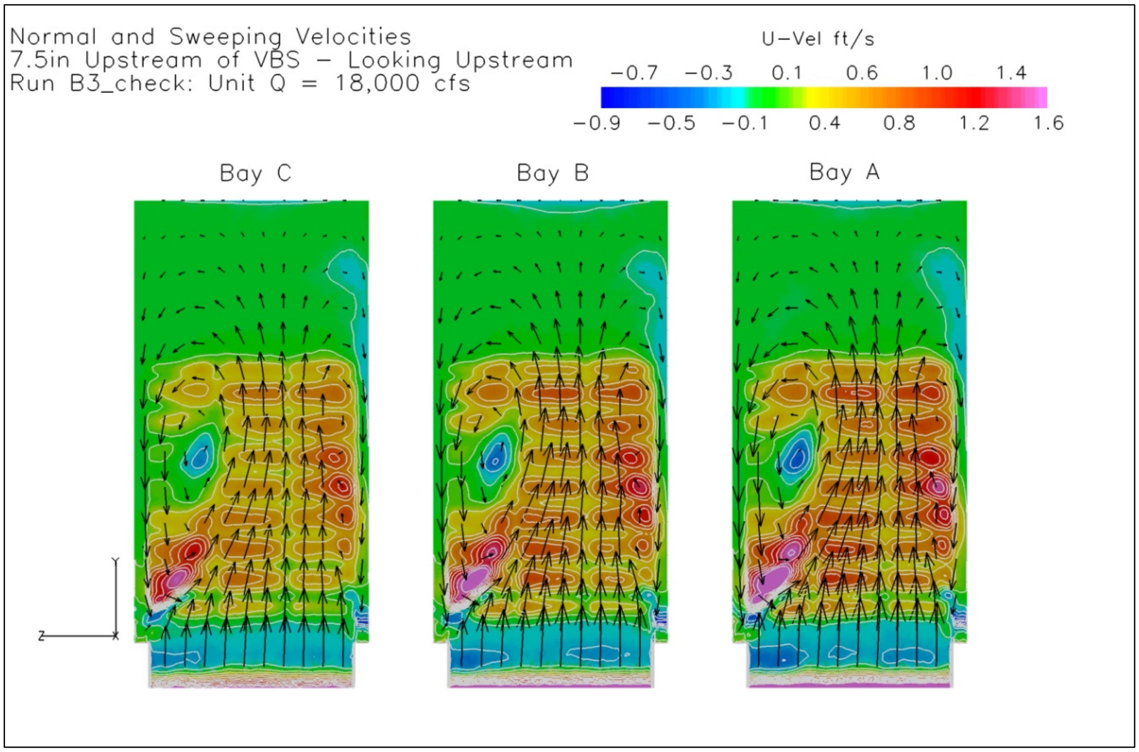
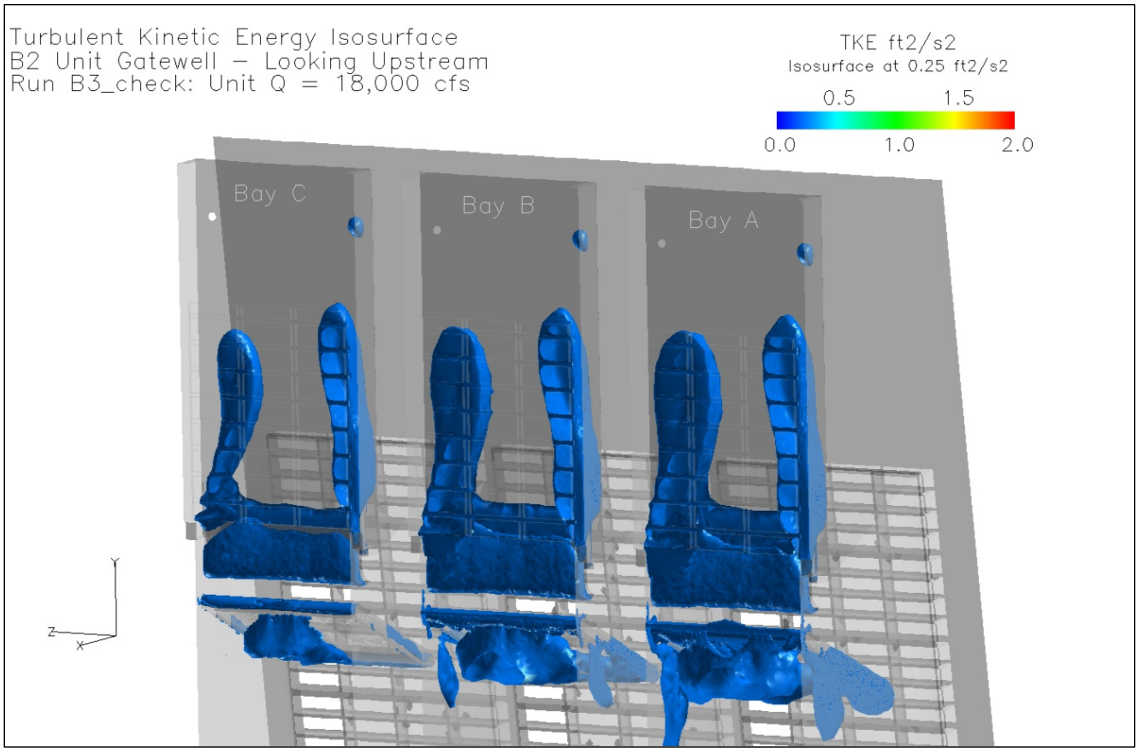


Figure 2-19. Baseline, Unit Q = 18,000 ft^3/s, Turbulent Kinetic Energy Isosurface (0.25 ft^2/s^2)



3. CONSIDERATIONS AND ASSUMPTIONS

3.1. GENERAL

The following issues have been identified that need to be considered during investigation of alternatives.

1. The vertical inlet opening that may require flow control is 25 feet, 3 inches in height by 21 feet, 3 inches in width. This represents an area of 539 square feet in which a flow control device may have to be installed and operate.
2. The horizontal inlet opening that may require flow control is 21 feet, 3 inches long by 7 feet, 8 inches wide. This represents an area of 163 square feet in which a flow control device may have to be installed and operated. This does not include any adjustment for the configuration of the downstream bulkhead guides.
3. The horizontal or normal downstream flow varies from 0.2 feet per second (ft/s) at the top intake elevation of 54.00 feet to a maximum of 0.6 ft/s at the bottom sill elevation 31.00 feet.
4. The vertical flow velocity varies from 1.5 ft/s at the top intake elevation to a maximum of 6.3 ft/s at the bottom sill elevation (note that this is based on the 1:12 physical model results as a source).
5. The VBS frames must be pulled and cleaned of heavy drift wood debris throughout the year. During peak months (October-December), they are pulled and cleaned two times a week.

3.2. BIOLOGICAL

The Biological Opinion for Bonneville Dam juvenile survival goal is 93% subyearling Chinook and 96% yearling Chinook and steelhead. Bonneville PH2 FGE improvements made to the turbine environment originally showed benefits with a 0.1% to 0.3% overall FGE improvement for yearling Chinook, subyearling Chinook, and steelhead during regular spill (April-August). A 0.7% FGE improvement was found after spill termination on September 1.

With the recent discovery of poor survival of SCNFH fish, the biological goal is to improve conditions for these fish while maintaining (or improving) the FGE and survival improvements of the original Bonneville PH2 FGE design. These are the current assumptions that are the driving factor for this study.

3.2.1. Assumptions

Current assumptions as to what is happening within the gatewell post-FGE improvements are as follows:

- After FGE modifications, juvenile migrants, especially SCNFH subyearling Chinook, are being impacted and mortality is higher due to higher gatewell turbulence at turbine loads at the current upper 1% operating range, which is making it more difficult for fish to exit.
- Higher turbine loads (mid to upper 1%) result in more flow up the slot increasing turbulence.
- Increased turbulence is causing fish housed within the gatewell to take more time to find the orifice that is their entrance to the DSM channel.
- Dead fish that are being collected at the Bonneville PH2 smolt monitoring facility are showing little or no signs of injury. It is speculated that these fish are spending greater time within the gatewell trying to exit. Under these more turbulent conditions, fish are expending excessive energy trying to exit the gatewell and are dying of exhaustion before being able to exit.

- Reducing turbine loads on the FGE-modified units to mid to lower turbine operational ranges have shown to bring fish passage mortality back to acceptable ranges (>1%).
- Opening an additional available orifice within the gatewell during loads at mid and upper 1% allows OPE to remain high and mortality/descaling is kept at acceptable historical levels (>1%).
- Taking actions that reduce turbulence either through operations or modifications to the gatewell environment will improve OPE, condition, and fish survival through the PH2 DSM system.

After improvements or operational changes are made to the system, the USACE will be able to measure and identify quantifiable improvements that have been achieved by comparing pre- and post-implementation success via historical smolt passage date that will determine what constitutes success.

3.3. HYDRAULIC

3.3.1. Assumptions and Evaluation Criteria

In general, the following working assumptions were used in developing and evaluating alternatives:

- Based on available biological information, at 12,000 ft^3/s unit flow, hydraulic conditions in the gatewell are favorable for fish passage. Conditions at 15,000 ft^3/s unit flow may be acceptable for fish passage, but available data is limited.
- Based on available biological information, at 18,000 ft^3/s unit flow, hydraulic conditions are unfavorable for fish passage.
- Based on the baseline CFD model results described in Section 2, alternatives for improving FGE will focus on the following to improve hydraulic conditions for fish passage:
    - Streamlining the sweeping velocities along the VBS,
    - reducing turbulence in the gatewell,
    - minimizing gatewell residence time, and
    - reducing and evenly distributing normal velocities on the VBS.
- The improvements listed above may be achieved by reducing gatewell flow through structural or operational means. Because FGE will likely decrease with decreased gatewell flow, flow control alternatives must be carefully balanced to achieve an overall improvement in FGE.
- Alternatives that streamline the gatewell geometry to reduce turbulence, change flow patterns, or reduce fish residence time while maintaining gatewell flow may improve hydraulic conditions for fish passage while maintaining FGE. These alternatives may be feasible as stand-alone alternatives or in combination with flow control alternatives.
- Structural alternatives will be included in the CFD model to a level of detail to capture hydraulic influence of structures (i.e., overall shape and dimensions as available, but not fasteners or minor structural details).

The CFD model results for alternatives will be compared to baseline results using the following metrics:

- Turbulent kinetic energy;
- Gatewell residence time; and
- Gatewell flow patterns (normal and sweeping velocities).

3.3.2. Turbine Intake Screens and Vertical Barrier Screens

Turbine intake screen and VBS at mainstem Columbia and Snake River hydroelectric dams are exception to design criteria for conventional screens. Turbine intake screens are considered partial screens, because they do not screen the entire turbine discharge. They are high-velocity screens, meaning approach velocities are much higher than allowed for conventional screens. Turbine intake screens were retrofitted at many mainstem Columbia and Snake River powerhouses (that cannot be feasibly screened using conventional screen criteria) to protect juvenile fish from turbine entrainment to the extent possible. Vertical barrier screens pass nearly all flow entering the gatewell from the intake screen and intake ceiling apex zone. Fish pass upward along the VBS and then accumulate in the upper gatewell, near an orifice that is designed to pass them safely into the DSM.

Alternatives should be designed to operate within the design forebay level range (elevation 71.5 to 76.5 feet). Forebay levels remain within this range 97.3% of time (1974-1981 forebay data).

3.3.2.1. Turbine Intake Screens – Specific Criteria

Maximum Approach Velocity: Maximum approach velocity (normal to the screen face) for turbine intake screens must be 2.75 ft/s.

Stagnation Point: The stagnation point (point where the component of velocity along the turbine intake screen face is zero ft/s) must be at a location where the submerged screen intercepts 40% to 43% of turbine intake flow, and must be within 5 feet of the leading edge of the screen.

3.3.2.2. Vertical Barrier Screens – Specific Criteria

Through-Screen Velocity: Average VBS through-screen velocity must be a maximum of 1.0 ft/s, unless field testing is conducted to prove sufficiently low fish descaling injury rates at a specific site. The VBS must be designed to achieve uniform velocity distribution and minimize turbulence in upper gatewell. If a flow vane is used at gatewell entrance to increase flow up the gatewell, VBS should be constructed of stainless steel bar screens with bars oriented horizontally and 1.75 mm maximum clearance between bars.

3.3.3. Downstream Migrant System – Specific Criteria

The hydraulic design of the DSM is driven by hydraulic criteria for safe passage of downstream migrating juvenile salmon. The primary objective of these criteria is to minimize injury or delay to the fish. Criteria provided by NOAA Fisheries for the forebay range, orifices, collection channel, dewatering structure, and exit section are listed below.

Design Forebay Operating Ranges

- Design forebay elevation for DSM constant flow operation: elevation 71.5 to 76.5 feet (normal operating range).

Orifices

- Plate velocity ≥ 10 ft/s.
- Orifice discharge ≥ 11 ft^3/s.
- Centerline trajectory of the orifice jets should enter the collection channel water surface at least 4 feet from the opposite wall.

Collection Channel

- Channel velocity ≥ 2 ft/s (acceptable for unit 11 per NOAA discussion).
- Channel velocity between 3 to 5 ft/s at downstream end.
- Channel water depth ≥ 4 feet.

Dewatering Facility

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

Exit Section

- Flow rate 30 ft^3/s.
- Ratio of bend radius to pipe diameter (R/D) ≥ 5.
- Velocities should not increase or decrease at rates > 0.1 ft/s per unit foot of conduit length.

3.4. STRUCTURAL

Structural features and criteria will be developed for each alternative to a conceptual level.

3.5. MECHANICAL/ELECTRICAL

Mechanical and electrical features and criteria will be developed for each alternative to a conceptual level. The upstream gate slot is where the STSs are deployed and where the inspection camera descends to inspect the STS while it is travelling. In addition, the VBSs are in this slot at the downstream face, dividing the upstream and downstream gate slots. The downstream gate slot is where the hydraulic head gates are permanently mounted, in a ready-to-deploy configuration. The deck area around both slots will need to be kept clear so that equipment and weight-handling devices can be used to service the turbine intakes. Alternatives developed will need to accommodate existing equipment and work activities.

If electrical power is needed, cabling can be routed through existing conduits from the Elevation 70 Gallery into the downstream head gate slot. The instrumentation for the VBS, the power supply, and instrumentation cabling for the STSs are in existing conduits; any new cabling will need to be routed around these existing features.

3.6. COST ENGINEERING

3.6.1. Total Project Costs

Total project costs will be generated for the recommended alternative. These costs are applicable to structural alternatives which require design and construction to modify the VBS or installation of additional equipment. These costs include design, construction, escalation to the mid-point of construction, supervision and inspection, engineering during construction, and contingency costs. Engineer Technical Letter 1110-2-573, *Construction Cost Estimating Guide for Civil Works*, provides the criteria for developing these costs, which is to estimate a fair and reasonable cost for the alternative.

3.6.2. Life Cycle Costs

Life cycle costs (LCC) will be generated for the alternatives considered in the second round of evaluation. LCC are used to compare alternatives with high initial costs and low operational costs, with other alternatives with low initial costs and high maintenance costs, or in this case, lost power costs. Life cycle costs will include *all* costs involved in the alternative during its project life, such as design, construction, operation, and lost power costs, as applicable. For comparison purposes, all of these costs will be calculated as the present worth using appropriate discount rates for future costs and assuming a nominal 50-year project service life. They will also be presented as an average annual cost. Engineering Regulation 1110-2-8159, *Life Cycle Design and Performance*, defines the policies for long-term performance and life cycle costs.

3.7. HYDROPOWER ECONOMIC ANALYSIS

Alternative B1 consists of operating Bonneville PH2 main units off the 1% peak range during the juvenile fish passage season (March-August). The estimated impacts of this alternative, in terms of foregone project generation and foregone hydropower benefits, are summarized in Section 4.6.7. Details regarding the procedures and methodology used to develop these estimates are presented in Appendix D, *Hydropower Impacts*. The main inputs and assumptions associated with the hydropower impacts analysis are summarized below.

3.7.1. Alternatives Defined for the Hydropower Impacts Analysis

The hydropower impacts of Alternative B1 were developed by estimating Bonneville generation output and hydropower benefits under each of two alternatives:

- **Base Case: Bonneville PH2 Units Operate to Upper 1% Operating Point.** This alternative assumes that all Bonneville first powerhouse (PH1) and PH2 main units operate between the peak efficiency operating point and upper 1% operating point during the juvenile fish passage season.
- **Alternative Case: Bonneville PH2 Units Operate at Peak Efficiency Operating Point.** This alternative assumes that all Bonneville PH1 main units operate between the peak efficiency operating point and upper 1% operating point during the juvenile fish passage season, while all Bonneville PH2 main units operate at the peak efficiency operating point during this time period.

3.7.2. Turbine Energy Analysis Model Inputs and Assumptions

The Turbine Energy Analysis Model (TEAM) was used to estimate the energy generation output of Bonneville under the base case and alternative case. Model inputs and assumptions are listed below.

- **Monthly Flow Releases and Forebay Elevations.** Bonneville monthly total flow releases and forebay elevations for a 50-year period served as input to TEAM. This monthly data was obtained as output from the USACE Hydro System Seasonal Regulation (HYSSR) model. This model is used to simulate the operation of the Columbia River Basin system of projects over the hydrologic period of record from August 1928 through July 1978.
- **Tailwater Rating Table.** The Bonneville tailwater rating table obtained from HYSSR served as input to TEAM. This table was used to estimate the tailwater elevation corresponding to each monthly total flow release. The model then used monthly forebay and tailwater elevations to estimate generating head for each month in 50-year period of record.

- **Monthly Non-power Discharges/Flow Losses.** TEAM allows for the input of a year of monthly non-power discharges/flow losses which represent flows not available for power generation. Included in this category are lockages, flows through fish ladders, juvenile bypass systems, ice and trash sluiceways, the Bonneville PH2 corner collector, and auxiliary water supply for fishways. Not included are spill for fish requirements, which are entered into TEAM separately. The year of monthly non-power discharges/flow losses were obtained from annual USACE data submittal and were subtracted from each of the 50 years of project monthly total flow releases.
- **Bonneville PH1 and PH2 Unit Performance Equations.** In order to estimate Bonneville monthly generation output under the base case and alternative case, TEAM required as input equations representing the combined performance of the unit turbine and generator. The Hydroelectric Design Center (HDC) developed performance equations for Bonneville PH1 and PH2 units, expressing unit output (MW) and unit efficiency as a function of generating head. Separate equations were developed by HDC for unit performance at the peak efficiency operating point and for unit performance at the upper 1% operating point.
- Since the interest of this study is unit operation during juvenile fish passage season, the unit performance equations assumed unit operation with STS fish screens in place. In addition, since PH1 major rehabilitation has been completed, the performance equations for PH1 units assume unit operation with turbine runner replacement and generator rewind for all 10 units.
- **Unit Loading Order.** A single unit loading order was assumed in TEAM for the juvenile fish passage season. Consistent with the predominant unit loading order listed in the annual Fish Passage Plan (FPP), Bonneville PH2 units were loaded ahead of Bonneville PH1 units.
- **Unit Outage Order.** TEAM allows for the input of one or more unit outage orders, indicating which units are to taken out of service during a given month. Based on an analysis of Bonneville historical unit outage data (planned and forced outages) for a recent 10-year period, from two to four units were assumed to be out of service during a given month. Units from Bonneville PH1 and PH2 were assumed to be placed on outage in the reverse of unit loading order. To the extent possible, units placed on outage were evenly split between PH1 and PH2.
- **Spill for Juvenile Fish.** Monthly spill for fish requirements for the April-August spill season were obtained from the annual FPP and the annual USACE data submittal and were entered into TEAM using two parameters: (1) percent of project flow spilled for fish, and (2) upper limit (in thousand ft^3/s) on project flow spilled for fish (i.e., spill cap). Since TEAM uses a monthly time step, it was not possible to model separate daytime and nighttime spill caps for each month of the spill season. TEAM assumed a weighted spill cap for each month, with the daytime and nighttime spill caps for any given month being weighted according to the number of hours per day that each spill cap applied.

3.7.3. COMPARE Spreadsheet Inputs and Assumptions

The Excel spreadsheet COMPARE was used to estimate the energy benefits for Bonneville Dam under the base case and alternative case. Spreadsheet inputs and assumption are listed below.

- **Energy Generation Output.** As noted in Section 3.7.2, estimates for Bonneville Dam's energy generation output under the base case and alternative case were obtained using TEAM. For each case, the model estimated weekly generation over a 50-year hydrologic period of record during each of the following three sub-periods: super-peak (SP) hours, heavy-load hours (HLH), and light-load hours (LLH). The weekly generation output from TEAM for each sub-period was imported into the COMPARE spreadsheet.

- **Value of Energy Generation.** Weekly energy values (in $/MW hour) for all years in the 50-year hydrologic period and for each of the three sub-periods were also imported into COMPARE. The weekly energy values are based on BPA's projected hourly market-clearing prices over the 50-year hydrologic period. These projections were developed using an electric energy market model called AURORA. For each of the 50 water years, AURORA determined the hourly marginal cost for each hour of the period October 2009 to September 2010, which is the load year assumed in AURORA. For each water year, the hourly marginal cost output from AURORA was grouped by week and sub-period to determine the weekly energy values for import to the COMPARE spreadsheet.

4. ALTERNATIVES

This section describes the configuration and components of the alternatives. The technical analyses used in the alternatives analysis and design are also described. The sectional CFD model grid was modified to include geometric features of select alternatives, as described in Section 4.3.2.

4.1. DESCRIPTION OF ALTERNATIVES

Alternatives are categorized into modifications for flow control, operations, and flow pattern change, as described below.

Flow control alternatives:

- A1 – Adjustable Louver Flow Control Device: Construct a device to control the flow up the gatewell. The device would be placed downstream of the VBS. Similar devices have been used at John Day and McNary dams.
- A2 – Sliding Plate Flow Control Device: Construct a sliding plate flow control device attached to the top of the gatewell beam.
- A3 – Modify VBS Perforated Plates.
- A4 – Modify Turning Vane and/or Gap Closure Device (GCD).

Operational alternatives:

- B1 – Operate Main Units Off 1% Peak Range: Operate the main turbine units at the lower to mid 1% peak operating range during the SCNFH juvenile fish release.
- B2 – Open Second DSM Orifices: Open the second DSM gatewell orifice to decrease fish retention time in the gatewell.
- B3 – Horizontal Slot for DSM: Construct a horizontal slot in place of the existing orifices to decrease fish retention time in the gatewell.

Flow pattern change alternative:

- C – Gate Slot Fillers: Install gate slot fillers in the slots above the turning vane and STS supports to reduce turbulence in the gatewell and streamline sweeping velocities up the VBS.

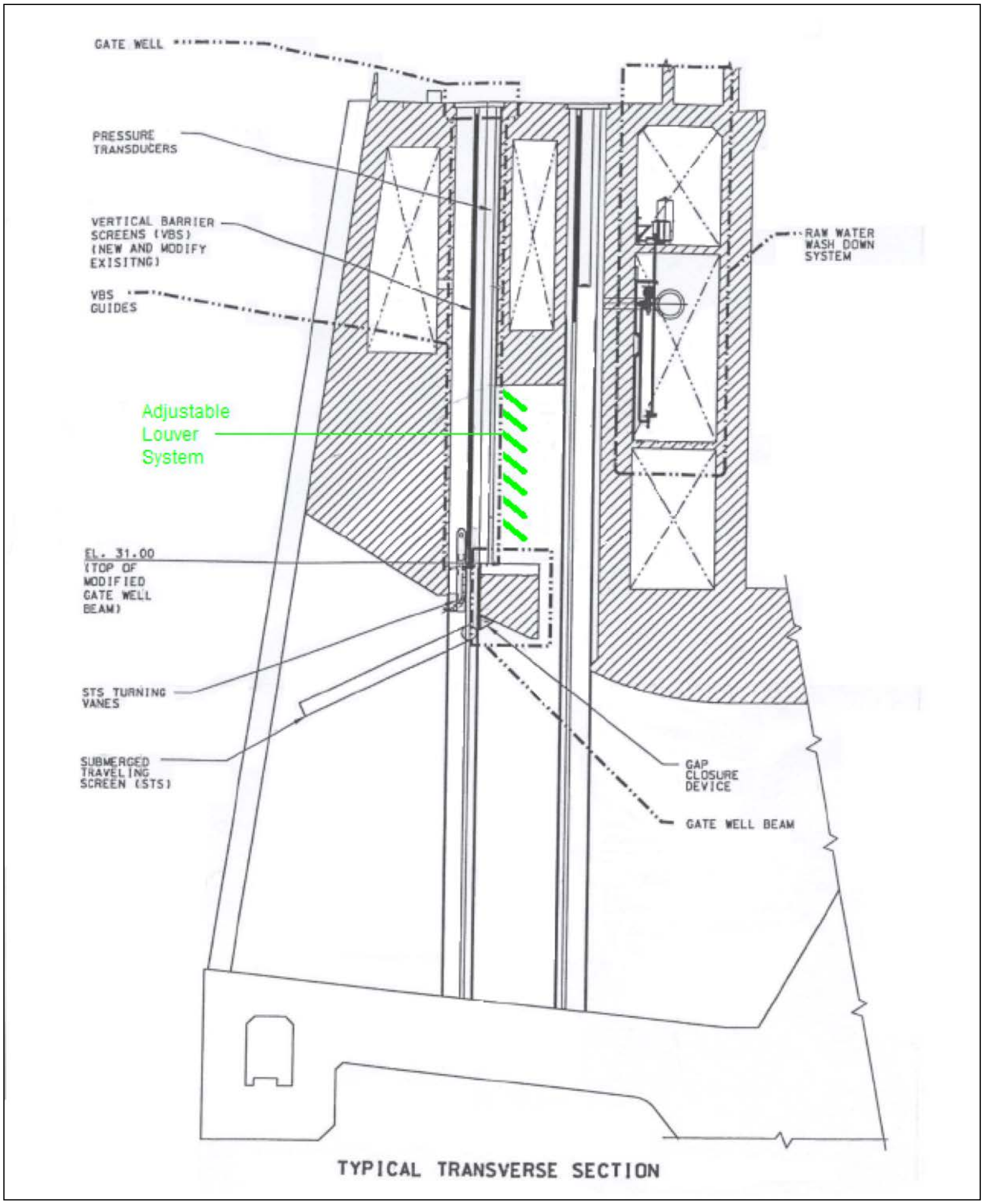
Each of the alternatives will require some degree of real time monitoring for flow velocity. This will be required to determine baseline flow conditions, compare prototype performance, and fine tune operations to meet the target requirements.

4.2. ALTERNATIVE A1 – ADJUSTABLE LOUVER FLOW CONTROL DEVICE

4.2.1. Description

Alternative A1 involves installation of a series of adjustable plates (louvers) in the opening downstream of the VBS (Figure 4-1). The louvers would be adjusted accordingly to meet the target flow in the gatewell. This system can be constructed of stainless or carbon steel and can be designed to vary the opening width at top and bottom. For a permanent design, opening and closing adjustments may be made from a separate device lowered into the downstream VBS slot, through a conduit cored through the existing concrete or by remote control.

Figure 4-1. Alternative A1 – Adjustable Louver Flow Control Device



4.2.2. Hydraulic Design

4.2.2.1. Hydraulic Modeling

Alternative A1 has not been evaluated using the CFD model. If the team prioritizes this alternative for further evaluation, the CFD model will be modified to include a hydraulic representation of the louvers downstream of the VBS. The alternative would be evaluated at high flow conditions (18,000 ft^3/s unit flow) to determine the impact on VBS velocities and flow patterns. Additional documentation runs at low and medium unit flows (12,000 and 15,000 ft^3/s, respectively) would confirm the performance of the alternative over a range of unit flows.

4.2.2.2. CFD Model Results

Alternative A1 was not prioritized for simulation in the CFD model because it is similar in principle to Alternative A2 – Sliding Plate Flow Control Device.

4.2.3. Structural Design

Alternative A1 would consist of stainless steel plates making up the louver system. Stainless steel is rigid and corrosion resistant. The louvers will be framed and anchored as a system. The frame will be made of stainless steel box sections anchored to the existing concrete using undercut with epoxy anchors due to the vibration present in the powerhouse that is caused by water passing over the louvers. The frames will be 10 feet in height and span the length of bay. An ANSYS model will be developed, and the louvers, frame, and connections will be analyzed. The analysis, along with engineering judgment, will determine the weld procedures, sizes, and connection methods. The design will allow for a variety of pivot designs and control of the friction points. The design will allow for individual replacement of the louvers. The inspection period would ideally be on a 5-year period after the prototype was built or the first year in service. Inspection would be during the unit outage and inspected from a crane basket.

4.2.4. Mechanical/Electrical Design

A louver system is suggested because the downstream gate slot is partially obstructed by the head gates, and there is concern that a flow control device in the slot would need to be designed around both the movement and the geometry of the head gate. It is unknown at this time if a head gate might be removed for servicing at the same time as the flow control device is needed. There is a risk that the flow control device in the downstream gate slot might interfere with deploying the headgate in an emergency. These two factors are the motivation that initiated consideration of an adjustable flow control device that is not located in the downstream gate slot, and the louver-type device is the outgrowth of that consideration.

The louver-type device would be installed in the space immediately downstream of the VBS in the rectangular opening between the upstream and downstream gate slots. In the existing arrangement, flow goes upward from the turbine intake tunnel into the upstream gate slot, passes through the VBS, through the rectangular opening into the downstream gate slot, and then flows back down into the turbine intake tunnel. Flow is currently modulated by panels of perforated plate that are integral to the VBS screen structure.

A louver-type device would be modeled after a flow control damper that is used to modulate flow in the heating, ventilation and air conditioning (HVAC) ducting. Similar devices do not exist for water, or other liquid systems, except in very rare instances such as flow modulation devices that also control turbulence in flow-testing tunnels, and these are always custom designs. The same approach would be employed in this case. The louver in the full open position will generate a small but significant amount of obstruction, causing increased resistance to flow. It is possible that the existing perforated plates will need to be modified to increase their porosity to compensate for the increase in resistance from the louver device. The increased resistance caused by the louver device will need to be distributed in a relatively uniform way across the surface of the VBS screen upstream face. Unless it is found to be helpful, the flow leaving the louver device should not have a dominant velocity vector direction which could tend to reduce the total energy loss through the louver. To accommodate and/or mitigate these concerns, the HVAC damper design is suggested as a suitable concept. The louver design is much like a Venetian blind, except that every other blade turns the opposite direction. By varying the angle of the blades, the occluded flow area varies, which causes variation in the overall flow rate.

Some means of control and operating power is needed to vary the position of the louver blades. The operating equipment will need to be located in a place that allows removal for servicing, possibly located in a recess created by core-drilling into the concrete intake deck. The louvers themselves will be very difficult to remove and service, so ultra-low maintenance design and materials should be employed.

4.2.5. Fisheries Considerations

Similar devices have been tried at both John Day and McNary dams to control the flow of water entering the gatewell. High velocities and turbulent flow result in poor fish conditions within the gatewell that reduces OPE, which is the measure of how effectively fish vacate and utilize the gatewell orifice to move into the juvenile bypass collection channel. This type of flow reduction device has shown to be effective at reducing flows up into the slot but not without reductions to FGE, increasing juvenile passage through the gap at the top of the screen and the turbine intake ceiling and also being problematic from an operational stand point due to having an obstacle in the permanent downstream head gate slot.

4.2.6. Operation and Maintenance (O&M)

Other operational issues may also be incurred due to the need to regularly adjust the louvered system from the intake deck by the rigging crew. Any additional manpower needs for fish bypass equipment also comes with labor and O&M cost increases that will need to be absorbed into currently tight O&M budgets.

4.3. ALTERNATIVE A2 – SLIDING PLATE FLOW CONTROL DEVICE

4.3.1. Description

Alternative A2 involves a system of two sliding plates attached to the top of the gatewell beam (Figures 4-2 and 4-3). Gatewell flow could be controlled by one plate sliding over the other to adjust the opening depending on the required velocity. Both plates can be made of carbon steel or stainless steel (with a Teflon coating to reduce friction) or aluminum. Similar to Alternative A1, a permanent design may be operated from a separate device lowered into the downstream VBS slot, through a conduit cored through the existing concrete or by remote control.

Figure 4-2. Alternative A2 – Sliding Plate Flow Control Device

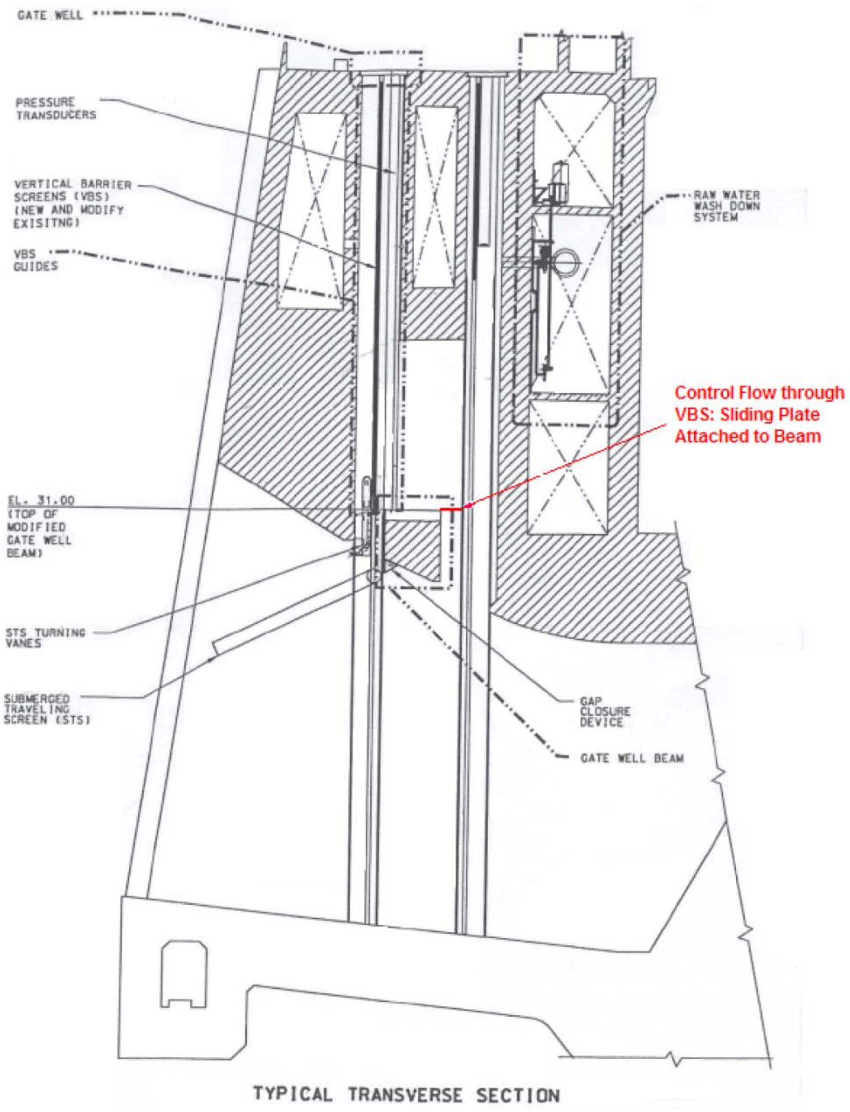
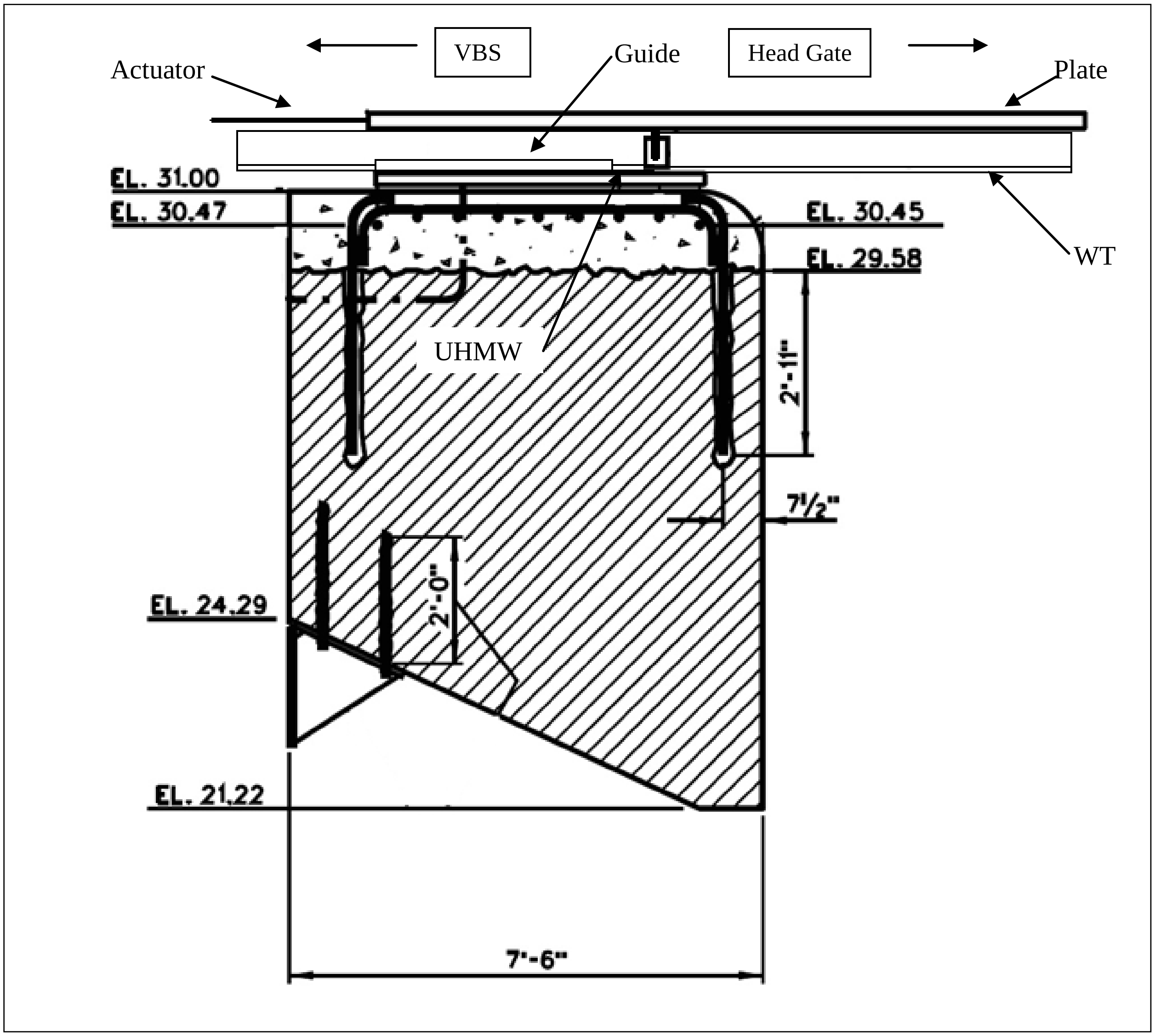


Figure 4-3. Alternative A2 – Sliding Plate Flow Control Device Detail

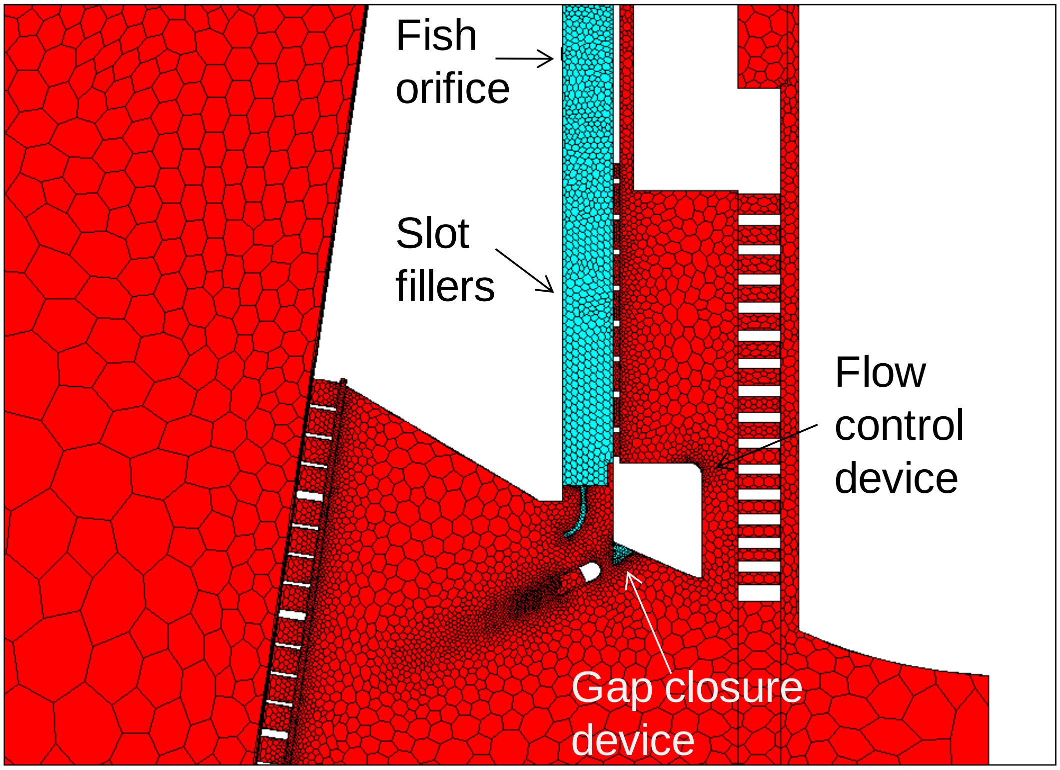


4.3.2. Hydraulic Design

4.3.2.1. Hydraulic Modeling

The sectional CFD model grid was modified to include the approximate geometric features of the sliding plate flow control device as described in Appendix C. The flow control device was modeled as a 6-inch thick plate, extending across the full width of each bay and with varied lengths in the downstream direction. The flow control device was included in the model grid in three segments representing occlusion of 25%, 50%, and 75% of the cross-sectional flow area between the gatewell beam and emergency gate as shown in Figure 4-4. Three CFD model runs were conducted at a unit flow of 18,000 ft^3/s to investigate the relative change in VBS flow with the flow control device occluding 25%, 50%, and 75% of the return flow area. All other geometric conditions in the model were representative of baseline conditions.

Figure 4-4. Alternative A2 – Sliding Plate Flow Control Device CFD Model Grid



4.3.2.2.   CFD Model Results

The VBS flows with the sliding plate flow control device occluding 25%, 50%, and 75% of the return flow area are summarized in Table 4-1. The 25% sliding plate setting results in a bay A VBS flow (272 ft^3/s) that is comparable to the VBS flow for the baseline conditions with 15,000 ft^3/s unit flow. The 50% sliding plate setting results in a bay A VBS flow (219 ft^3/s) that is comparable to the bay A VBS flow for the baseline conditions for 12,000 ft^3/s unit flow. For brevity, the results of the 25% sliding plate setting sectional CFD model run are described below.

Table 4-1. VBS Flow Control with Sliding Plate Flow Control Device

Unit Flow (ft^3/s)	Sliding Plate Setting	Bay A VBS Flow (ft^3/s)
18,000	25%	276
18,000	50%	216
18,000	75%	116

The sectional CFD model results for the sliding plate flow control device occluding 25% of the return flow area are summarized in Figures 4-5 to 4-7. The velocity magnitudes approaching the STS and gatewell look similar with the 25% sliding plate installed (Figure 4-5) to those for the baseline 18,000 ft^3/s unit flow case (see Figure 2-17), as expected, since the unit flows are the same. As the flow enters the gatewell, the influence of the flow control device can be seen in the lower gatewell velocities in Figure 4-5 that are more comparable to the baseline 15,000 ft^3/s unit flow case (see Figure 2-13). The

25% sliding plate alternative appears to have slightly more flow up the upstream side of the turning vane and less up the downstream side of the turning vane than in the baseline 15,000 ft^3/s unit flow case for an equivalent gatewell flow.

Normal velocities and flow patterns on the VBS are similar for the 25% sliding plate alternative and the baseline 15,000 ft^3/s unit flow case (Figure 4-6 and Figure 2-14), as expected for comparable VBS flows. Turbulent kinetic energy in the gatewell for the 25% sliding plate alternative (Figure 4-7) is slightly reduced from the baseline 18,000 ft^3/s unit flow case (see Figure 2-19), but not quite to the level seen in the baseline 15,000 ft^3/s unit flow case (see Figure 2-15). This may be due to the difference in velocities and flow patterns approaching the gatewell along the turning vane described above.

Figure 4-5. Alternative A2 – Bay A Centerline Velocity Magnitude

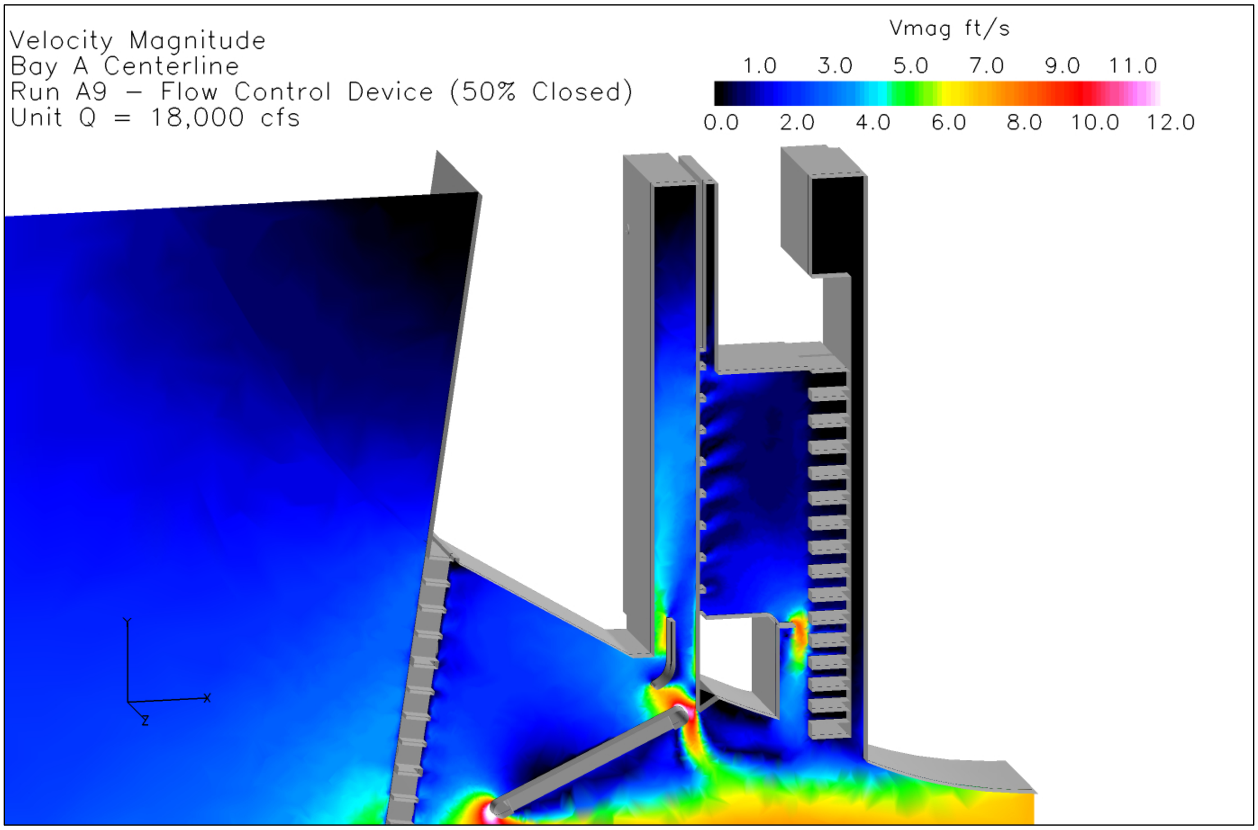


Figure 4-6. Alternative A2 – VBS Normal Velocities and Flow Patterns

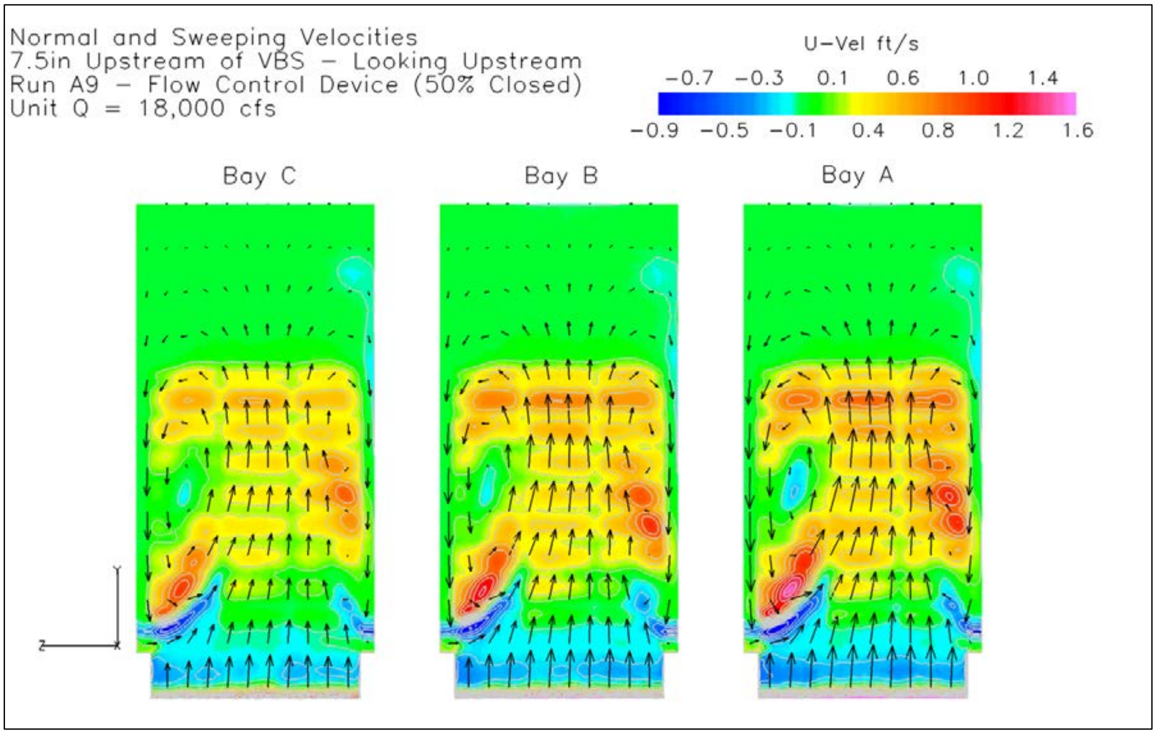
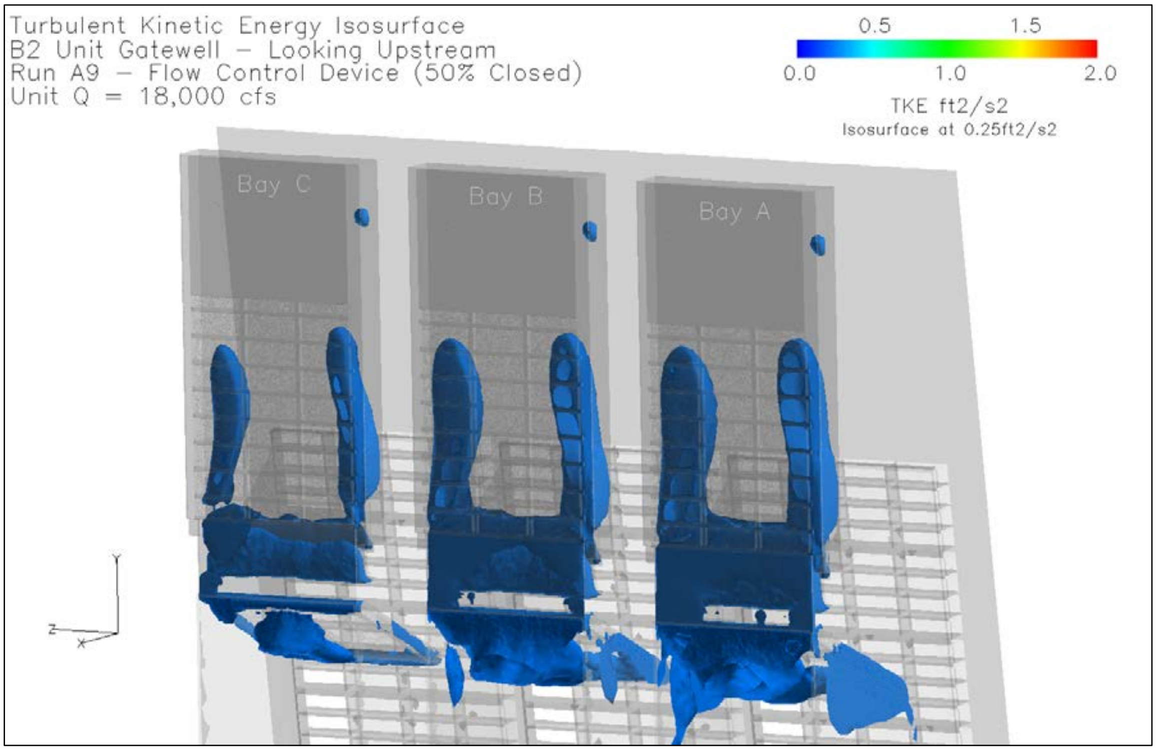


Figure 4-7. Alternative A2 – Turbulent Kinetic Energy Isosurface



4.3.3. Structural Design

Alternative A2 will be designed using a combination of materials: stainless steel and ultra-high molecular weight (UHMW) plastic. The sliding plate will be placed just upstream of the headgate slot and on top of the gatewell beam. The plate that covers the gatewell slot will be a 2-inch plate supported by a wide-tee section (WT12x52) spaced 4 feet on center. The WT sections will be fillet welded, web to the plate. A guide made of bent plate will overlap the flange of the WT sections (see Figure 4-3). The inspection period would ideally be on a 5-year period after the prototype was built or the first year in service. Inspection would be during the unit outage and inspected from a crane basket.

4.3.4. Mechanical/Electrical Design

The sliding plate concept is suggested because the downstream gate well and head gate configuration provides a location where flow can be throttled by a plate that slides horizontally outward from the bottom of the rectangular opening between gate slots. The plate would move out in the downstream direction and partially close off the flow passing down into the turbine intake tunnel. Two key issues for consideration include not allowing the plate to be capable of failing in a manner that allows the plate device to interfere with deployment of the head gates, and determining if there is ever a time when the plate device would be needed when the head gate has been removed from the slot for servicing.

The plate will be carrying the hydraulic load in a partially cantilevered mode, so it will likely need gusseting and reinforcing ribs. In addition the trailing edge where flow is cleaving away will need to be streamlined to resist vibration. The supports and operating machinery will need to be streamlined, since there is a risk that the VBS and the STS may be pulled out of the slots in high-debris situations, and juvenile fish will be carried past the equipment by the flow.

Instrumentation and operating machinery will likely need to be underwater, although the electric or hydraulic motors could be located remotely with power transmission shafting extending down to the location of the operating equipment. This equipment will be very difficult to service, so ultra-low maintenance materials and components should be selected.

4.3.5. Fisheries Considerations

As with Alternative A1, this alternative does provide for a controlled gatewell flow and may provide acceptable conditions that allow the implementation of the full turbine unit operational range but with reduced FGE outcomes.

4.3.6. Operation and Maintenance

This option also has a sizeable O&M component but also is retained in the downstream headgate slot that is problematic for emergency headgate deployment.

4.4. ALTERNATIVE A3 – MODIFY VBS PERFORATED PLATES

4.4.1. Description

Alternative A3 involves modifying the existing VBS perforated plates resulting in a reduction of gatewell flow. A separate, modified perforated plate would be attached to the existing perforated plate and be allowed to slide to constrict flow to meet a target flow velocity. This perforated plate can be constructed of carbon steel with a Teflon coating to reduce friction during operation. A prototype could be built that would be adjustable and locked in place by hand. A permanent design may be attached to the existing perforated plate and mechanically or remotely controlled.

4.4.2. Hydraulic Design

This alternative has not been evaluated using hydraulic modeling because it is considered similar in principle to Alternative A2. If the team prioritizes this alternative for further evaluation, physical hydraulic modeling investigations will be needed. Preliminary investigation can be conducted using the CFD model to gain an initial understanding of the relative change in VBS flow from changes to the screen perforated plates. A physical hydraulic model would need to be constructed to evaluate actual required changes to prototype perforated plate porosities to maintain balanced normal velocities within criteria.

4.4.3. Structural, Mechanical and Electrical Design

This alternative involves a concept wherein two identical perforated plates are stacked (or layered) face to face on the back of the VBS (Figure 4-8). Flow of water passing through the VBS is regulated by an existing perforated plate, and the layered perforated plate concept would be accomplished by adding a second perforated plate to the backside of the VBS.

Figure 4-8. Alternative A3 – Modify VBS Perforated Plates

The initial position of the two perforated plates would have all the holes in both perforated plates concentrically aligned and open. To reduce the volume of water flowing through the VBS, the outer perforated plate would slide with respect to the inner perforated plate, so that the outer plate holes are not perfectly concentric with the holes in the inner plate anymore, but are now partially occluding each other. Further movement increases the amount of occlusion, and increases restriction in flow.

The existing perforated plate and fish screen assembly is not readily adaptable to the sliding perforated plate concept. The existing perforated plates are roughly 2 feet by 6 feet, and are separated by the VBS structural frame made out of 6-inch by 6-inch square structural tubing. The perforated plates are inset about 5/8 inch into rectangular openings in the back of the VBS, and are not flush with the back surface of the framing. The perforated plates are carbon steel with an epoxy coating system. Furthermore, bolting tabs that hold the existing perforated plates and fish screens in place in the VBS frame are on the back of the perforated plates. There is a limited amount of space between the downstream side of the VBS and the concrete gate slot wall, which constrains the thickness of any sort of machinery or mechanism that extends downstream beyond the VBS structural framing to about one inch. The design for the sliding perforated plate concept would need to include replacement of the existing perforated plates and also take into account all of the issues presented here. This is a formidable design challenge.

4.4.4. Fisheries Considerations

Adjustments may be needed during the juvenile passage season which would impact passage and fish survival. This may require the screens be pulled to make the adjustments.

4.4.5. Operation and Maintenance

This alternative could present significant operational challenges when adjustments are needed. Any mechanical adjustments will need to be made while the screens are in the dogged position and up out of the water. This requires the unit to be shut down and out of service while adjustments are being made. Also, this concept may include many moving parts that have historically been problematic from an O&M perspective when operated in a debris-rich environment.

4.5. ALTERNATIVE A4 – MODIFY TURNING VANE AND GAP CLOSURE DEVICE

4.5.1. Description

Alternative A4 involves modifying the existing turning vane and/or GCD to reduce the discharge flowing into the gatewell. Turning vanes direct the flow up the gate slot and are installed just above the top of the STS. The GCD is mounted on the intake roof just downstream of the STS to prevent fish from travelling through the turbine, as well as divert more flow up the gatewell.

4.5.2. Hydraulic Design

4.5.2.1. Hydraulic Modeling

The sectional CFD model grid was modified to model the removal of the GCD to reduce gatewell flow in all three bays. The grid cells representing the gap closure device in the sectional CFD model (see Figure 4-4) were defined as fluid cells rather than solid cells to allow flow freely through the region previously occupied by the GCD. One CFD model run was conducted at a unit flow of 18,000 ft^3/s to investigate the relative change in VBS flow with the GCD removed. All other geometric conditions in the model were representative of baseline conditions.

4.5.2.2. CFD Model Results

The sectional CFD model results for Alternative A4 are summarized in Figures 4-9 to 4-11. With the GCD removed, more flow passes through the gap between the STS and the gatewell beam, resulting in lower VBS flow (approximately 110 ft^3/s). Velocity magnitude through the gap is increased over that for the baseline condition as shown in Figure 4-9. The higher velocities at the upper end of the STS and through the gap result in an altered flow pattern at the base of the VBS with flow actually recirculating and passing upstream through the lower VBS panels as shown in Figure 4-10. It is important to note that the VBS porosity settings for this alternative were set the same as the baseline condition and no attempt was made to compensate for the backflow through the VBS in this particular model run. Turbulent kinetic energy in the gatewell is similar to baseline conditions, though some effect of the backflow through the lower VBS is apparent in the turbulence plots in Figure 4-11.

4.5.3. Structural Design

The modifications to the STS and the GCD would be similar in style and material as the current design. The existing anchor system for the GCD would likely not be able to be put back in service once the GCD is removed for modification. A new anchoring schema would need to be designed, likely to be similar to the original design only located the appropriate distance adjacent to the existing anchors. The STS turning vane would be modified on the STS to meet the shape required to meet the ideal shape developed for the CFD model.

4.5.4. Mechanical/Electrical Design

No significant mechanical or electrical involvement, unless designers discover that some modifications to existing STS electrical or mechanical equipment are necessary.

Figure 4-9. Alternative A4 – Bay A Centerline Velocity Magnitude

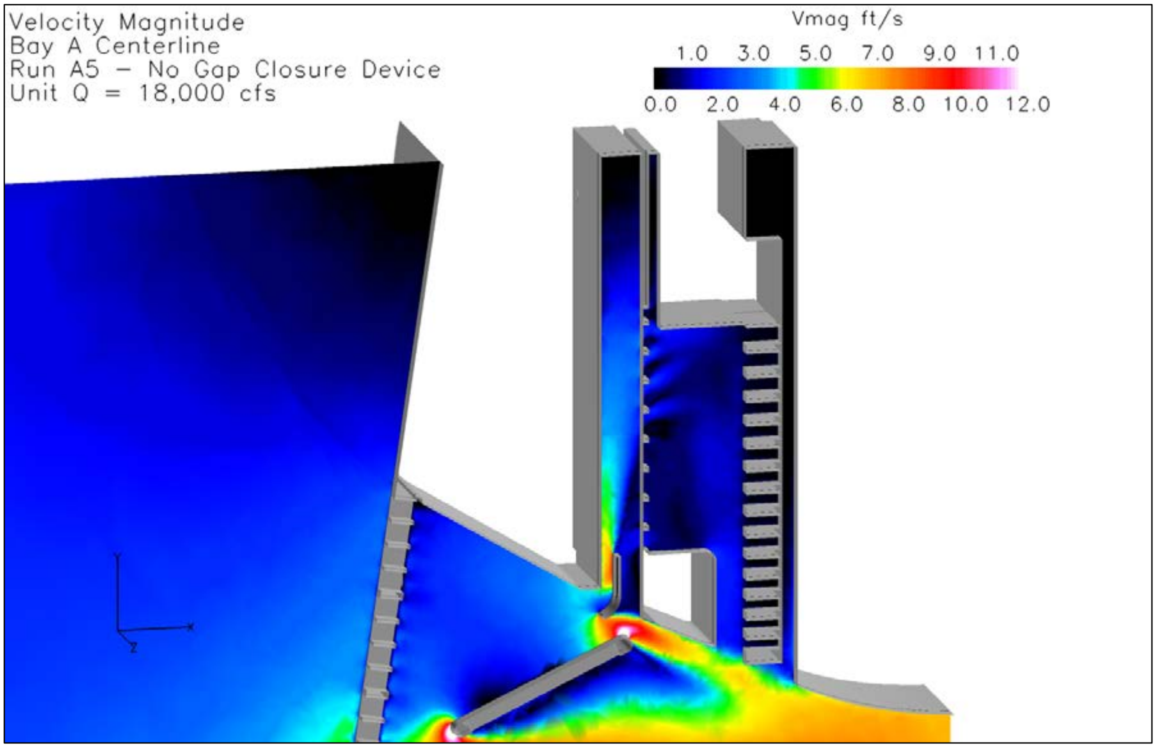


Figure 4-10. Alternative A4 – VBS Normal Velocities and Flow Patterns

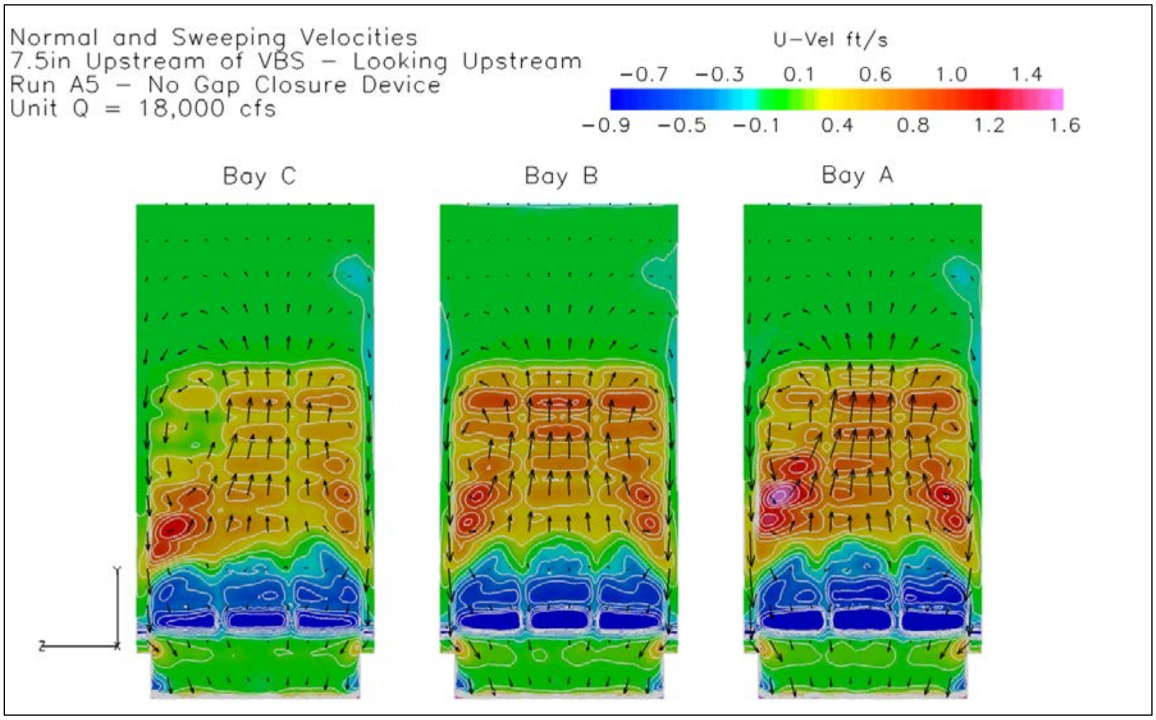
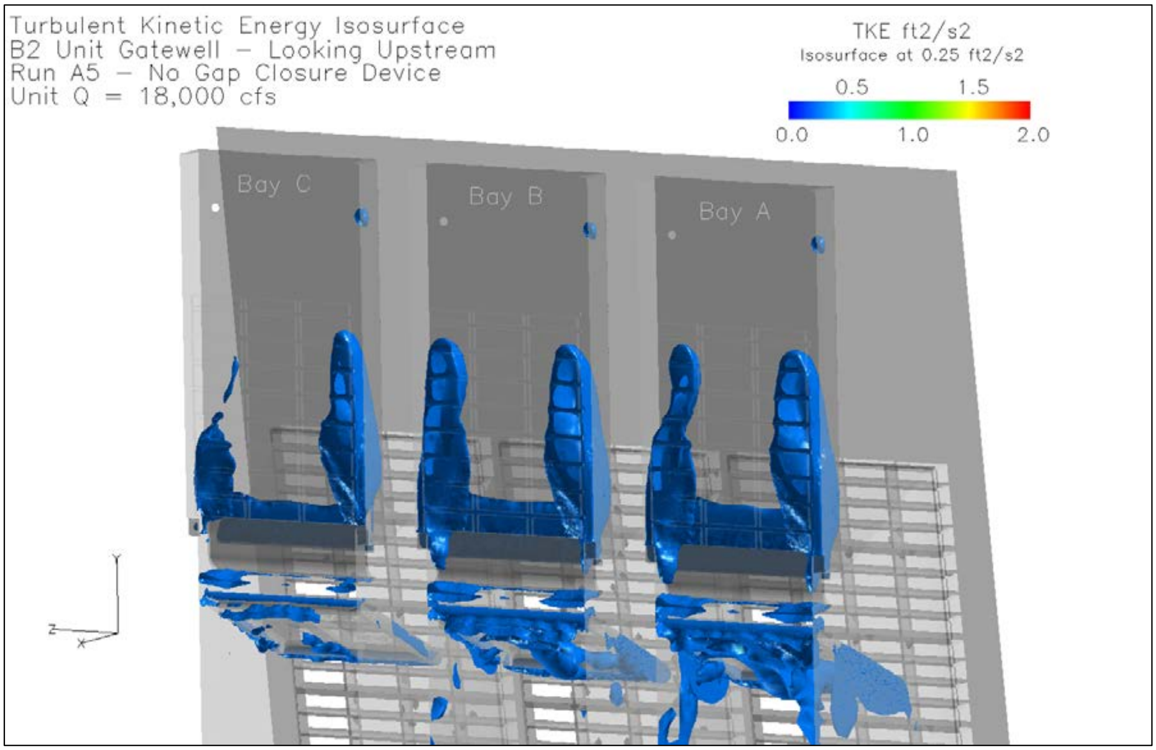


Figure 4-11. Alternative A4 – Turbulent Kinetic Energy Isosurface



4.5.5. Fisheries Considerations

Hydraulic CFD analysis has identified problematic areas with this design. The removal of the GCD would allow fish normally directed upward and into the gatewell to now be directed through the top gap thus reducing FGE. Hydraulics also identified a problematic reverse backflow that was problematic as well and no real reduction to the turbulent kinetic energy that is what we have determined that is most critical to remove in a system modification. Modifications to the turning vane design will also have an effect of reduced FGE by reducing the amount of water shunted up the gatewell. The goal of this alternatives phase is to reduce gatewell turbulence but also maintain the full range of turbine operations and FGE guidance. This option reduces FGE and may even increase the amount of fish that would normally be diverted through the gap by removing it and its effectiveness.

4.5.6. Operation and Maintenance

The O&M requirements will be similar to the current system.

4.6. ALTERNATIVE B1 – OPERATE MAIN UNITS OFF 1% PEAK RANGE

4.6.1. Description

Alternative B1 involves reducing the gatewell flow by operating the Bonneville PH2 main units off the 1% peak operating range (lower to mid 1% or 12,000 to 15,000 ft^3/s, respectively) to improve fish survival. In spring during the 2008 juvenile fish passage season, SCNFH released hatchery subyearlings over a period of 3 months (March-May). Biological testing conducted by NOAA (spring 2008-citation) suggests that SCNFH subyearlings are incurring high mortality and descaling when turbine units were operated at the upper 1% range; thus, the reduced unit flows are expected to improve hydraulic conditions for fish passage. Typical unit flow for this operation would be approximately 12,000 to 15,000 ft^3/s.

4.6.2. Hydraulic Design

4.6.2.1. Hydraulic Modeling

This operational alternative does not involve any changes to the baseline geometry of the unit, gatewell, or screens. Therefore, the results of the baseline sectional CFD model runs at lower unit flows (12,000 and 15,000 ft^3/s) are indicative of the hydraulic conditions in the gatewell with the unit operating in the lower and mid 1% range.

4.6.2.2. CFD Model Results

The hydraulic conditions expected during unit operations in the lower and mid 1% range are described in the 12,000 and 15,000 ft^3/s baseline results, respectively (see Section 2 and Figures 2-6 to 2-19).

4.6.3. Structural Design

Structural engineering is not required for this alternative.

4.6.4. Mechanical/Electrical Design

Mechanical/electrical engineering is not required for this alternative.

4.6.5. Fisheries Considerations

This unit operational constraint has been used during times of SCNFH fall Chinook releases to reduce the turbulence associated with higher turbine operations. It has been the alternative design team's goal to maintain FGE but reduce turbulence. This reduction in turbine discharge is problematic due to several operational issues. First, the reduced turbine discharge equates to a reduction in anticipated FGE through PH2. Gatewell turbulence and the associated byproducts such as increased passage descaling and mortality are reduced and brought back into normal parameters with this curtailed unit operation but at the sake of reduced FGE. Second, with these restricted turbine discharge operations comes an issue throughout the spring and even summer outmigration that may increase total dissolved gas (TDG) effects by having to spill above the 120% TDG limits. If unit operations are curtailed, any water that is not bypassed through Bonneville PH2 turbines has to be either be spilled or picked up as generation at PH1.

During a majority of the outmigration season (April-June), the project is at or is exceeding its hydraulic capacity to pass water through the powerhouses and maintain our court mandated spill cap of 100,000 ft^3/s. As spill is increased, so does the TDG produced by this forced spill. Clean Water Act regulations, as well as Oregon and Washington state water quality standards, indicate that USACE is to manage TDG generated through spill at its projects below the 120% guidelines over a 24-hour period. If turbine operations are restricted, the USACE may be forced to exceed these standards that affect a much larger amount of juvenile and adult fish that would not be as affected if units were operated at their normal upper end of 1% range. Reduced unit operational alternatives should be used sparingly and other methods should be investigated as to head off this as a final option.

4.6.6. Operation and Maintenance

Bonneville PH2 is required to maintain and support BPA's transmission system to provide voltage over the 230 kilovolt (kV) system. Supporting the system grid is a Western Electricity Coordinating Council/North American Electric Reliability Council requirement that cannot be compromised with a reduction of unit operations during the operations season. System reliability and regional commitments to BPA cannot be compromised by limiting powerhouse operations without being fully vetted and agreed upon within the Federal Columbia River Power System (FCRPS) reliability community.

4.6.7. Cost

An analysis to estimate the impact to project generation and corresponding hydropower benefits was conducted by HDC's Hydropower Analysis Center. Details regarding the procedures and methodology used for the analysis are provided in Appendix D. Analysis of the hydropower impacts of restricting Bonneville PH2 units to peak efficiency operation during the juvenile fish passage season (March through August) involves estimating project generation output and corresponding hydropower benefits under each of two alternatives, which are briefly described below.

1. **Base Case – Bonneville PH2 Units Operate to Upper 1% Operating Point.** This assumes that all PH1 and PH2 units operate between the peak efficiency and upper 1% operating points during juvenile fish passage season. The project is assumed to conform to operating requirements summarized in the April 2009 FPP and USACE 2009-2010 data submittal.
2. **Alternative Case – Bonneville PH2 Units Operate at Peak Efficiency Operating Point.** This assumes that all PH1 units operate between the peak efficiency and upper 1% operating points during the juvenile fish passage season, while all PH2 units operate at the peak efficiency operating point during this time period. The project is assumed to conform to operating requirements summarized in the April 2009 FPP and USACE 2009-2010 data submittal.

The Turbine Energy Analysis Model (TEAM) was used to estimate the energy production output of Bonneville under the base case and alternative case. Table 4-2 shows the monthly average energy generation for the base case and alternative case. The BPA developed and provided the projected hourly market-clearing prices based on the 50 years of hydrologic data used in estimating energy production. These projections were developed using an electric energy market model called AURORA, which is owned and licensed by EPIS Incorporated. To determine the energy benefits associated with the Bonneville base case and alternative case, an Excel spreadsheet called COMPARE was developed that utilized as input TEAM output for each case, along with the weekly energy values. The results of this process are summarized in Table 4-3. The energy benefits estimates summarized in the table are consistent with the energy generation estimates summarized in Table 4-2. The last column of each table shows losses during the months March through July and gains during the month of August.

Table 4-2. Bonneville 1929-1978 Monthly Average Energy Generation

Month	Generation (MWh)		
	Base Case	Alternatives Case	BC - AC
March	482,580	474,690	7,890
April	411,610	393,860	17,750
May	447,770	414,730	33,040
June	441,620	413,250	28,370
July	329,410	326,770	2,640
August	218,360	219,000	-640
TOTAL	2,331,350	2,242,300	89,050

MWh = megawatt hours

Table 4-3. Bonneville 1929-1978 Monthly Average Energy Benefits

Month	Benefits ($1000)		
	Base Case	Alternatives Case	BC - AC
March	19,670	19,390	280
April	14,670	14,090	580
May	12,760	11,950	810
June	11,170	10,650	520
July	12,490	12,430	60
August	10,770	10,800	-30
TOTAL	81,530	79,310	2,220

4.7. ALTERNATIVE B2 – OPEN SECOND DSM ORIFICES

4.7.1. Description

The Bonneville DSM has two gated fish passage orifices in each gatewell slot of units 11-14 and fish unit 2; one gated and one sealed orifice in each gatewell of units 15-18 and fish unit 1. Under present operating conditions, one orifice in each gatewell is typically used. This alternative involves opening the second gatewell orifice in units 11-14 and unsealing and operating the second orifice in each gatewell of units 15-18 and fish unit 1 to decrease fish retention time in the gatewell. Unsealing the second orifice in units 15-18 and fish unit 1 requires a gate be installed.

4.7.2. Hydraulic Design

Opening the second orifice could require modification of the DSM to meet system flow and operating criteria. Addressing potential modifications to the DSM is outside the scope of this project. However, a brief discussion of the general considerations for the DSM follows:

Considerations

- Per criteria and hydraulic design standards, this system is at maximum capacity.
- The orifices open or close to maintain a constant DSM water level (between collection channel and dewatering) at 64.3 feet.
- Do not want to increase this level (64.3 feet), as the discharge to the flume is a function of this level and we are already at or near dewatering capacity at the smolt monitoring facility.

Collection Channel

- Maintain a constant water level at 64.3 feet to deliver the right amount of flow down the flume.
- Maintaing collection channel water velocity range of 3-5 ft/s
- To maintain a constant water level, flexibility is needed to open/close the second orifices as the forebay changes (elevation 71.5 to 76.5 feet).
- Given the need for a constant water level at 64.3 feet, the increased flow would force a higher backwater and begin to incrementally reduce the flow from upstream units (unit 11, 12...).
- Channel widening at the upstream end could partially alleviate the height of the backwater, but the trade off is channel velocity (meets NOAA Fisheries criteria well at this time).
- The above impacts and options cannot be quantified without analytical tools.

Dewatering System

- In order to increase the dewatering rate, there are two options:
  - Violate screen velocity criteria by some amount. Drainage is limited on several of the larger screens, so some concrete would be excavated to improve drainage to emergency relief conduit (ERC).
  - Add a second dewatering system outside the building (this option was biologically rejected in design memorandum phase.) Also, the existing dewatering would have to be redesigned.
- Modify the existing dewatering so there is a longer converging section so that screens can be added on upstream end. This requires excavation of concrete in order to provide drainage to the ERC. Given the previous difficulties found in the retrofit design, this is easier said than done.

4.7.2.1. Hydraulic Modeling

The operation of two fish passage orifices was incorporated into the sectional CFD model by applying a velocity boundary condition to both fish passage orifices in each bay, corresponding to 11 ft^3/s through each fish orifice. No changes to the sectional CFD model grid were made. All other model boundary conditions were representative of baseline conditions. One CFD model run was conducted at a unit flow of 18,000 ft^3/s to investigate the relative change in gatewell hydraulics with the second fish orifice operating. If this requires further evaluation, an existing numerical spreadsheet model may be used to analyze the hydraulics in the downstream migrant system due to opening two orifices per gatewell.

4.7.2.2. CFD Model Results

The sectional CFD model results for Alternative B2 are summarized in Figures 4-12 to 4-14. Velocity magnitudes along the STS, past the turning vane and up the gatewell are similar for two orifice operation (Figure 4-12) and baseline conditions with one orifice operating (see Figure 2-17). The VBS normal velocities are similar in magnitude with two orifices operating (Figure 4-13) and one orifice operating (Figure 2-18), but the recirculation to either side on the VBS is intensified slightly with two orifices operating. In addition, the side with the larger recirculation zone flips in bays A and B from the left side, looking upstream, during single orifice operation (see Figure 2-18) to the right side, looking upstream, during the double operation. The change in the asymmetry from bay to bay is apparent in the prototype VBS data as well may indicate that the recirculation patterns in the gatewell is a relatively stable, yet transient condition that flips from side to side. Turbulent kinetic energy is slightly higher with the second orifice operating (Figure 4-14) as compared to baseline (see Figure 2-19). Overall, the flow patterns on the VBS are not more uniform with the second orifice operating, but the second orifice may provide fish a second opportunity for exit from the upper portion of the gate slot.

4.7.3. Structural Design

Structural engineering is not required for this alternative.

4.7.4. Mechanical/Electrical Design

Mechanical/electrical engineering is not required for this alternative.

4.7.5. Fisheries Considerations

PIT tagged fish released and collected in spring and summer 2009 at Bonneville PH2 DSM by NOAA researchers indicated that fish passage, descaling, and survival through the DSM system and through the orifice could be maintained at normal levels while running Bonneville PH2 units at the upper 1% range (citation). Researchers measured the effects of a single orifice operation compared to a double orifice open and measured a significant reduction in OPE and descaling as compared to a single orifice open at these high turbine ranges. The action of opening two orifices also brought mortality and descaling within historical smolt monitoring facility percentages (>1%). It is recommended that this alternative be investigated and implemented in conjunction with any improvements adopted.

4.7.6. Operation and Maintenance

Operational issues may also be incurred due to the need to adjust the existing DSM to manage the increase in flow from opening a second orifice. Additional funding requirements for labor and/or O&M cost increases will have to be absorbed into the currently tight O&M budgets.

Figure 4-12. Alternative B2 – Bay A Centerline Velocity Magnitude

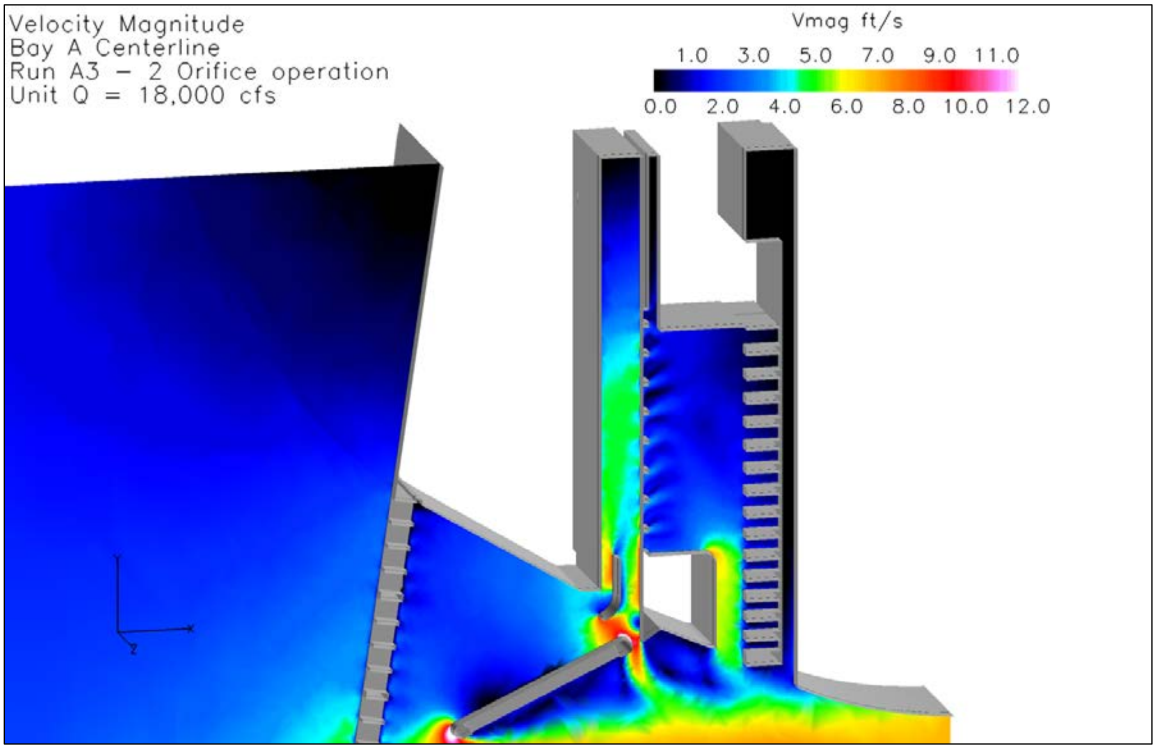


Figure 4-13. Alternative B2 – VBS Normal Velocities and Flow Patterns

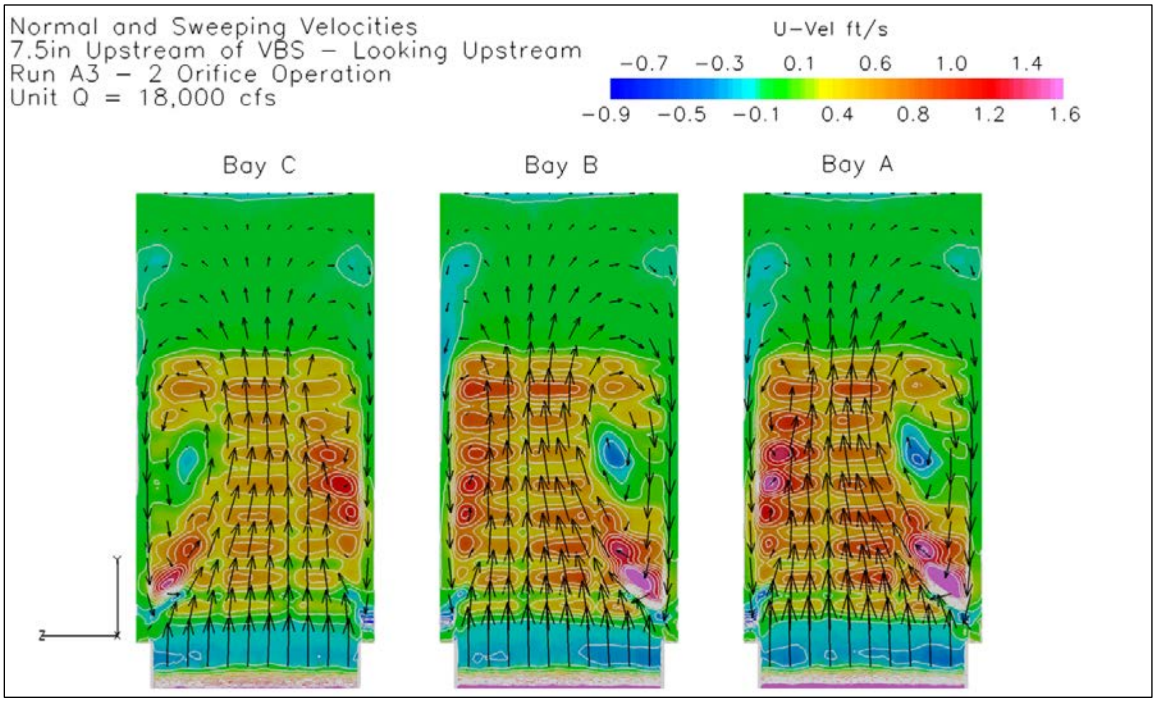
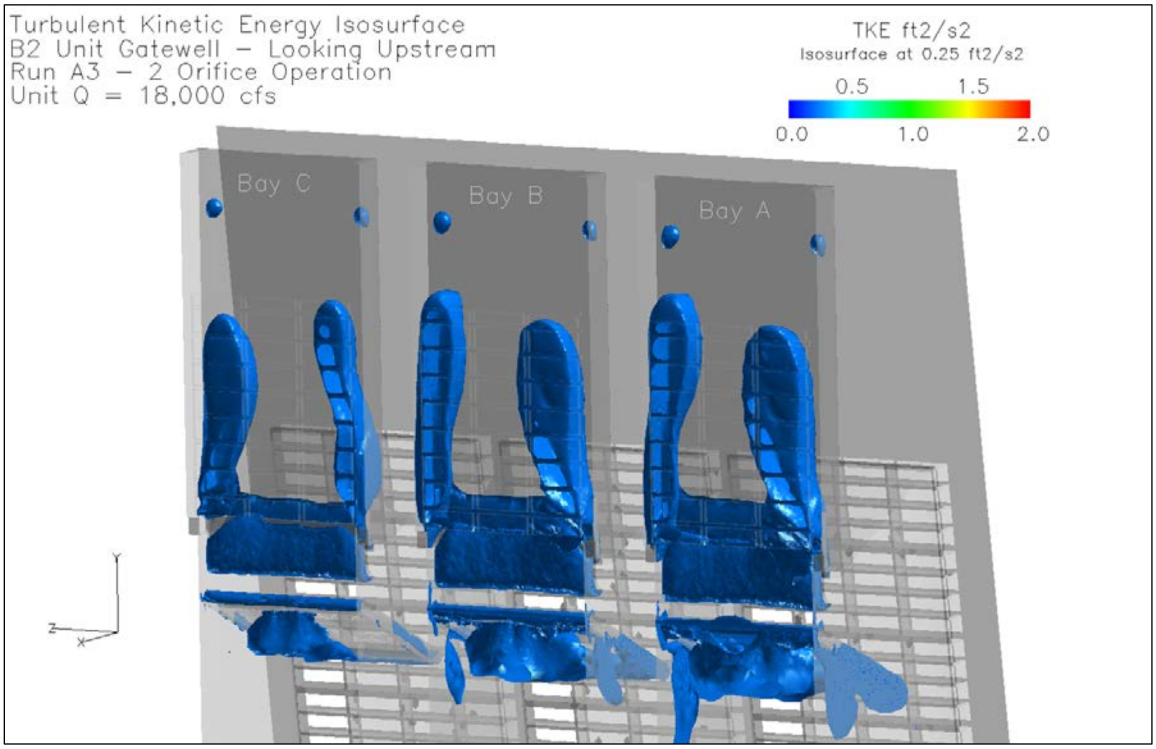


Figure 4-14. Alternative B2 – Turbulent Kinetic Energy Isosurface



4.8. ALTERNATIVE B3 – HORIZONTAL SLOT FOR DSM

4.8.1. Description

The DSM has two fish passage orifices in the gatewell slots of units 11-14. Each are located toward the side walls and are about 20 feet apart. Under present operating conditions, one orifice in each gatewell is used. This alternative involves constructing a slot to help decrease fish retention time in the gatewell.

4.8.2. Hydraulic Design

4.8.2.1. Hydraulic Modeling

Alternative B3 has not been evaluated using the CFD model because it is similar in principle to Alternative B2 and is subject to similar considerations for the downstream migrant system. If the team prioritizes this alternative for further evaluation, the CFD model will be modified to include modified orifices or a horizontal slot leading to the downstream migrant system rather than the existing fish orifices. Alternative B3 would be evaluated at high flow conditions (18,000 ft^3/s unit flow) to determine the impact on VBS velocities and flow patterns. Additional documentation runs at low and medium unit flows (12,000 and 15,000 ft^3/s, respectively) would confirm the performance of the alternative over a range of unit flows.

4.8.2.2. CFD Model Results

This alternative has not been evaluated using the CFD model.

4.8.3. Structural Design

The horizontal slot for the DSM orifice will be similar to that of the Lower Granite Dam horizontal broad crested overflow weir. A 24-inch wide by 10-foot high penetration in the downstream wall. The penetration will allow for the various forebay elevations by providing room for the hydraulically operated weir to travel with the forebay. The track or guide for the broad-crested weir will be stainless steel 3/8 inch bent plate and recessed into the wall. The track will be mechanically fastened with post installed stainless steel anchors that employ epoxy and mechanical-type bonding. The broad crested weir will be bent polished stainless steel plate. A 48-inch long HSS 8-inch x 4-inch x 5/8-inch stainless steel lintel beam will be symmetrically embedded in the concrete to support the gravity load above.

4.8.4. Mechanical/Electrical Design

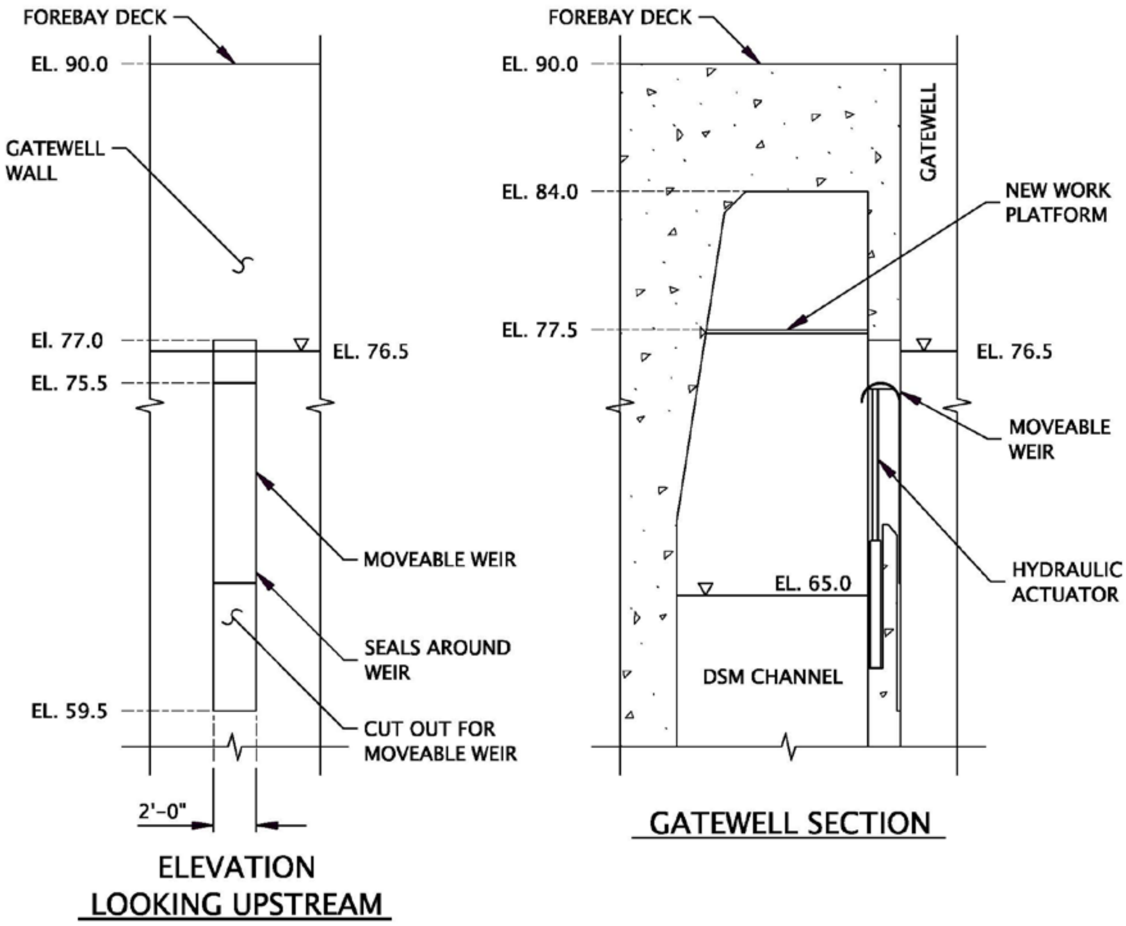
This project is somewhat similar to the Lower Granite Prototype Collection Channel Orifice Weirs project. The USACE Walla Walla District performed the design, which was nearing completion in August 2010 (Kevin Renshaw, mechanical engineer from Walla Walla District, is the point of contact for further information). The Lower Granite design uses an overflow weir that is adjustable and has a control system that causes the weir depth to remain constant as the forebay level changes (Lower Granite is a run-of-river project and forebay levels do not change more than a few feet). The overflow weir is cut into the wall that divides the gatewell and the DSM channel, allowing water and fish in the gatewell to flow over ht weir and into the DSM channel.

At Bonneville PH2, this concept could be installed in a very similar way to Lower Granite, except that there are a small number of site-specific differences that must be accounted for in the design. In addition, there is a minor refinement that could be added to the design and this will be discussed later near the end of this sub-section. The overall concept is illustrated in Figure 4-15.

There are several issues to address when considering this design at Bonneville PH2. First, the existing orifices have valves, lighting, compressed air piping, electrical conduits, solenoid valves and electrical control panels that will need to be removed. Second, there is a tapered concrete filler that has been installed along the west wall of the DSM collection channel, which effectively narrows the collection channel as it approaches the dewatering structure. This tapered concrete filler begins near main units 12 or 13, is about 2 inches in thickness, and extends from the collection channel floor up to the elevation of the top of the existing orifice core drills. The filler gradually thickens as it goes northward and is about 12 inches in thickness at main unit 18. It is below the deck grating, which spans the entire width of the collection channel.

The water level inside the DSM collection channel was observed in November 2011 at about elevation 64.7 feet. The collection channel floor runs from elevation 51.8 feet at main unit 18 up to elevation 57.0 feet near main unit 11. The deck grating is at elevation 67.0 feet. The orifices are centered at elevation 65.5 feet, and are a 16-inch pipe penetrating the 24-inch thick concrete wall between the bulkhead slot and the DSM channel. The ceiling of the collection channel is at elevation 84.4 feet. There is a 12-inch by 12-inch chamfer at the floor and ceiling corners.

Figure 4-15. Alternative B3 – Horizontal Slot Concept



To implement this design, the weir opening would be cut into the 24-inch thick wall. Additional reinforcement would need to be added, as discussed in the structural paragraph above. Inside the DSM channel, water from the bulkhead slot gatewell would flow in from levels that can be anywhere from about elevation 67 feet up to about elevation 77 feet. This means the weir will need to have 10 feet in height adjustment (the Walla Walla District design had about 6.8 feet of adjustment). Toward the southern end of the powerhouse, some excavation of concrete below the floor of the DSM channel will be required, perhaps as much as to elevation 54.0 feet to provide this range of vertical motion.

The design concept uses a sliding weir plate that moves vertically. It is rounded at the top to permit flow to fall vertically from the downstream side of the weir. It has a ramped approach on the upstream side to gradually accelerate the flow and to spread out the upstream velocity field into a wider pattern. The sides and bottom lip of the sliding weir plate have seals to restrict leakage flows. At the ceiling of the weir opening, there is a crush seal so that the weir can close off the opening when in a fully raised position. The vertical motion is accomplished by a hydraulic cylinder located below the weir and extending upward. Position indication is internal to the cylinder. At Bonneville Dam, the bulkhead slot gatewell has water level indication installed for the VBS system, with signals sent to the elevation 72 feet piping gallery inside the powerhouse. The position indication for the hydraulic cylinders would be sent to a programmable logic controller (PLC) that would also pull the gatewell level signals from the VBS system and then cause the weirs to track gatewell level, such that the depth of weir submergence is held constant.

A new hydraulic power system would be required to supply pressure and fluid to the cylinders that actuate the weirs. An environmentally friendly hydraulic fluid would be used, such as saturated synthetic ester or polyalkyline glycol.

To implement this concept at Bonneville Dam, an opening would need to be cut into the existing deck grating. The flow coming from the weir would need to be contained inside of guide ducting or rectangular conduit to send flow through the opening in the deck grating. At the wall, where the tapered concrete filler interferes with the path of the falling water, a ramp or curve would need to be added to guide the flow out into the collection channel and prevent fish from impacting on the top of the filler.

All existing electrical power and compressed air piping would need to be moved up near the ceiling of the DSM channel, and the hydraulic pressure piping would be routed in the same area.

In general, this concept is feasible. One refinement that could be implemented is to add a formed intake conduit to the upstream side of the weir and move the intake to a point some distance below the water surface. This may improve FGE if juvenile fish are known to be more densely located at a certain depth.

4.8.5. Fisheries Considerations

This alternative should maintain FGE because it is not expected to restrict flow into the gatewell to a significant degree. It is possible juvenile salmon and lamprey may have improved egress out of the gatewell with this design, which may help improve survival and condition. The CFD modeling should provide more information about gatewell hydraulics and the area of entrainment around the opening.

All materials and shapes used would be constructed to have little impact on fish and this alternative could solve many of the problems that exist with orifice passage. Another Fish Passage Improvement Team is currently working on orifice improvements with the design goals for improving the ability of the project to detect debris accumulation at the orifice, reducing the likelihood of fish impingement due to misalignment of orifice flow, and improving gatewell egress times with improved lighting.

The existing orifice design and operation provides a regular automatic and manual closure of the orifice with an air burst to move and float trash away from the orifice. This alternative would need to be equipped with similar operation or another mechanism to discourage debris accumulation both in auto and manual control. Juvenile salmonid and lamprey contact with the existing orifice actuator gate would be eliminated with this alternative. Adult fish gatewell passage would most likely benefit from the changes in dimension from the current 12 5/8 inch orifice. Lighting improvements could be fit near the weir and opening to reduce gatewell residence time. Many improvements to the DSM channel downstream of the current orifices have occurred since its inception and the current system functions well biologically. This alternative should not significantly change the DSM transport channel configuration and add in water supply function. It is expected that the adjustable slot would not reduce velocities in the channel or exceed flow through velocity criteria at the primary dewatering screen.

The inspection accessibility to each slot may be reduced due to the available space in the DSM for walkway construction, as well as size and elevation of the working dimensions of the adjustable weir and slot that would be needed to control flow. Gatewell hydraulics may change near the slot but may not be enough to correct the sweeping velocity recirculation, turbulent kinetic energy, and hot spots on the VBS that are suspected of producing the unacceptable fish condition and mortality at the smolt monitoring facility, as well as during the gatewell performance evaluations conducted in 2008 and 2009.

4.8.6. Operation and Maintenance

Raising the work platform to elevation 77.5 feet would reduce the amount of head room available for the employees to approximately 7 feet. The location of the actuators of about 10 feet below the platform, or 15 feet above the bottom of the DSM will require careful consideration of access requirements for maintenance.

The presence of a hydraulic system in the DSM greatly increases our risk of having a spill into the river. Environmentally friendly fluid spills must still be reported and cleaned up as if it were a petroleum-based product. Complicating matters is that vegetable based lubricants are “sticky” and more difficult to clean up than traditional petroleum based lubricants.

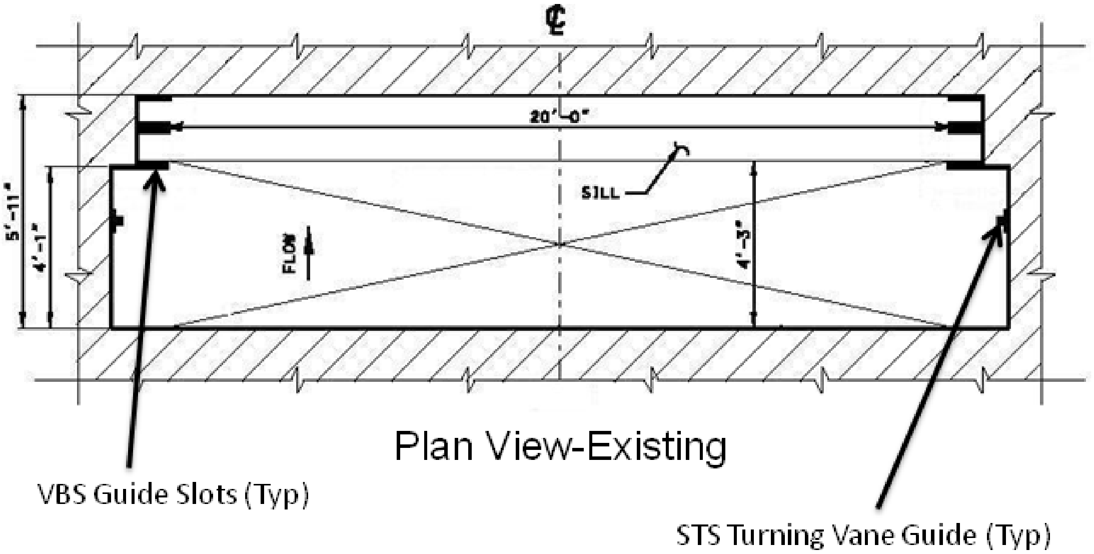
Additional funding requirements for labor and/or O&M cost increases will have to be absorbed into the currently tight O&M budgets.

4.9. ALTERNATIVE C –GATE SLOT FILLERS

4.9.1. Description

In the existing configuration, the STS and turning vane side supports occupy the 4 foot, 1-inch x 1 foot, 4-inch gate slot on either side of each bay. Above the STS side supports, the gate slot expands abruptly and is open to flow up the gatewell. At the abrupt expansion to the gatewell slot above the STS side supports, baseline CFD model results have shown that flow can not immediately expand into the slot and an area of recirculation and higher turbulence results. Gate slot fillers are considered to eliminate the abrupt expansion into the gate slot, reduce turbulence, and streamline sweeping velocities up the VBS. The slot fillers would be installed on each side of each of the three bays and would be dogged off to extend from the top of the STS side supports to above the gatewell water surface (Figures 4-16 to 4-18).

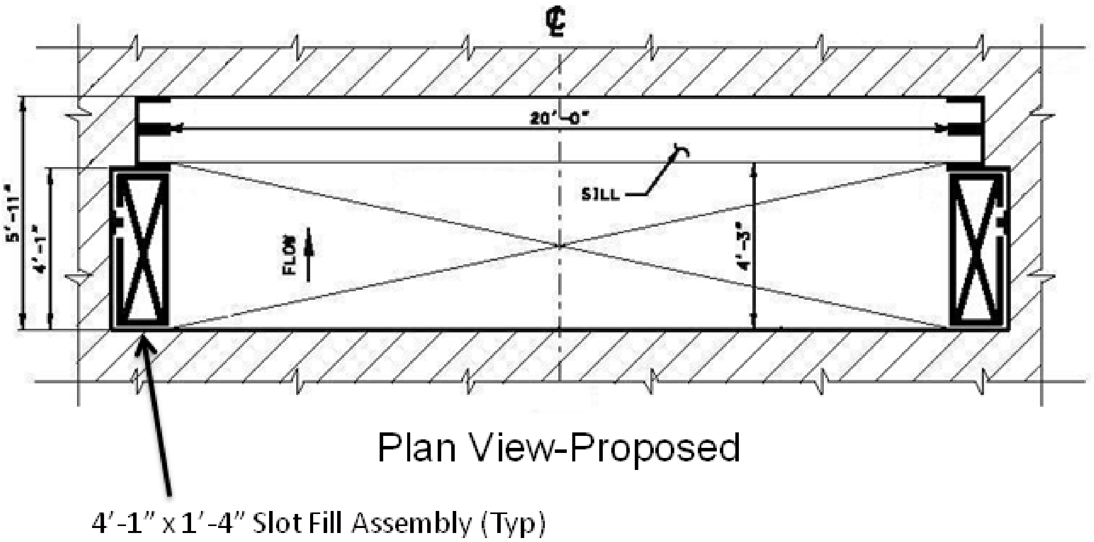
Figure 4-16. Alternative C – Slot Fillers (Plan View)



Plan View-Existing

VBS Guide Slots (Typ)

STS Turning Vane Guide (Typ)



Plan View-Proposed

4′-1″ x 1′-4″ Slot Fill Assembly (Typ)

Figure 4-17. Alternative C – Slot Fillers (Section View)

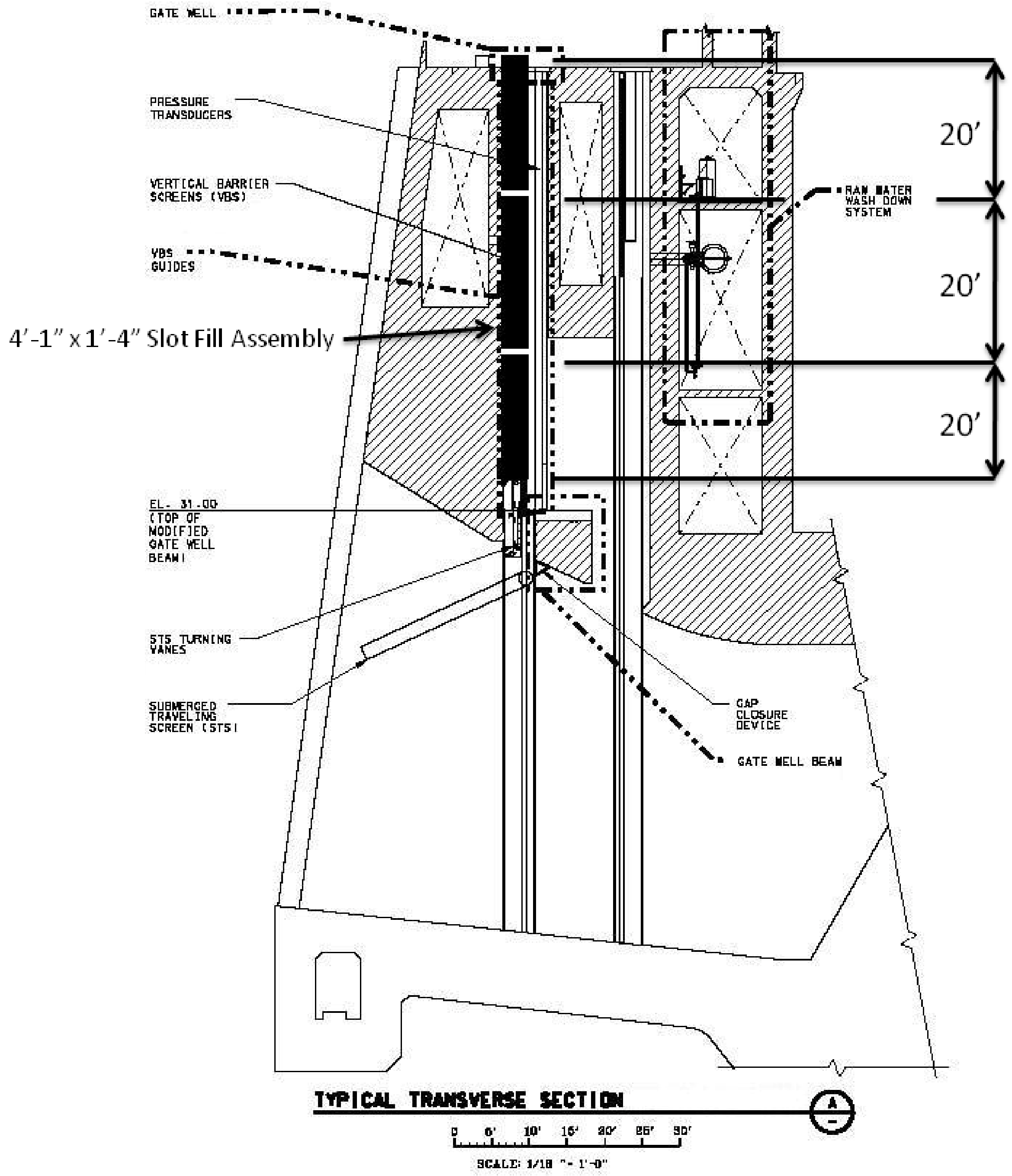
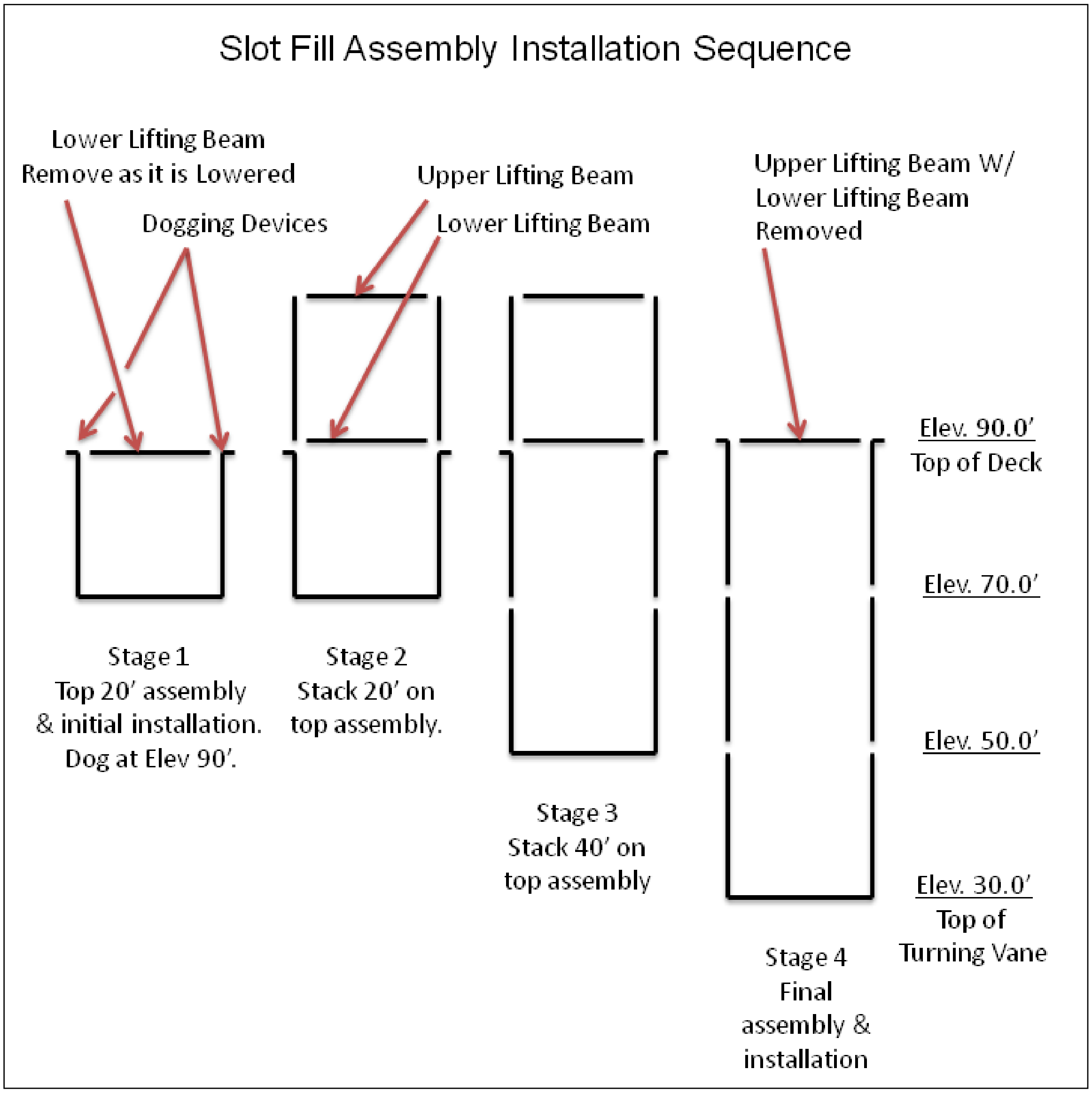


Figure 4-18. Alternative C – Slot Fillers (Front View)



4.9.2. Hydraulic Design

4.9.2.1. Hydraulic Modeling

The sectional CFD model grid was modified to model the gate slot fillers above the STS side supports in all three bays (see Figure 4-4). The sectional CFD model grid cells inside the gate slots were isolated and defined as solid cells rather than fluid cells to simulate the presence of the slot fillers. The solid cells representing the slot fillers extended from the top of the STS side supports to the top of the model domain. One CFD model run was conducted at a unit flow of 18,000 ft^3/s to investigate the relative change in gatewell hydraulic conditions with the slot fillers installed. All other geometric conditions in the model were representative of baseline conditions.

4.9.2.2. CFD Model Results

The sectional CFD model results for Alternative C are summarized in Figures 4-19 to 4-21. Based on the CFD model results, bay A VBS flow increased to 366 ft^3/s with the gate slot fillers in place due to more streamlined flow and reduced turbulent energy loss in the gatewell. This is approximately an 11% increase in VBS flow. In general, the velocity magnitude approaching the STS and turning vane with the gate slot fillers in place (Figure 4-19) is very similar to the baseline 18,000 ft^3/s unit flow case (see Figure 2-17), as expected. The influence of the gate slot fillers can be seen in the gatewell where the centerline velocity magnitude actually decreases with the gate slot fillers in place. This is due to a more even distribution of the flow up the slot, reducing the centerline sweeping velocities. The effect of the gate slot fillers can be seen in Figure 4-20 with the more uniform upward flow pattern and the more even distribution of normal velocities over the VBS panels. The regions of recirculation present in the baseline due to the abrupt slot expansion are significantly reduced to a small region of less intense recirculation in the upper portion of the VBS on either side (Figure 4-20). The turbulent kinetic energy in the gatewell is significantly reduced with the gate slot fillers in place as shown in Figure 4-21 by the elimination of the turbulent regions on the VBS.

4.9.3. Structural Design

The slot fill assembly is assembled with a lower 4-foot, 1-inch by 1-foot, 4-inch U-frame, upper and lower lifting beams and a series of four 4-foot, 1-inch by 1-foot, 4-inch tubes that stack and interlock on top of each other to create a simple, rigid frame to cover the STS traveling screen and turning vane slot (see Figures 4-1 and 4-2). The bottom U-frame can be rigid or be designed as a bolted moment frame. The two lifting beams are designed to raise or lower the frame assembly in pieces. The subassemblies lock together in stages and can be dogged off at the necessary elevations. Each subassembly is 20 feet high with a total assembled height of 60 feet. All of the subassemblies are made of aluminum to reduce weight and eliminate the need for painting.

4.9.4. Mechanical/Electrical Design

Alternative C involves streamlining the upstream gate slots with a fixed-flow guiding surface that would be located in the recesses for the gate guides at the right and left ends of the upstream gate slot. The slot filler would be designed to replicate the surfaces in the CFD model that streamlined the gatewell flow and produced a reduction in turbulence energy.

At the design stage, an important aspect of this alternative that needs to be considered is the potential for conflict with the existing operating equipment. The STSs are in this slot, and the operating cables used to extend or retract the STS rotating screen are currently anchored in the guide slots. The video inspection camera uses this slot for inspection of the STS traveling screen and the VBS screen surfaces. Work on the intake deck uses the space around the gate slot opening, so any equipment that extends into this area will need to be carefully coordinated. The mechanical aspects of this concept could involve designing how the slot fillers stack onto the STS, and various mechanisms to anchor the gate slot fillers in the gate guides.

Figure 4-19. Alternative C – Bay A Centerline Velocity Magnitude

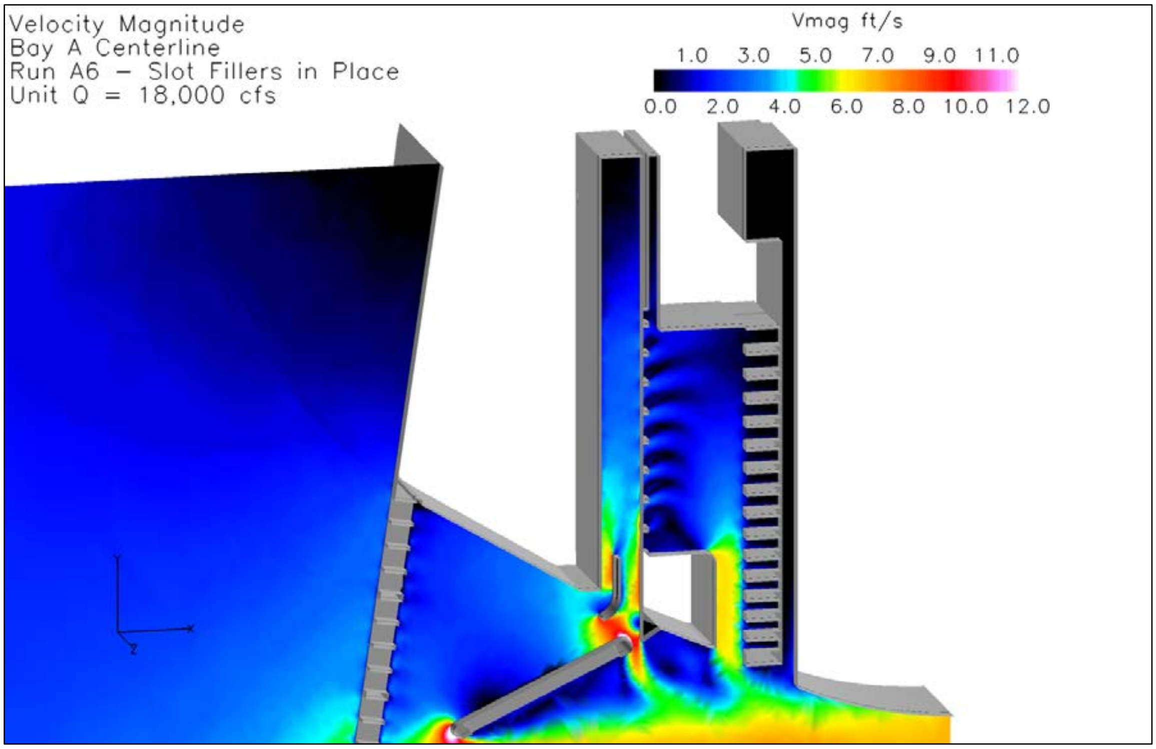


Figure 4-20. Alternative C – VBS Normal Velocities and Flow Patterns

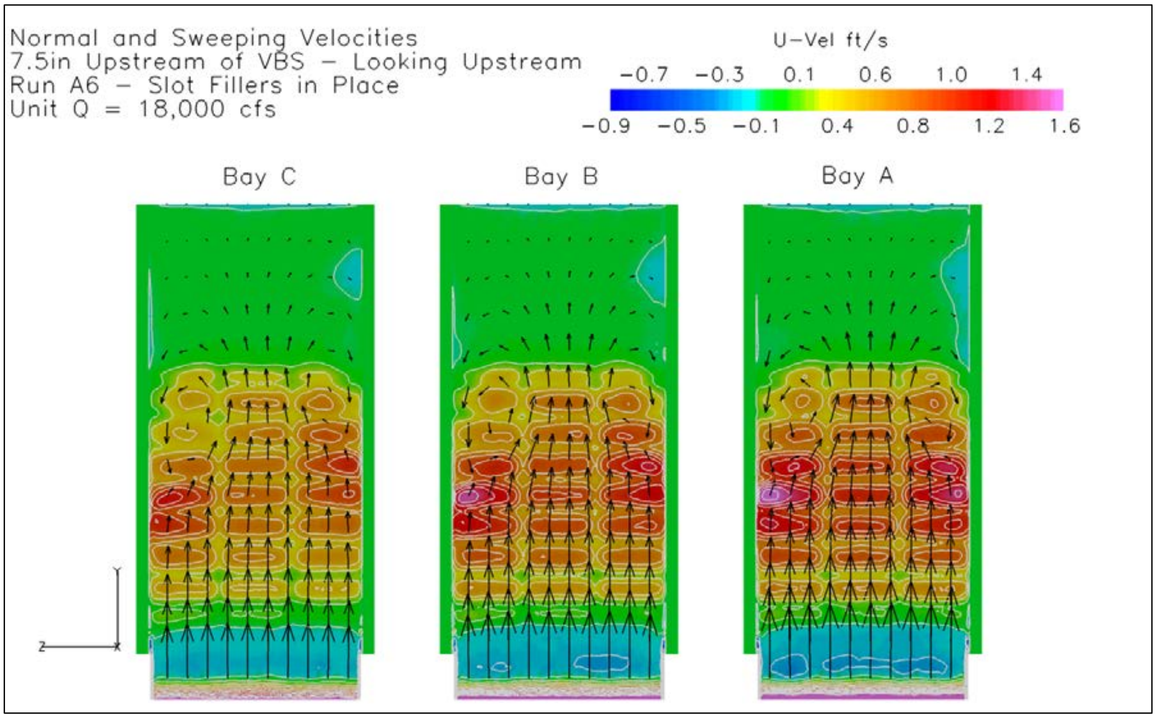
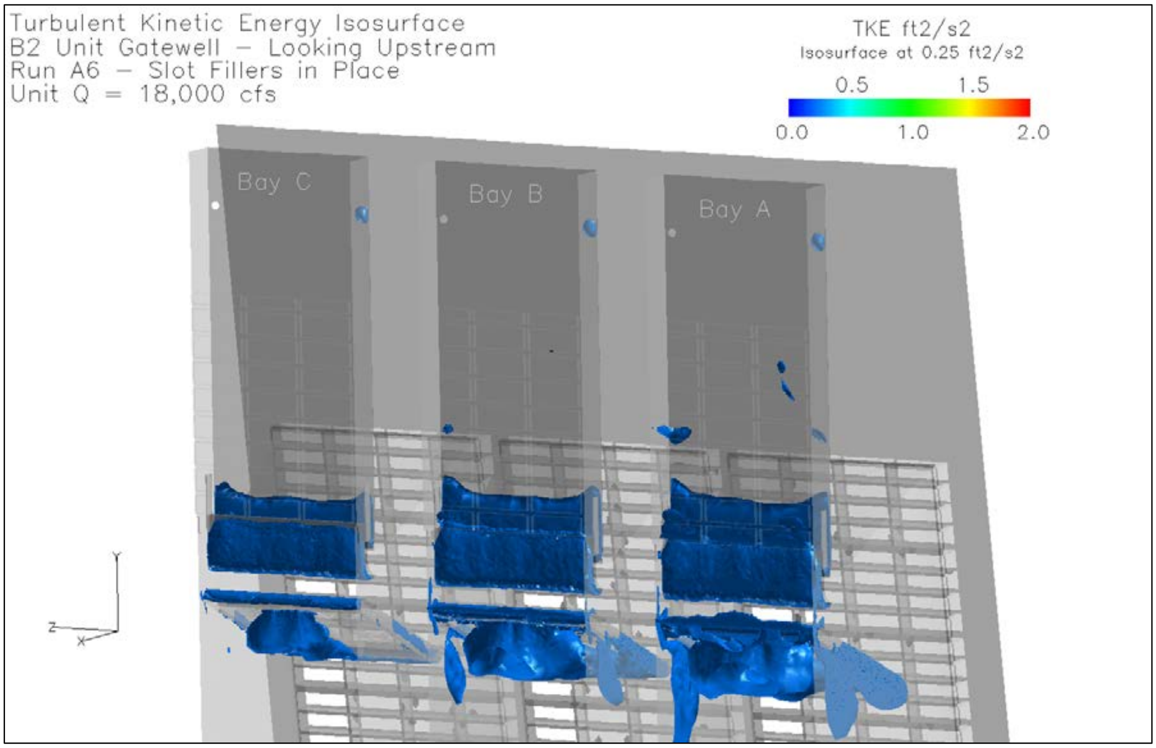


Figure 4-21. Alternative C – Turbulent Kinetic Energy Isosurface



4.9.5. Fisheries Considerations

The CFD modeling of the current slot filler design has shown great promise in streamlining the flow up the gatewell, reducing turbulence, and more evenly distributing VBS normal velocities, even under high unit operations. This slot filler alternative may improve hydraulic conditions for passage, while also allowing the USACE to maintain the current unit operational range and without impacting FGE. These slot fillers are also capable of being designed, built and testing in a timely manner and if accepted can be easily outfitted throughout the entire powerhouse in one in-water-work season.

4.9.6. Operation and Maintenance

The bottom U-frame is lowered 20 feet into the gate slot with the lower lifting beam and dogged off (Figure 4-18, stage 1). Two 20-foot high filler tubes are stacked on top of the bottom U-frame and locked together. The upper lifting beam is then attached to the top, the lower lifting beam is removed, the dogs are retracted, and the frame is lowered an additional 20 feet (total of 40 feet; Figure 4-18, stage 2). The process is repeated and the frame is lowered another 20 feet to reach the intended elevation at the bottom (Figure 4-18, stages 3 and 4). The lower U-frame serves as a stiffened structural element, while the upper lifting beam serves to move the frame assembly and provide required structural support at the top.

At the operational stage, an important aspect of this alternative that needs to be considered is the potential for conflict with the existing operating equipment. The STSs are in this slot, and the operating cables used to extend or retract the STS rotating screen are currently anchored in the guide slots. The video inspection camera uses this slot for inspection of the STS traveling screen and the VBS screen surfaces. Additional labor will be required to work the gate slot fillers in with current operations at the gate slot.

5. EVALUATION OF ALTERNATIVES

5.1. INTRODUCTION

Each alternative was evaluated using a point-based matrix approach. The matrix included the following evaluation factors: biological benefits, construction costs, construction time, O&M costs, operational effectiveness, reliability, impacts to power revenues, and environmental factors. Numerical scoring for construction cost, O&M costs, and impacts to power revenue range from 0 to 4, with 0 being a highly unfavorable score and 4 being a highly favorable score. The numerical scoring for the remainder of the evaluation factors range from 1 to 4, with 1 being a highly unfavorable score and 4 being a highly favorable score. Weighting was applied to each factor to describe the relative importance of each on with respect to the others. The value of the weight was determined qualitatively using professional judgment.

Two rounds of evaluation scoring were conducted. First-round scoring was used to screen alternatives to move into the second round. Construction, O&M costs during first round scoring were qualitative in nature. Biological issues were given higher priority over non-biological issues; thus, the total biological benefit score was considered a primary factor in selecting alternatives to consider further. Cost estimates were developed for alternatives selected for second round scoring. The evaluation factors used to score the alternatives are described below.

- Biological benefits evaluation factors were based on the ability of the alternative to meet the fish passage goals at Bonneville PH2.
- Construction costs are considered in the evaluation of each alternative. Construction costs for the first round scoring are qualitative in nature. Cost estimates are developed for alternatives that were selected for second round scoring.
- Construction time is the overall difficulty or ease of constructing the alternative.
- Operation and maintenance cost considers the overall maintenance and cost of the alternative. For example, if a component needs to be inspected weekly, it will receive a low ranking score. If an alternative that has yearly maintenance or components that require less frequent inspections, it will receive a higher ranking score.
- Reliability evaluation factors are based on the overall ease to operate the alternative. For example, if the alternative had complicated steps required to operate or needed to be monitored on a continuous basis, it will receive a low score. If the alternative required few steps, less frequent monitoring, or required little or no adjustments to operate, it will receive a higher score.
- Impacts to power revenues were considered in the evaluation of each alternative.
- Environmental factors are based on the alternatives overall effect on water quality (total dissolved gas) in the river. Alternatives that increase the level of total dissolved gas from current estimated levels without the alternative will receive lower scores.

5.2. FIRST ROUND OF EVALUATION

5.2.1. Alternative A1 – Flow Control Device Adjustable louver

Figure 5-1 shows the first-round alternative evaluation matrix. Alternative A1 was the lowest-ranked alternative with an overall score of 25.1 and a total biological benefit score of 4.5. Impacts to power revenue costs were scored low because the turbine unit could operate at full load. Construction costs and construction time were scored medium and fair, respectively. This alternative would be somewhat difficult to construct because of existing infrastructure and confined space issues, and could take up to 3 years to implement. This alternative was scored good for OPE because survival in the gatewell would be improved due to less turbulent conditions as a result of reduced discharge in the gatewell. This alternative was scored between poor to fair for overall FGE. Because of the reduction in flow, less fish would be diverted from the turbine into the gatewell and would be forced to enter the turbine either below the fish screen or through the gap at the upper end of the screen.

5.2.2. Alternative A2 – Flow Control Device, Sliding Plate

Alternative A2 has an overall score of 25.8 and a total biological benefit score of 4.5. Impacts to power revenue costs were scored low because the turbine unit could operate at full load. Construction costs and construction time were scored low-medium and fair, respectively. This alternative would be somewhat difficult to construct because of existing infrastructure and confined space issues, and could take up to 3 years to fully implement. This alternative was scored good for OPE because survival in the gatewell would be improved due to less turbulent conditions as a result of reduced discharge in the gatewell. This alternative was scored between poor to fair for overall FGE. Because of the reduction in flow, less fish would be diverted from the turbine into the gatewell and would be forced to enter the turbine either below the fish screen or through the gap at the upper end of the screen.

5.2.3. Alternative A3 – Modify Vertical Barrier Screen Plates

Alternative A3 has an overall score of 25.1 and a total biological benefit score of 4.5. Construction costs were scored as medium. The current VBS slot would need to be modified to accept an adjustable VBS. Construction time was scored good because it could be installed in one season. Reliability was rated as fair. This alternative would require monitoring and adjustment to maintain the hydraulic conditions in the gatewell for fish survival. This alternative was scored good for OPE because survival in the gatewell would be improved due to less turbulent conditions as a result of reduced discharge in the gatewell. This alternative was scored between poor to fair for overall FGE. Because of the reduction in flow, less fish would be diverted from the turbine into the gatewell and would be forced to enter the turbine either below the fish screen or through the gap at the upper end of the screen.

5.2.4. Alternative A4 – Modify Turning Vane and/or Gap Device

Alternative A4 has an overall score of 25.6 and a total biological benefit score of 4.5. Impacts to power revenue costs were scored low since the turbine unit could operate at full load. Construction costs and construction time were scored medium and fair, respectively. This alternative may require the fabrication of new turning vanes and gap closure devices, and could take up to 3 years to fully implement. Modifications to the existing gatewell would not be expected. This alternative was scored good for OPE because survival in the gatewell would be improved due to less turbulent conditions as a result of reduced discharge in the gatewell. This alternative was scored between poor to fair for overall FGE. Because of the reduction in flow, less fish would be diverted from the turbine into the gatewell and would be forced to enter the turbine either below the fish screen or through the gap at the upper end of the screen.

5.2.5. Alternative B1 – Operate Main Unit Off 1% Peak

Alternative B1 has an overall score of 27.9 and a total biological benefit score of 5.0. Impacts to power revenue costs were scored poor since the turbine unit would not operate at peak operating efficiency. Environmental factors were scored fair since increased TDG may result if spill is needed to manage the excess flow from the curtailed unit operation. This alternative was scored good for OPE because survival in the gatewell would be improved due to less turbulent conditions as a result of reduced discharge in the gatewell. This alternative was scored fair for overall FGE. Because of the reduction in flow, less fish would be diverted from the turbine into the gatewell.

5.2.6. Alternative B2 - Open Second DSM Orifice

Alternative B2 was the highest-ranked alternative with an overall score of 34.3 and a total biological benefit score of 7.0. Construction cost was scored low-medium because a second orifice would be needed only in units 15-18 (units 11-14 already have two orifices in each bay) and assumes DSM operating at fingerling criteria. Construction time was scored good because it could take 2 years to complete. This alternative was scored excellent for OPE; as a result of operating a second orifice, the amount of time that fish would be in the gatewell would be reduced, which would improve their survival. This alternative was scored good for overall FGE because the unit could be operated at peak efficiency. However, the impact to the existing DSM cannot be ignored. The current dewatering system is at capacity. Additional flow as a result of opening a second orifice per gatewell will require a larger dewatering facility and associated flow control components.

5.2.7. Alternative B3 – Horizontal Slot

Alternative B3 has an overall score of 30.9 and a total biological benefit score of 7.0. Construction costs were scored medium-high because of the need to construct new slots and overflow weirs. Construction time was scored poor because construction could possibly take up to 4 years. Reliability was scored poor because this would be a new, untested concept and the current downstream migrant system is successful. This alternative was scored excellent for OPE; as a result of operating the horizontal slot, the amount of time that fish would be in the gatewell would be reduced, which would improve their survival. This alternative can take advantage of passing fish at the gatewell water surface.

5.2.8. Alternative C – Gate Slot Fillers

Alternative C has an overall score of 31.8 and a total biological benefit score of 6.5, which ranks this alternative in second place. Operation and maintenance costs were scored medium. There is the potential for conflict with the existing operating equipment. The STSs and the video camera used to inspect the STS and VBS use the same gate slot. Construction time was scored as fair since it may take 3 years to fully implement. This alternative was scored good for FGE because the turbine can be operated at peak efficiency. This alternative was scored good for OPE because fish survival in the gatewell would be improved due to less turbulence in the gatewell as a result of the gate slot filler.

5.2.9. Summary of First Round of Evaluation

Alternatives A1, A2, A3 and A4 were not considered for the second round of evaluation. Each of these alternatives had relatively low total biological benefit scores of 4.5. Each had total scores ranging from 25.1 to 25.8. To put these scores in perspective, the total biological benefit and total score for the baseline condition are 4.0 and 24.5, respectively. Alternatives B1, B2, B3 and C were carried forward for a second round of evaluation.

5.3. SECOND ROUND OF EVALUATION

For the second round of evaluation, cost estimates were developed for Alternatives B1, B2, B3 and C. Also, there were additional factors that needed to be considered specifically for Alternative B2 (Open Second DSM Orifices) and Alternative B3 (Horizontal Slot for DSM), which affected the overall ranking of these alternatives.

Figure 5-1. First Round Alternatives Evaluation Matrix

Alternative	Biological Benefits	a. Overall FGE	b. OPE	**Total Biological Benefit (un-weighted)**		Construction Costs	Construction Time	O & M Cost	Reliability	Impacts to Power Revenue	Environmental Factors	Comments	**Total Weighted Score**
weighting (out of 10 total)		3	4			0.7	0.5	0.5	0.5	0.5	0.3		**10**
						BASELINE							
Baseline Condition		3	1	**4.0**		4	4	4	3	4	4		**24.5**
						Flow Control Alternatives							
1. A1 - Flow Control Device, Adj. Louvers		1.5	3	**4.5**		2	2	3	3	4	4		**25.1**
2. A2 - Flow Control Device, Sliding Plate		1.5	3	**4.5**		3	2	3	3	4	4		**25.8**
3. A3 - Modify Vertical Barrier Screen Plates		1.5	3	**4.5**		2	3	3	2	4	4		**25.1**
4. A4 - Modify Turning Vane and/or Gap Device		1.5	3	**4.5**		2	2	4	3	4	4		**25.6**
						Operational Alternatives							
5. B1 - Oper. Main Unit Off 1% Peak		2	3	**5.0**		4	4	4	4	1	2		**27.9**
6. B2 - Open Second DSM Orifice		3	4	**7.0**		3	3	3	2	4	4		**34.3**
7. B3 - Horizontal Slot		3	4	**7.0**		1	1	2	1	4	4		**30.9**
						Flow Pattern Change Alternative							
8. C - Gate Slot Fillers		3	3.5	**6.5**		3	2	2	3	4	4		**31.8**

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

Alternative B2 – Open Second DSM Orifice. Operating the second orifice for each gatewell will increase the discharge in the DSM channel. Although determining detailed modifications to the DSM is outside the scope of this project, it needs to be addressed since it affects cost and schedule. It is reasonable to assume that in addition to adding equipment to the blind-flanged orifices to make them operational, modifications to the dewatering facility and possibly the downstream migrant channel will need to be made. To reflect this, the rankings for construction cost, construction time, and O&M cost were revised to 0, 1 and 2 , respectively. This resulted in a total weighted score of 30.7.

Alternative B3 – Horizontal Slot for DSM. The concept uses a sliding weir gate that moves vertically. An opening as deep as 10 feet will be cut into the existing gatewell wall to accommodate the gate. To implement this concept, a slot for a sliding weir will need to be constructed, and a hydraulic system will be required to supply pressure to the cylinders that actuate the weirs. Modifications will affect the cost and construction schedule ratings. To reflect this, construction cost and construction time were revised to 1 and 1, respectively, resulting in a total weighted score of 30.9.

Alternative C – Gate Slot Fillers. Alternative C cost estimate showed that construction cost was similar to Alternative B3. To reflect this, the construction cost the ranking was revised to 1. This resulted in a total weighted score of 30.9.

5.3.1. Cost Estimate for Second Round Alternatives

Estimated costs for the second round alternatives are shown in Table 5-1. Details for Alternative B1 are discussed in Section 4.6.7. Details for the remaining alternatives are provided in Appendix E, *Construction Cost Estimates*. Construction costs include contingency based on an Abbreviated Cost Risk Analysis for each of the alternatives, and does not include engineering or supervision and administration (S&A) costs. Life cycle costs are based on Engineering Regulation 1110-2-8159 using a 50-year project life and a discount rate of 2% per Office of Management and Budget Circular No. A-94, Appendix C, revised December 2011. The LCC includes engineering, plans and specifications, construction, S&A, contingency costs, and additional O&M costs for the alternative.

Table 5-1. Estimated Costs for Second Round Alternatives

Alternatives	Construction Cost Estimate (2012 $)	Life Cycle Costs Avg. Annualized (2012, $/year)
B1 – Operate Unit Off 1% Peak	N/A	2,220,000
B2 – Open Second DSM Orifice	59,800,000	2,300,000
B3 – Horizontal Slot	6,900,000	410,000
C – Gate Slot Fillers	6,600,000	400,000

5.3.2. Risk Analysis - Key Cost Risk Drivers

Paragraph 20 in Engineer Regulation 1110-2-1302, *Civil Works Cost Engineering*, requires risk analysis to be performed to identify and measure the cost impact of project uncertainties on the estimated costs. Cost risk analysis indentifies the amount of contingency that must be added to the cost estimate to reduce the uncertainties (of cost over-runs) to an acceptable level. This process identifies areas where additional effort could reduce the uncertainties and provide a more reliable cost estimate.

Cost risk analysis is an ongoing process. Management and the PDT should use the risk analysis to focus key cost risk drivers to manage the risks to the project. The key cost risk drivers noted in the Abbreviated Risk Analysis for Alternative C are summarized below. See Appendix E for the risk registers, details of the concerns, and additional discussion.

External Project Risks. External project risks currently present the greatest uncertainty for the costs of Alternative C. Funding priorities and biological focus could change. The basis for Alternative C is from computer modeling and some agencies do not fully agree with this approach. Prototype testing is planned for the upcoming season to address some of this risk.

Project Scope. The external project risks would be reflected in equal magnitude scope changes. Some types of materials (i.e., low-carbon steel vs. stainless steel) are yet to be coordinated. These considerations could change the scope of the project, resulting in critical cost impacts.

Acquisition Strategy. Acquisition strategy for construction is yet to be determined. The work falls in the range of an Section 8a-type of solicitation (small disadvantaged businesses). A strategy of design-build vs. design-bid-build is not yet decided. These considerations leave uncertainty in the cost estimating.

Cost Estimating Methods. The preliminary nature of the design, construction, and quantities needed require the cost estimate to rely on assumptions and experience of the PDT. A limited number of contractors have experience with this type of work in the gate slots and could have improved or clever methods, unknown to other contractors or the cost estimator. It is unknown if such contractors will be in the bid pool.

5.3.3. Second Round Alternatives Evaluation Matrix

Figure 5-2 shows the second round alternatives evaluation matrix. Alternative B3 (Horizontal Slot for DSM) and Alternative C (Gate Slot Fillers) received the highest scores for the second-round alternatives (both at 30.9). With respect to Alternative C, hydraulic model results indicate this alternative can significantly reduce the level of turbulence inside the gatewell potentially improving the hydraulic conditions for fish passage. Of all the alternatives presented, Alternative B3 and Alternative C should not impact FGE because the turbine unit can be operated in its current operating range, and the discharge into the gate slot would not change. Reliability with Alternative B3 was scored poor since this is a new, untested concept and the current downstream migrant system has been successful.

Figure 5-2. Second Round Alternatives Evaluation Matrix

Alternative	Biological Benefits	a. Overall FGE	b. OPE	**Total Biological Benefit (un-weighted)**		Construction Costs	Construction Time	O & M Cost	Reliability	Impacts to Power Revenue	Environmental Factors	Comments	**Total Weighted Score**
weighting (out of 10 total)		3	4			0.7	0.5	0.5	0.5	0.5	0.3		**10**
						BASELINE							
Baseline Condition		3	1	**4.0**		4	4	4	3	4	4		**24.5**
						Flow Control Alternatives							
1. A1 - Flow Control Device, Adj. Louvers		1.5	3	**4.5**		2	2	3	3	4	4		**25.1**
2. A2 - Flow Control Device, Sliding Plate		1.5	3	**4.5**		3	2	3	3	4	4		**25.8**
3. A3 - Modify Vertical Barrier Screen Plates		1.5	3	**4.5**		2	3	3	2	4	4		**25.1**
4. A4 - Modify Turning Vane and/or Gap Device		1.5	3	**4.5**		2	2	4	3	4	4		**25.6**
						Operational Alternatives							
5. B1 - Oper. Main Unit Off 1% Peak		2	3	**5.0**		4	4	4	4	1	2		**27.9**
6. B2 - Open Second DSM Orifice		3	4	**7.0**		0	1	2	2	4	4		**30.7**
7. B3 - Horizontal Slot for DSM		3	4	**7.0**		1	1	2	1	4	4		**30.9**
						Flow Pattern Change Alternative							
8. C - Gate Slot Fillers		3	3.5	**6.5**		1	3	2	3	4	4		**30.9**

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

6. RECOMMENDATION

Alternative B3 (Horizontal Slot for DSM) and Alternative C (Gate Slot Fillers) were the two highest ranked alternatives. The biological impacts of Alternative B3 are not clear, particularly the transition from the gate well environment to the DSM. Alternative C can be prototype tested without permanent impacts to the unit. Hydraulic model results for Alternative C indicated that the alternative significantly reduces the level of turbulence inside the gatewell which could potentially improve hydraulic conditions for fish passage. Alternative C should not impact FGE since the turbine can be operated in its current operating range with no changes to the turning vane or VBS. Therefore, Alternative C is recommended for prototype testing.

Prototype testing of Alternative C should involve hydraulic and biological testing to evaluate the effectiveness of the gate slot filler on hydraulic conditions and fish survival. As part of the prototype evaluation and in preparation for detailed design in the Design Documentation Report (DDR) phase of the B2 FGE solution, it is recommended the existing CFD models of baseline and alternatives be probed to determine hydraulic design criteria to be used in the DDR phase. The hydraulic criteria will be field verified using the prototype test results. The prototype studies and development of hydraulic design criteria will be documented in the future DDR.

The hydraulics and juvenile fish passage at Bonneville Dam are interrelated and complex. Should the evaluation of Alternative C be unfavorable, it is recommended that the remaining alternatives identified in this report be readdressed.

7. REFERENCES

ENSR. August 2004. Bonneville Second Powerhouse Fish Guidance Efficiency Program Interchangeable VBS Investigation, Contract No. DACW57-02-D-0004, Task Order No. 1, Modification Nos. 4 through 7, Final Submittal, Document No. 09000-309(2).

Pacific Northwest National Laboratory. 2009. Bonneville Powerhouse 2, 3-D CFD for the Behavioral Guidance System, Draft Report. Richland, WA.

Pacific Northwest National Laboratory. November 2010. Water Velocity Measurements on a Vertical Barrier Screen at the Bonneville Dam Second Powerhouse, Draft Final Report. Richland, WA.

U.S. Army Corps of Engineers. August 1997. Bonneville Second Powerhouse Downstream Migrant System Improvements, Supplement No. 6 to Design Memorandum No. 9.

APPENDIX A

Relevant Correspondence

Appendix A – Relevant Correspondence

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Appendix A. Relevant Correspondence

A.1. Gatewell Fish Condition Test Results Meeting (October 3, 2008)

CENWP-PM-E October 3, 2008

MEMORANDUM FOR THE RECORD

SUBJECT: B2 Gatewell Fish Condition Test Results Meeting with NMFS, BPA, and FWS

On 23 September, 2008 the Portland District Corps met with BPA, NMFS, and FWS to discuss 2008 Bonneville Dam gatewell testing results and path forward to address fish injury and debris issues experienced at the Second Powerhouse in 2007 and 2008. The following individuals were in attendance:

Thomas North, Corps Portland
Lyle Gilbreath, NOAA
Jim Calnon, Corps Portland
Mike Gessel, NOAA
Gary Fredricks, NOAA
Mike Langeslay, Corps Portland
Dennis Schwartz, Corps Portland
Randy Lee, Corps Portland
Dave Wills, USFWS
Steve Haeseker, USFWS
Jason Sweet, BPA
Scott Bettin, BPA
Tammy Mackey, Portland District

Phone Conference Line:

Naameh Nomie, Troutdale Resident Office
John Rerecich, BON
Ben Hausmann, BON

Lyle Gilbreath and Mike Gessel discussed mortality estimates for fish released into B2 gatewells with turbines operating at low, mid, and high end of the 1% efficiency range (Table 1). The following are conclusions drawn by the group.

- Spring Creek Hatchery subyearling Chinook showed a significant and substantial mortality difference between the low and high end of the operating range.
- The magnitude of the SCNFH fish mortality at the mid point (1-3%) was also a concern, but there were not enough replicates. If we want to operate at the mid point during the SCNFH release, then we need more gatewell mortality data at this operation.
- For run of river yearling and subyearling Chinook gatewell mortality, there is a trend that causes concern. Mortality was higher at the higher operating points. COE will look at

SMP mortality info during the same period for upper 1% ops, since this should match the gatewell data.

Next Steps

1. Immediate interim solution for 09
   - Drop B2 units back to between mid and lower end of 1% range during spring SCNFH releases. Scott Bettin pointed out that we will need to incorporate how we will deal with TDG during this operation (i.e. run all units at B2 at lower Q, spill as per FPP, load PH-1 to max, spill to TDG cap, start ramping up B2 unit Q starting with lower priority units…).
   - Collect enough yearling and subyearling Chinook ROR gatewell mortality data in 09 to detect a 3% additive difference. NOAA to develop final proposal for 2009 that incorporates this objective.
   - Repeat SCNFH gatewell research releases in 2009. Delete canister release and have intake hose and JBS channel as the two test release sites. Continue to test High vs. low turbine operations as well as mid point in some replicates.
   - Develop solution to gap between VBS panels so that project can ensure no gap is there once panels are deployed. Ops to develop strategy and incorporate comments and recommendations into the 2009 FPP.
   - Continue with parallel track on alternatives study to address operational and structural fixes to the fish injury and debris issue.

2. Longer term solution involves implementing recommendation from the alternatives report.

A Special FFDRWG meeting slated for Wednesday Oct 8th 9:00 a.m. at the NOAA office at Lloyd Center.

Table 1. Observed mortality of juvenile Chinook salmon recaptured after passage through the Bonneville Dam Second Powerhouse juvenile bypass system in 2008. Preliminary data for subyearling Chinook salmon obtained from Spring Creek NFH and for yearling and subyearling run-of-river (ROR) Chinook salmon collected at Bonneville Dam.

Test series and release location	Turbine operation	Replicates	Released (N)	Recap. live (%)	Recap. dead (%)	Not recap. (%)
Series 0 - Spring Creek NFH subyearling Chinook salmon released 4-5 March						
Collection Channel	NA	2	1801	99.7	0.3	1.7
Gatewell 12A	Lower 1%	2	799	98.1	1.9	17.3
Gatewell 12A	Mid 1%	2	854	85.8	14.2	18.7
Gatewell 12A	Upper 1%	2	799	67.7	32.3	33.4
Series 1 - Spring Creek NFH subyearling Chinook salmon released 18-21 March						
Collection Channel	NA	4	592	99.7	0.3	1.5
Gatewell 14A	Lower 1%	4	775	95.6	4.4	32.2
Gatewell 14A	Upper 1%	4	937	93.0	7.0	43.6
Intake 14A	Lower 1%	4	781	99.7	0.3	25.3
Intake 14A	Upper 1%	4	1012	92.6	7.4	61.7
Series 2 - Spring Creek NFH subyearling Chinook salmon released 26 March - 18 April						
Collection Channel	NA	3	2682	100.0	0.0	0.5
Gatewell 14A	Lower 1%	3	2658	99.2	0.8	3.3
Gatewell 14A	Upper 1%	3	2521	93.4	6.6	25.5
Intake 14A	Lower 1%	3	2607	98.7	1.3	5.4
Intake 14A	Upper 1%	3	2616	87.2	12.8	34.0
Series 3 - Spring Creek NFH subyearling Chinook salmon released 23 April - 9 May						
Collection Channel	NA	3	899	99.8	0.2	1.6
Gatewell 14A	Mid 1%	3	2369	98.7	1.3	2.9
Gatewell 14A	Upper 1%	3	2464	86.8	13.2	15.4
Intake 14A	Mid 1%	3	2433	97.2	2.8	3.9
Intake 14A	Upper 1%	3	2394	81.2	18.8	20.2
Series 4 - ROR yearling Chinook salmon released 14-21 May						
Collection Channel	NA	2	255	98.5	1.5	3.4
Intake 14A	Mid 1%	1	250	95.1	4.9	1.2
Intake 14A	Upper 1%	2	564	93.2	6.8	4.2
Series 5 - ROR subyearling Chinook Salmon released 1-17 July						
Collection Channel	NA	3	560	99.6	0.4	2.7
Intake 14A	Mid 1%	3	743	99.4	0.6	5.4
Intake 14A	Upper 1%	3	821	97.4	2.6	5.1

A.2. FGE Gatewell Improvements Alternatives 30% Report Comments

April 22, 2009 F/NWO3

FILE MEMORANDUM

FROM: Gary Fredricks

SUBJECT: Bonneville 2nd Powerhouse FGE Program Gatewell Improvements Alternatives 30% Report Comments

1. More biological background is needed regarding gatewell studies that were done in 2008. What we know about both Spring Creek hatchery and river-run fish should be summarized. It will be important to know if the gatewell fish condition problem is limited to only Spring Creek Fish or also applies to river-run fish. A short term operational change may be all that is necessary if the problem occurs only two times a year for a few days.

2. Measurable gatewell environment goals should be developed for this program. There appears to be a relatively consistent response in fish condition (at least for Spr. Cr. hatchery fish) to changes in unit flow. What are the gatewell conditions associated with each of the operating points and can these be used to develop some design criteria for this program?

3. Alternative A and A1 are both flow control devices that should be carried forward. These will allow free use of the turbine units which may help maintain best turbine survival and reduce TDG during the higher flow periods at the project. Also, there was a suggestion at the April 21 meeting for an alternative flow control idea (A2?) that would incorporate a modification to the head gate that would restrict gatewell flow. This might simplify the construction, deployment and maintenance of a flow control device and should be carried forward.

4. Alternative B - Modifying the unit operation is one of the cheaper alternatives from a construction standpoint but this does have the concerns of reduced turbine survival, increased TDG during high river flows (due to a restriction in powerhouse capacity) and, as pointed out by BPA, loss of generation. The new B2 turbine model down at ERDC should be used to compare fish passage conditions for the unit operating at the upper, middle and lower points in the 1% peak operating range.

5. Alternative C – Opening the second DSM orifices (regulating orifices) might move more fish out of the gatewell, however, I believe the residence time for fish in these gatewells is already quite short. A review of this would determine if opening the second orifice might help. The downside of this would be increased flow in the collection channel and potential dewatering issues downstream. Also, only units 11 through 14 have regulating orifices.

6. Alternative C1 – A vertical slot, overflow weir would probably improve general fish condition by providing a larger and perhaps more natural egress option for gatewell fish. This type of system would also eliminate the need for future orifice modifications. It would be less likely to have debris problems and would be much easier to observe for debris problems. However, the usefulness of this alternative in the context of this report also depends on fish residence time. If time is low, then a better gatewell exit probably would not help the problem.

7. Alternative D – modification to the VBS perforated plates would reduce the flow into the gatewell but it would also have the effect of reducing fish guidance efficiency. While this is effect is true with other alternatives, a perforated plate change would be very difficult to change in-season. This would be undesirable if the gatewell injury problem is limited to a couple of hatchery releases. Hydraulic modeling of the gatewell environment would be necessary.

8. Alternative X – The issue of Spring Creek Hatchery fish acclimation to the river environment should be further investigated. We know there are significant differences in water temperature between the hatchery and the river, particularly in the early releases. Since these fish encounter the dam only a day or so after release, they may not have acclimated to the river water temperature and flow environment. Studies to determine if this is true and methods to mitigate for it should be considered (Little White Salmon releases?).

A.3. Minutes for 02 June 2011 FFDRWG Meeting

CENWP-OD 02 June 2011

MEMORANDUM FOR THE RECORD

Subject: DRAFT minutes for the 02 June 2011 FFDRWG meeting.

The meeting was held in the RDP 3C Meeting Room, Portland OR. In attendance:

Last	First	Agency	Office/Mobile	Email
Baus	Doug	USACE-NWD	503-808-3995	Douglas.m.baus@usace.army.mil
Conder	Trevor	NOAA	503-231-2306	Trevor.conder@noaa.gov
Cutts	Matt	USACE-NWP	503-808-4397	Matthew.e.cutts@usace.army.mil
Ebner	Laurie	USACE-NWP	503-808-4880	Laurie.l.ebner@usace.army.mil
Eppard	Brad	USACE-NWP	503-808-4780	Matthew.b.eppard@usace.army.mil
Fielding	Scott	USACE-NWP	503-808-4777	Scott.d.fielding@usace.army.mil
Fredricks	Gary	NOAA	503-231-6855	Gary.fredricks@noaa.gov
Keller	Pat	USACE-NWP	503-808-4293	Patrick.j.keller@usace.army.mil
Kuhn	Karen	USACE-NWP	808-503-4897	Karen.a.kuhn@usace.army.mil
Lee	Randy	USACE-NWP	503-808-4876	Randall.t.lee@usace.army.mil
Lorz	Tom	CRITFC	503-238-3574	lort@critfc.org
Mackey	Tammy	USACE-NWP	503-961-5733	Tammy.m.mackey@usace.army.mil
Meyer	Ed	NOAA	503-230-5411	ed.meyer@noaa.gov
North	Tom	USACE-NWP	503-808-4952	Thomas.north@usace.army.mil
Petross	Dennis	USACE-NWP	808-503-4915	Dennis.w.petross@usace.army.mil
Ploskey	Gene	PNNL	509-427-9500	Gene.ploskey@pnl.gov
Richards	Natalie	USACE-NWP	503-808-4755	Natalie.A.Richards@usace.army.mil
Roy	Liza	USACE-NWP	503-808-4849	Elizabeth.W.Roy@usace.army.mil
Ruckwardt	Sondra	USACE-NWP	503-808-4691	Sondra.k.ruckwardt@usace.army.mil
Schlenker	Steve	USACE-NWP	808-503-4881	Stephen.j.schlenker@usace.army.mil
Schwartz	Dennis	USACE-NWP	503-808-4779	Dennis.e.schwartz@usace.army.mil
Stokke	Alan	USACE-NWP	808-503-4926	Alan.m.stokke@usace.army.mil
Sweet	Jason	BPA	503-230-3349	jcsweet@bpa.gov
Wills	David	USFWS	360-604-2500	David_wills@fws.gov
Zorich	Nathan	USACE-FFU	541-374-8801	Nathan.a.zorich@usace.army.mil

1. Finalized results from this meeting.

2. The following documents were provided or discussed.

2.1. *Agenda.*
2.2. *BON spillway issues from Cutts.*
2.3. *Avian attacks at TDA/JDA from Zorich*
2.4. *Flow forecast from Eppard.*
2.5. *Richards handout.*
2.6. *Meeting minutes from 09 May special FFDRWG.*
2.7. *B2 Orifice improvements from Kuhn.*
2.8. *B2 FGE CFD modeling handout from Roy.*

3. Action Items

3.1. B2FGE - Schwartz to re-send the 30% Alternatives report and schedule a special FFDRWG for early May. ***Completed.***

3.2. TDA AWS - Tackley to schedule a special FFDRWG in conjunction with the B2FGE meeting. ***TDA AWS meeting completed. B2FGE to be discussed after the 2 June FFDRWG.***

3.3. [Mar 11] Adult PIT tag detectors at TDA and JDA. **ACTION:** Eppard will schedule a special FFDRWG to discuss the PIT tag plan. ***To be removed from the action items.***

3.4. [Mar 11] JDA north ladder improvements. **ACTION:** Richards will check with Schlenker to determine at what flows ladder criteria will be violated with only four pumps. ***Completed.***

3.5. [Mar 11] JDA survival study. **ACTION:** Skalski will submit an addendum to the study proposal. The addendum will outline all the various assumptions and how the analysis will occur post study. ***Completed.***

3.6. [Jun 11] Avian hazing/lethal take. **ACTION:** Schwartz will send the document to Mackey and it will be included on the FPOM agenda.

3.7. [Jun 11] TDA/JDA PIT tag detectors. **ACTION:** Tackley will send an itinerary for the PIT detector site visit and a Doodle Poll for the special FFDRWG.

3.8. [Jun 11] B1 Turbine ops. **ACTION:** Schwartz will draft a FPP change form for PH1 turbine ops.

3.9. [Jun 11] JDA COP. **ACTION:** Eppard will follow up with NWD and hopefully get the draft to the Region soon.

3.10. [Jun 11] B2 Orifice Improvements. **ACTION:** FFDRWG members are asked to review alternatives as well as the evaluation and ranking criteria information. Comments are due by 17 June.

3.11. [Jun 11] B2 FGE alternatives. **ACTION:** The team will finish the documentation based on comments from FFDRWG.

4. Bonneville Spillway Rehab. Cutts provided a handout and described the last known condition of the BON spillway apron. Cutts explained the issue is that not only could the spillway apron fail, but BiOp spill may not be maintained if the Bay 3 and Bay 4 slab fails. Cutts requested assistance getting a Tech Lead from EC. Schwartz suggested a survey for September. Fredricks asked that Cutts provide this information to FPOM at the 9 June FPOM meeting. Ebner said she would like to have the BON survey combined with the TDA survey (she reported some oddities seen at the end of the spill wall. She doesn't know what is going on, but suggested something as changed). Ebner said she would like it to be one contract, even though there would be two funding streams. Fredricks suggested it would be necessary to look at the ERDC models to see what the impacts might be in the event of failure.

5. Avian Predation Actions

5.1. Island construction. Need two more acres. Looking at Malheur and San Francisco Bay. Malheur is flooded, which is causing some construction issues. The island construction will occur by barge rather than by truck. This will accommodate the flooding and potentially reduce costs. Contract should be awarded by end of FY11 with construction in winter FY12.

5.2. Estuary monitoring. Eagles are attacking the terns. Gulls are eating the tern chicks and eggs.

6. TDA Avian Wire Array. Zorich provided a heat map showing the attacks. He said the arrays are working fairly well though he reminded everyone that the arrays are coupled with hazing. He reported that birds have penetrated the gaps in the new TDA array at the bridge. The recommendation to close the gaps were well received and would be carried forward. He also reported that boat hazing is more effective than shore-based hazing, even when they both haze the same location.

6.1. Fredricks said he would like to claim the array is successful but with the flows, the upwell isn't as pronounced this spring as compared to lower flow years. Zorich said the attacks are in the same general location, even with the changes in flows. Fredricks added at the sluiceway at TDA normally plunges but this year the outfall goes all the way across the river and impacting the other side, roughly in the same place as the heat spot on the map.

6.2. Schwartz asked if there has been a shift in birds from JDA to TDA or vice versa. Zorich explained the highest bird counts are normally seen during the juvenile lamprey out-migration, which seems to have already appeared for this year.

6.3. Wills requested a historical line be added to the diagrams for future handouts. Zorich said he is working on that and also hopes to get the avian array on the heat map as well.

6.4. Schwartz asked if Zorich had seen the Aphis document requesting lethal take. Aphis has asked USACE to review their document. **ACTION:** Schwartz will send the document to Mackey and it will be included on the FPOM agenda.

7. Lower Columbia River Survival Study.

7.1. 2011 Summer Study. Eppard provided a STP graph. Based on flows, the summer survival study has been cancelled. Fredricks requested the spring study results three months sooner since the researchers won't be busy with the summer study. The last release above JDA was 27 May and the last release below BON was 30 May.

8. Survival Study Methods. No update at this time.

The meeting was interrupted by Mr. Thomas Lorz entering the room. Please see the pictures below.

9. JSATS Transmitter Downsize. Eppard said there could be a trip to the Richland lab. Fredricks suggested Eppard talk to NWW to coordinate trips to Walla Walla.

10. JDA/TDA Adult PIT Detectors. Pat Keller is the new PM. He didn't have a lot of past information but was told he needed to talk with various regional folks. Fredricks suggested Keller should talk to Scott Bettin at BPA. Richards reported that she didn't do much with the PIT detectors. Keller explained that Marie Phillips is the TL and she would be scheduling a special FFDRWG to further discuss this issue with the region.

10.1. Keller said he would be going through the alternatives and costs so SCT can rank the project. Fredricks said NOAA is very interested in getting the detectors installed. He said if there was any extra money (say from a summer study not going forward) NOAA would like to see the designs moving forward this year. He suggested the telescoping weirs at TDA, but expressed some concern about the lack of repetition. They expect the same efficiency rates should be met.

10.2. There will be a site meeting at TDA on 8 June. Lorz commented that there is a Snake River COP meeting at TDA on 8 June so that timing would work well. Fredricks and Wills said they thought the COP meeting was for MCN. Either way, many reps would be there.

10.3. Keller said he thought they may start at TDA around 0830 then head up to JDA. **ACTION:** Tackley will send an itinerary for the PIT detector site visit and a Doodle poll for the special FFDRWG.

10.4. Lorz asked about lamprey. Will there be half duplex detectors incorporated as well?

11. Lamprey Program. Richards provided a handout. She recapped a few of the last meetings. The next Lamprey bi-monthly meeting will be 7-8 July.

11.1. Washington Shore Ladder Improvements. Currently trying to route the pipeline through all the conduits. The z axis is not quantified as desired, so more ground-truthing is needed. Fredricks asked if the area wasn't just torn up for the B2 bypass a few years ago. Richards said yes, but the as-builts do not appear to be correct. Schwartz clarified that "a few years ago" has been 12 years now. Fredricks commented that the current LPS is underwater and a potential fish trap. He would like to see that removed. Richards and Schwartz assured him there is nothing like that on the new LPS system.

11.2. Adult Salmon and Steelhead Studies. The TDA ITS special operations will continue through 2013. The B2CC kelt triggers meeting needs to be rescheduled. **ACTION:** Schwartz is working on that.

11.3. John Day North Ladder Improvements. BCOE should be out in July. Contracting requested a continuing contract clause, which requires it go through the Secretary of the Army. Richards is working on a work around since the entrance can reasonably be broken into two separate projects.

12. Bonneville Fish Unit Trash Rake. Assigned to Captain Robert Lee. Schwartz explained he is part of the regular army. He has experience with BON and works well with them. Schwartz has briefed Captain Lee on the history of the trash rake. A budget and scope of work has been created, still working on a PDT.

13. B1 Turbine Ops. The white paper will be updated per comments from the conference call on 24 May. Schwartz recapped the comments from the Regional reps from the 24 May meeting to make sure they were accurately captured. Fredricks, Lorz and Wills further discussed the implementation of the new turbine ops. Fredricks and Lorz debated the option of not implementing the turbine ops at TDG levels below 130. CRITFC is not in support of changing turbine ops at TDG lower than 130. Fredricks suggested it is a no-brainer to adjust turbine ops at TDG levels of 120. Fredricks suggested he would take this to RIOG. Lorz expressed disbelief that this issue would be elevated to RIOG when there are other issues. Wills and Sweet suggested the TDG levels are regulated by law. Lorz, Fredricks and Wills discussed the adaptive management piece of the BiOp and how it would be nice if it was applied more broadly.

13.1. Fredricks had three triggers for implementation he will bring to FPOM. They are to address spring issues such as sea lions, fallback, etc; reduce TDG impacts (when bumping against 120); to reduce the loads at PH2 for Spring Creek fish or fish condition, debris, etc. Lorz asked if COMPASS will be reconfigured to include the survival with this operation. Fredricks suggested Lorz carry that forward. Sweet suggested it may show that less spill showed higher survival. **ACTION:** Schwartz will draft a FPP change form for PH1 turbine ops.

14. B2 Turbine Ops. Fredricks requests the TSP team accelerate the B2 model and examine the best geometry for PH2 units, with and without screens.

15. B2 Corner Collector Gate Hoist. The hoist contract has been awarded. Work will begin once the B2CC is closed for the season. Lorz asked if any channel repairs would occur at the same time. Schwartz confirmed that the grout work will occur at the same time.

16. Turbine Survival Program. Looking at one-pagers for next year.

17. JDA Configuration and Operation Plan. Eppard sent the draft to NWD a few weeks ago. **ACTION:** Eppard will follow up with NWD and hopefully get the draft to the Region soon.

17.1. COP Addendum. This updates the COP with the 2008-2010 data and actions.

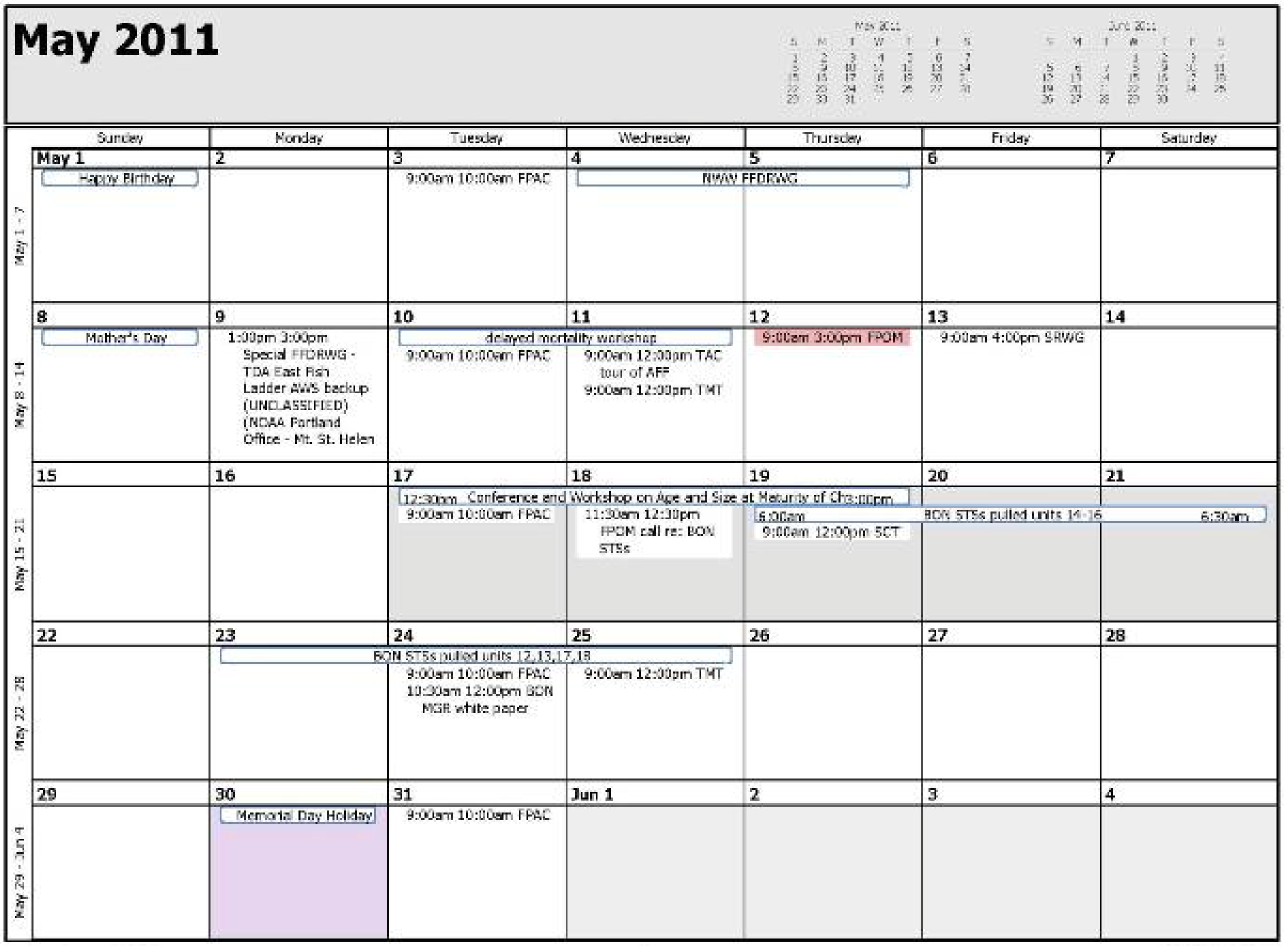
17.2. CAES. Wills asked what CAES stood for. No one could remember but everyone knew it addresses the tailrace mods at JDA.
17.3. Deflector Optimization. This is complete.
17.4. Avian Wires. The wires and poles are quiet and normal.

18. **The Dalles North and East Adult Fish Ladder Study**. A meeting was held on 9 May. A decision document should be out in June 2011.

Lunch break

19. **B2 Orifices**. Kuhn gave a powerpoint presentation. As she was going through the slides, she commented that BON Fisheries has provided feedback as to the condition of the jet and the location of the driver. The north drivers set into the wall nearly always have a perfect jet. The north drivers set on the wall have a perfect jet about 50% of the time. The south drivers (all set off the wall) rarely have a perfect jet.
19.1. The design criteria is to the same as the existing DSM- forebay range 71.5- 76.5.
19.2. Fredricks expressed some concern about changing all the orifices to 12”, as that could negatively affect FGE.
19.3. **ACTION:** FFDRWG members are asked to review alternatives as well as the evaluation and ranking criteria information. Comments are due by 17 June.

20. **B2 FGE**. R. Lee provided some background as to why FGE was investigated. Based on findings by Lyle Gilbreath, fish condition didn’t appear to be as good as expected, an alternatives report was drafted in about 2009. Alternatives include flow control structures, reduced turbine loading, etc. AS the alternatives were modeled, turbulence was seen in the CFD modeling.
20.1. Roy explained the B2FGE CFD modeling. She explained the STS slots were not in the original model but were added in the new model. She went through four different scenarios (baseline, gap closure device removed, slot fillers in place, flow control device) and the changes in velocity and flow patterns from baseline.
20.2. Fredricks asked if the porosity parameters are the same. Liza said they are. She said with the slot filler in place, there is nothing that dictates a porosity change would be needed. Slot fillers appear to remove the hot spots and turbulence. The recirculation areas are higher in the gatewell, closer to the orifices. The slot fillers prevent the water from expanding, which will reduce the turbulence caused by the expansion of the flow once it reaches the STS slots. This will create faster, uniform flow through the VBS as well. The general consensus from the engineers was that the flow wouldn’t increase, but the uniformity would increase.
20.3. Fredricks asked if further analysis would occur on the three alternatives. He recommends testing the slot fillers as soon as possible.
20.4. Schwartz reminded everyone that the alternatives were chosen because they didn’t limit unit operation and there was limited impact on FGE. **ACTION:** The team will finish the documentation based on comments from FFDRWG.



May 2011

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 1 - 7	**May 1** Happy Birthday	**2**	**3** 9:00am 10:00am FPAC	**4** NWW FFDRWG	**5**	**6**	**7**
May 8 - 14	**8** Mother's Day	**9** 1:00pm 3:00pm Special FFDRWG - TDA East Fish Ladder AWS backup (UNCLASSIFIED) (NOAA Portland Office - Mt. St. Helen	**10** delayed mortality workshop 9:00am 10:00am FPAC	**11** 9:00am 12:00pm TAC tour of AFF 9:00am 12:00pm TMT	**12** 9:00am 3:00pm FPOM	**13** 9:00am 4:00pm SRWG	**14**
May 15 - 21	**15**	**16**	**17** 12:30pm Conference and Workshop on Age and Size at Maturity of Chi3:00pm 9:00am 10:00am FPAC	**18** 11:30am 12:30pm FPOM call re: BON STSs	**19** 6:00am BON STSs pulled units 14-16 6:30am 9:00am 12:00pm SCT	**20**	**21**
May 22 - 28	**22**	**23** BON STSs pulled units 12,13,17,18	**24** 9:00am 10:00am FPAC 10:30am 12:00pm BON MGR white paper	**25** 9:00am 12:00pm TMT	**26**	**27**	**28**
May 29 - Jun 4	**29**	**30** Memorial Day Holiday	**31** 9:00am 10:00am FPAC	**Jun 1**	**2**	**3**	**4**

June 2011

June 2011

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July 2011

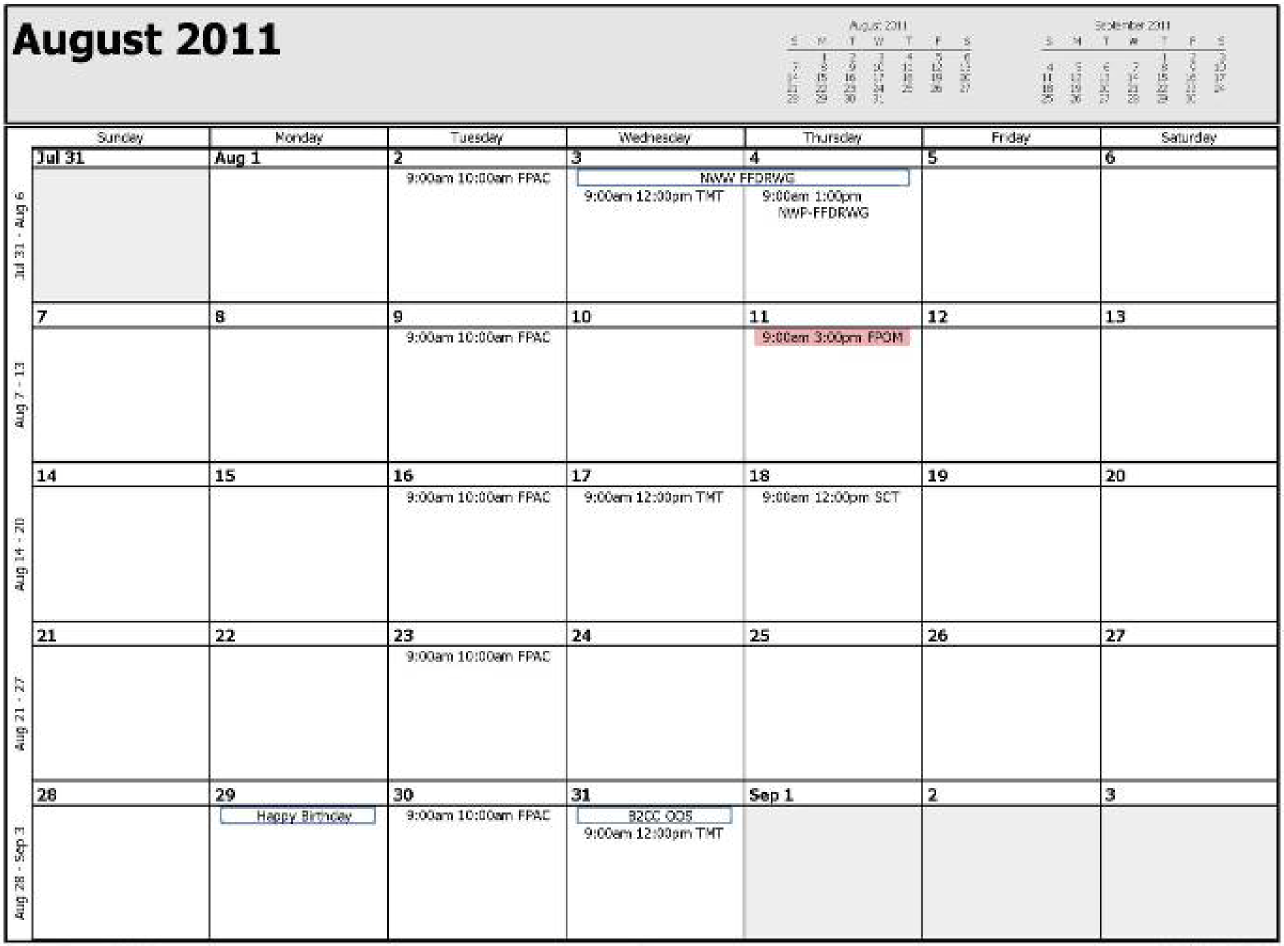
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 29 - Jun 4	**May 29**	**30**	**31**	**Jun 1**	**2** 9:00am 1:00pm NWP-FFDRWG - Mackey, Tammy M NWP	**3**	**4**
Jun 5 - 11	**5**	**6**	**7** 9:00am 10:00am FPAC	**8** 9:00am 5:00pm COPS Regional Meeting #1 (The Dalles) 9:00am 12:00pm TMT	**9** 9:00am 3:00pm FPOM	**10**	**11**
Jun 12 - 18	**12**	**13**	**14** 9:00am 10:00am FPAC	**15**	**16** 9:00am 12:00pm SCT	**17**	**18**
Jun 19 - 25	**19** Father's Day	**20**	**21** 9:00am 10:00am FPAC	**22** 9:00am 12:00pm TMT	**23**	**24**	**25** Happy Birthday
Jun 26 - Jul 2	**26**	**27**	**28** 9:00am 10:00am FPAC	**29**	**30**	**Jul 1**	**2**

Mackey, Tammy M NWP 6 5/27/2011 2:58 PM

July 2011

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jun 26 - Jul 2	**Jun 26**	**27**	**28**	**29**	**30**	**Jul 1**	**2**
Jul 3 - 9	**3**	**4** Independence Day Hol	**5** 9:00am 10:00am FPAC	**6** 9:00am 12:00pm TMT	**7**	**8** Happy Birthday	**9**
Jul 10 - 16	**10**	**11** Happy Birthday	**12** 9:00am 10:00am FPAC	**13** 9:00am 5:00pm COPS Regional Meeting #2 - Granite + Transport (in Portland (Actual location TBD))	**14** 9:00am 3:00pm FPOM	**15**	**16**
Jul 17 - 23	**17**	**18**	**19** 9:00am 10:00am FPAC	**20** 9:00am 12:00pm TMT	**21** 9:00am 12:00pm SCT	**22** Happy Birthday	**23**
Jul 24 - 30	**24**	**25**	**26** 9:00am 10:00am FPAC	**27**	**28**	**29**	**30**
Jul 31 - Aug 6	**31**	**Aug 1**	**2**	**3**	**4**	**5**	**6**



August 2011

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jul 31 - Aug 6	**Jul 31**	**Aug 1**	**2** 9:00am 10:00am FPAC	**3** NWW FFDRWG 9:00am 12:00pm TMT	**4** 9:00am 1:00pm NWP-FFDRWG	**5**	**6**
Aug 7 - 13	**7**	**8**	**9** 9:00am 10:00am FPAC	**10**	**11** 9:00am 3:00pm FPOM	**12**	**13**
Aug 14 - 20	**14**	**15**	**16** 9:00am 10:00am FPAC	**17** 9:00am 12:00pm TMT	**18** 9:00am 12:00pm SCT	**19**	**20**
Aug 21 - 27	**21**	**22**	**23** 9:00am 10:00am FPAC	**24**	**25**	**26**	**27**
Aug 28 - Sep 3	**28**	**29** Happy Birthday	**30** 9:00am 10:00am FPAC	**31** B2CC OOS 9:00am 12:00pm TMT	**Sep 1**	**2**	**3**

APPENDIX B

Biological Considerations

Appendix B – Biological Considerations

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Appendix B. Biological Considerations

B.1. BIOLOGICAL BACKGROUND

B.1.1. Overview

National Oceanic and Atmospheric Administration (NOAA) Fisheries began evaluating fish guidance efficiency (FGE) at Bonneville's second powerhouse (PH2) in 1983 after construction of the powerhouse was completed in 1982. Initial measurements of FGE with standard-length submerged traveling screens (STS) were less than 25% for yearling Chinook salmon (*Oncorhynchus tshawytscha)* and coho salmon (*O. kisutch*) and approximately 33% for steelhead (*O. mykiss).* These guidance levels were considerably lower than the expected design level of 70% or greater for all species (Krcma et al. 1984).

From 1984 to 1989, the U.S. Army Corps of Engineers (USACE) and NOAA Fisheries tested various design modifications to improve FGE at PH2. The results of this research indicated that modifications to increase flows above the STS and smooth flows into and within the turbine intake could substantially increase FGE for yearling Chinook during the spring migration (Gessel et al. 1991). Tests in 1985 showed that lowering the STS by 0.8 meters in conjunction with streamlined trashracks increased the FGE to about 40% and the gap-net catch (percent of fish escaping over the STS back into the intake) remained at less than 1%. However, lowering the STS by 1.2 meters increased the gap-net catch to 12%, which resulted in a decreased FGE of 29% (Gessel et al. 1986). From 1987 to 1989, in tests conducted with an 0.8-meter lowered STS, streamlined trashracks and turbine intake extensions (TIEs) installed in units 11, 12, and 13, the FGE ranged from 51% to 74% during 4-5 day test series. Based on these results, STSs were lowered by 0.8 meters and TIEs (in front of every other intake) and streamlined trashracks were installed across the powerhouse in 1991.

In 1993 and 1994, FGE was again measured at PH2 and FGE averaged 57% for yearling Chinook in unit 15 with all eight units in operation. With units 11, 12, 13, 16, 17, and 18 operating, FGE averaged 53% and 32% in units 12 and 17, respectively. During all of these tests, the average gap-net catch for all species combined was less than 1% (Monk et al. 1994, 1995).

Hydroacoustic FGE estimates for all juvenile salmonids in 1996, 1998, and 2000 were similar to estimates reported in the NOAA Fisheries studies described above, and FGE was lower for end units than for units nearer to the center of the powerhouse. In spring 1996, the three highest FGE estimates were 65% (unit 12), 52% (unit 15), and 40% (unit 13), and the average for all eight units was only 37% (Ploskey et al. 1998). In summer 1996, the average FGE was only 26%, and estimates ranged from 10% at unit 11 to 42% at unit 12). In 1998, hydroacoustic estimates of FGE for units 11-13 averaged about 55% in spring and 30% in summer during closed sluice-chute treatments (Ploskey et al. 2001). In 2000, the fish-passage efficiency of PH2, based upon sampling of all units, was 54% in spring and 35% in summer (Ploskey et al. 2002).

To investigate ways to improve FGE, hydraulic model studies of PH2 intakes were conducted. Flows of 270 cubic feet per second (ft^3/s) into the gatewell slot and 215 ft^3/s over the top of the STS were measured, indicating the potential for fish to be lost through the gap as substantially larger than that measured by previous FGE studies, and for possible FGE improvements by increasing flow up into the gatewell slot.

To increase flow from the turbine intake into the gatewell, three modifications were proposed: (1) increase the size of the VBS by partial removal of a concrete beam; (2) install a turning vane just below the picking beam on the STS; and (3) install a gap closure device (GCD) on the ceiling intake downstream from the top edge of the STS. To meet new design criteria for salmonid fry established by NOAA Fisheries, screen mesh openings on the new VBS were decreased to 0.08 inches with a porosity of 44%. These modifications, as well as a larger VBS, were hydraulic model tested and gatewell flows of 13.6 m^3/s (480 ft^3/s) and gap flows of 2.5 m^3/s (90 ft^3/s) were measured. Based on these promising results of hydraulic model study, in the spring of 2001 the modifications were installed in unit 15.

Both FGE and orifice passage efficiency (OPE) tests were conducted in the B intake gatewell where no TIE was present (Monk et al. in preparation). In spring, yearling Chinook FGE averaged 71% (SE = 2.5) and FGE for steelhead and coho were greater than 80%. These FGE values were the highest measured at PH2 since testing began in the early 1980s and were 15% to 33% higher than comparable values measured in unit 15 in 1994. In summer, subyearling Chinook FGE averaged 57%, which was 17% higher than earlier measurements.

The hydroacoustic estimate of FGE at intake 15B in spring 2001 (70%) was the highest of any unit sampled at PH2. In summer, hydroacoustic FGE was 52%, slightly lower than the 57% estimated by Monk and others (in preparation).

In 2001, OPE in 15B for yearling Chinook salmon in the spring and for subyearling Chinook in the summer was high, 94% and 99%, and the averaged median passage times were 1.6 and 0.8 hours, respectively. There were no significant differences between unit 15 and an unmodified unit for either OPE or passage times.

During both FGE and OPE tests, descaling and injury rates were low for all species sampled. During spring testing, average descaling ranged from 2% to 3% for all species with no significant differences between the modified and unmodified units, and no differences between the B and A gatewell (with and without the gap closure device, respectively). During summer testing, descaling rates for subyearling Chinook salmon was 2% or less in both units with no significant differences between units.

Based on these favorable results, further testing of these intake modifications in additional units and gatewells was warranted to characterize results across the entire powerhouse and gatewell slots with TIEs. Therefore, in 2002, FGE and OPE tests were conducted in unit 17 and all three turbine intake slots were monitored to test for potential slot effects. Results from spring 2002 indicate that FGE for yearling Chinook salmon averaged 47%, 67%, and 31% for the A, B, and C slots, respectively. Steelhead FGE averaged 49%, 54%, and 36%, and coho salmon averaged 51%, 71%, and 60% for the A, B, and C slots, respectively. The differences in FGE between slots were statistically different for yearling Chinook salmon (P=0.001), but not for steelhead (P=0.14) or coho salmon (P=0.096). Although the results from unit 17 are higher than those observed in previous studies with the unmodified configuration (36% in 1994), they were not as high as unit 15 in 2001 under a similar configuration. Interestingly, steelhead guidance appeared lower than expected. Fish injury and descaling rates were low throughout the spring. In contrast with previous findings, OPE in unit 17 during the spring was variable, ranging from 70% to 100% for yearling Chinook. In addition, travel time from time-of-release to time-of-detection at PH2 smolt monitoring facility over 3-day periods was evaluated, and based on preliminary estimates, the 10th, 50th, and 90th percentiles were highly variable.

Results from summer 2002 indicate that FGE for subyearling Chinook salmon averaged 47% and 57% for the A and B slots, respectively, which is similar to the 57% FGE observed in 15B in 2001. Fish injury and descaling rates were low throughout the summer. Similar to results from previous years, OPE in unit

17 during the summer was high, ranging from 98% to 100%, except on June 26 when OPE was 80%. Again, travel times to PH2 smolt monitoring facility over 3-day periods was evaluated, and the 10th, 50th, and 90th percentiles were found to also be highly variable.

The results from 2002 corroborate findings from 2001 that the CGMs tested improved the level of fish guidance into the gatewells with little, if any, effect on fish condition over the existing configuration. However, the 2002 results also indicate that FGE varies between units and intake slots at PH2 and OPE may be more variable under the new configuration. Extended (3 days) OPE tests were also conducted for the first time when units could be run over a weekend, and observed 50th and 90th percentiles that were highly variable. For example, the 90th percentile in travel time from unit 17 ranged from 60 to 1,539 minutes and 70 to 1,010 minutes during the spring and summer, respectively.

B.1.2. Data Analysis 2000-2003 (Pre-Corner Collector)

From 2000-2003, FPE and FGE for PH2 were collected with several different biological measurement tools such as radiotelemetry, hydroacoustics and fyke netting (Ploskey, PNNL; Counihan and Adams, USGS; Monk, NOAA Fisheries). This analysis uses previous baseline (pre-2000 gatewell modifications) FGE data from PH2 for yearling and subyearling Chinook and steelhead for all units and compares it with FGE data post gatewell modifications. The pre-2000 FGE numbers were 48%, 26%, and 48%, respectively (Table B1-1). Radiotelemetry, hydroacoustics and fyke netting data from 2000-2003 were looked at to quantify the net FGE gain to the fish stocks at modified units 15 and 17.

Table B1-1. Historic Baseline for FGE at Second Powerhouse

Post-2000 Improvements FGE			
Species	**Baseline FGE**	**Gap Loss**	**Corrected Baseline FGE**
Yearling Chinook & steelhead	48%	13%	35%
Subyearling Chinook	26%	13%	13%

During the analysis, USACE looked at how well fyke netting, hydroacoustics, and radio tag FGE estimates compared over the same season and over varying water years. On average, the comparisons between fyke netting (NOAA) and hydroacoustics by the Pacific Northwest National Laboratory (PNNL) were very close and the standard errors were below 3.5%. In the analysis, large discrepancies between PNNL hydroacoustic data and U.S. Geological Survey (USGS) radio tag data were very common and reduced the soundness of the data comparisons with a standard error between the two of 12.3%. For example, fyke netting and hydroacoustic FGE averages were within 5 percentage points for all species for all years. In contrast, hydroacoustics and radio tag data showed an average spread of 17% over all years and a 22% difference between fyke netting over all years. This trend led us to believe that hydroacoustics and fyke netting were much more closely matched; because of their very tight similarities, they were given more weight in the data analysis.

B.1.3. Data Analysis 2004 (Post-Corner Collector)

In 2004, USACE continued an aggressive biological research evaluation at Bonneville looking to bolster the survival and passage data sets post corner collection operation. Special emphasis was placed on research programs that would continue to measure standard survival and passage indices along with several new research components aimed at assessing biological performance of the new PH2 corner collector. Hydroacoustic, DIDSON, and radio tag programs were used in a research partnership to evaluate and assess survival and route specific species data for juvenile salmonids migrating past PH2 and the Project under two spill conditions: 50,000 ft^3/s 24-hour vs. NOAA Fisheries Biological Opinion 75,000 ft^3/s day/total dissolved gas cap/night. Special emphasis was placed on measuring the particular nuances on FPE and FGE relative to past years without the corner collector operating.

B.1.4. Radiotelemetry Data

Three radiotelemetry studies were conducted at PH2 to measure route-specific survival of yearling and subyearling Chinook salmon and steelhead. Route-specific data for both yearlings and steelhead are presented in Tables B1-2 and B1-3. Although radio tracking was not used for guidance efficiencies, it was deemed appropriate to use for survival estimates.

Table B1-2. Radio Tracking Route-specific Survival, Yearling Chinook and Steelhead

Route-specific Survival Model Probabilities, Yearling Chinook 2004				
Juvenile Bypass System (JBS)	**PH2 (unguided) Turbines**	**Corner Collector**	**Spillway**	**PH1** Turbines**
97.0% (94.3, 99.5)*	95.1% (92.9, 97.2)	101.6% (99.9, 100.3)	91.0% (88.8, 93.1)	91.3% (87.3, 94.9)
Dam Survival = 95.1% (93.6, 96.6)				

Route-specific Survival Model Probabilities, Steelhead 2004				
JBS	**PH2 (unguided) Turbines**	**Corner Collector**	**Spillway**	**PH1 Turbines**
95.1% (90.7, 98.9)	88.9% (84.8, 92.7)	103% (101, 105)	97.9% (95.6, 100.2)	96.5% (92.6, 99.9)
Dam Survival = 99.1% (97.5, 100.7)				

*(Survival Estimate) **PH1 = Bonneville first powerhouse

Table B1-3. Radio Tracking Route-specific Survival, Subyearling Chinook

Route-specific Survival Model Probabilities, Subyearling Chinook 2004 (a) 50,000 ft^3/s spill vs. (b) BiOp 75,000 ft^3/s spill				
JBS	**PH2 (unguided) Turbines**	**Corner Collector**	**Spillway**	**PH1 Turbines**
(a) = 92.9% (b) = 84.0%	(a) = 76.0% (b) = 72.4%	(a) = 95.5% (b) = 97.0%	(a) = 76.4% (b) = 85.6%	(a) = 73.4% (b) = 75.4%

The highest route survival for both yearling Chinook and steelhead was through the corner collector with a relative survival estimate of 101% and 103%, respectively. No significant differences were found between the two differing spill treatments. Route-specific survival for fish traveling through the PH2 juvenile bypass system (JBS) were also high for the same species at 97% and 95%, respectively. Subyearling Chinook showed greater variance in survival under the different routes and spill conditions.

Highest survival for both spill treatments was through the PH2 corner collector with 95.5% and 97.0% survival. The second highest survival was through the JBS system with 93% and 84% survival. This study also measured movement, distribution, and passage behavior at Bonneville in 2004. Significant findings of the study were: (1) 74% of steelhead passing the second powerhouse did so by way of the PH2 corner collector, where yearlings and subyearlings passed at a significantly lower rate of 37%; (2) FGE at PH2 was significantly higher for 2004 compared to 2002 when the PH2 corner collector was not operating; and (3) yearling/subyearling Chinook and steelhead that previously traveled exclusively through PH2 turbines and the JBS system are still traveling through these routes and are not being robbed by the PH2 corner collector at a significant rate. These data seem to point out that significant amounts of fish, particularly steelhead, prefer the surface bypass route.

B.1.5. Hydroacoustics, Distribution, and FGE Results

The 2004 PNNL research program consisted of a detailed look at FGE and vertical distribution of juvenile salmonids at PH2 along with the effects of the corner collector with the absence of TIEs from units 11-14. Initial research indicated that FGE was significantly higher in those units that have been modified and that have gap closure devices. Powerhouse distribution data showed a higher FGE in the modified units in general (units 15 and 17) compared to unmodified units across the powerhouse (Figures B1-1 and B1-2). Summer FGE estimates also show an increase in FGE for migrants during the summer months in modified units when FGE historically falls off later in the season.

Figure B1-1. PH2 Horizontal Hydroacoustic Distribution 2002

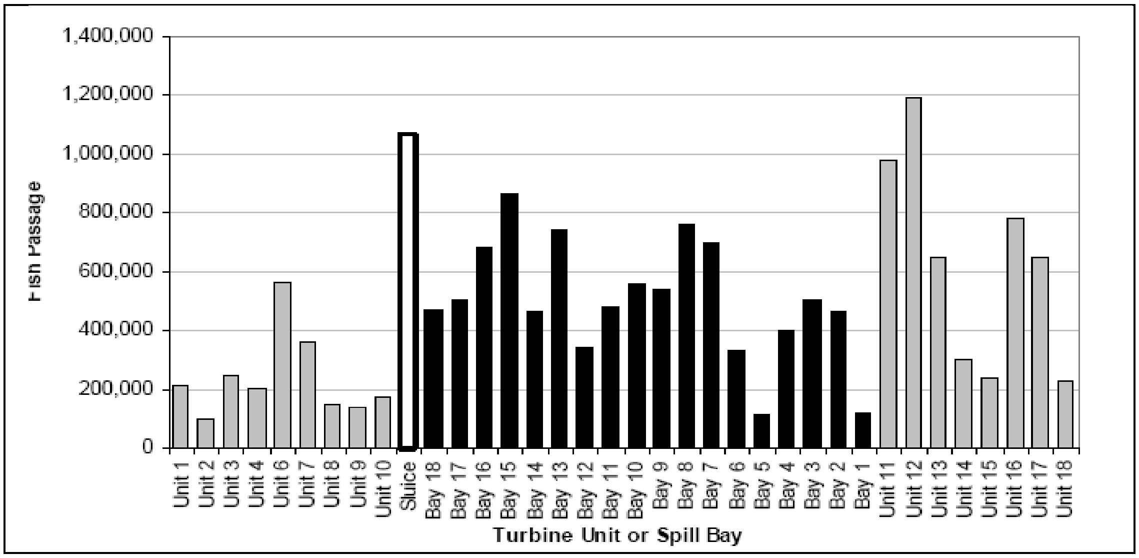
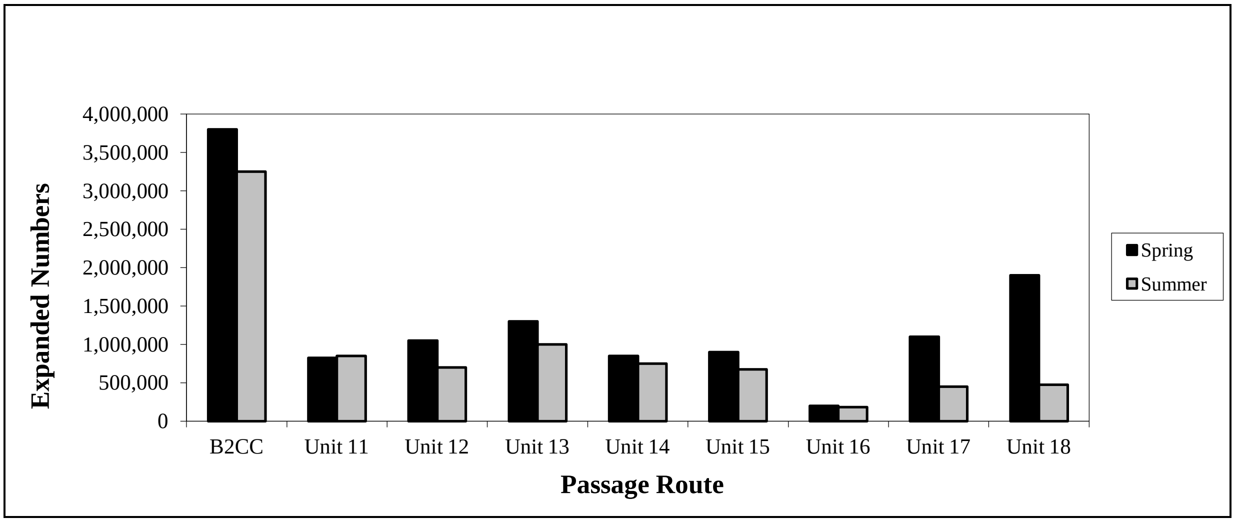
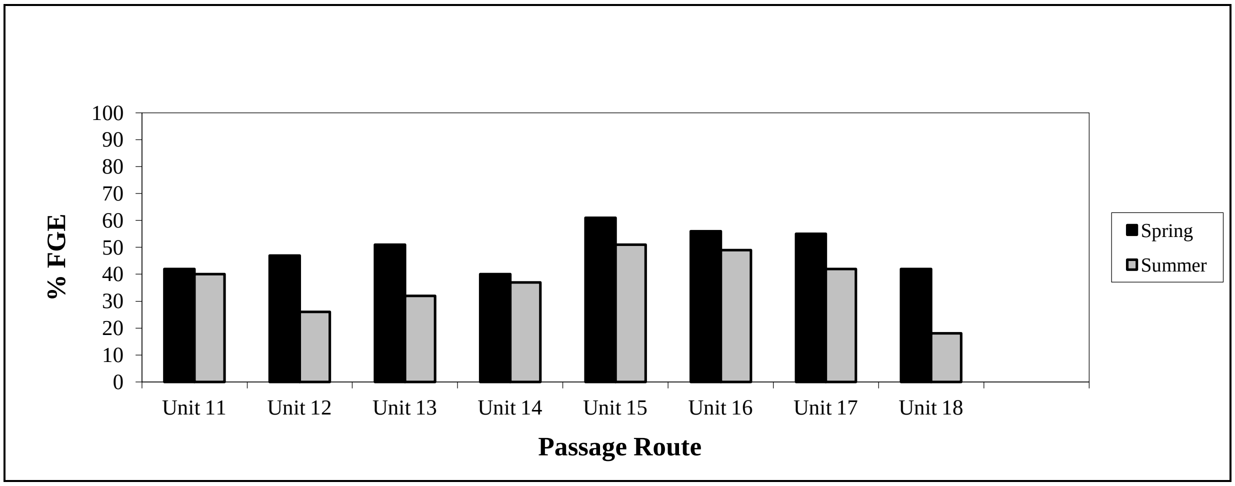


Figure B1-2. 2004 Horizontal Distribution



Horizontal distribution in 2004 was extremely skewed towards the corner collector with over two times more fish being guided into it than the highest unit in the spring (unit 18) and over three times as many during the summer as with the highest passage unit 13. Historical passage data shows that units 11 and 12 traditionally and consistently had the highest number of fish passage through the passage season. This effect was attributed to fish that were shoreline oriented, as well as the end units being operated as "last off, first on" due to powerhouse priority and adult attraction benefits in the PH2 tailrace. In contrast, units 11 through 13 in 2004 with the corner collector operating showed a major shift towards a more even distribution (Figure B1-3). The 2004 data also shows a significant propensity for passage at unit 18 in the spring, which is a major shift from the norm.

Figure B1-3. 2004 Hydroacoustics PH2 FGE



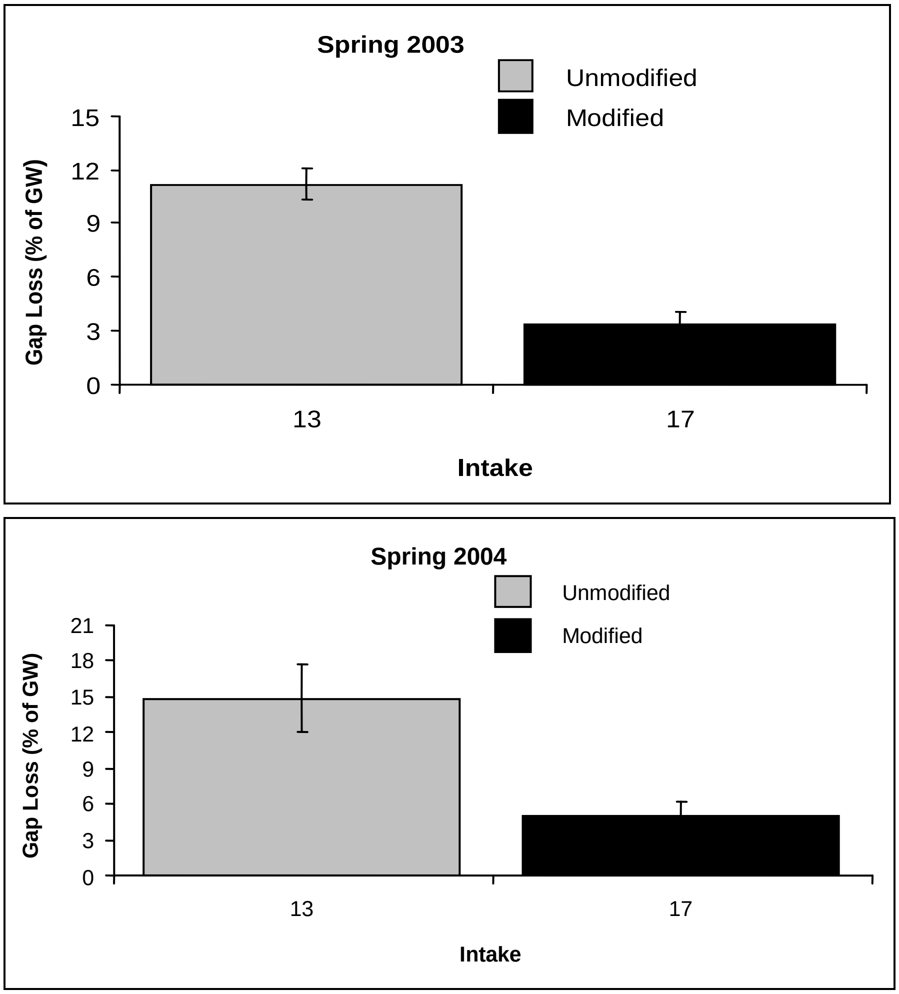
B.1.6. Gatewell Modifications and Gap Loss

During the hydraulic modeling evaluations, a high proportion of colored dye representing flow was observed exiting the gap between the top of the intake and the end of the STS. Second powerhouse FGE fyke netting conducted by NOAA (Monk 1999-2000) identified that low numbers of fish were being captured in the gap net that fished this gap. The high volume of flow identified moving through the gap and very low fish collected in the NOAA gap nets raised suspicions about the validity of the fyke netting results. In 2003, USACE imitated a study to use DIDSON technology to view the turbine ceiling gap environment and to see if we could readily identify and quantify fish passing through.

Units 15 and 17 were modified to allow more water up the gatewell slot to introduce more fish to the gatewell and JBS systems, as well as installing a gap closure structure to reduce fish loss through the gap between the STS and intake beam. In 2003, units 13, 15 and 17 were examined during both spring and summer for gap loss. After determining that the DIDSON camera was also detecting non-fish objects like waterlogged sticks and other aquatic debris during the study, the data was reexamined and filtered accordingly to remove this debris bias from the samples. Tests concluded that gap loss was found to be approximately 3-4 times as much in an unmodified unit than units with a TV and GCDs. Unit 13 showed in the spring an average gap loss of 11% compared to units 15 and 17, which showed an average of 3.5%. Summer results were consistent with spring results, showing a higher gap loss in unit 13 than units 15 and 17 with 10% and 3%, respectively.

Both units 13 and 17 we evaluated for gap loss in the spring of 2004. Gap loss shows a steady 3% during spring for the modified units where as the unmodified units consistently show higher losses ranging between 11% in 2003 and up to 15% in 2004 (Figure B1-4).

Figure B1-4. Gap Loss Data for 2003 and 2004



B.1.7. Decision Criteria and Anticipated Benefits

For the PH2 FGE improvements program, five distinct and measurable objectives were identified to assist the region in formulating a sound basis for and implementation decision (Table B1-4). From 2000-2004, USACE developed a research scope to measure PH2 FGE improvements with fyke netting, hydroacoustics, and radio tags. DIDSON technology was developed to monitor and quantify the improvements from adding a GCD to minimize the loss of juvenile salmonids. In 2004, the PH2 corner collector was operated in conjunction with the JBS system for the first time. This allowed measurement and quantification of the effects and efficiencies of the newly constructed surface bypass route.

Table B1-4. PH2 FGE Project Objectives

Improve survival?	Yes: Mar-Aug (0.1% – 0.3%) Yes: Sep-Oct (0.7%)
Improve FGE?	
Increase gatewell flow?	
Improve gatewell environment?	Yes: screens within criteria and closer to meeting fry criteria
Improve O&M of screens and gatewell?	

Biological Benefits Option 1 - No Implementation

There were no increased biological benefits due to the "no implementation" option; in fact, there are known biological losses from the previous baseline FGE assumptions due to the gap loss phenomenon. If the status quo at PH2 continues, then a loss of 13% of guided fish or higher is expected at all unmodified units, thus reducing current FGE assumptions for yearling and subyearling Chinook salmon and steelhead. It can also be deduced that that stocks of later migrating subyearling Chinook salmon will have a lower FGE. Significant benefits to both FGE and survival for fish passing during spill and post spill could only be realized if the full complement of FGE modifications are implemented across PH2.

Biological Benefits Option 2 - Full Powerhouse Implementation

With more flow up the slot due to gatewell improvements, FGE was improved (0.1% - 0.3%) for yearling and subyearling Chinook salmon and steelhead in the modified units during the regular spill season (April through August). A more significant FGE increase of 0.7% was measured for subyearlings after spill is terminated (September 1). Table B1-5 lists affected subyearling stocks that would be aided with the VBS modifications.

Table B1-5. Impacted Subyearling Fish Stocks

Species	Subyearling Fish Stocks
Summer Chinook	Upper Columbia
Fall Chinook	Upriver Bright Priest Rapids & Ringold Springs Hatcheries Hanford Reach Natural Yakima River & Marion Drain Snake River Bright Listed Wild Snake River Unlisted Lyons Ferry Hatchery Unlisted Nez Perce and Big Canyon Hatcheries Mid-Columbia Bright Deschutes River Klickitat River Umatilla River Little White Salmon River

The addition of a GCD to these modified units has reduced salmonids being lost through the gap and passing through turbines. This gap loss translates into a direct reduction of more than 13% less than modified units.

B.1.8. Other Positive Factors

In addition to the biological benefits of the turbine intake modifications, additional benefits to the hydropower project were realized. Regional salmon managers and USACE agree that the proposed improvement strategy was a positive step towards achieving operational flexibility of the Federal Columbia River Power System, specifically how Bonneville Dam could be better managed to pass migrating juvenile salmonids and improve the varying operational scenarios available during all times of the year.

More Robust Bonneville Project Operational Configuration

Bonneville second powerhouse FGE improvements did bolster the set of operational configurations that can benefit out-migrants over a wide spectrum of river conditions. Increasing flexibility to operate PH2 during both the spill and post-spill seasons while also increasing survival enhances the ability to manage known and unknown environmental and operational conditions. This flexibility is key to providing better or improved survival conditions during reduced spill or no spill events during drought years. As seen from the 2004 radio tag route-specific survival study, the spillway, which has historically shown high survival (+98%), can and will show variability in survival according to different spill operations and river conditions (91% radio tag spillway survival 2004, USGS). Robustness of routes of project passage helps offset this variability in specific route passage.

SIMPAS Project Survival

SIMPAS (New Spreadsheet Model for Fish Passage Survival Estimates) prediction model data sets for varying spill conditions (75,000-150,000 ft^3/s) were tabulated to produce new project survival estimates for fish during the spill season and post spill operations (Table B1-6).

Table B1-6. SIMPAS Project Survival Estimate for Varying Spill Conditions

Spill (ft^3/s)	Species	Baseline	Full Powerhouse (units 11-18)	Survival Increase
75,000	Yearling Chinook	97.3%	97.5%	0.2%
	Steelhead	98.1%	98.1%	0
	Subyearling Chinook	97.5%	97.8%	0.3%
120,000	Yearling Chinook	97.5%	97.7%	0.2%
	Steelhead	98.1%	98.1%	0
	Subyearling Chinook	97.6%	97.7%	0.3%
150,000	Yearling Chinook	97.7%	97.8%	0.1%
	Steelhead	98.1%	98.1%	0
	Subyearling Chinook	97.6%	97.8%	0.2%

The data set in Table B1-6 represents new SIMPAS model runs for varying spill conditions with PH2 as the priority powerhouse and the corner collector operating. Project survival increases, although small, are observed in all three runs. The greatest survival benefit was seen in the SIMPAS model runs when spill is terminated on September 1 when late traveling subyearling Chinook are the bulk of the out-migrating species. Table B1-7 shows subyearling project survival for full implementation verses no implementation and the corner collector operating. The significance of this data is that a substantial survival benefit is captured with and without the corner collector operating. A 0.7% overall project survival benefit to these late traveling subyearling Chinook is expected with full prototype implementation and the corner collector not operating. The current Fish Passage Plan (FPP) has corner collector and spill shut off by September 1. Fish studies in 2005 will determine if the corner collector can be operated without spillway flow. However, SIMPAS model runs show a 0.5% project survival increase for full VBS implementation and the corner collector operating.

Table B1-7. Corner Collector Comparison

SIMPAS Project Survival Estimate Fall Chinook Sep/Oct (0 ft^3/s, PH2 priority)					
Parameter		**Without Corner Collector**	**With Corner Collector**	**Delta**	
*Corner Collector Operation Change	Baseline	95.4%	96.7%	1.3%	
Implement Full VBS Modifications	Full Powerhouse	96.1%	97.2%	97.2%	
	Delta	0.7%	0.5%	1.8%	Operation Change + VBS Mods

Table B1-8. Comparison between Baseline and Prototype FGE

Baseline FGE				**FGE after VBS Modifications**			
Species	**Baseline FGE**	**Gap Loss**	**Corrected Baseline FGE**	**FGE**	**Gap Loss**	**Corrected FGE**	**FGE Increase**
Yearling Chinook & Steelhead	48%	13%	35%	59%	3%	56%	21%
Subyearling Chinook	26%	13%	13%	49%	3%	46%	31%

B.1.9. Literature Cited

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Ploskey et al. 2001

Ploskey et al. 2002

B.2. FISH CONDITION TEST RESULTS, BONNEVILLE SECOND POWERHOUSE, 2008-2009

B.2.1. Subyearling Chinook Salmon from Spring Creek National Fish Hatchery

The results of tests conducted with this species in 2008-2009 are shown in Tables B2-1 to B2-5 and in Figure B2-1. Statistical treatment of the data shows that mortality increases at higher operating levels within the 1% peak efficiency range. Figure B2-1 illustrates the interaction between fish size and mortality for subyearling Chinook salmon from Spring Creek National Fish Hatchery (SCNFH).

Table B2-1. Recapture rates and observed mortality of juvenile SCNFH Chinook released in the bypass system collection channel or gatewell 12A on 3-4 March 2008 at Bonneville second powerhouse. Average fork length of fin-clipped test fish was 63 millimeters (mm).

Parameter	Collection Channel	Gatewell 12A Lower 1% 11.6-11.8 kcfs	Gatewell 12A Middle 1% 13.9-14.0 kcfs	Gatewell 12A Upper 1% 16.8-16.9 kcfs
Test blocks (no.)	2	2	2	2
Test duration (h)	4	4	4	4
Fish released (no.)	1,801	799	854	799
Recaptured (%)	98.3	82.7	81.3	66.6
Mortality (%)	0.3	1.9	14.2	32.3

T-test results for comparisons of recapture and mortality percentages: P<0.01 for all comparisons except for recapture of lower and middle 1% gatewell releases where P=0.44.
kcfs = thousand cubic feet per second

Table B2-2. Recapture rates and observed mortality of juvenile SCNFH Chinook salmon released from 18-21 March 2008 into the bypass system collection channel or 14A turbine intake at Bonneville second powerhouse. Average fork length in PIT-tagged test groups ranged from 68-69 mm.

Parameter	Collection Channel	Intake 14A Lower 1% 11.6-11.9 kcfs	Intake 14A Upper 1% 16.1-16.6 kcfs	P[a]
Test blocks (no.)	4	4	4	
Test duration (h)	4	4	4	
Fish released (no.)	592	787	1,010	
Recaptured (%)[b]	98.6	65.1	38.1	0.03
Mortality (%)	0.5	1.8	6.9	0.08

[a] ANOVA. P values are for load comparisons.
[b] Recapture percentages for intake releases were reduced by fish loss between barrier screen sections.
kcfs = thousand cubic feet per second

Table B2-3. Recapture rates, observed mortality, and timing of juvenile SCNFH Chinook salmon released from 26 March to 18 April 2008 into the bypass system collection channel or 14A turbine intake at Bonneville second powerhouse. Average fork length in PIT-tagged test groups ranged from 69-79 mm.

Parameter	Collection Channel	Intake 14A Lower 1% 12.1-12.8 kcfs	Intake 14A Upper 1% 17.1-18.6 kcfs	P[a]
Test blocks (no.)	3	3	3	
Test duration (h)	48	48	48	
Fish released (no.)	2,681	2,607	2,616	
Recaptured (%)[b]	98.8	94.6	65.9	<0.01
Mortality (%)	0.0	1.3	12.7	<0.01
Timing (median, h)	0.7	6.9	0.8	<0.01

[a] ANOVA. P values are for load comparisons.
[b] Recapture percentages for intake releases were reduced by fish loss between barrier screen sections.
kcfs = thousand cubic feet per second

Table B2-4. Recapture rates, observed mortality, and timing of juvenile SCNFH Chinook salmon released from 23 April to 9 May 2008 into the bypass system collection channel or 14A turbine intake at Bonneville second powerhouse. Average fork length in PIT-tagged test groups ranged from 81-86 mm.

Parameter	Collection Channel	Intake 14A Middle 1% 14.9-15.7 kcfs	Intake 14A Upper 1% 17.9-18.7 kcfs	P[a]
Test blocks (no.)	3	3	3	
Test duration (h)	48	48	48	
Fish released (no.)	899	2,433	2,394	
Recaptured (%)	98.4	96.4	78.9	<0.01
Mortality (%)	0.2	2.8	17.8	<0.01
Timing (median, h)	0.7	1.4	0.8	0.15

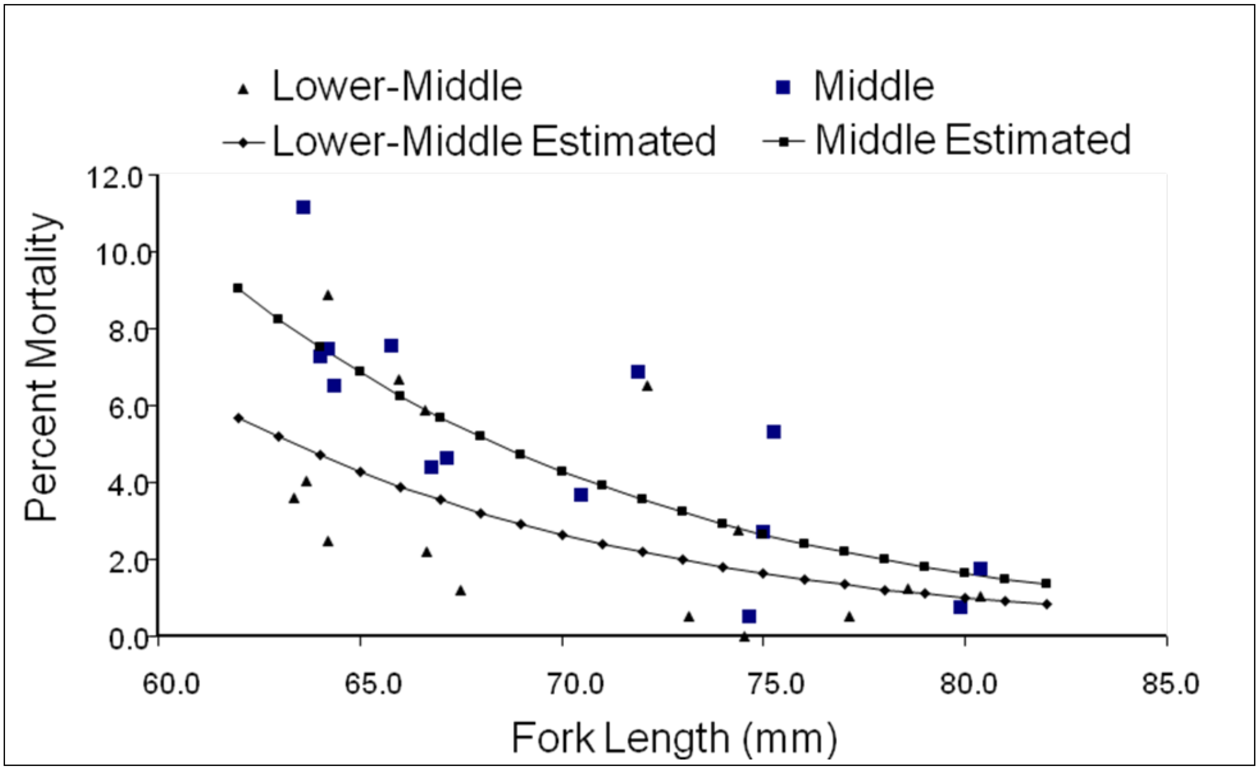
[a] ANOVA. P values are for load comparisons.
kcfs = thousand cubic feet per second

Table B2-5. Recapture rates, observed mortality, and passage timing data for subyearling Chinook salmon obtained from SCNFH, PIT-tagged, and released into the Bonneville second powerhouse bypass system collection channel or 14A turbine intake in 2009.

Parameter	Collection Channel	Intake 14A Lower-middle 1% 14.9-15.7 kcfs	Intake 14A Middle 1% 17.9-18.7 kcfs	P[a]
Test blocks (no.)	14	14	14	
Test duration (h)	24	24	24	
Fish released (no.)	1,393	5,829	5,855	
Recaptured (%)	97.4	93.2	92.1	0.20
Mortality (%)	0.5	3.3	5.4	<0.01
Timing (median, h)	0.6	3.3	2.1	0.08

[a] ANOVA. P values are for load comparisons.
kcfs = thousand cubic feet per second

Figure B2-5. Results of logistic regression modeling using data obtained from release and recapture of juvenile Chinook salmon obtained from SCNFH in 2009. Estimation lines show how mortality rates decrease as fish size increases during lower-middle and middle 1% operation.



B.2.2. Run-of-River Yearling Chinook Salmon

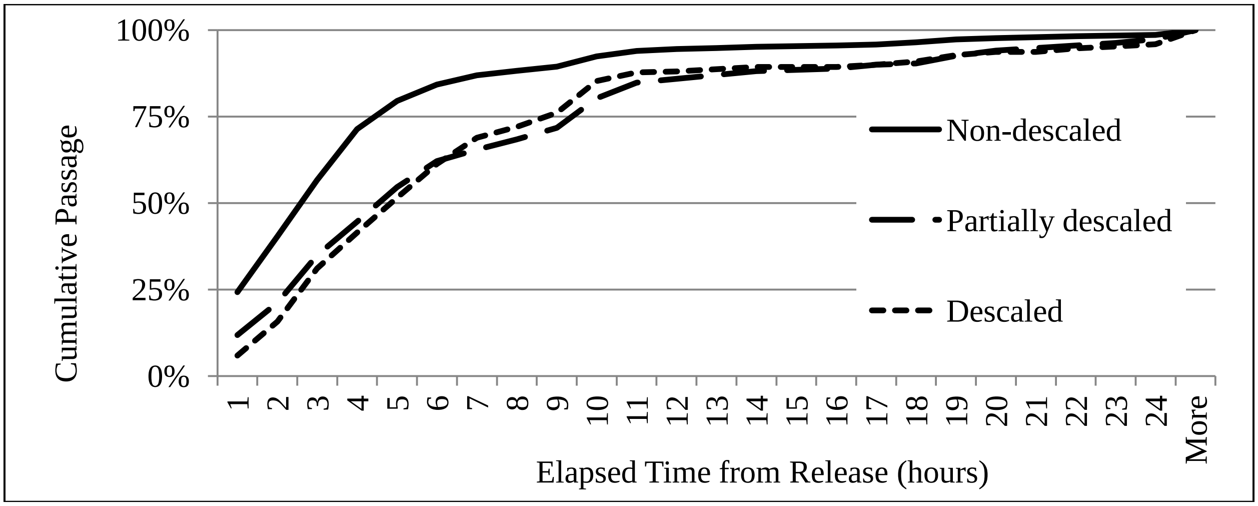
In 2008, yearling Chinook salmon tests were not completed due to high debris loading of the second powerhouse vertical barrier screens, which led to the regional decision to pull the submersible traveling screens in May. Results of tests conducted by NOAA Fisheries in 2009 are shown in Table B2-6 and in Figure B2-2. Statistical treatment of the data shows that mortality, descaling, and passage timing increase as turbine operation increases from 14.7 to 17.8 thousand cubic feet per second (kcfs) within the 1% peak efficiency range. Figure B2-2 shows how passage timing differed among non-descaled, partially descaled, and descaled fish.

Table B2-6. Recapture rates, observed mortality, passage timing, and descaling data for yearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT-tagged and released into the Bonneville second powerhouse turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish that were descaled ≥20% on at least one side.

Parameter	Collection Channel	Intake 14A Middle 1% 14.7 kcfs	Intake 14A Upper 1% 17.8 kcfs	P[a]
Test blocks (no.)	8	8	8	
Test duration (h)	24	24	24	
Fish released (no.)	389	3,229	3,153	
Recaptured (%)	97.7	98.4	97.4	0.05
Mortality (%)	0.3	0.5	4.4	<0.01
Timing (median, h)	0.6	1.7	2.7	<0.01
Descaling (%)	0.3	1.0	11.5	<0.01

[a] ANOVA. P values are for load comparisons.
kcfs = thousand cubic feet per second

Figure B2-6. Passage timing by descaling classification for yearling Chinook salmon at Bonneville second powerhouse in 2009. Time computed from turbine intake release to first detection at the Juvenile Fish Monitoring Facility.



Run-of-River Subyearling Chinook Salmon

Limited test releases of subyearling run-of-river Chinook salmon were completed in 2008 Results are shown in Table B2-7. Although mortality, descaling, and passage timing increased as turbine operation increased within the 1% peak efficiency range, differences were not statistically significant.

Table B2-7. Recapture rates, observed mortality, passage timing, and descaling data for subyearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT-tagged and released into the Bonneville second powerhouse turbine 14A intake in 2008. Descaling is expressed as the percentage of recaptured fish that were descaled ≥20% on at least one side.

Parameter	Collection Channel	Intake 14A Middle 1% 14.1-15.1 kcfs	Intake 14A Upper 1% 16.6-18.1 kcfs	P[a]
Test blocks (no.)	3	3	3	
Test duration (h)	24	24	24	
Fish released (no.)	560	743	820	
Recaptured (%)	97.4	94.6	94.9	0.86
Mortality (%)	0.4	0.6	2.6	0.29
Timing (median, h)	0.6	2.7	4.0	0.24
Descaling (%)	0.7	0.4	3.3	0.18

[a] ANOVA. P values are for load comparisons.
kcfs = thousand cubic feet per second

In 2009, mortality, descaling, and passage timing increased as turbine operation increased within the 1% peak efficiency range and differences were statistically significant. Data from the initial tests of middle and upper 1% loading with one open gatewell orifice are shown in Table B2-8.

Standard one-orifice operation with two-orifice operation at upper 1% loading also were compared to determine if faster egress from the gatewells and reduced negative passage effects could be achieved with the two-orifice operation. Results of this comparison were promising, as shown in Table B2-9.

Table B2-8. Recapture rates, observed mortality, passage timing, and descaling data for subyearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT-tagged, and released into the Bonneville second powerhouse turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish descaled ≥20% on at least one side. Tests conducted with one open gatewell orifice.

Parameter	Collection Channel	Intake 14A Middle 1% 14.7 kcfs	Intake 14A Upper 1% 17.8 kcfs	P[a]
Test blocks (no.)	8	8	5	
Test duration (h)	24	24	24	
Fish released (no.)	400	3,167	2,058	
Recaptured (%)	96.7	97.2	96.5	0.13
Mortality (%)	0.3	2.6	4.5	0.01
Timing (median, h)	0.6	2.6	6.1	0.03
Descaling (%)	0.3	0.5	2.6	<0.01

[a] ANOVA. P values are for load comparisons, one open gatewell orifice.
kcfs = thousand cubic feet per second

Table B2-9. Recapture rates, observed mortality, passage timing, and descaling data for subyearling Chinook salmon obtained from the Bonneville Smolt Monitoring Program, PIT tagged, and released into the Bonneville second powerhouse turbine 14A intake in 2009. Descaling is expressed as the percentage of recaptured fish descaled ≥20% on at least one side. Tests conducted with one or two open gatewell orifices.

Parameter	Collection Channel	Intake 14A Upper 1% One orifice	Intake 14A Upper 1% Two orifices	P[a]
Test blocks (no.)	8	5	4	
Test duration (h)	24	24	24	
Fish released (no.)	400	2,058	1,641	
Recaptured (%)	96.7	96.5	95.9	0.08
Mortality (%)	0.3	4.5	2.4	0.04
Timing (median, h)	0.6	6.1	2.9	0.06
Descaling (%)	0.3	2.6	1.2	0.10

[a] ANOVA. P values are for comparisons of one with two open gatewell orifices.
kcfs = thousand cubic feet per second

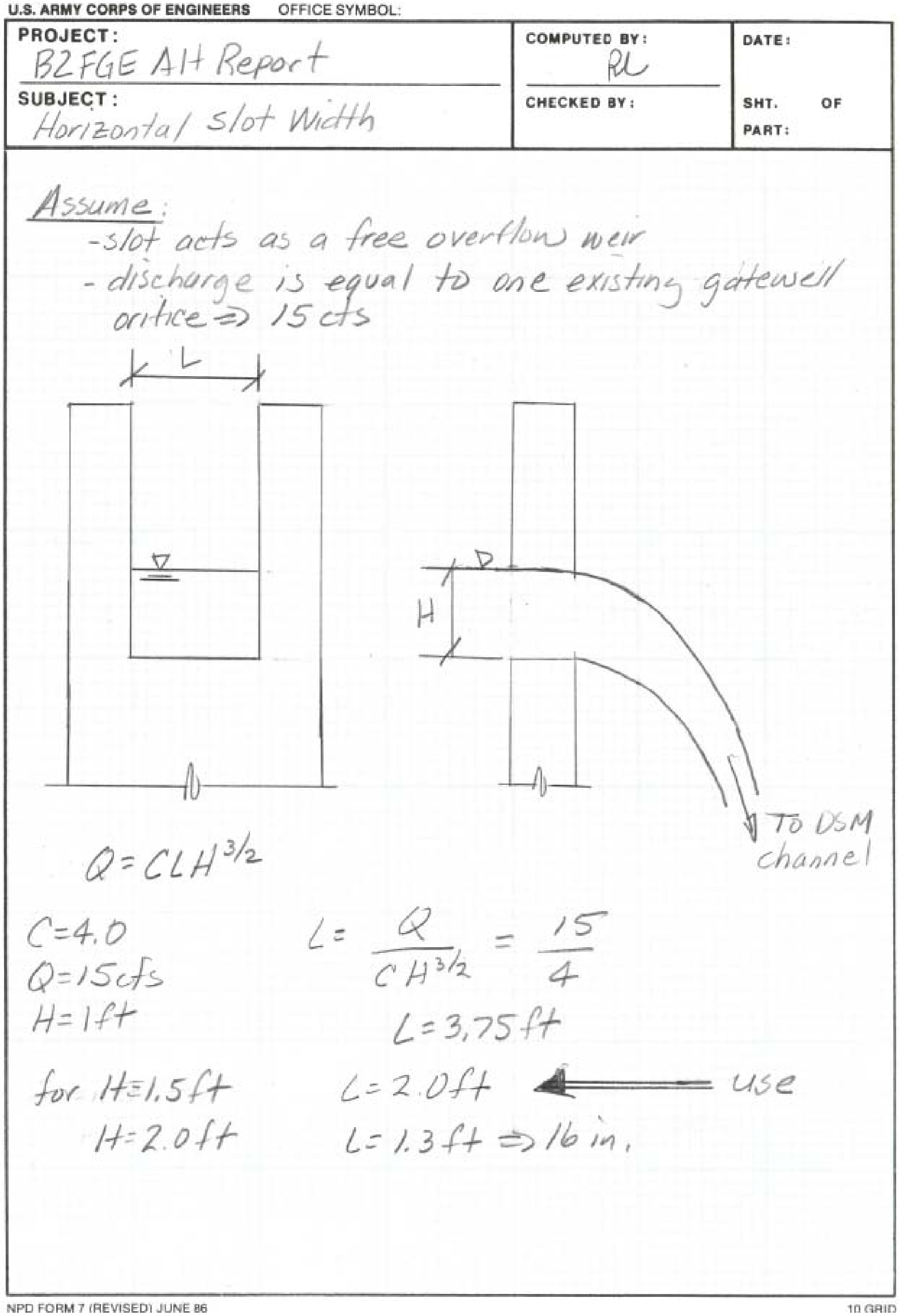
B.3. WATER VELOCITY MEASUREMENTS ON A VERTICAL BARRIER SCREEN AT BONNEVILLE SECOND POWERHOUSE, SEPTEMBER 2011

This final report was prepared by the Pacific Northwest National Laboratory in Richland, Washington, for the U.S. Army Corps of Engineers, Portland District, under an Interagency Agreement with the U.S. Department of Energy. The study was designed to sample water velocities inside the gatewell at the Bonneville second powerhouse at turbine units 12A and 14A to determine whether adverse conditions for migrating juvenile salmonids are present. High approach velocities or hot spots were found to be characteristic for turbine units 12A and 14A at all levels of discharge. Based on the measurement results, researchers considered the flow conditions in turbine units 12A and 14A of the second powerhouse to not be within NOAA Fisheries fish screen criteria.

APPENDIX C

Hydraulic Considerations

Horizontal Slot Width Computation



U.S. ARMY CORPS OF ENGINEERS OFFICE SYMBOL:

PROJECT: B2FGE AIt Report	COMPUTED BY: RL	DATE:
SUBJECT: Horizontal slot Width	CHECKED BY:	SHT. OF PART:

Assume:

- slot acts as a free overflow weir
- discharge is equal to one existing gatewell orifice ⇒ 15 cfs

$$Q = CLH^{3/2}$$

$C = 4.0$

$Q = 15 cfs$

$H = 1 ft$

$$L = \frac{Q}{CH^{3/2}} = \frac{15}{4}$$

$L = 3.75 ft$

for $H = 1.5 ft$ $L = 2.0 ft$ ⟵ use

$H = 2.0 ft$ $L = 1.3 ft$ ⇒ 16 in.

NPD FORM 7 (REVISED) JUNE 86 10 GRID

US Army Corps
of Engineers ®
Portland District

Draft Report

Bonneville Second Powerhouse Fish Guidance Efficiency Computational Fluid Dynamics Modeling

Bonneville Dam

September 2011

Draft CFD Modeling Report

Bonneville Second Powerhouse Fish Guidance Efficiency Computational Fluid Dynamics Modeling

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ABBREVIATIONS AND ACRONYMS

B1	Bonneville First Powerhouse
B2	Bonneville Second Powerhouse
B2CC	Bonneville Second Powerhouse Corner Collector
BGS	Behavioral Guidance Structure
CFD	Computational Fluid Dynamics
cfs	cubic feet per second
FGE	Fish Guidance Efficiency
ft/s	feet per second
JBS	Juvenile Bypass System
MIPR	Military Interdepartmental Purchase Requisition
PDT	Project Delivery Team
PNNL	Pacific Northwest National Laboratory
STS	Submerged Traveling Screen
TIE	Turbine Intake Extension
VBS	Vertical Barrier Screen

1. INTRODUCTION

1.1. BACKGROUND

In 1999, the region agreed to pursue a phased approach and focus on improving guidance and survival by maximizing the flow up the turbine intake gatewells (a guideline that has been used on similar programs to improve FGE). As a result, prototypes were designed and installed from 2001 to 2004 at units 15 and 17. These modifications included an increase in vertical barrier screen (VBS) flow area, installation of turning vanes to increase flow up the gatewell, addition of a gap closure device to eliminate fish loss at the submerged traveling screen, and installation of interchangeable VBS to allow for screen removal and cleaning without outages or intrusive gatewell dipping. Physical hydraulic modeling was conducted to design the turning vanes, VBS, and gap closure devices.

Prior to implementation of improvements across the powerhouse, gatewell testing was conducted on prototypes to make sure that improvements were beneficial to fish. Results from the biological studies showed an increase in FGE by 21% for yearling Chinook and 31% for subyearling Chinook. Test fish conditions showed no problem with descaling and gatewell retention time including fry in a newly modified unit. Based on these results the changes were implemented across the entire powerhouse. The changes cost approximately $20 million and were completed in 2008.

During the 2008 juvenile fish passage season, Spring Creek National Fish Hatchery (SCNFH) released hatchery sub-yearlings in early spring 2008, over a period of 3 months (March, April, May). Recent biological testing conducted by NOAA (Spring 2008) suggests that SCNFH subyearling are incurring high mortality and descaling when the newly modified units are being operated at the upper 1% range. Evidence suggests a relationship may exist between the operation of the powerhouse units (lower, mid and upper one percent) and survival of the SCNFH sub-yearlings. Poor hydraulic conditions within the gatewell may be the culprit.

The B2FGE was designed based on a "clean" B2 forebay, with no B2 Corner Collector (B2CC) or Behavioral Guidance Structure (BGS) in place. The design used a 1:12 scale physical sectional model of a single intake of one turbine unit. Flow to the upstream end of the physical model was straight in with no lateral flow. Improvements to FGE are in order and in order to develop alternatives on a holistic level, a CFD model of an individual unit and full powerhouse is being used to evaluate and design alternatives.

1.2. OBJECTIVES

Hydraulic Design has carried out a modeling study to meet the following objectives:

1. Understand the relative impact the Bonneville 2nd Powerhouse Corner Collector (B2CC), Behavioral Guidance Structure (BGS), Turbine Intake Extensions (TIEs), and unit loadings have on gatewell hydraulic conditions and flows.
2. Identify an appropriate hydraulic model of adequate detail to characterize baseline hydraulic conditions in the Bonneville 2nd Powerhouse (B2) gatewell with existing FGE improvements in place and support development of additional improvements.
3. Apply the selected model to characterize baseline hydraulic conditions in the B2 gatewell including velocities, turbulence, flow patterns, and flows for a range of turbine operating conditions.
4. Apply the selected model to support FGE Improvement Alternatives Study alternatives analysis.
5. Confirm the performance of select FGE improvement alternatives under a range of forebay configurations and unit loadings with an appropriate forebay model.

2. EXISTING FOREBAY CFD MODELING

2.1. EXISTING FOREBAY CFD MODEL

The first modeling objective to understand the relative impact of forebay configuration and unit loadings on gatewell hydraulic conditions and flows was met using an existing B2 forebay Computational Fluid Dynamics (CFD) model developed by Pacific Northwest National Laboratory (PNNL 2009). The model was developed using the Star CD software and includes the model domain shown in Figure 1.

The model is a truncated version of a full forebay model, with a bay-by-bay spillway, truncated Bonneville 1st Powerhouse (B1) forebay, Bonneville 2nd Powerhouse (B2) turbine intakes, and forebay bathymetry extending approximately 1.5 km upstream from the tip of Cascade Island (PNNL, 2009). In addition, detail was added to include the Behavioral Guidance Structure (BGS) as part of the model grid.

The B2 turbine intakes in this model included a representation of the trash racks, Submerged Traveling Screens (STSs), Vertical Barrier Screens (VBSs), and Turbine Intake Extensions (TIEs). The B2 forebay model as described will be referred to as the Existing Forebay CFD Model in this report. It is important to note that the Existing Forebay CFD Model represents conditions in the intakes as of 2000, and does not include recent FGE improvements to the B2 gatewell configuration, such as beam modification, turning vane, gap closure device, and increased VBS area. The Existing Forebay CFD Model was selected for this analysis as an available and appropriate tool for a preliminary investigation into the relative unit-by-unit impacts of forebay configuration on gatewell hydraulic conditions. However, because it does not contain the current intake geometry, the Existing Forebay CFD Model is not adequate for prediction of actual gatewell flow amounts for the existing gatewell configuration.

2.2. EXISTING FOREBAY CFD MODEL RUNS

The Existing Forebay CFD Model was used to define the relative gatewell flows for various forebay configurations (B2CC in/out, BGS in/out, TIEs in/out) and B2 flows. A total of 24 runs were conducted with the Existing Forebay CFD Model for the forebay configurations and flows summarized in Table 2-1. The naming convention used for the model runs in Table 2-1 consists of 4 characters defined as follows:

- First character indicates flow condition: High (H), Medium (M), or Low (L);
- Second character indicates whether the B2CC is in operation in the run: Yes (Y) or No (N);
- Third character indicates whether the BGS is in place: Yes (Y) or No (N); and
- Fourth character indicates whether the TIEs are in place: Yes (Y) or No (N).

Cells representing the BGS were changed from fluid cells and shells to solid cells and baffles in model runs where the BGS was considered in place. TIEs were modeled by converting a layer of fluid cells just inside the shell cells representing the TIEs into solid cells. For forebay configurations where the TIEs were in place, the TIEs were modeled only in units 15A, 15C, 16B, 17A, 17C, and 18B, not across the entire powerhouse. No re-meshing of the model was required for these runs, but it is important to note that they provide a relative comparison of the influence of forebay configuration and river flow on gatewell flows, not actual gatewell flow ratings, as the current gatewell VBS configuration was not in the existing model.

After the models were set up, the model setup and boundary conditions were quality control checked, and the models were run. The 15 runs were completed in July 2010; each model run required approximately 18 hours of processor run-time.

2.3. EXISTING FOREBAY CFD MODEL RESULTS

The CFD model results were post-processed in Star-CD for mass-flux at the gatewells in the center (B) bay of Units 11, 14, and 18 as representative of priority units and the expected extremes of forebay flow influence. These mass-flux values were then converted to cfs and combined into a scatter plot for comparison (Figure 2). From this plot it was noted that the presence of the TIEs in the model was highly correlated with changes in gatewell flows in units 11b and 18b.

Five velocity contour plots were created in Tecplot for each model run (Figures 3 through 42):

- Plan view surface velocity magnitude contours for the entire model domain;
- Plan view surface velocity contours and vectors in the B2 forebay, extending from the BGS to the powerhouse;
- Three vertical sections through the powerhouse showing velocity magnitude contours at the powerhouse intakes. See the bottom of Table 1 for the location of the cross section slices used in Slices 1, 2, and 3, with Slice 1 taken through the intakes downstream of the gatewell, Slice 2 through the intakes upstream of the gatewell, and Slice 3 upstream of the powerhouse.

The “XXXX_zoom.lay” plots for all 24 model runs were compared visually (Figures 42 and 44). It was noted that a given forebay configuration affected all three flow conditions (High, Medium, and Low) in a similar manner (the velocity magnitudes at the water surface were less for lower flow conditions, but the general shape of the velocity contours were very similar). There was generally an increase in the surface velocity at the south end of the powerhouse when the TIES were in place versus when they were not in place. Velocity vectors indicate that when the BGS is in place water near the surface flows parallel to the BGS – surface and subsurface flow direction are not the same.

Results were compared to understand the relative impact the B2CC, BGS, and TIEs have on gatewell hydraulics and flows and to select conditions requiring further CFD model investigation with the current VBS configuration.

It was originally assumed that there would be a total of 28 model runs: the 24 runs discussed above, and an additional four runs with partial loads for units 11, 12, 17, and 18. After completing the first 24 runs it was determined that the partial-load model runs would be conducted with the updated model at a later date.

Table 2-1: Run Summary - forebay configurations, boundary conditions, gatewell flows, and arbitrary slice coordinates for 24 CFD model runs.

Summary		HNN(N)	HYN(N)	HNYN	HNNY	HYY(N)	HYNY	HYYY	HNYY(2)	MNN(N)	MYN(N)	MNYN	MNNY	MYY(N)	MYNY	MYYY	MNYY	LNN(N)	LYN(N)	LNYN	LNNY	LYY(N)	LYNY	LYYY	LNYY
	5/21 @9 PM	5/22 @ 3 PM	5/23@ 8 AM	7/2 @ 2 AM	7/7 @ 9 AM	5/23 @ midnight	7/8 @ 1 AM	7/8 @ 7 PM	7/9 @ noon	5/24 @ 6 PM	5/25 @ 11 AM	7/10 @ 6 AM	7/10 @ 10 PM	5/26 @ 4 AM	7/11 @ 3 PM	7/12 @ 8 AM	7/13 @ 2 AM	5/26 @ 9 PM	5/27 @ 2 PM	7/13 @ 8 PM	7/14 @ noon	5/28 @ 7 AM	7/15 @ 4 AM	7/15 @ 10 PM	7/16 @ 2 PM
		18 hours	17 hours	17 hours	17 hours	16 hours	16 hours	18 hours	17 hours	18 hours	17 hours	17 hours	16 hours	17 hours	17 hours	17 hours	17 hours	17 hours	17 hours	19 hours	16 hours	17 hours	16 hours	18 hours	17 hours
B2CC	no/yes	no	yes	no	no	yes	yes	yes	no	no	yes	no	no	yes	yes	yes	no	no	yes	no	no	yes	yes	yes	no
BGS	no/yes	no	no	yes	no	yes	no	yes	yes	no	no	yes	no	yes	no	yes	yes	no	no	yes	no	yes	no	yes	yes
TIES	no/yes	no	no	no	yes	no	yes	yes	yes	no	no	no	yes	no	yes	yes	yes	no	no	no	yes	no	yes	yes	yes
B2CC	cfs	0	5000	0	0	5000	5000	5000	0	0	5000	0	0	5000	5000	5000	0	0	5000	0	0	5000	5000	5000	0
T11	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T12	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T13	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T14	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T15	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T16	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T17	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
T18	cfs	17600	17600	17600	17600	17600	17600	17600	17600	15300	15300	15300	15300	15300	15300	15300	15300	13000	13000	13000	13000	13000	13000	13000	13000
F1	cfs	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
F2	cfs	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
Total B2	cfs	146200	151200	146200	146200	151200	151200	151200	146200	127800	132800	127800	127800	132800	132800	132800	127800	109400	114400	109400	109400	114400	114400	114400	109400
B1	cfs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spill	cfs	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Total River	cfs	246200	251200	246200	246200	251200	251200	251200	246200	227800	232800	227800	227800	232800	232800	232800	227800	209400	214400	209400	209400	214400	214400	214400	209400
Run Inputs QC'd		GSH	GSH	EWR	EWR	EWR/GSH	EWR	EWR	EWR	GSH	GSH	EWR	EWR	GSH	EWR	EWR	EWR	GSH	GSH	EWR	EWR	GSH	EWR	EWR	EWR
Date		6/24/2010	6/24/2010	7/26/2010	7/26/2010	6/23/2010	7/26/2010	7/26/2010	7/26/2010	6/24/2010	6/23/2010	7/26/2010	7/26/2010	6/24/2010	7/26/2010	8/3/2010	8/3/2010	6/24/2010	6/24/2010	8/3/2010	8/3/2010	6/24/2010	8/3/2010	8/3/2010	8/3/2010
11b	100	2180	2061	1904	1860	2039	1822	1848	1880	1857	1715	1548	1506	1648	1467	1503	1528	1621	1410	1184	1175	1283	1134	1168	1182
	cfs	77	73	67	66	72	64	65	66	66	61	55	53	58	52	53	54	57	50	42	42	45	40	41	42
14b	101	2202	2159	2082	2065	2200	2037	2134	2160	1762	1716	1761	1739	1799	1705	1791	1820	1348	1307	1424	1427	1406	1378	1447	1471
	cfs	78	76	74	73	78	72	75	76	62	61	62	61	64	60	63	64	48	46	50	50	50	49	51	52
18b	102	2133	2108	2018	1912	2042	1904	1894	1904	1756	1734	1638	1537	1648	1529	1532	1542	1373	1358	1272	1181	1270	1174	1189	1196
x	cfs	75	74	71	68	72	67	67	67	62	61	58	54	58	54	54	55	48	48	45	42	45	42	42	42
	x1	y1	z1	x2	y2	z2	x3	y3	z3																
Slice 1	753.414	1649.94	9.96135	902.682	1809.2	9.98845	902.682	1809.2	22																
Slice 2	755.462	1647.23	22.7076	905.391	1807.29	22.7076	905.391	1807.29	9																
Slice 3	756.926	1645.85	22.7076	910.613	1809.92	22.7076	910.613	1809.92	9																

3. SECTIONAL CFD MODELING

An updated Sectional CFD Model of the existing features of the B2 Powerhouse was developed to investigate the existing hydraulic conditions and support alternative development for FGE improvement (objectives 2 through 4 in Section 1.2). The model was developed as a sectional model of a single powerhouse unit to investigate the hydraulic conditions with existing geometry of recent fish guidance efficiency improvements included. The following sections describe the model selection, development, and application of the Sectional CFD Model to existing conditions.

3.1. HYDRAULIC MODEL SELECTION

As described in Section 2, the Existing Forebay CFD Model was applied to investigate the relative impacts of forebay configuration on hydraulic conditions approaching and in the intake gatewells. However, the Existing Forebay CFD Model does not include the current details of improvements to the gatewell geometry and an updated model was needed to characterize existing hydraulic conditions in the gatewells and support alternatives analysis for the FGE Alternatives Study.

During earlier phases of the Alternatives Study, the thought was to build a physical sectional model to investigate FGE improvement alternatives. After reviewing the physical and numerical models developed to date it was determined that the gatewell hydraulics could be impacted by the physical configuration of the Bonneville Second Powerhouse Forebay. Therefore, using a CFD model to analyze FGE alternatives would allow for investigation of alternatives in a Sectional CFD Model with secondary confirmation of selected alternatives over a range of forebay configurations and operations in the full Forebay CFD Model. A summary of the advantages and limitations of the selected CFD model are summarized below:

Advantages:

- The Sectional CFD Model can be linked to the forebay model to investigate the impacts of forebay configuration and powerhouse operations on gatewell hydraulics. This capability will be important in confirming the performance of FGE improvement alternatives over a range of forebay configurations and powerhouse operations.
- Relevant geometric features in the powerhouse unit that affect gatewell hydraulics can be readily included in the Sectional CFD Model. These features are described in Section 3.2.
- Model results can be queried at any location in the model domain for velocity, pressure, turbulence. Particles seeded into the model results can provide quantifiable information on gatewell residence time and flow patterns.
- Alternatives (operational or functional changes) can be included in the Sectional CFD Model relatively efficiently.
- CFD models can be maintained on a computer system in backup files. If the model is compatible with future software versions, it can be used for many years with little maintenance.

Limitations:

- Significant changes to VBS velocities that require rebalancing of VBS screen porosities will result in the need for a physical model. The CFD model cannot be used to directly identify updated porosity plate configurations for screen balancing as configured. The CFD model represents the VBS as a porous baffle and uses two porosity parameters to represent the pressure change across the screen panels rather than direct porosity.

- The Sectional CFD Model calibration is adequate to investigate the relative change in gatewell flow between existing conditions and FGE alternatives. If the Sectional CFD Model is to be used to develop detailed gatewell flow rating curves, additional prototype velocity data is recommended to minimize uncertainty in the rating curves.
- The Sectional CFD Model is a steady-state representation of hydraulic conditions and the influence of transient conditions needs to be considered when interpreting the results.
- Real time viewing of results in a CFD model is limited to available computing resources.

3.2. SECTIONAL CFD MODEL DEVELOPMENT

An updated Sectional CFD Model of the B2 powerhouse unit was developed to support alternative development and analysis for FGE improvement. The Sectional CFD Model was developed of a single B2 turbine unit to include the following geometric features in sufficient detail to capture the hydraulic influence of the features:

- TIEs;
- Trash rack, including main horizontal and vertical support members;
- STS, including structural members and a with a zero-thickness porous baffle representing the STS screen for each bay;
- Gap closure device;
- Turning vane;
- Gate slots, including overall width and depth of gate slots;
- Modified gatewell beam;
- VBS, including structural members and zero-thickness porous baffles representing the nine VBS screen panels in each bay;
- Fish Orifice; and
- Emergency Gate, including horizontal structural members on upstream face of gate.

The Sectional CFD Model was developed by creating a solid geometry of the turbine unit to define the domain for the CFD model. The solid geometry consisted of a three-dimensional (3D) computer aided design (CAD) representation of the structures through which flow passes, Figures 45 and 46.

The CFD model mesh generator requires a “watertight” solid geometry model with defined boundaries (inlets/outlets, walls, baffles) inside which to constrain the computational grid elements. The B2 Sectional CFD Model geometry model was created by PNNL from construction drawings using SolidWorks™ (CAD) software. USACE engineers provided clarification of certain details and review of the final product prior to grid generation.

The geometry model includes a single turbine intake unit, 94 ft wide from mid-pier to mid-pier, extending from 26 ft-11 in upstream of the trashracks downstream to 1 ft-3 in upstream of the intake pier tails. The fluid surface is set at elevation 72 ft. The major structural components are the intake concrete, consisting of the floor, roof, slots, and piers, TIEs, trashracks, STSs, VBSs, and emergency gates (Figure 45). The ultimate CFD grid resolution determined the level of detail in the geometry model, so this geometry model excludes most features that are less than about 4 in. Complex geometries that significantly influence flow, as are found in the various screens and porous backing plates, are not explicitly modeled, but treated in the CFD model as zero-thickness baffles with appropriate porosity parameters applied.

Paper construction drawings were the primary references for creation of the solid model in SolidWorks™. Scanned images of the hard copy drawings were used as “underlays” in the CAD for verification and, in some cases, to estimate dimensions not explicitly shown on the drawings. Table 3-1 lists the drawing numbers used to construct the B2 intake geometry model.

Table 3-1. Drawings Referenced in Creation of the CFD Solid Model

Structure	**Documents**
Intake Concrete	BDP-1-4-2/1, BDP-1-2/1.1, BDP-1-4-2/117
TIEs	BD-20-100/9
Trashracks	BDP-1-5-2/1
STS	BDP-5-3-4/1
VBS	BDF-0-46/02, BDF-0-60/04, BDF-0-60/06, BDF-0-60/15, BDF-0-60/16, BDF-0-60/18
Emergency Gates	BDP-1-5-2/8, BDP-1-5-2/9

The Star CCM+ CFD meshing software used to create the computational grid requires a "watertight" geometry of the fluid domain. However, the geometry created in SolidWorks™ represents the solid structures of the intake, so an inversion of the model was performed in SolidWorks™ to obtain the fluid-domain geometry rather than the solid-domain geometry (Figure 46). The fluid-domain was exported from SolidWorks™ in IGES 5.3 format for use in the Star CCM+ grid generation software.

The computational grid for the model domain was developed using the grid generation program in the Star CCM+ modeling software and consists of approximately 2.4 million polyhedral (or many-sided) cells, as shown in Figures 47 and 48. The CFD Model is of sufficient detail for analyzing relative impacts of FGE improvement alternatives on gatewell hydraulic conditions and flow.

3.3. SECTIONAL CFD MODEL CALIBRATION

VBS normal and sweeping velocity data were available for CFD Model calibration and validation from a previous physical model and the prototype as described below. Both data sets include normal (approaching the VBS screen) and sweeping (parallel to the VBS screen) velocities at points on a grid approximately 7.5 inches upstream of the VBS.

- VBS sweeping and normal velocities were measured in a 1:12 scale physical model of a single unit bay in the Bonneville 2nd Powerhouse (ENSR, 2004). VBS velocity data were collected in the 1:12 scale physical model using a Laser Doppler Anemometer (LDA) for three bay flows summarized in Table 3-2.
- VBS sweeping and normal velocities from the prototype for Units 12 and 14 Bay A (PNNL, 2010). The prototype VBS velocities were measured in Units 12 and 14 Bay A by PNNL using an array of Acoustic Doppler Velocimeters (ADVs) for the bay flows shown in Table 3-2. The data sets are arranged by comparable bay flow (within 5%) in Table 3-2.

For purposes of the model calibration and validation, the normal and sweeping velocity components were each averaged over each VBS panel for comparison of panel-averaged normal and sweeping velocities. The flow through the VBS was estimated as the sum of the flow through each VBS panel (panel-averaged normal velocity x panel area).

Table 3-2. VBS Velocity Comparison Data Sets

1:12 Physical Model Bay Flow (cfs) (ENSR, 2004)	Prototype Bay Flow (cfs) (PNNL, 2010)
3270	NA
4790	4536
NA	5557
NA	5972
6540	NA

For the calibration and validation process, the CFD Model was run for unit flows that resulted in similar bay flows (within 5%) in one of the unit bays to the bay flow during the 1:12 physical model or prototype data collection (Table 3-3). The CFD Model runs were conducted with prescribed outflow velocities at the downstream boundaries for Bays A, B, and C corresponding to 37.8%, 34.2%, and 28.0% of the unit flow, respectively. A pressure boundary at the upstream boundary allowed for equivalent inflow into the model domain. In all runs, the left fish orifice (looking downstream) was in operation in each bay with an outflow of 11 cfs.

Table 3-3. CFD Model Calibration and Validation Runs

CFD Model Unit Flow (cfs)	Bay/ (% Unit Flow)	VBS Velocity Data Source		
		CFD Model Bay Flow (cfs)	1:12 Physical Model Bay Flow (cfs) (ENSR, 2004)	Prototype Bay Flow (cfs) (PNNL, 2010)
11,700	Bay C (28.0%)	3276	3270	NA
16,500	Bay C (28.0%)	4620	4790	4536
16,500	Bay B (34.2%)	5643	NA	5557
15,800	Bay A (37.8%)	5972	NA	5972
17,300	Bay A (37.8%)	6540	6540	NA

The CFD Model-predicted VBS normal and sweeping velocities were extracted from the model results at the same locations as the 1:12 physical model measurement grid. Panel-averaged normal and sweeping velocities were calculated for comparison to the physical model and prototype data. The VBS flow was estimated for each bay by querying the CFD model for the mass flux across the baffle representing the VBS and converting the mass flux to flow.

The CFD Model was calibrated against the 1:12 physical model VBS normal and sweeping velocities for similar bay flows by adjusting the porosity coefficients for the STS and VBS through an iterative process. In the initial series of calibration model runs, the STS and VBS porosity coefficients were adjusted until the overall flow through the VBS was comparable to that for the same bay flow condition in the 1:12 Physical Model. A comparison of the VBS flows as a function of bay flow for the CFD Model and the 1:12 Physical Model is shown in Figure 49.

After the VBS flows from the Sectional CFD Model matched those calculated for the 1:12 physical model within 10%, the porosity coefficients for each of the nine VBS panels were adjusted individually to uniformly distribute the flow through the VBS. The same porosity coefficients were used for each bay and are shown in Table 3-4. The final STS α and β parameters for the calibrated and validated model were 500 and 1, respectively.

Table 3-4. Calibrated Model VBS Baffle Porosity Parameters

VBS Panel	VBS baffle porosity parameters	
	α	β
1	0.02	0.4
2	0.19	0.4
3	0.61	0.4
4	0.61	0.4
5	0.39	0.4
6	0.39	0.4
7	0.39	0.4
8	0.05	0.4
9	0.007	0.4

As validation, the CFD Model was run for comparable bay flows (Table 3-3) to compare the VBS flow from the CFD Model and the prototype (Figure 49). In addition, the VBS normal and sweeping velocities from the calibrated CFD Model were compared to those from the prototype. Comparison plots of the VBS normal and sweeping velocities for the CFD Model, 1:12 physical model, and prototype for the bay flows in Table 3-3 are provided in Figure 50 through Figure 54. In general, the normal velocities for the CFD model compare well with both the 1:12 physical model and prototype, both in magnitude and overall vertical distribution over the VBS panels. The sweeping velocities predicted by the CFD model generally more closely represent the sweeping velocities measured in the prototype than the 1:12 physical model. This may be due to the narrower width of the gateslot region in the 1:12 physical model than in the CFD Model or prototype. The 1:12 physical model was a single-bay flume type model without expansions for the additional width of the gateslots. Therefore, the cross-sectional area in the gatewell in the physical model was smaller than the Sectional CFD Model or prototype, resulting in higher sweeping velocities.

3.4. SECTIONAL CFD MODELING OF BASELINE CONDITIONS

Following calibration and validation, the CFD Model was run for unit flow conditions representing the low, medium, and high 1% efficiency unit operation as shown in Table 3-5. The runs were conducted with existing gatewell geometry to establish a hydraulic baseline for evaluation of alternatives.

Table 3-5. Baseline Run Outflow Conditions

Unit Flow (cfs)	Bay A Flow (cfs)	Bay B Flow (cfs)	Bay C Flow (cfs)
12,000	4,536	4,104	3,360
15,000	5,670	5,130	4,200
18,000	6,804	6,156	5,040

The 18,000 cfs unit flow provided a baseline for hydraulic conditions assumed to represent unfavorable flow conditions for fish passage at the high 1% efficiency range, while the 15,000 cfs unit flow provided a baseline for assumed minimally favorable hydraulic conditions for fish passage at the medium 1% efficiency range. The 12,000 cfs provided a low flow baseline for assumed favorable hydraulic conditions for fish passage at the low 1% efficiency range.

In each case, the model was run with prescribed outflow velocities at the downstream boundaries for Bays A, B, and C corresponding to the flows in Table 3-5. A pressure boundary at the upstream boundary allowed for equivalent inflow into the model domain. In all runs, the left fish orifice (looking downstream) was in operation in each bay with an outflow of 11 cfs. The CFD Model results were post-processed using FieldView, a CFD model post-processing software program.

3.4.1. Low Unit Flow Conditions – 12,000 cfs

With the existing gatewell geometry in place and a unit flow of 12,000 cfs, the CFD model-predicted Bay A VBS flows are summarized in Table 3-6. Bay A has the highest flow of the three bays in each unit, and therefore the highest VBS and gatewell flow. The VBS flow for each bay was calculated from the CFD model results by converting the mass flux (kg/s) across the VBS baffle to flow (cfs). The VBS flows for the Baseline CFD Model runs in Table 3-6 show increasing VBS flow with increasing unit flow, as expected.

Table 3-6. Baseline Run VBS Flow Summary

Unit Flow (cfs)	Bay A VBS Flow (cfs)
12,000	219
15,000	272
18,000	328

The CFD Model results for the low unit flow condition are summarized in Figure 55 through Figure 60 show flow passing through the trashrack, with a portion of the flow passing up the STS to the gatewell, and the remainder passing into the intake. Flow up the STS accelerates to up to 5-6 ft/s, with a portion of the flow returning to the intake between the gap closure device and the STS. The gatewell flow passes along the turning vane, with some separation downstream of the upstream intake roof and the turning vane, as shown by the low velocity areas in Figure 55.

As the flow passes above the turning vane, the gateslot width increases abruptly above the turning vane and STS side supports and the flow can not immediately expand to fill the volume. An opposing recirculation of flow upward and then downward on either side of each bay results as the flow expands downstream of the abrupt gateslot transition (Figure 58). The CFD model results show that the recirculation is more intense on one side (generally the left side, looking upstream), likely as a result of slightly asymmetrical approach conditions generated by the different bay flows for Bays A, B, and C.

Normal velocities just upstream of the VBS are generally less than the 1ft/s criteria, with some velocities approaching 1 ft/s in the recirculation areas on either side of the VBS (Figure 58). Sweeping velocities up the VBS are generally positive (positive upward), but negative in the recirculation on either side of the VBS. The general level of turbulence in the gatewell is characterized by the turbulent kinetic energy isosurface plots in Figure 59 and Figure 60. In the isosurface plots, regions with a specified level of turbulent kinetic energy (0.25 ft2/s2 and 0.5 ft2/s2 in Figure 59 and Figure 60, respectively) are plotted as a 3-D surface to indicate location. For low flow conditions, regions of turbulence are present downstream of the intake roof, on the downstream face of the turning vane, and extending along either side of the VBS downstream of the gateslot expansion above the STS side supports.

3.4.2. Medium Flow Conditions – 15,000 cfs

The CFD Model results for the medium unit flow condition are summarized in Figures 61 through 66. The VBS flow for the medium unit flow condition (15,000 cfs) is approximately 270 cfs (Table 3-6). The gatewell flow patterns for the 15,000 unit flow condition are generally similar to those for the low unit flow condition, but the velocity magnitudes and intensity of the turbulence in the gatewell are increased. As flow passes up the STS to the gap closure device and turning vane, velocities reach 7-8 ft/s (Figure 62) as compared to 5-6 ft/s for the low unit flow condition. The plots of VBS normal velocity show increased intensity of the recirculation regions downstream of the gateslot expansion, and VBS normal velocities as high as 1.3-1.5 ft/s in the “hot spots” inside the left and right recirculation zones in Bay A (Figure 64).

The positive sweeping velocities are concentrated to the center portion of the VBS, with negative sweeping velocities on the outer left and right portions of the VBS (Figure 64). Turbulent kinetic energy increased in the gatewell with increased unit flow as shown by the larger volume isosurfaces in Figure 65 and Figure 66.

3.4.3. High Unit Flow Conditions – 18,000 cfs

The CFD Model results for the high unit flow condition are summarized in Figure 67 through Figure 72. The VBS flow for the high unit flow condition (18,000 cfs) is approximately 330 cfs (Table 3-6). The gatewell flow patterns for the 18,000 unit flow condition are generally similar to those for the low and medium unit flow condition, but the velocity magnitudes and intensity of the turbulence in the gatewell are further increased. As flow passes up the STS to the gap closure device and turning vane, velocities reach 9-10 ft/s (Figure 68) as compared to 5-6 ft/s for the low unit flow condition. The plots of VBS normal velocity show increased intensity of the recirculation regions downstream of the gateslot expansion, and VBS normal velocities as high as 1.4-1.6 ft/s in the “hot spots” inside the left and right recirculation zones in Bay A (Figure 70). The positive sweeping velocities are concentrated to the center portion of the VBS, with negative sweeping velocities on the outer left and right portions of the VBS (Figure 70). Turbulent kinetic energy increased in the gatewell with increased unit flow as shown by the larger volume isosurfaces in Figure 71 and Figure 72.

It is unknown whether there is a specific threshold for tolerance of turbulence by juveniles, but the increased turbulent kinetic energy coincident with higher recirculation and normal velocities on the VBS may be a significant factor in exhaustion and subsequent injury for juveniles. Therefore, alternatives for improving FGE will focus on streamlining the sweeping velocities along the VBS, reducing turbulence in the gatewell, minimizing gatewell residence time, and reducing and evenly distributing normal velocities on the VBS.

3.4.4. Baseline Grid Sensitivity Test

After the Baseline model runs were complete, the CFD Model grid was refined to double the number of grid cells in the model domain, with particular attention to the STS and gatewell region. This grid sensitivity test was conducted to ensure that the Baseline model results were not dependent on the grid resolution. The VBS flow increased approximately 7% over that for the calibrated grid, indicating some increased resolution of the flow field. However, results of the doubled-resolution grid showed similar flow patterns in the gatewell, including the regions of recirculation and turbulence, and do not indicate a significant change to the baseline hydraulic conditions predicted by the calibrated grid. The calibration grid was used to evaluate alternatives described in Section 4, since it provided reasonable results with practical model run times of approximately 12 hours per run. The doubled-resolution grid will be used for a final performance check of the preferred alternative during a later phase of the alternatives study.

3.5. SECTIONAL CFD MODELING OF FGE ALTERNATIVES

The Sectional CFD Model was applied to support the FGE Improvements Alternatives Study. The alternatives developed during the 30% Alternatives Study phase were categorized into modifications for flow control, operations, and flow pattern change as described below.

Flow control alternatives include:

- A1 – Adjustable Louver Flow Control Device: Construct a device to control the flow up the gatewell. The device would be placed downstream of the VBS. Similar devices have been used at John Day and McNary dams.

- A2 – Sliding Plate Flow Control Device: Construct a sliding plate flow control device attached to the top of the gatewell beam.
- A3 – Modify VBS Perforated Plates
- A4 – Modify Turning Vane and/or Gap Closure Device

Operational alternatives include:

- B1 – Operate Main Units Off 1% Peak Operating Range: Operate the main turbine units at the lower to mid 1% peak operating range during the SCNFH juvenile fish release.
- B2 – Open Second Downstream Migrant System Orifices: Open the second Downstream Migrant System (DSM) gatewell orifice to decrease fish retention time in the gatewell.
- B3 – Horizontal Slot for Downstream Migrant System: Construct a horizontal slot in place of the existing orifices to decrease fish retention time in the gatewell.

Flow pattern change alternative:

- C1- Install Gateslot Fillers: Install gateslot fillers in the slots above the turning vane and STS supports to reduce turbulence in the gatewell and streamline sweeping velocities up the VBS.

Alternatives A2, A4, B1, B2, and C1 were modeled using the Sectional CFD Model as described in the following sections.

3.5.1. Alternative A1 – Adjustable Louver Flow Control Device

The adjustable louver flow control device alternative involves installation of a series of adjustable plates (louvers) in the opening downstream of the VBS (Figure 73). The louvers would be adjusted accordingly to meet the target flow in the gatewell. This system can be constructed of stainless or carbon steel and can be designed to vary the opening width at top and bottom. For a permanent design, opening and closing adjustments may be made from a separate device lowered into the downstream VBS slot, through a conduit cored through the existing concrete or by remote control.

This alternative was not prioritized for simulation in the CFD model as it is similar in principle to Alternative A2 – Sliding Plate Flow Control Device. If the team prioritizes this alternative for further evaluation, the CFD model will be modified to include a hydraulic representation of the louvers downstream of the VBS. The alternative would be evaluated at high flow conditions (18,000 cfs unit flow) to determine the impact on VBS velocities and flow patterns. Additional documentation runs at low and medium unit flows (12,000 and 15,000 cfs, respectively) would confirm the performance of the alternative over a range of unit flows.

3.5.2. Alternative A2 – Flow Control Device – Sliding Plate

The sliding plate flow control device alternative involves a system of two sliding plates attached to the top of the gatewell beam (Figure 74). Gatewell flow could be controlled by one plate sliding over the other to adjust the opening depending on the required velocity. Both plates can be made of carbon steel or stainless steel (with a Teflon coating to reduce friction) or aluminum. Similar to Alternative A1, a permanent design may be operated from a separate device lowered into the downstream VBS slot, through a conduit cored through the existing concrete or by remote control.

3.5.2.1. Sectional CFD Model Grid

The CFD model grid was modified to include the approximate geometric features of the sliding plate flow control device. The flow control device was modeled as a 6-inch thick plate, extending across the full width of each bay and with varied lengths in the downstream direction. The flow control device was included in the model grid in three segments representing occlusion of 25%, 50%, and 75% of the cross-sectional flow area between the gatewell beam and the emergency gate as shown in **Figure 75**. The grid cells inside the flow control device segments can be switched from solid to fluid cells in the CFD model to either engage them as flow control devices (solid) or treat them as an unrestricted flow path (fluid). Three CFD model runs were conducted at a unit flow of 18,000 cfs to investigate the relative change in VBS flow with the flow control device occluding 25%, 50%, and 75% of the return flow area. All other geometric conditions in the model were representative of baseline conditions.

When the model grid was modified to include the flow control device features, additional geometric features were incorporated into the grid with the flexibility to include the features as solid or fluid cells (**Figure 75**), including:

- Gap closure device
- Turning vane
- Slot fillers

Additional discussion about these features is provided in relevant sections below.

3.5.2.2. Sectional CFD Model Results

The VBS flows with the sliding plate flow control device occluding 25%, 50%, and 75% of the return flow area are summarized in Table 3-7. The 25% sliding plate setting results in a Bay A VBS flow (272 cfs) that is comparable to the VBS flow for the Baseline conditions with 15,000 cfs unit flow. The 50% sliding plate setting results in a Bay A VBS flow (219 cfs) that is comparable to the Bay A VBS flow for the Baseline conditions for 12,000 cfs unit flow. For brevity, the results of the 25% sliding plate setting Sectional CFD Model run are described below.

Table 3-7. VBS Flow Control with Sliding Plate Flow Control Device

Unit Flow (cfs)	Sliding Plate Setting	Bay A VBS Flow (cfs)
18,000	25%	276
18,000	50%	216
18,000	75%	Fill in

The CFD Model results for the sliding plate flow control device with 50% of the return flow area occluded are summarized in Figure 76 through Figure 78. The velocity magnitudes approaching the STS and gatewell look similar with the 50% sliding plate installed (Figure 76) to those for the Baseline 18,000 cfs unit flow case (Figure 68), as expected, since the unit flows are the same. As the flow enters the gatewell, the influence of the flow control device can be seen in the lower gatewell velocities in Figure 76 that are more comparable to the Baseline 15,000 cfs unit flow case (Figure 79). The 50% sliding plate alternative appears to have slightly more flow up the upstream side of the turning vane and less up the downstream side of the turning vane than in the Baseline 15,000 cfs unit flow case for an equivalent gatewell flow. Normal velocities and flow patterns on the VBS are similar for the 25% sliding plate alternative and the Baseline 15,000 cfs unit flow case (Figure 77 and Figure 64), as expected for comparable VBS flows. Turbulent kinetic energy in the gatewell for the 50% sliding plate alternative (Figure 78) is slightly reduced from the Baseline 18,000 cfs unit flow case, but not quite to the level seen in the Baseline 15,000 cfs unit flow case. This may be due to the difference in velocities and flow patterns approaching the gatewell along the turning vane described above.

3.5.3. Alternative A3 – Modify VBS Perforated Plates

This alternative involves modifying the existing VBS perforated plates resulting in a reduction of gatewell flow. A separate, modified perforated plate would be attached to the existing perforated plate and be allowed to slide to constrict flow to meet a target flow velocity. This perforated plate can be constructed of carbon steel with a Teflon coating to reduce friction during operation. A prototype could be built that would be adjustable and locked in place by hand. A permanent design may be attached to the existing perforated plate and mechanically or remotely controlled.

This alternative has not been evaluated using hydraulic modeling to date as it is considered similar in principle to Alternative A2 – Sliding Plate Flow Control Device. If the team prioritizes this alternative for further evaluation, physical hydraulic modeling investigations will be needed for this alternative. Preliminary investigation can be conducted using the CFD model to gain an initial understanding of the relative change in VBS flow from changes to the screen perforated plates. A physical hydraulic model would need to be constructed to evaluate actual required changes to prototype perforated plate porosities to maintain balanced normal velocities within criteria.

3.5.4. Alternative A4 – Modify Turning Vane and Gap Closure Device

This alternative involves modifying the existing turning vane and/or gap closure device to reduce the discharge flowing into the gatewell. Turning vanes direct the flow up the gateslot and are installed just above the top of the submerged travelling screen (STS). The gap closure device is mounted on the intake roof just downstream of the STS to prevent fish from travelling through the turbine as well as divert more flow up the gatewell.

3.5.4.1. Sectional CFD Model Grid

The CFD model grid was modified to model the removal of the gap closure device to reduce gatewell flow in all three bays. The grid cells representing the gap closure device in the CFD model (Figure 75) were defined as fluid cells rather than solid cells to allow flow freely through the region previously occupied by the gap closure device. One CFD model run was conducted at a unit flow of 18,000 cfs to investigate the relative change in VBS flow with the gap closure device removed. All other geometric conditions in the model were representative of baseline conditions.

3.5.4.2. Sectional CFD Model Results

The CFD model results for Alternative A4 – Modify Gap Closure Device are summarized in Figure 79 through Figure 80. With the gap closure device removed, the more flow passes through the gap between the STS and the gatewell beam, resulting in lower VBS flow, approximately 110 cfs. Velocity magnitude through the gap is increased over that for the baseline condition as shown in Figure 79. The higher velocities at the upper end of the STS and through the gap result in an altered flow pattern at the base of the VBS with flow actually recirculating and passing upstream through the lower VBS panels as shown in Figure 80. It is important to note that the VBS porosity settings for this alternative were set the same as the baseline condition and no attempt was made to compensate for the backflow through the VBS in this particular model run. Turbulent kinetic energy in the gatewell is similar to baseline conditions, though some effect of the backflow through the lower VBS is apparent in the turbulence plots in Figure 80.

3.5.5. Alternative B1 – Operate Main Units Off 1% Peak Operating Range

Alternative B involves reducing the gatewell flow by operating B2 main units off the 1% peak operating range (lower to mid one percent or 12,000 cfs to 15,000 cfs, respectively) to improve fish survival.

During the 2008 juvenile fish passage season, Spring Creek National Fish Hatchery (SCNFH) released hatchery released sub-yearlings in early spring 2008, over a period of 3 months (March, April, May). Biological testing conducted by NOAA (Spring 2008) suggests that SCNFH sub-yearling are incurring high mortality and descaling when turbine units are being operated at the upper 1% range, so the reduced unit flows are expected to improve hydraulic conditions for fish passage. Typical unit flow for this operation would be approximately 12,000 cfs to 15,000 cfs.

3.5.5.1. Sectional CFD Model Grid

This operational alternative does not involve any changes to the baseline geometry of the unit, gatewell, or screens. Therefore, the results of the Baseline CFD model runs at lower unit flows (12,000 cfs and 15,000 cfs) are indicative of the hydraulic conditions in the gatewell with the unit operating in the lower- and mid-1% range.

3.5.5.2. Sectional CFD Model Results

The hydraulic conditions expected during unit operations in the lower- and mid-1% range are described in the 12,000 cfs and 15,000 cfs Baseline results, respectively, in Section 2.0 and Figures 55 through 66.

3.5.6. Alternative B2 – Open Second Downstream Migrant System Orifices

The DSM system has two fish passage orifices in the gatewell slots of units 11-14. Under present operating conditions one orifice in each gatewell is typically used. This alternative involves opening the second gatewell orifice to decrease fish retention time in the gatewell.

3.5.6.1. Sectional CFD Model Grid

The operation of two fish passage orifices was incorporated into the CFD model by applying a velocity boundary condition to both of the fish passage orifices in each bay. The velocity corresponds to 11 cfs through each fish orifice. No changes to the CFD model grid were made. All other boundary conditions in the model were representative of baseline conditions. One CFD model run was conducted at a unit flow of 18,000 cfs to investigate the relative change in gatewell hydraulic conditions with the second fish orifice operating.

An existing numerical spreadsheet model may be used to analyze the hydraulics in the downstream migrant system due to opening two orifices per gatewell if this alternative requires further evaluation.

3.5.6.2. Sectional CFD Model Results

The CFD Model results for Alternative B2 – Open Second Downstream Migrant System Orifices are summarized in Figures 82 through 84. Velocity magnitudes along the STS, past the turning vane and up the gatewell are similar for two orifice operation (Figure 82) and baseline conditions with one orifice operating (Figure 68). The VBS normal velocities are similar in magnitude with two orifices operating (Figure 83) and one orifice operating (Figure 70), but the recirculation to either side on the VBS is intensified slightly with two orifices operating. In addition, the side with the larger recirculation zone flips in Bays A and B from the left side, looking upstream, during single orifice operation (Figure 70) to the right side, looking upstream, during the double operation (Figure 83). The change in the asymmetry from bay to bay is apparent in the prototype VBS data as well may indicate that the recirculation patterns in the gatewell is a relatively stable, yet transient condition that flips from side to side. Turbulent kinetic energy is slightly higher with the second orifice operating (Figure 84) as compared to baseline (Figure 72).

Overall, the flow patterns on the VBS are not more uniform with the second orifice operating, but the second orifice may provide fish a second opportunity for exit from the upper portion of the gateslot.

3.5.7. Alternative B3 – Horizontal Slot for Downstream Migrant System

The DSM system has 2 fish passage orifices in the gatewell slots of units 11-14. Each are located toward the side walls and are about 20' apart. Under present operating conditions one orifice in each gatewell is used. This alternative involves constructing additional orifices, or a slot to help facilitate faster movement of fry through the orifices and decrease fish retention time in the gatewell.

3.5.7.1. Sectional CFD Model Grid

This alternative has not been evaluated using the CFD model to date as it is similar in principle to Alternative B2 – Open Second Downstream Migrant System Orifices and is subject to similar considerations for the downstream migrant system. If the team prioritizes this alternative for further evaluation, the CFD model will be modified to include modified orifices or a horizontal slot leading to the downstream migrant system rather than the existing fish orifices. The alternative would be evaluated at high flow conditions (18,000 cfs unit flow) to determine the impact on VBS velocities and flow patterns. Additional documentation runs at low and medium unit flows (12,000 and 15,000 cfs, respectively) would confirm the performance of the alternative over a range of unit flows.

3.5.7.2. Sectional CFD Model Results

This alternative has not been run in the CFD model to date.

3.5.8. Alternative C1 – Install Gateslot Fillers

In the existing configuration, the STS and turning vane side supports occupy the 4'-1" x 1'-4" gate slot on either side of each bay. Above the STS side supports, the gate slot expands abruptly and is open to flow up the gatewell. At the abrupt expansion to the gatewell slot above the STS side supports, Baseline CFD model results have shown that flow can not immediately expand into the slot and an area of recirculation and higher turbulence results. Gateslot fillers are considered to eliminate the abrupt expansion into the gateslot, reduce turbulence, and streamline sweeping velocities up the VBS. The slot fillers would be installed on each side of each of the three bays and would be dogged off to extend from the top of the STS side supports to above the gatewell water surface.

3.5.8.1. Sectional CFD Model Grid

The CFD model grid was modified to model the gateslot fillers above the STS side supports in all three bays (**Error! Reference source not found.**). The CFD model grid cells inside the gateslots were isolated and defined as solid cells rather than fluid cells to simulate the presence of the slot fillers. The solid cells representing the slot fillers extended from the top of the STS side supports to the top of the model domain. One CFD model run was conducted at a unit flow of 18,000 cfs to investigate the relative change in gatewell hydraulic conditions with the slot fillers installed. All other geometric conditions in the model were representative of baseline conditions.

3.5.8.2. Sectional CFD Model Results

The CFD Model results for Alternative C1 – Install Gateslot Fillers are summarized in Figures 85 through 87. Based on the CFD Model results, Bay A VBS flow increased to 366 cfs with the gateslot fillers in place due to decreased turbulence in the gatewell. This is approximately an 11% increase in VBS flow. In general the velocity magnitude approaching the STS and turning vane with the gateslot fillers in place (Figure 85) is very similar to the Baseline 18,000 cfs unit flow case, as expected. The influence of the gateslot fillers can be seen in the gatewell where the centerline velocity magnitude actually decreases with the gateslot fillers in place. This is due to a more even distribution of the flow up the slot, reducing the centerline sweeping velocities. The effect of the gateslot fillers can be seen in Figure 86 with the more uniform upward flow pattern and the more even distribution of normal velocities over the VBS panels. The regions of recirculation present in the baseline due to the abrupt slot expansion are significantly reduced to a small region of less intense recirculation in the upper portion of the VBS on either side (Figure 86). The turbulent kinetic energy in the gatewell is significantly reduced with the gateslot fillers in place as shown in Figure 87by the elimination of the turbulent regions on the VBS.

4. UPDATED FOREBAY CFD MODELING

In development.

5. CONCLUSIONS AND RECOMMENDATIONS

The various CFD models have provided significant insight into the hydraulic impacts of different project configurations and project operations. But the tool only provides hydraulic information and is one piece of the work needed to be done as part of the alternative study. To date alternatives have been evaluated in a single turbine unit and work is ongoing to look at the full powerhouse.

6. REFERENCES

ENSR, 2004. Bonneville Second Powerhouse Fish Guidance Efficiency Program Interchangeable VBS Investigation, Contract No. DACW57-02-D-0004, Task Order No. 1, Modification Nos. 4 through 7, Final Submittal, Document No. 09000-309(2), August, 2004.

PNNL, 2009, Bonneville Powerhouse 2 3D CFD for the Behavioral Guidance System, DRAFT Report, 2009.

PNNL, 2010. Water Velocity Measurements on a Vertical Barrier Screen at the Bonneville Dam Second Powerhouse, Draft Final Report, November 2010.

7. FIGURES

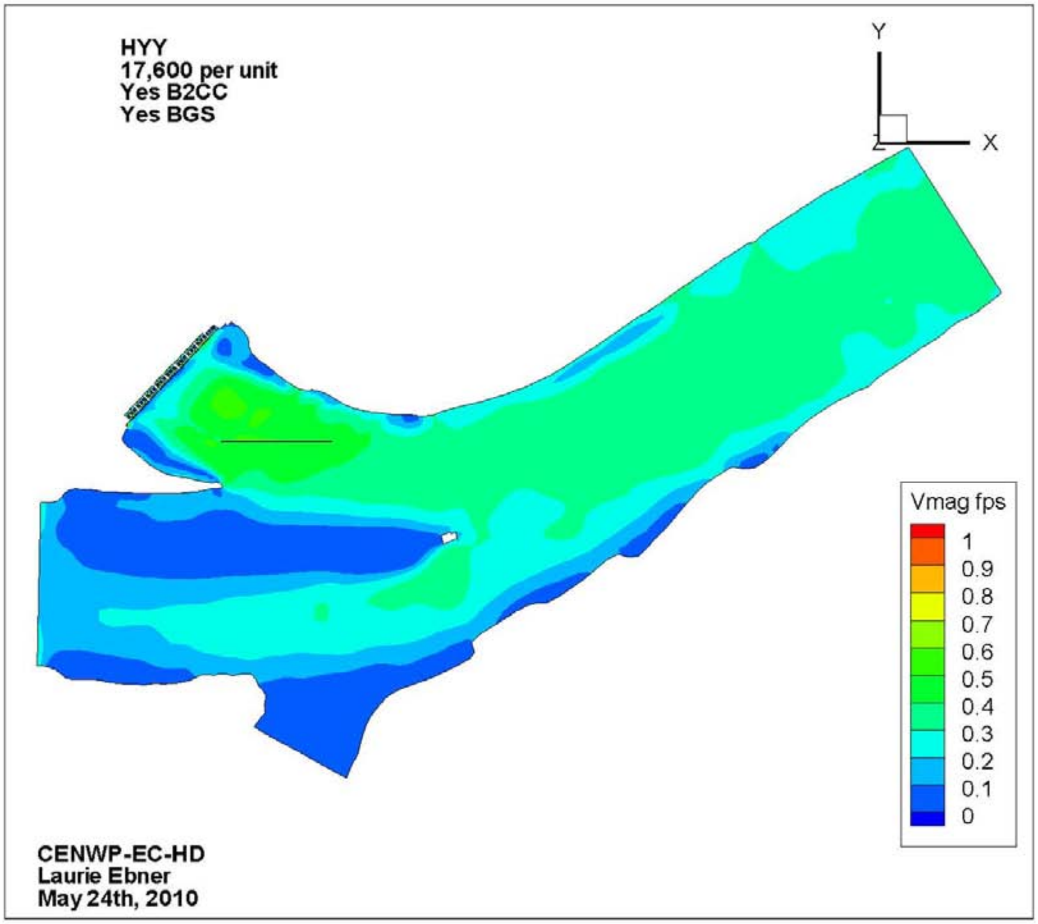


Figure 1. Existing Forebay CFD Model Domain

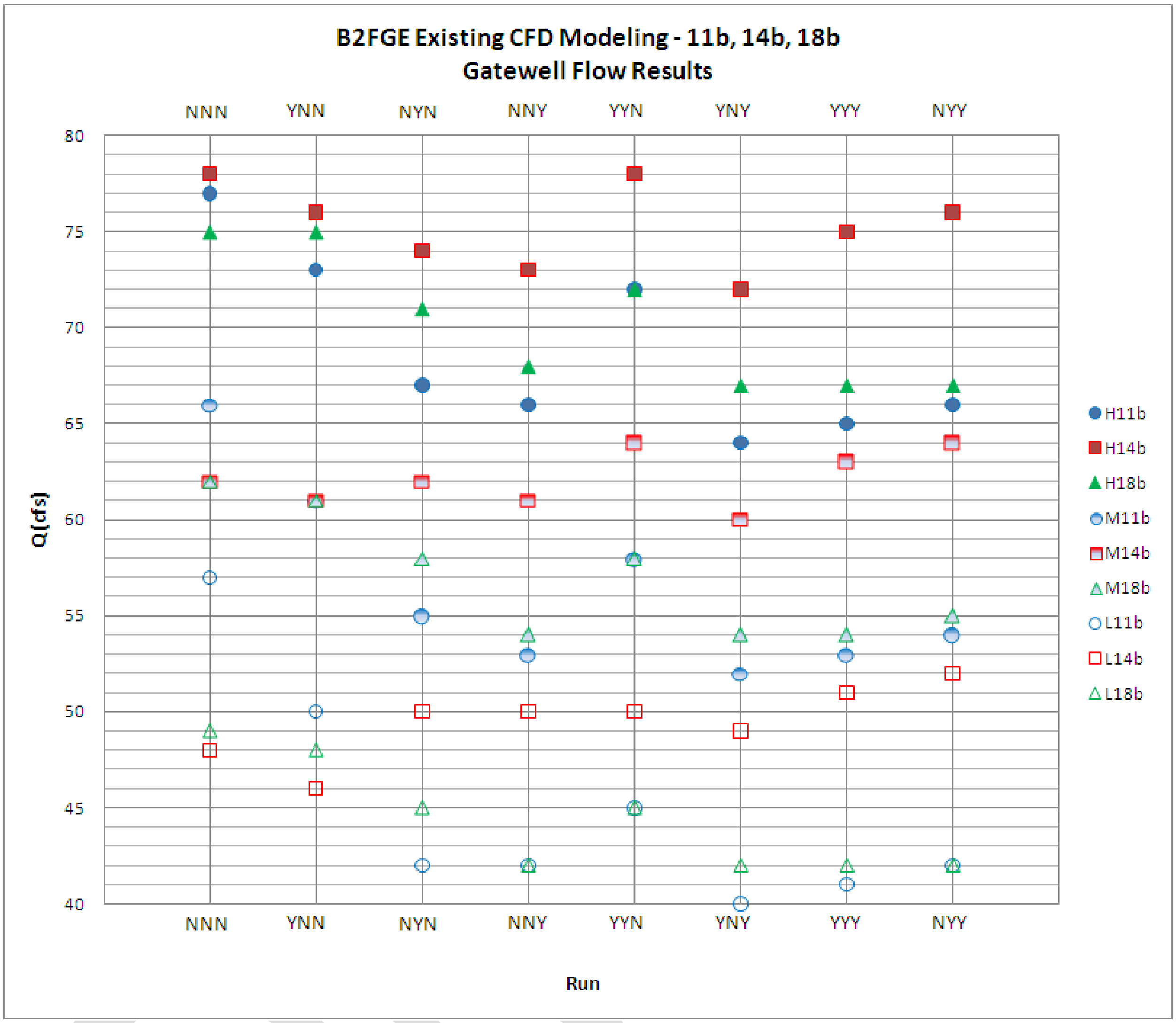


Figure 2. Plot of vertical gatewell flow results for powerhouse units 11b, 14b, and 18b.

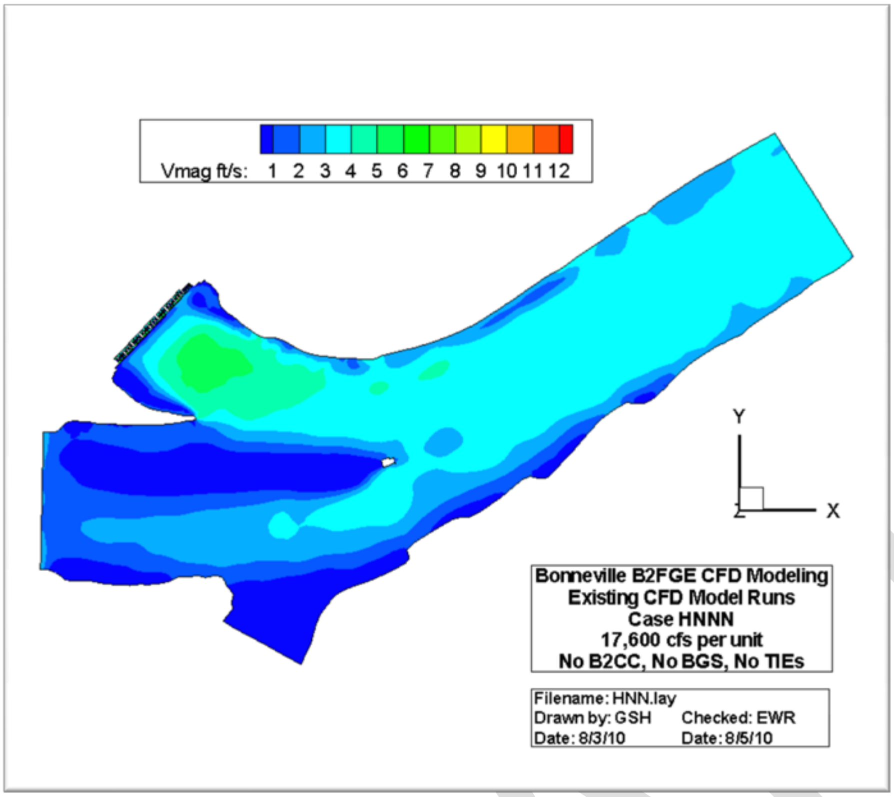


Figure 3. HNNN – Surface Velocity Magnitude, Entire Model Domain

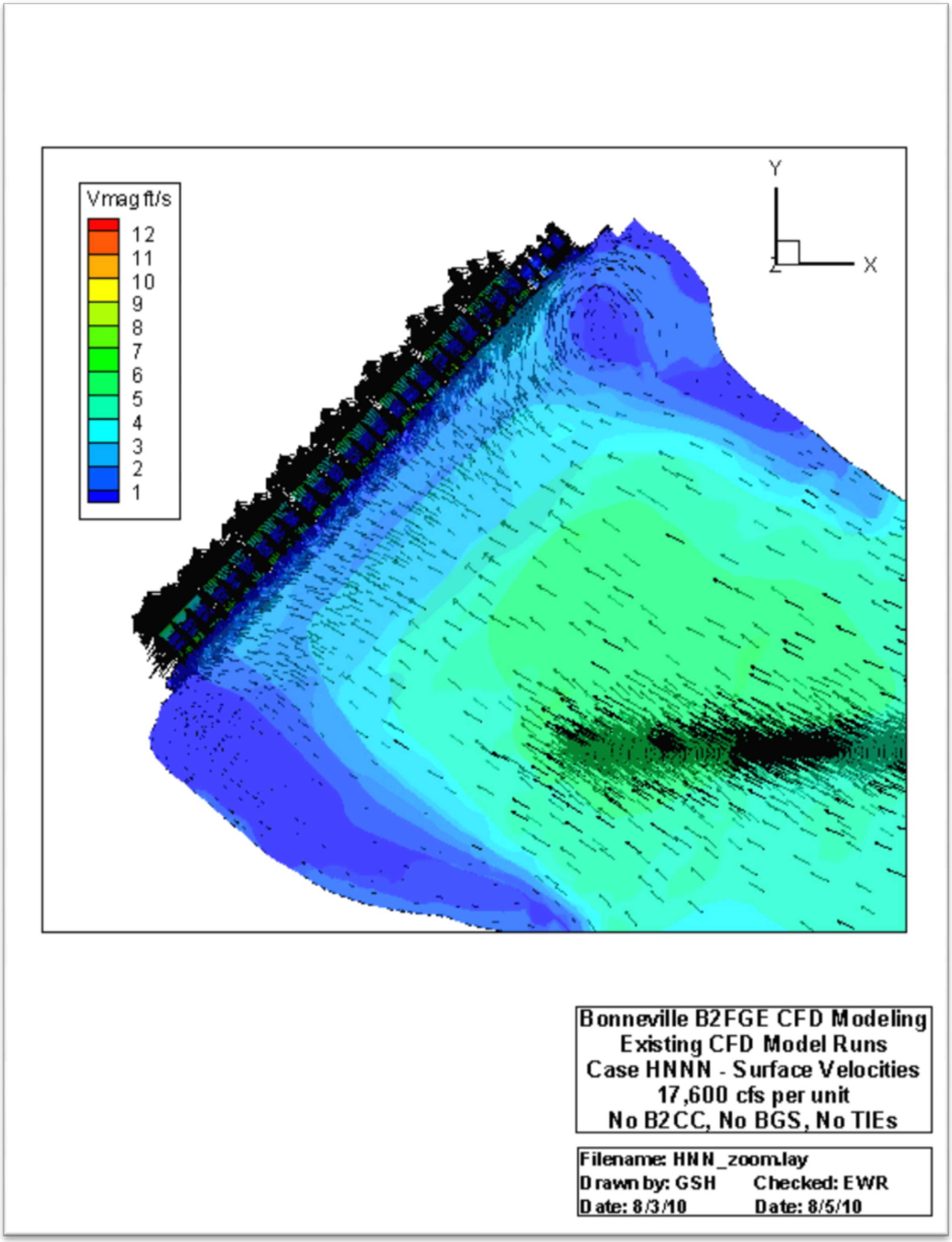


Figure 4. HNNN – Surface Velocities, near B2

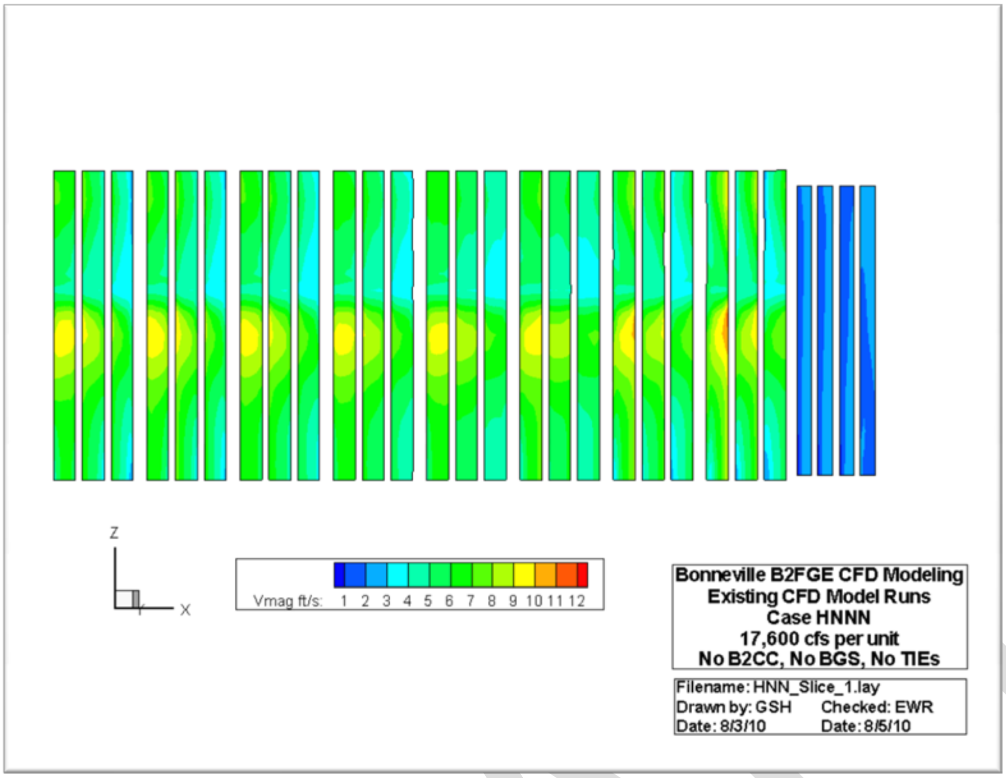


Figure 5. HNNN – Velocity Magnitude, Slice 1

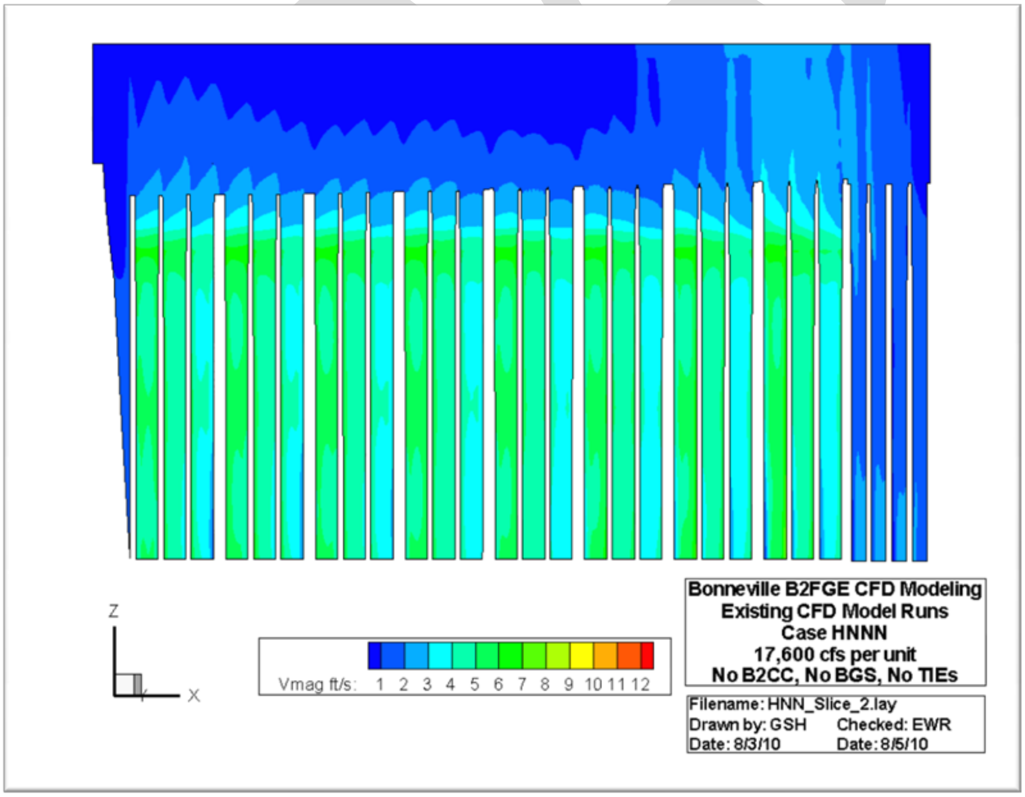


Figure 6. HNNN – Velocity Magnitude, Slice 2

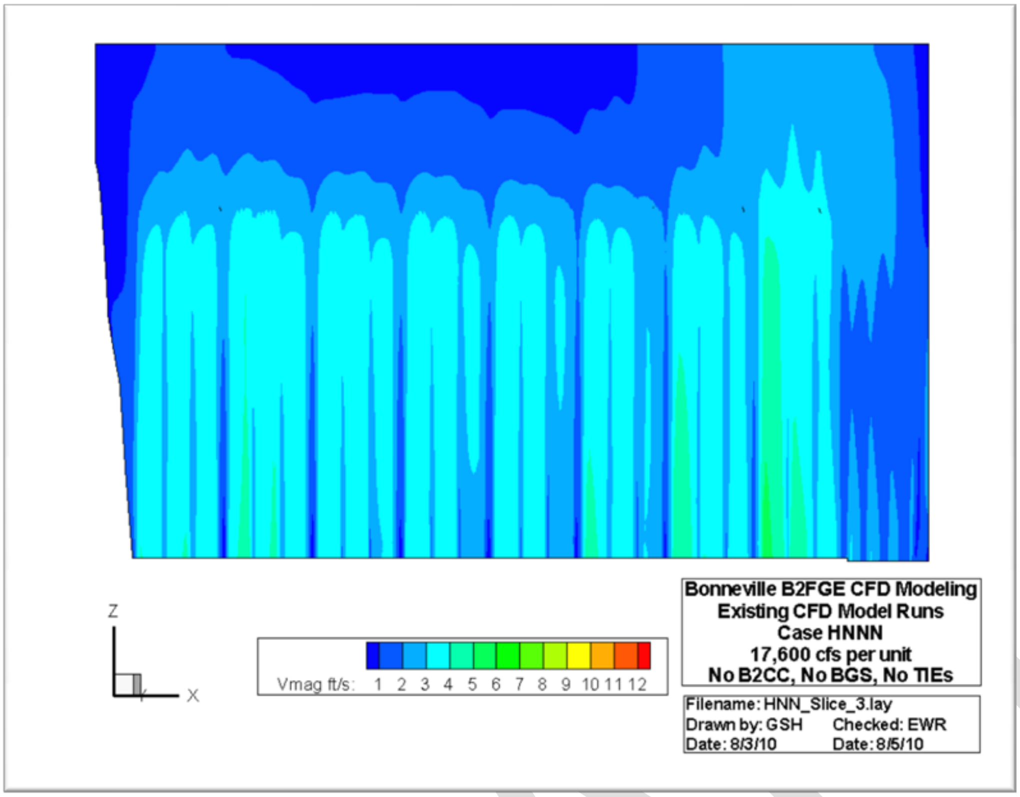


Figure 7. HNNN – Velocity Magnitude, Slice 3

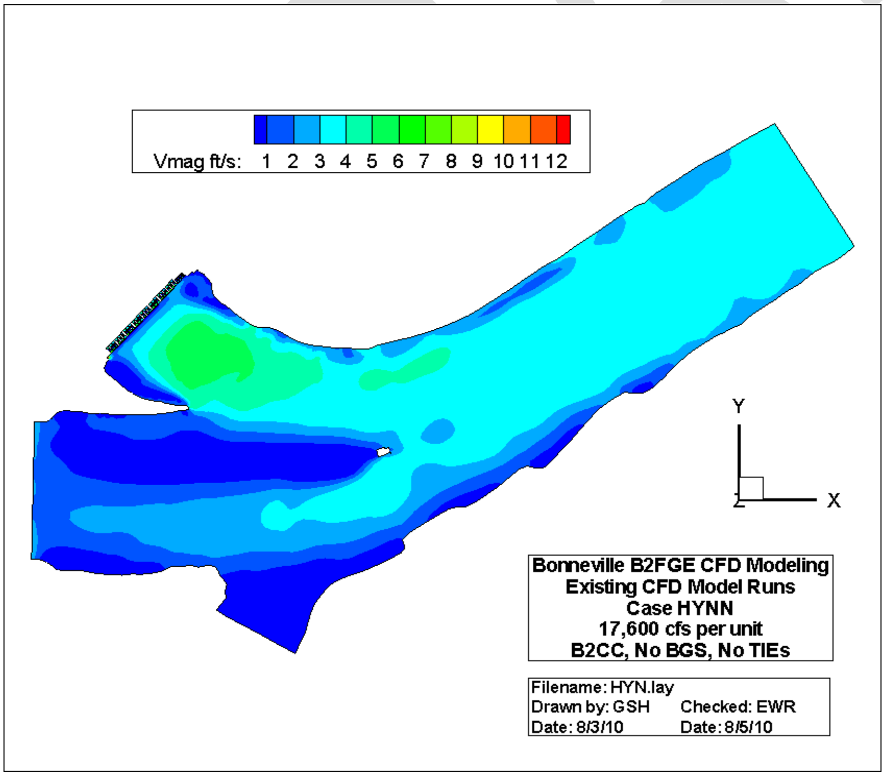


Figure 8. HYNN – Surface Velocity Magnitude, Entire Model Domain

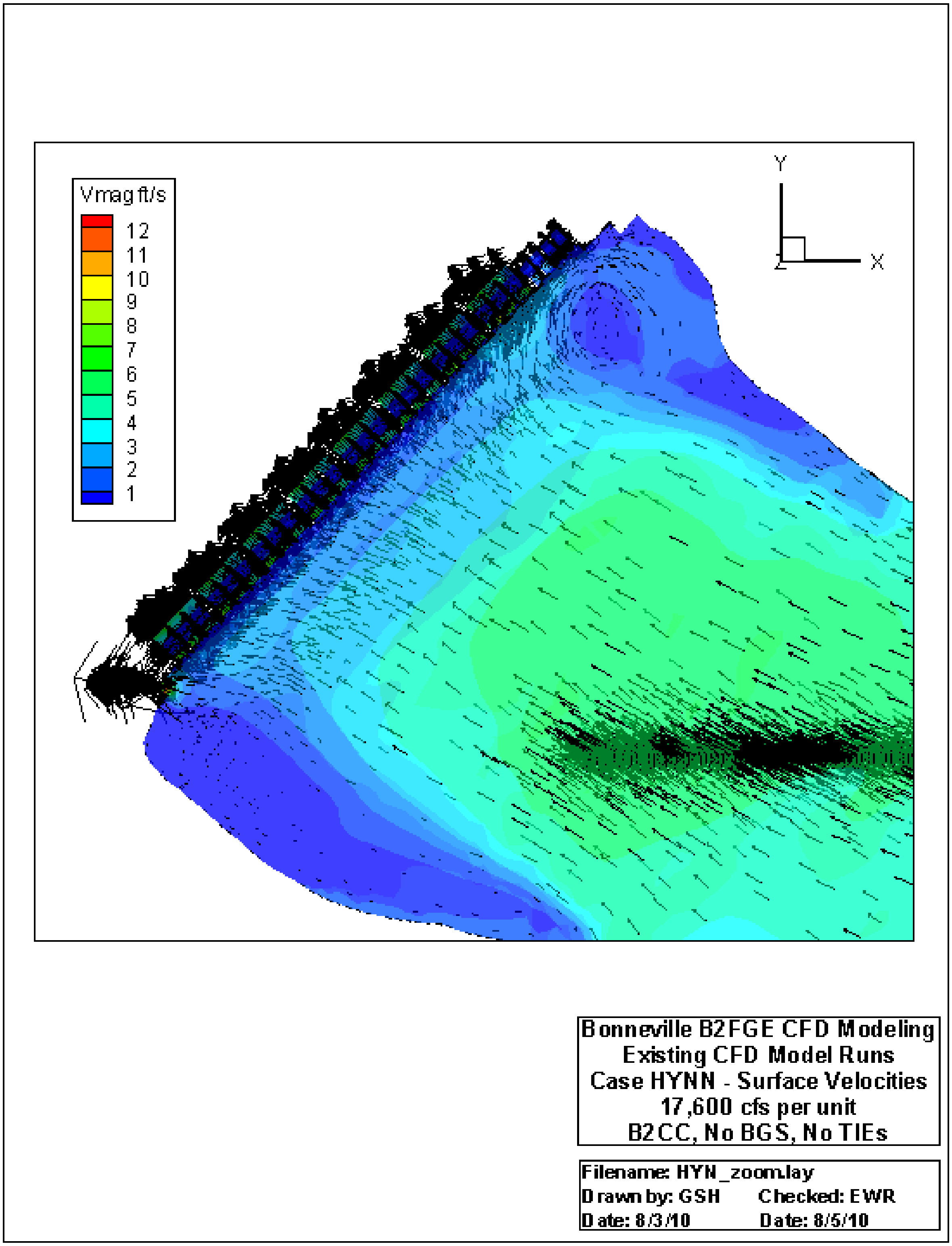


Figure 9. HYNN – Surface Velocities, near B2

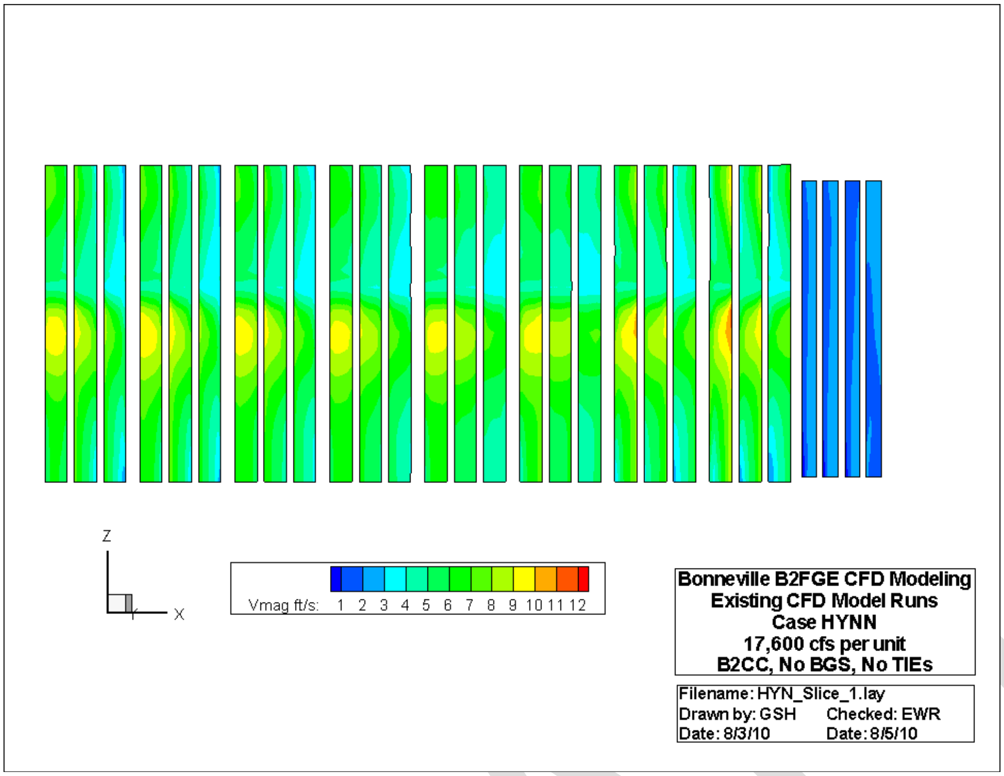


Figure 10. HYNN – Velocity Magnitude, Slice 1

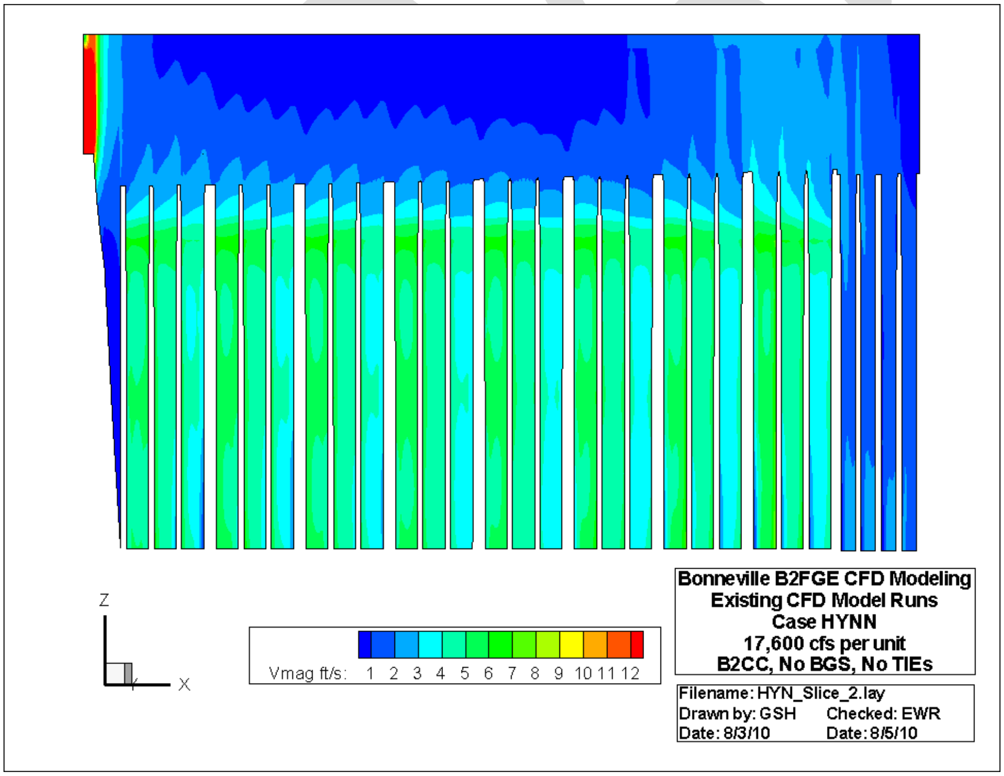


Figure 11. HYNN – Velocity Magnitude, Slice 2

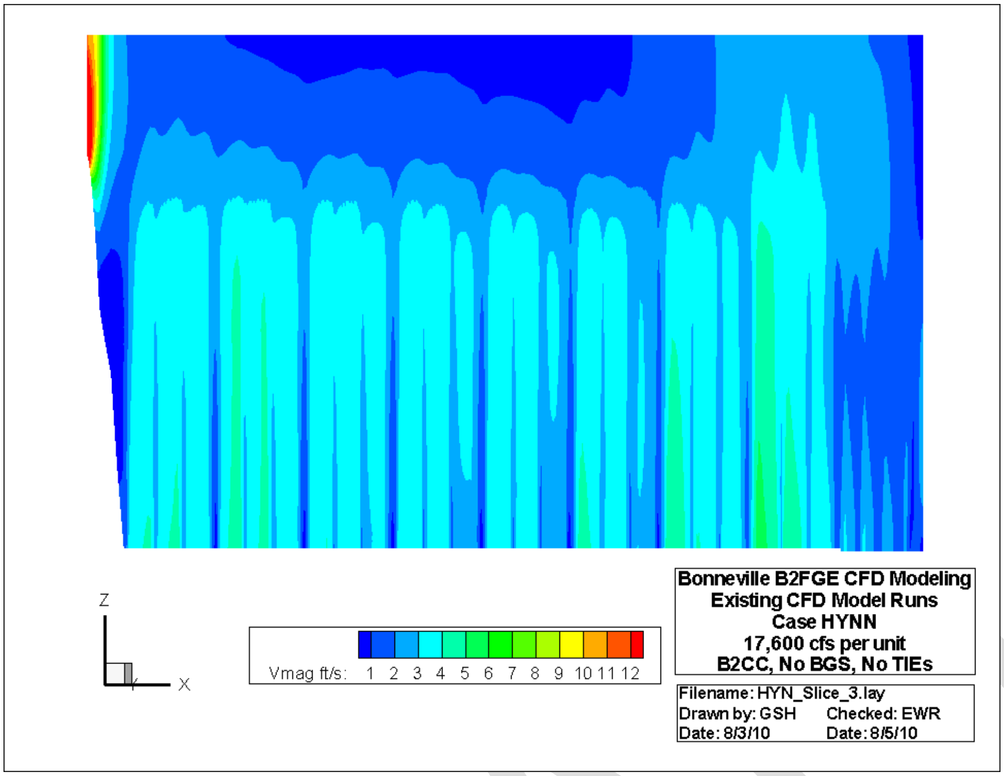


Figure 12. HYNN – Velocity Magnitude, Slice 3

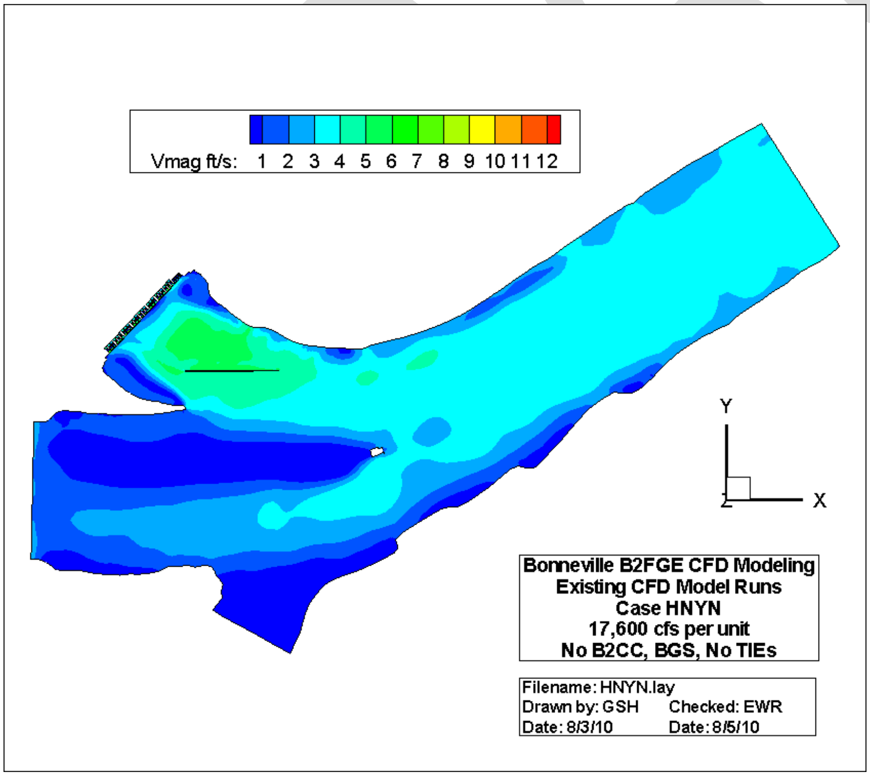


Figure 13. HNYN Surface Velocity Magnitude, Entire Model Domain

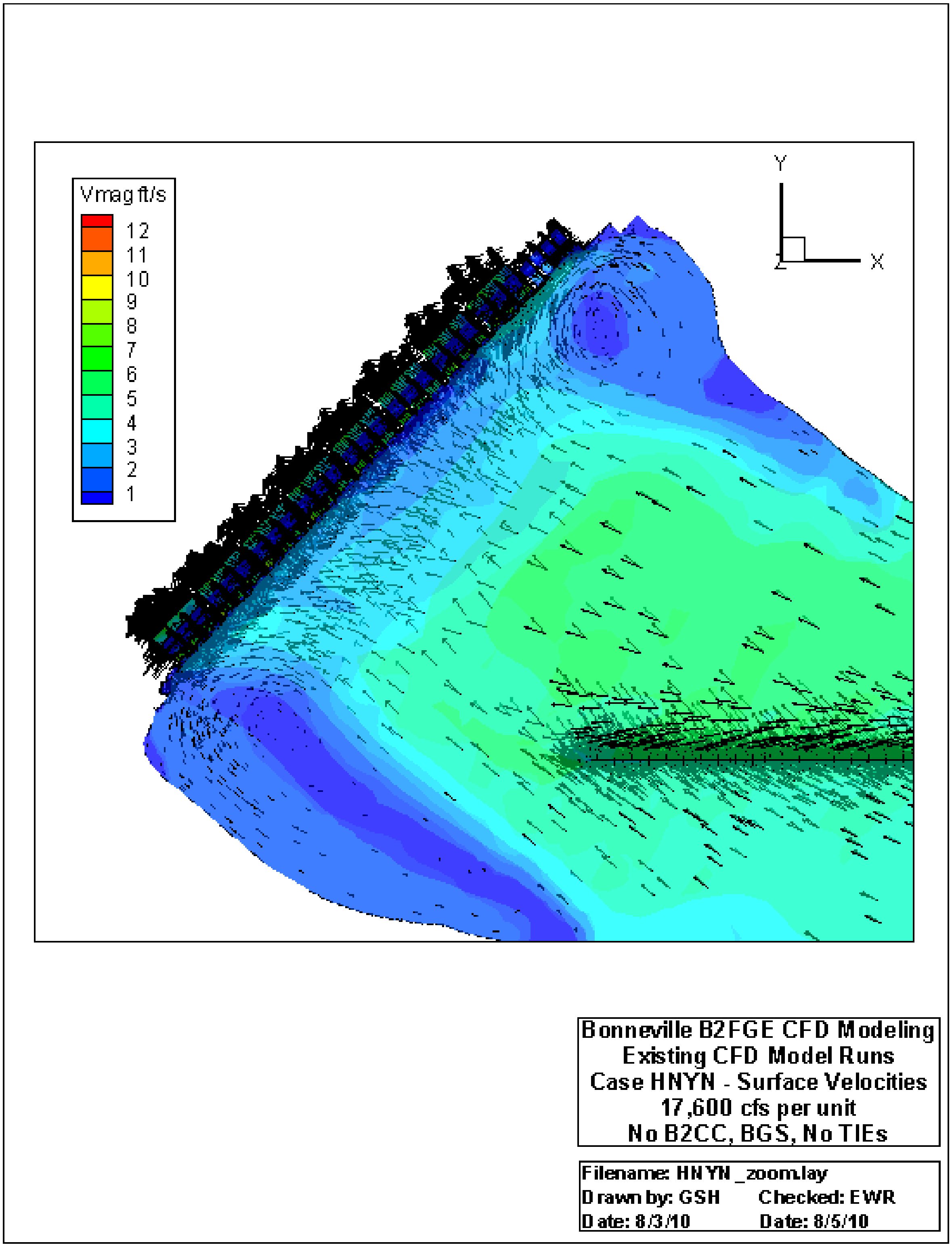


Figure 14. HNYN - Surface Velocities, near B2

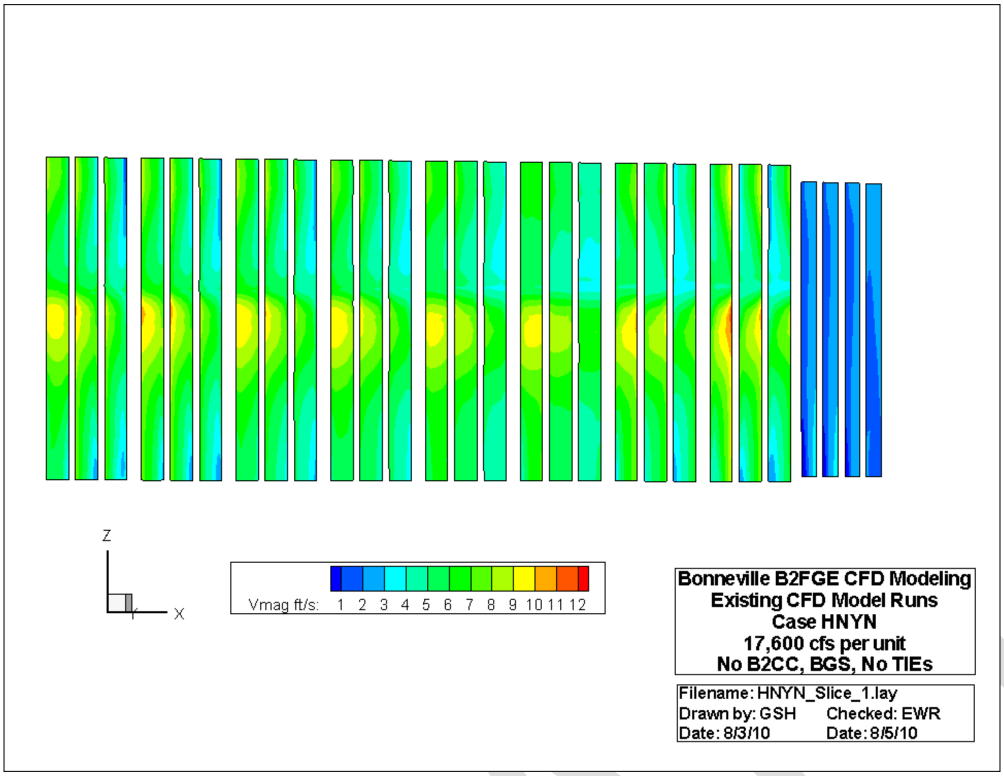


Figure 15. HNYN – Velocity Magnitude, Slice 1

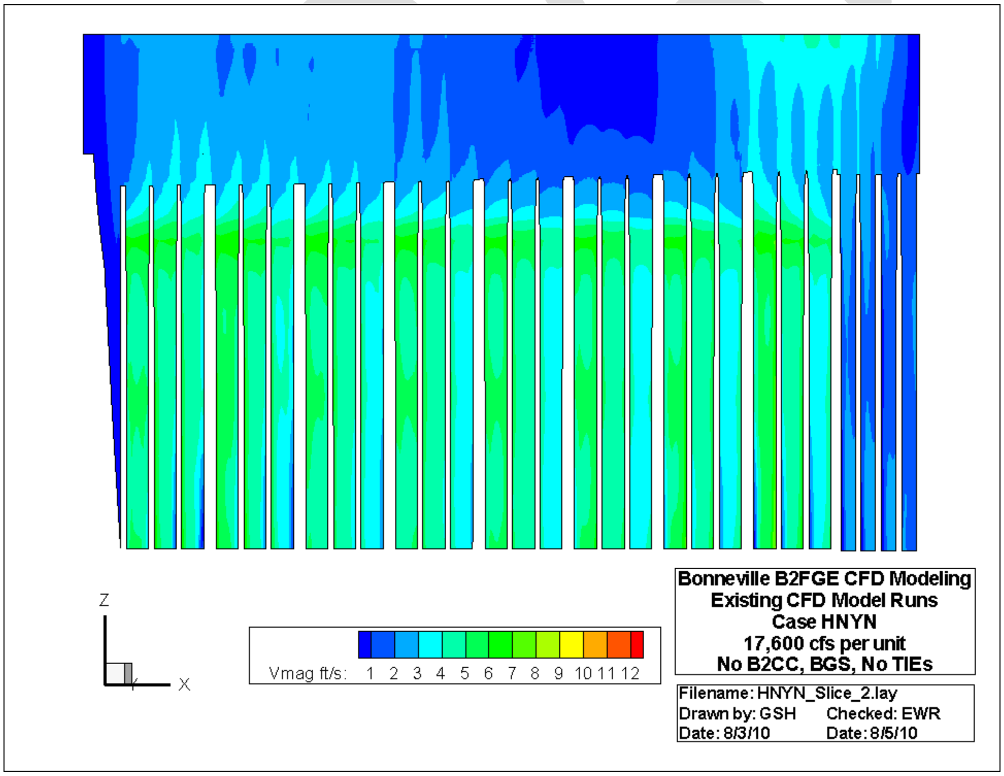


Figure 16. HNYN – Velocity Magnitude, Slice 2

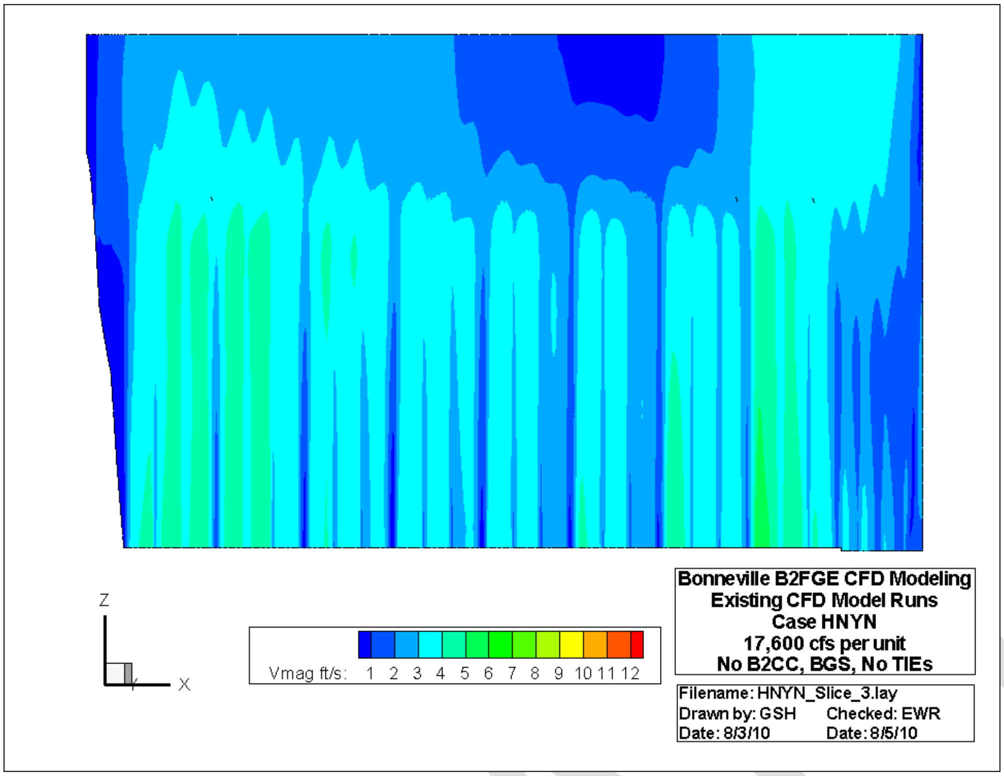


Figure 17. HNYN – Velocity Magnitude, Slice 3

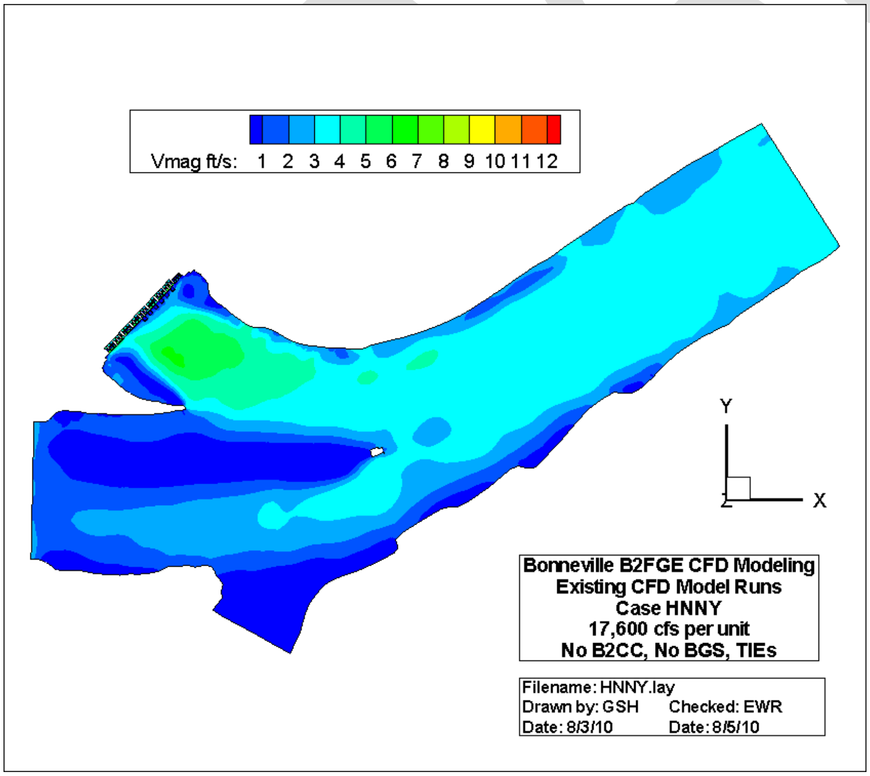


Figure 18. HNNY – Surface Velocity Magnitude, Entire Model Domain

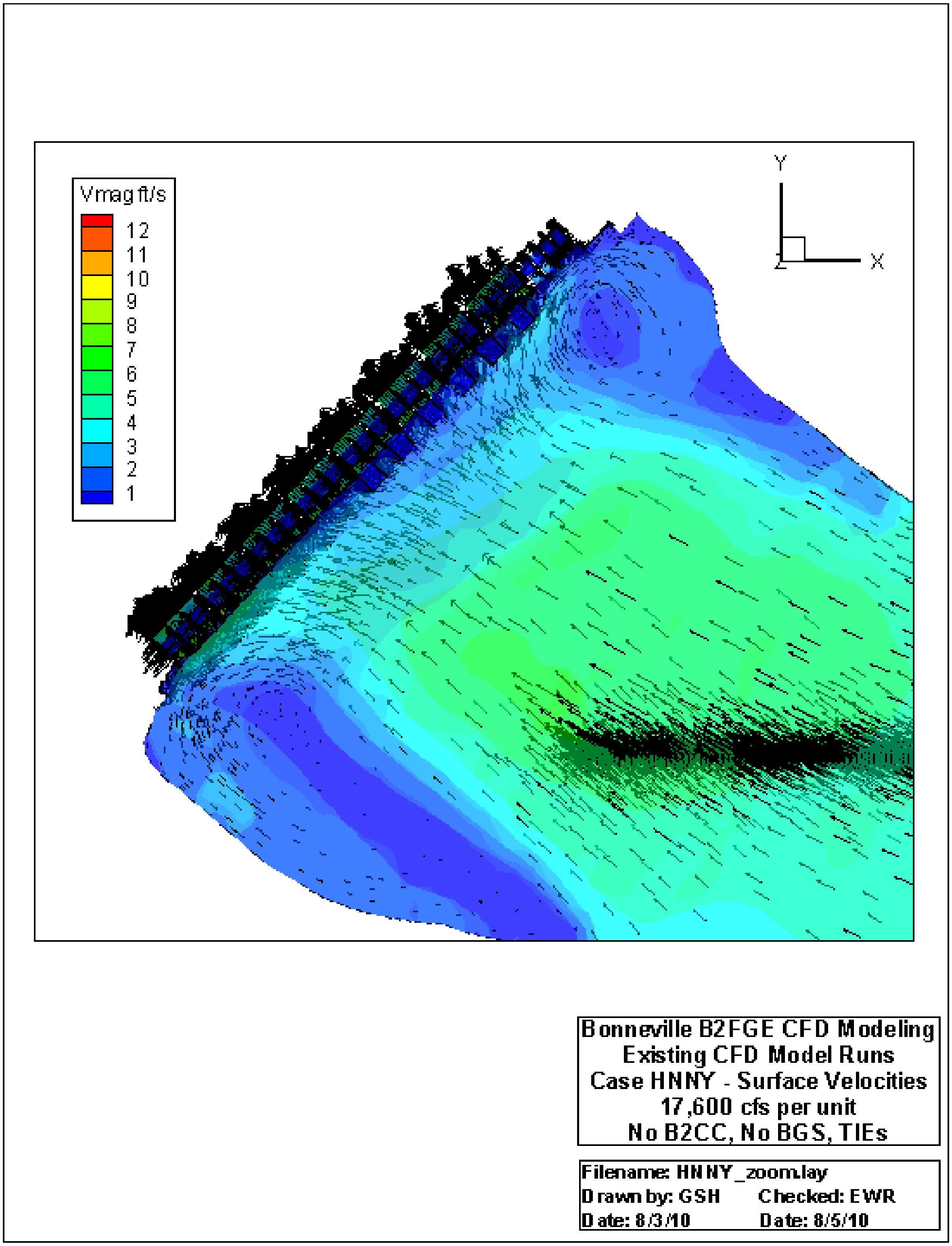


Figure 19. HNNY – Surface Velocities, near B2

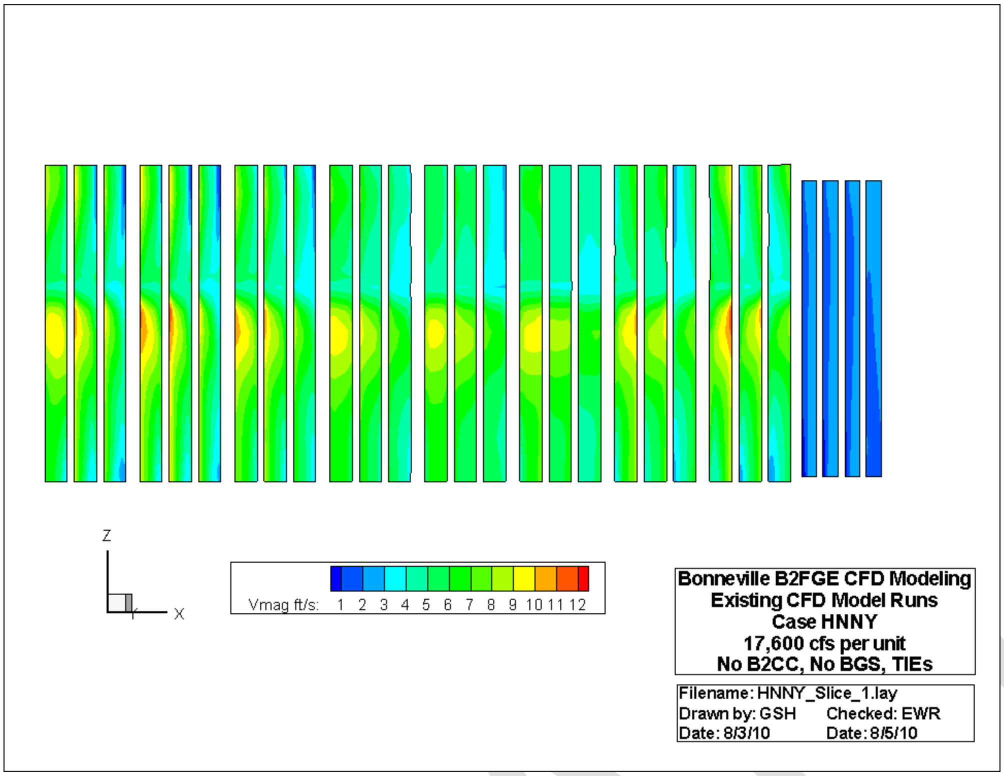


Figure 20. HNNY – Velocity Magnitude, Slice 1

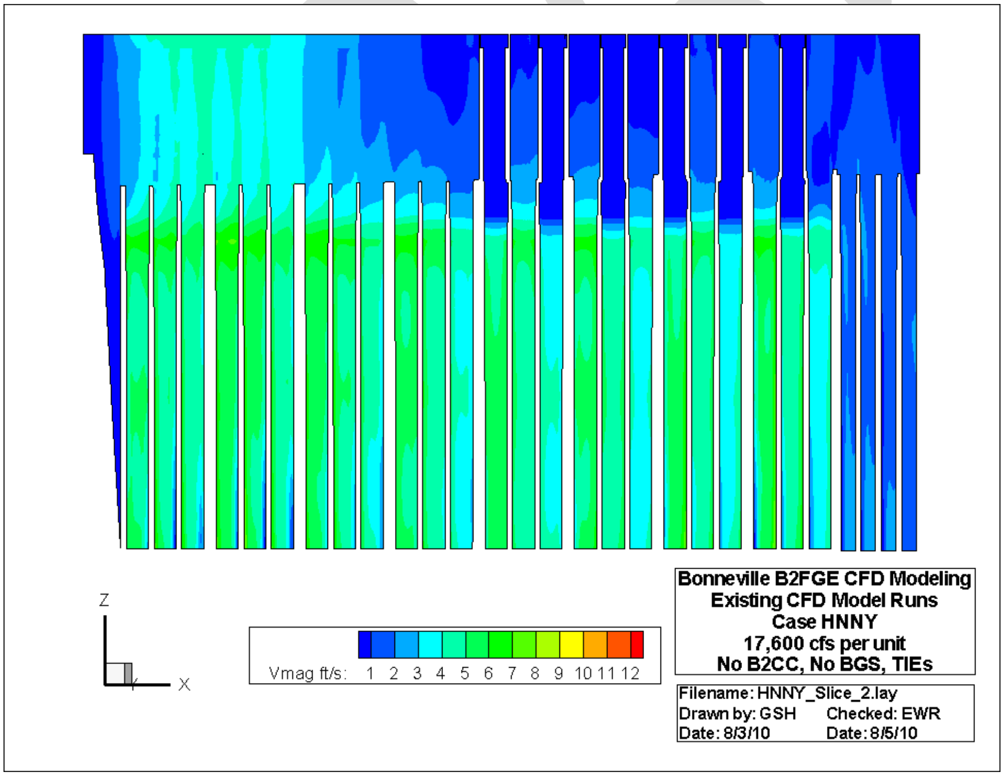


Figure 21. HNNY – Velocity Magnitude, Slice 2

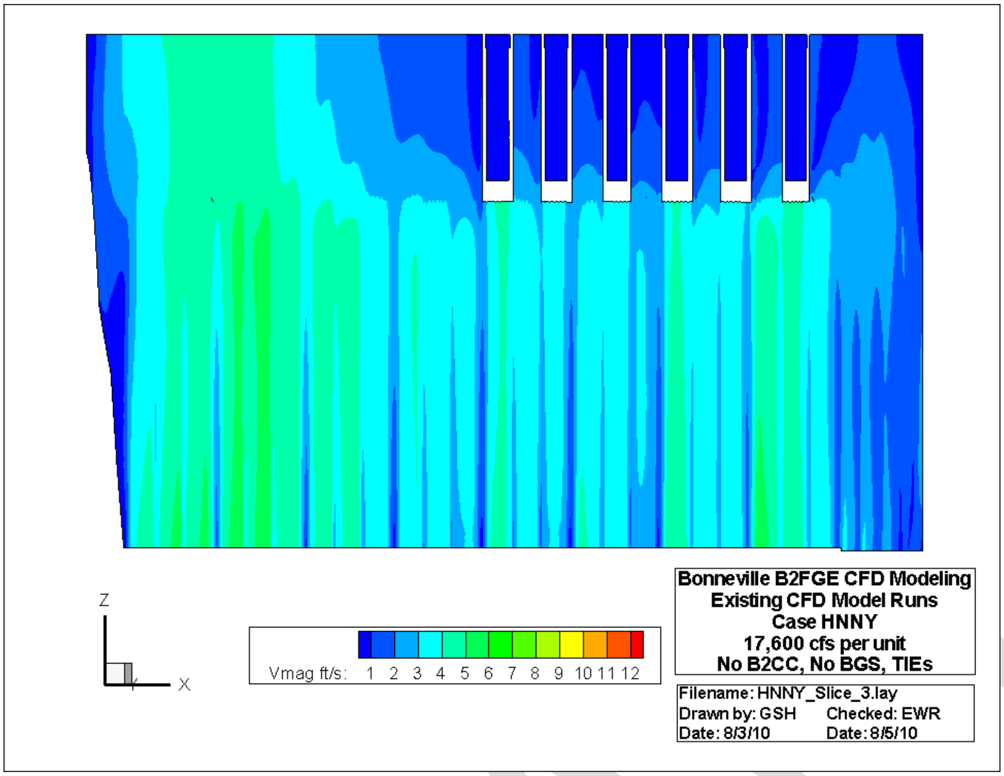


Figure 22. HNNY – Velocity Magnitude, Slice 3

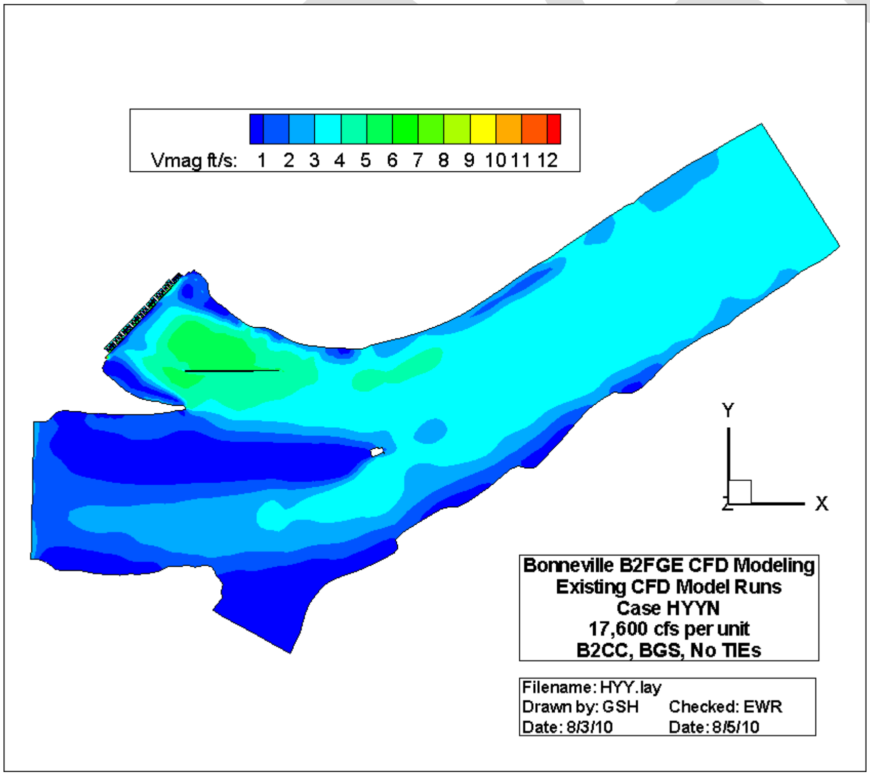


Figure 23. HYYN – Surface Velocity Magnitude, Entire Model Domain

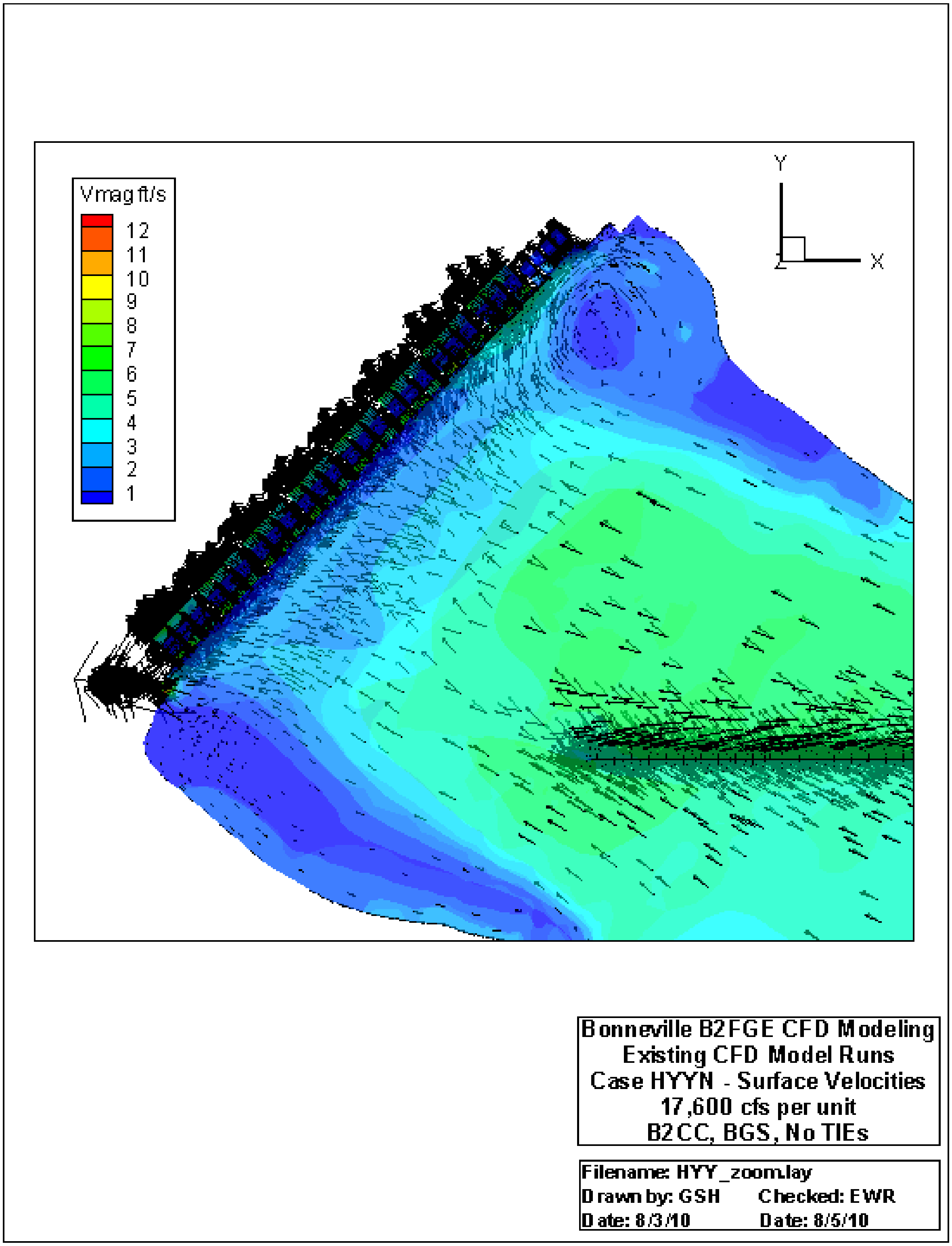


Figure 24. HYYN – Surface Velocities, near B2

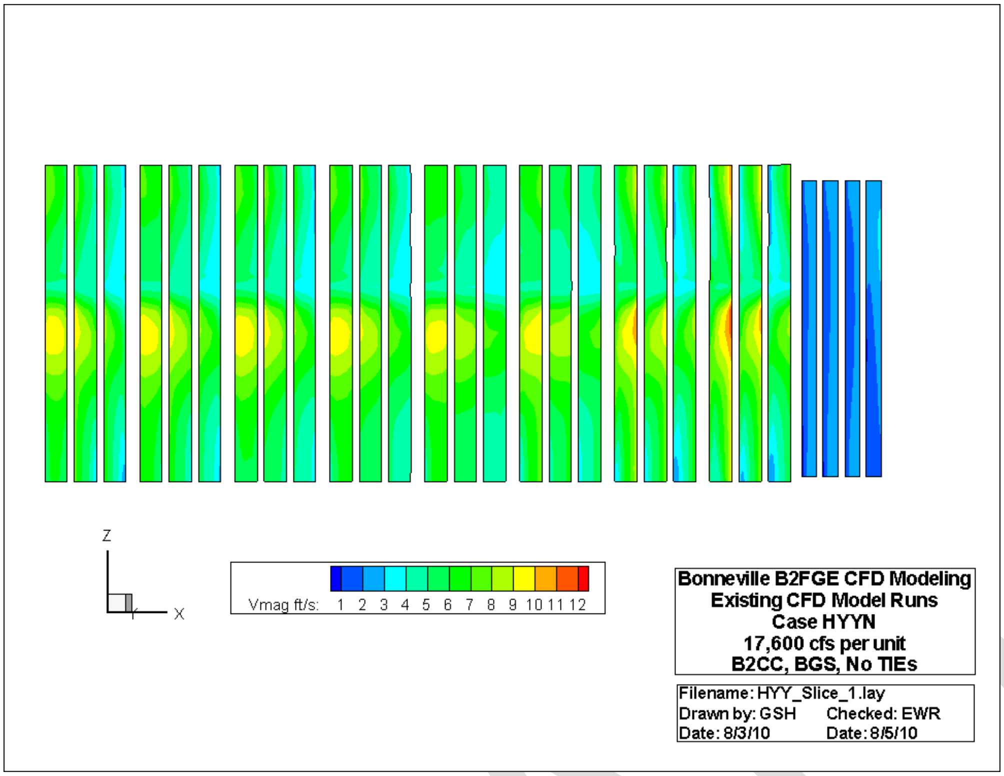


Figure 25. HYYN – Velocity Magnitude, Slice 1

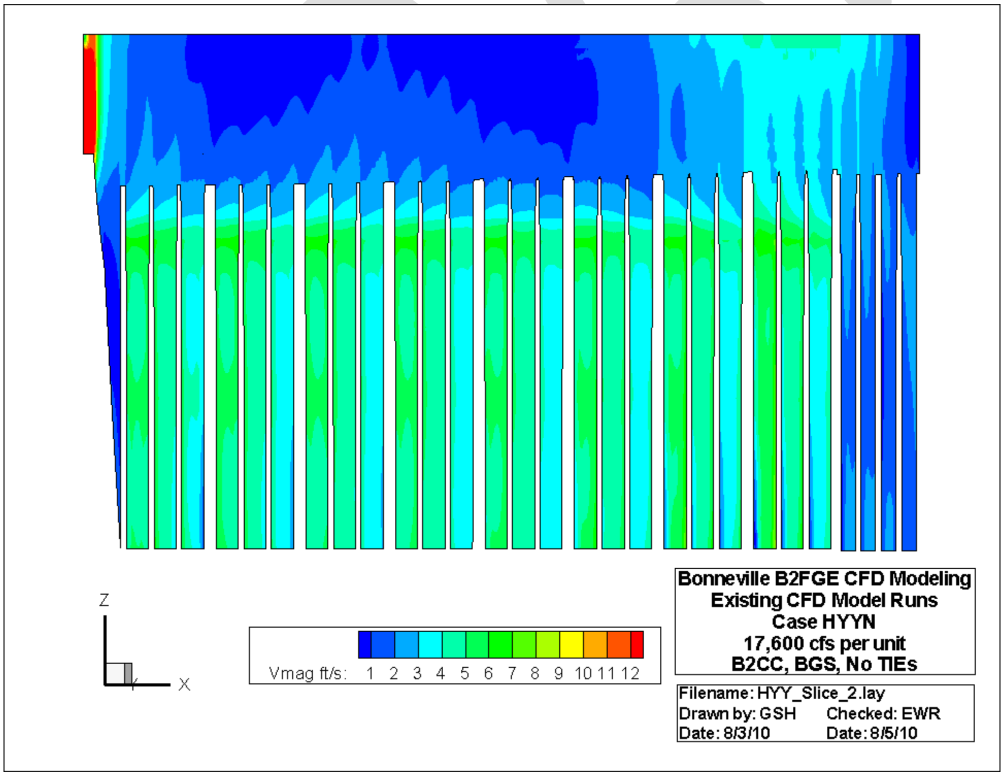


Figure 26. HYYN – Velocity Magnitude, Slice 2

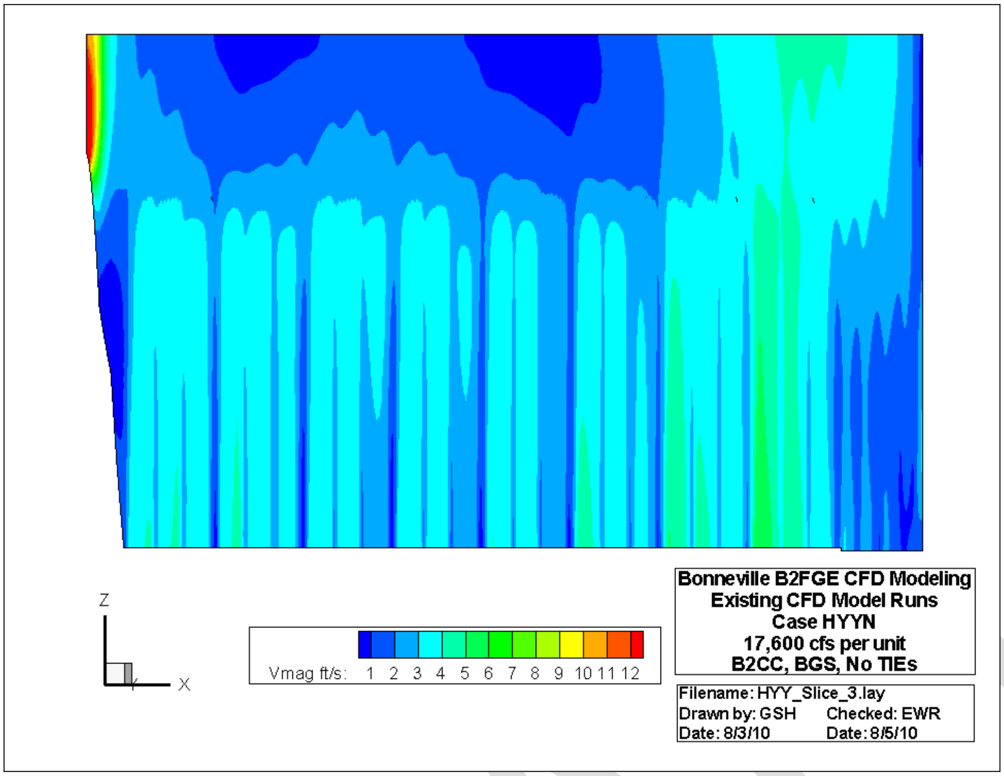


Figure 27. HYYN – Velocity Magnitude, Slice 3

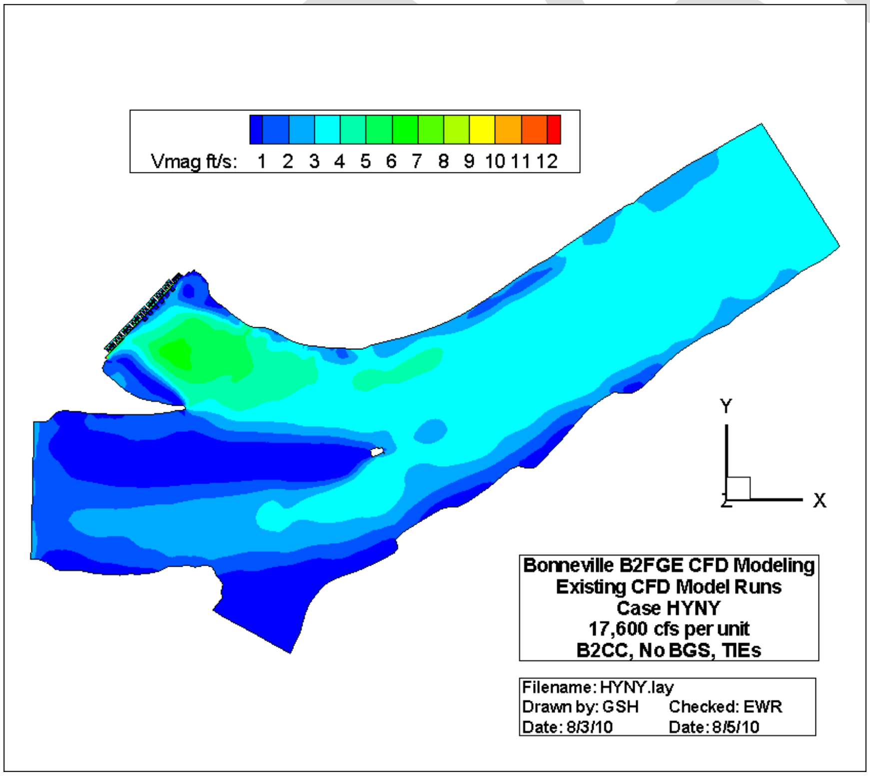
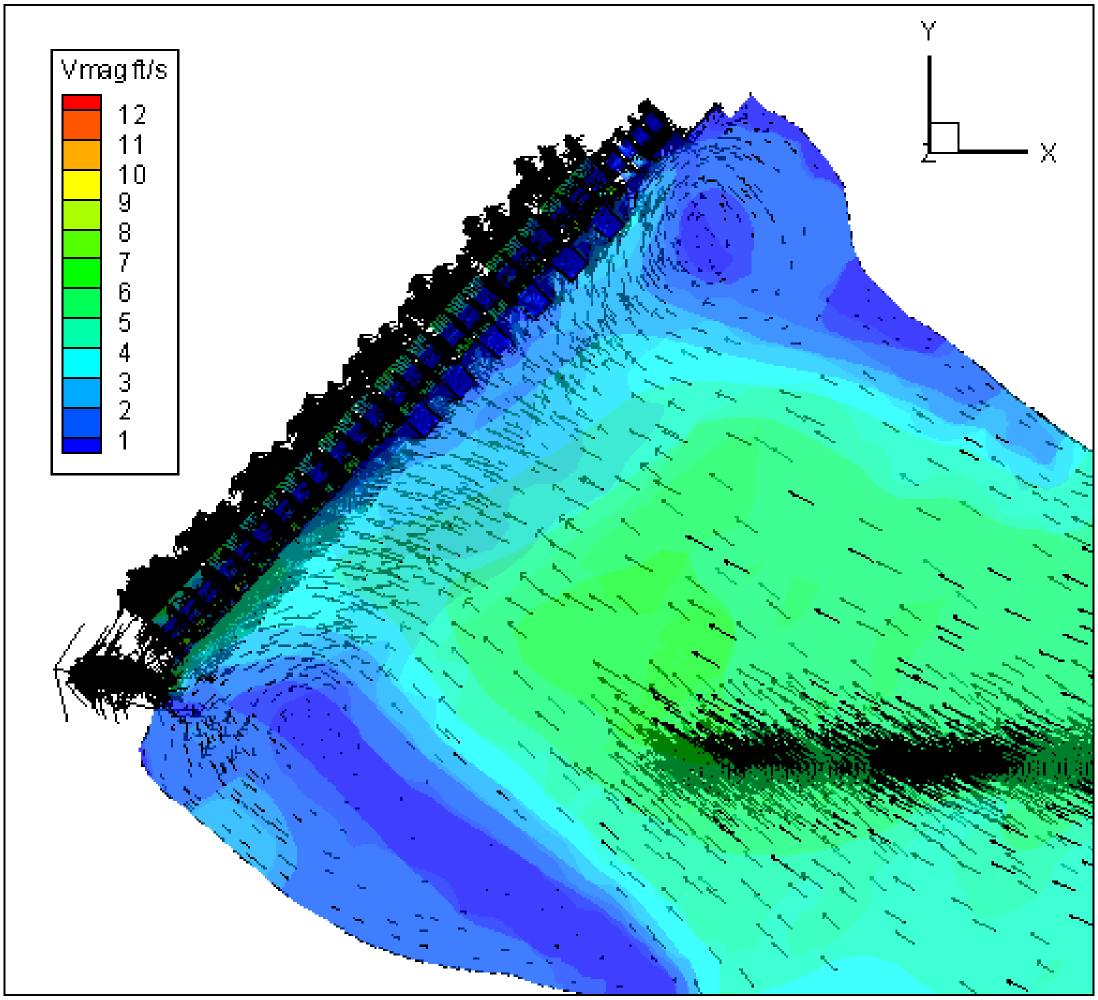


Figure 28. HYNY – Surface Velocity Magnitude, Entire Model Domain



Bonneville B2FGE CFD Modeling
Existing CFD Model Runs
Case HYNY - Surface Velocities
17,600 cfs per unit
B2CC, No BGS, TIEs

Filename: HYNY_zoom.lay
Drawn by: GSH Checked: EWR
Date: 8/3/10 Date: 8/5/10

Figure 29. HYNY – Surface Velocities, near B2

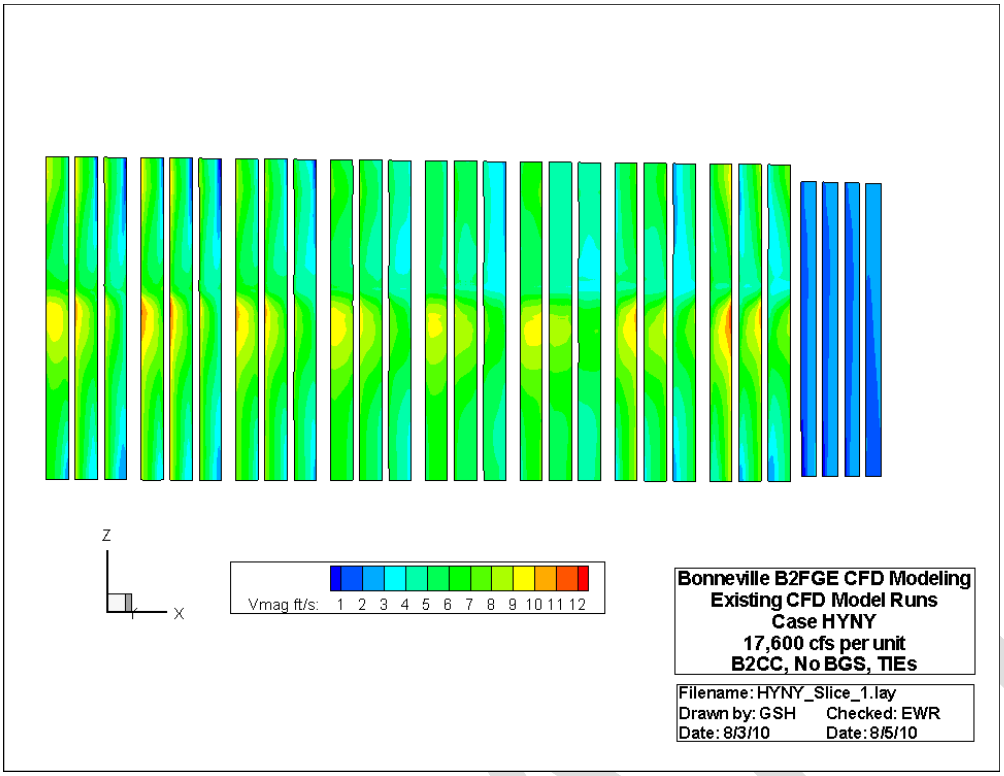


Figure 30. HYNY – Velocity Magnitude, Slice 1

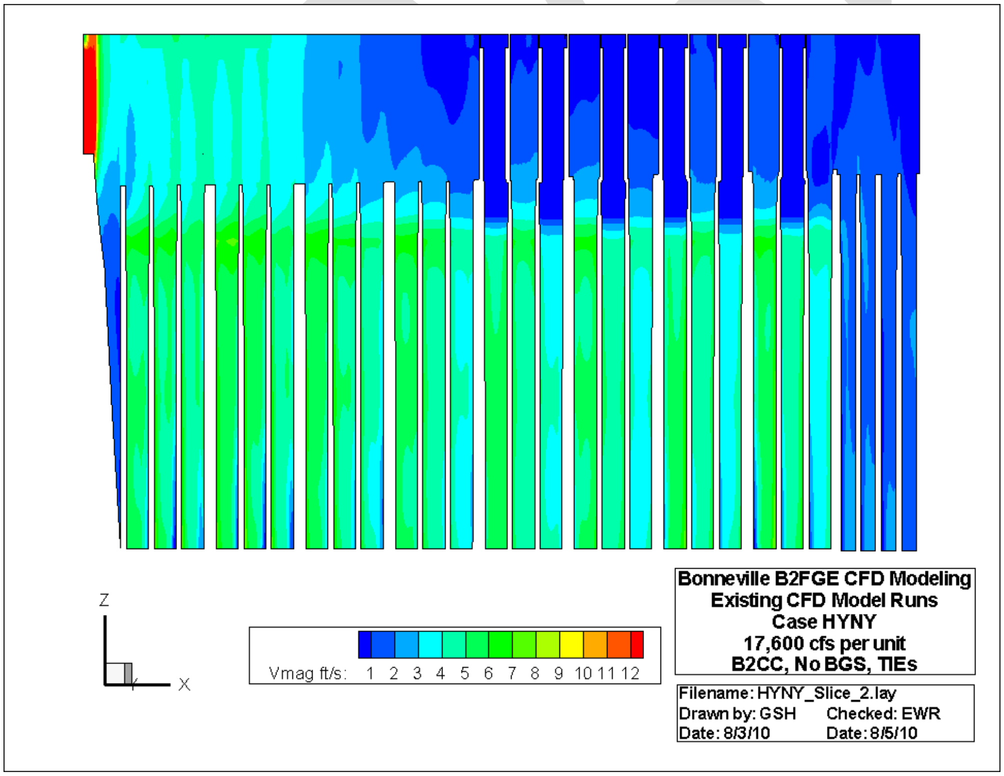


Figure 31. HYNY – Velocity Magnitude, Slice 2

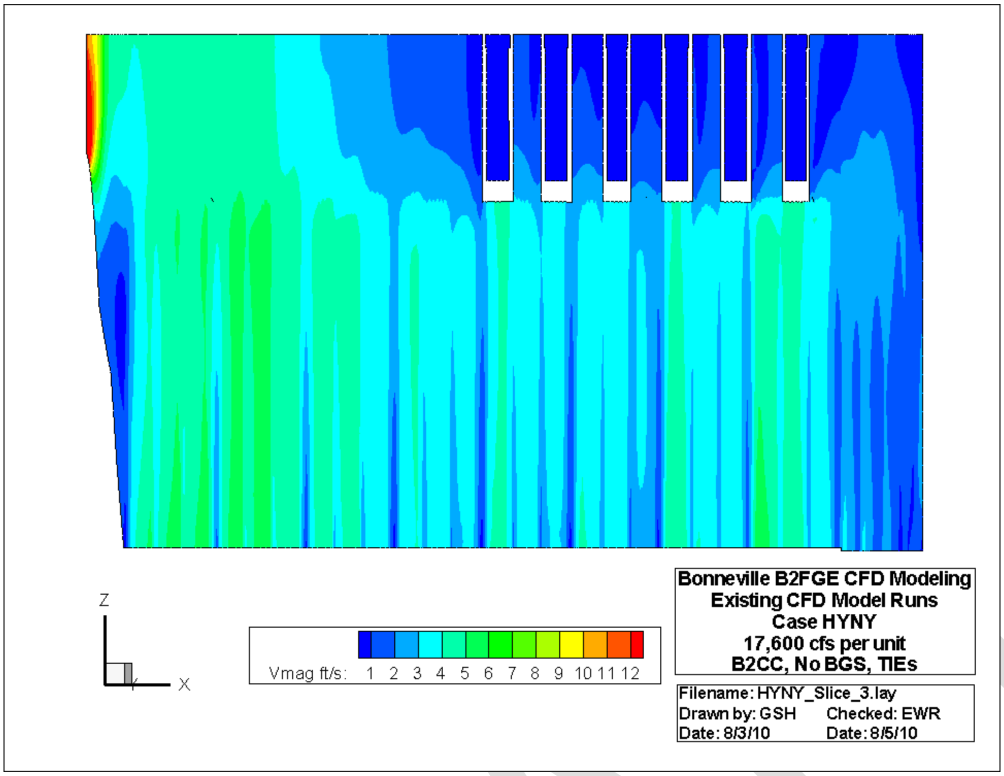


Figure 32. HYNY – Velocity Magnitude, Slice 3

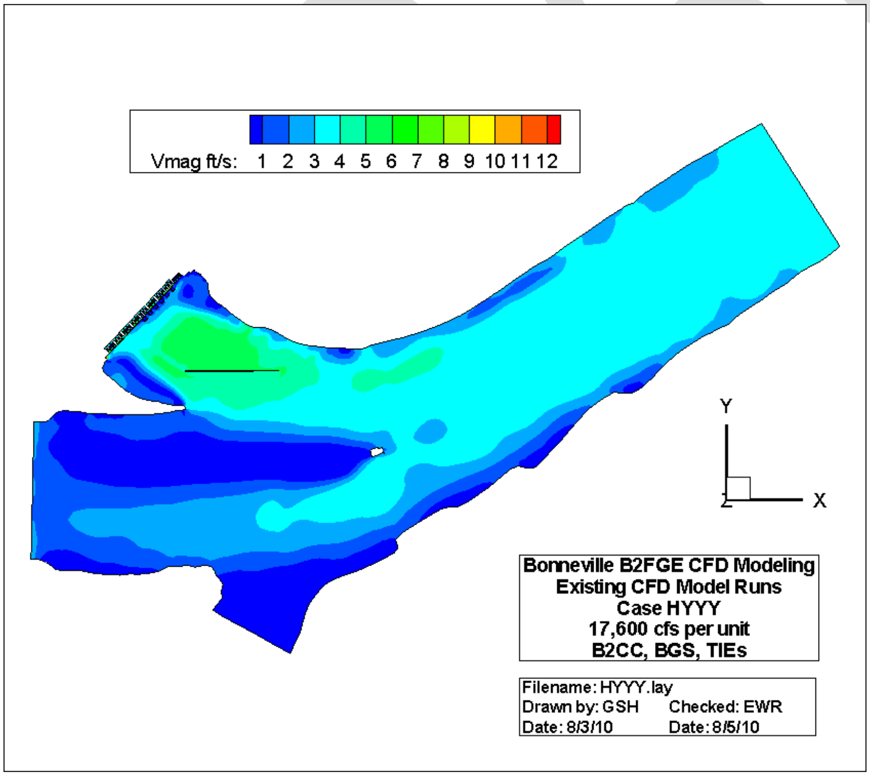


Figure 33. HYYY – Surface Velocity Magnitude, Entire Model Domain

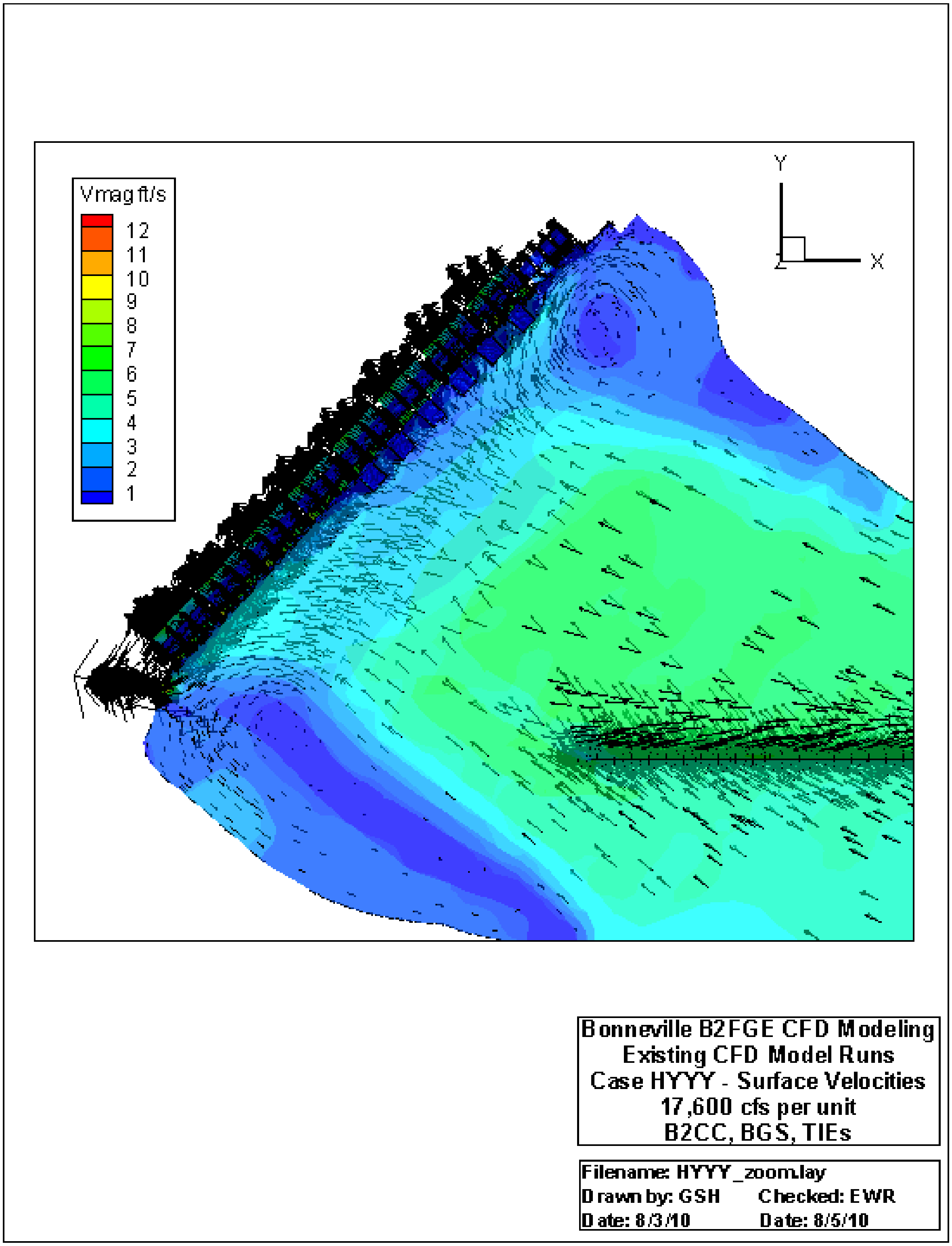


Figure 34. HYYY – Surface Velocities, near B2

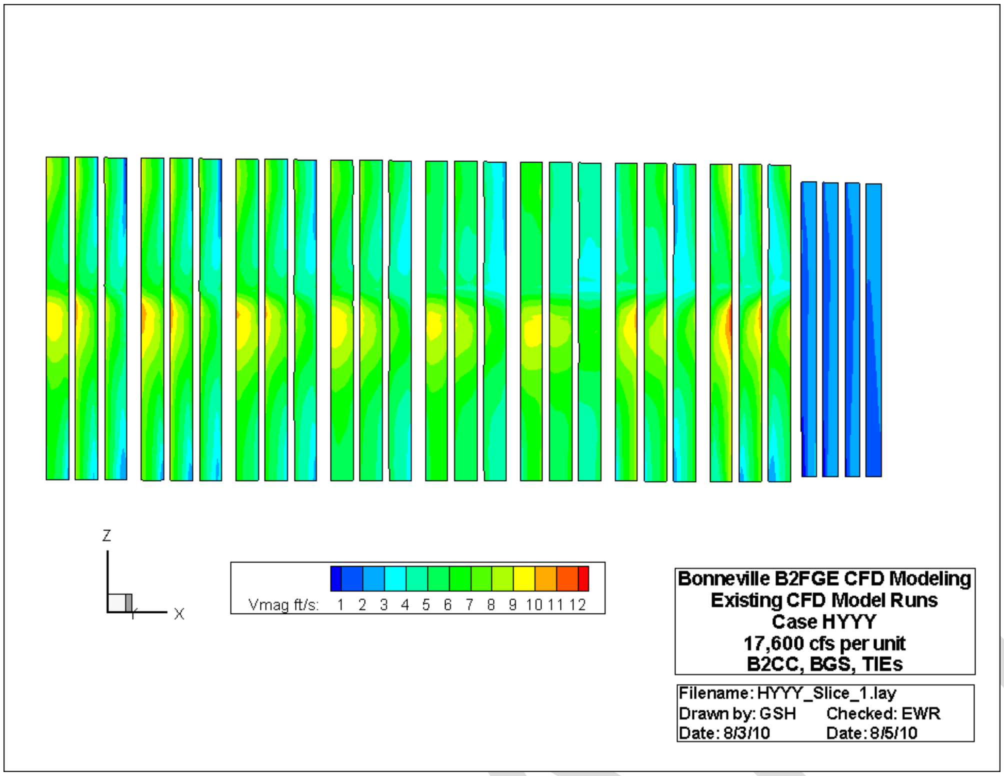


Figure 35. HYYY – Velocity Magnitude, Slice 1

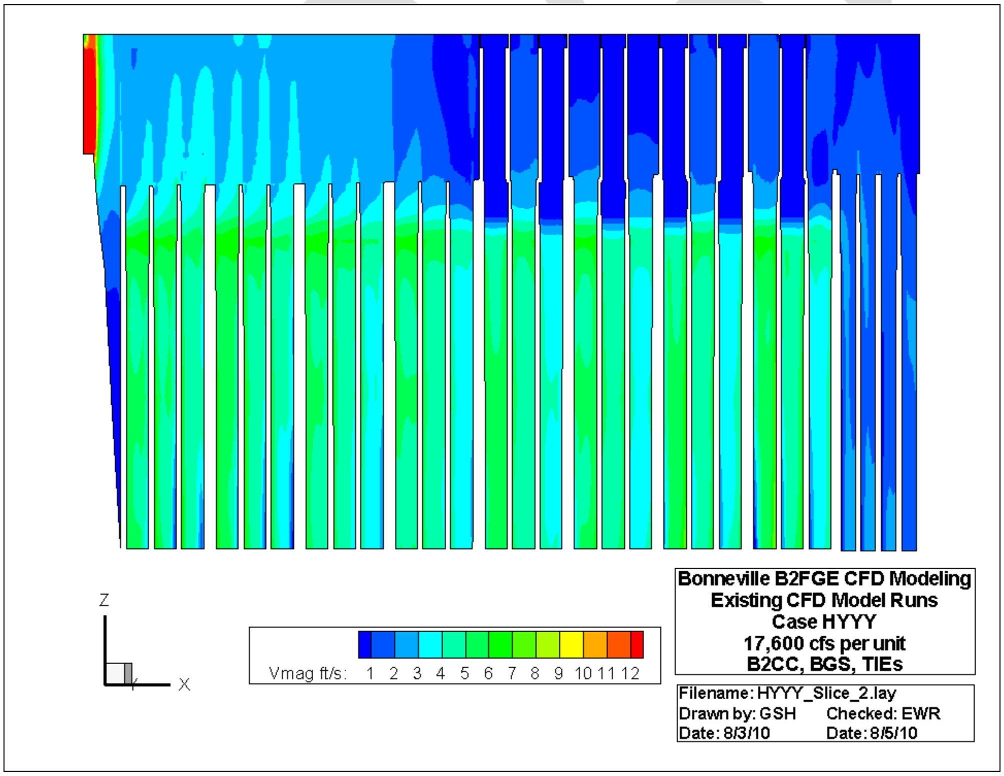


Figure 36. HYYY – Velocity Magnitude, Slice 2

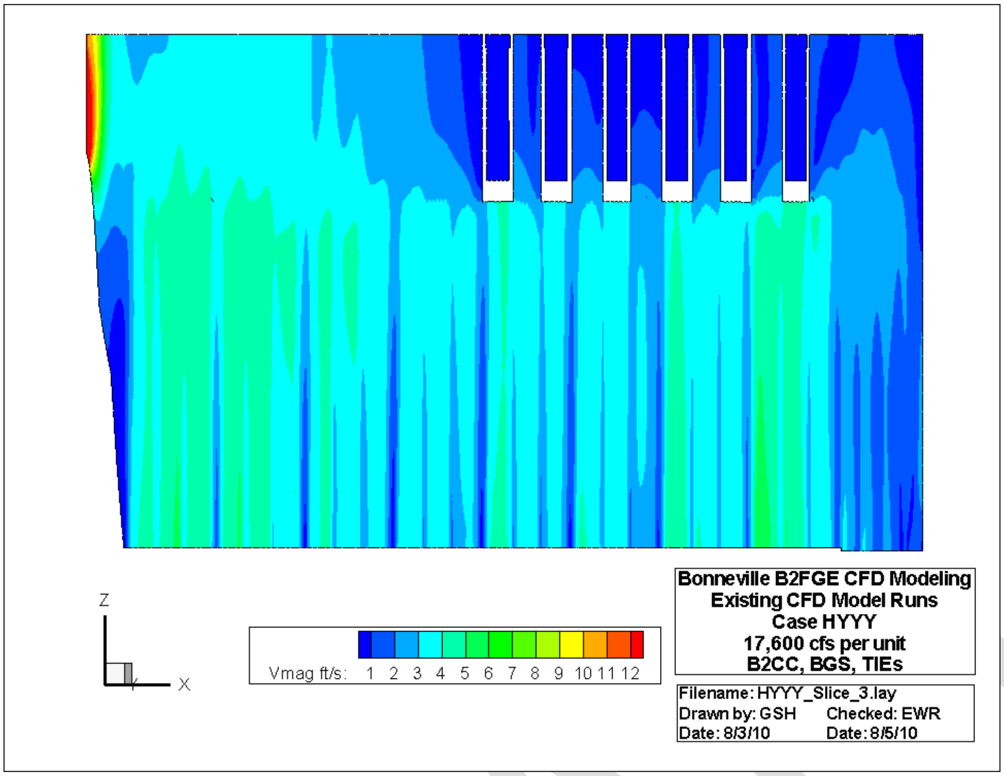


Figure 37. HYYY – Velocity Magnitude, Slice 3

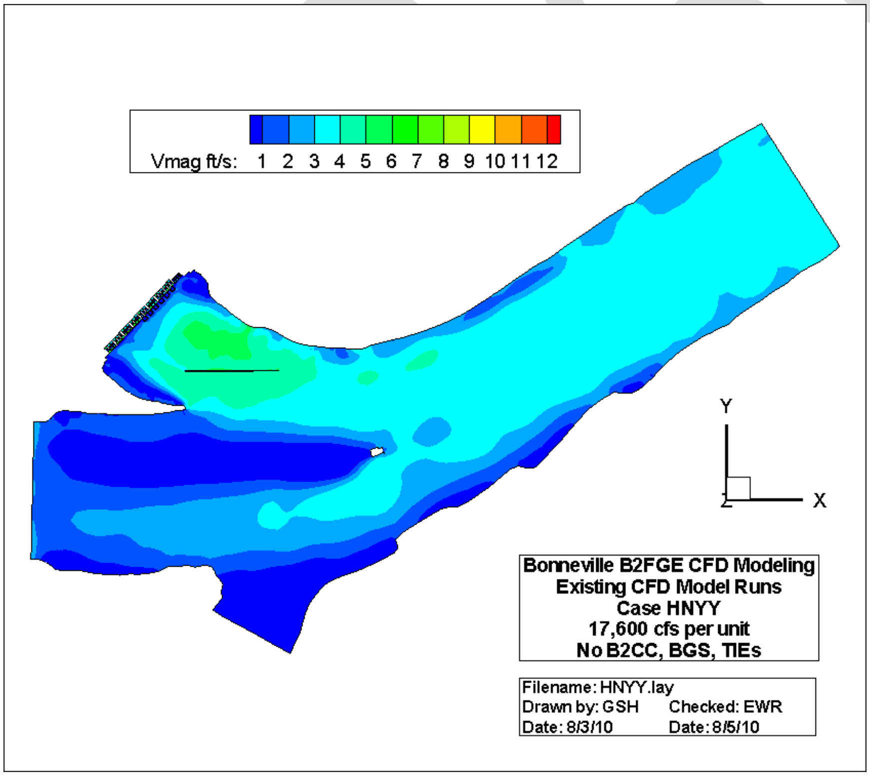


Figure 38. HNYY – Surface Velocity Magnitude, Entire Model Domain

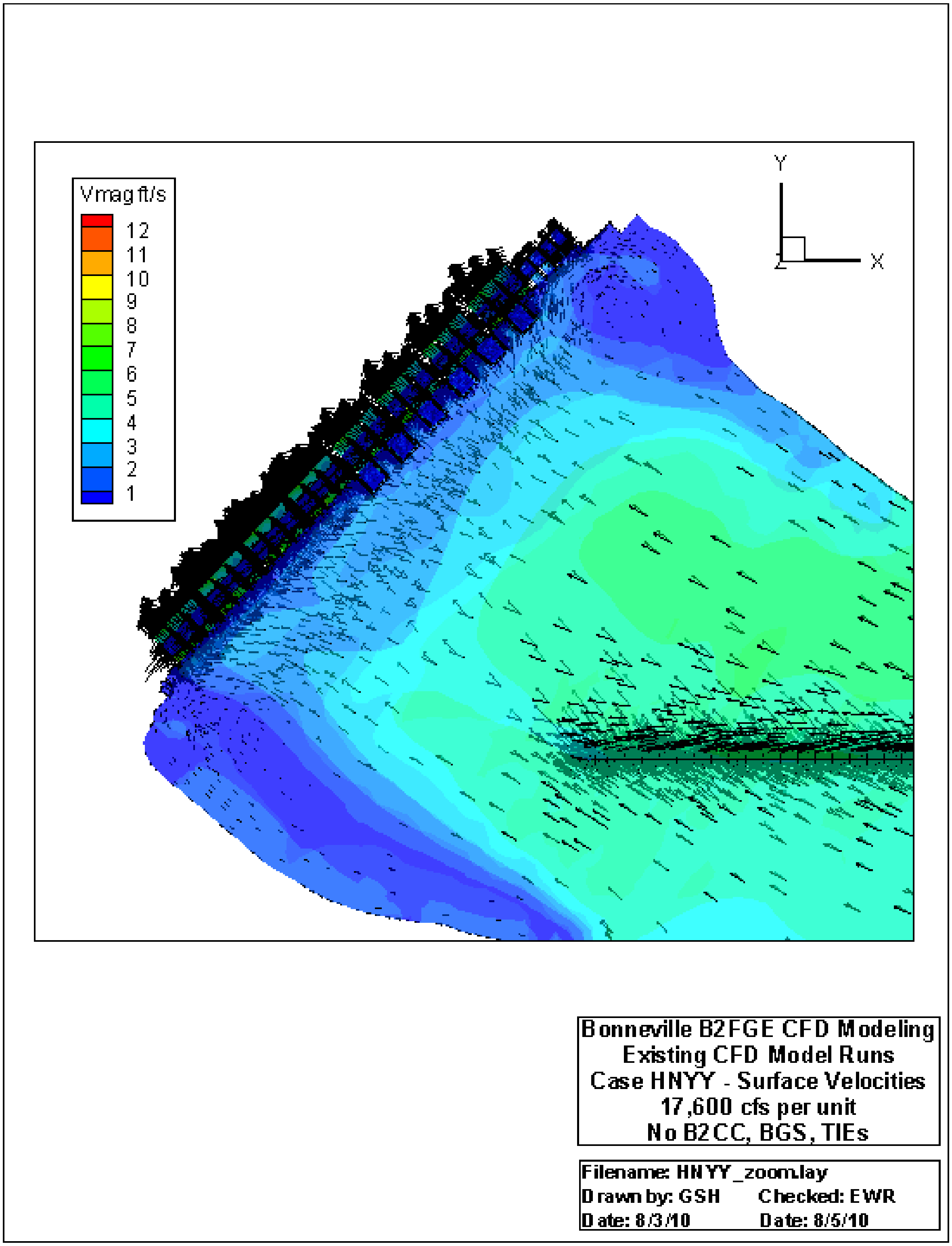


Figure 39. HNYY – Surface Velocities, near B2

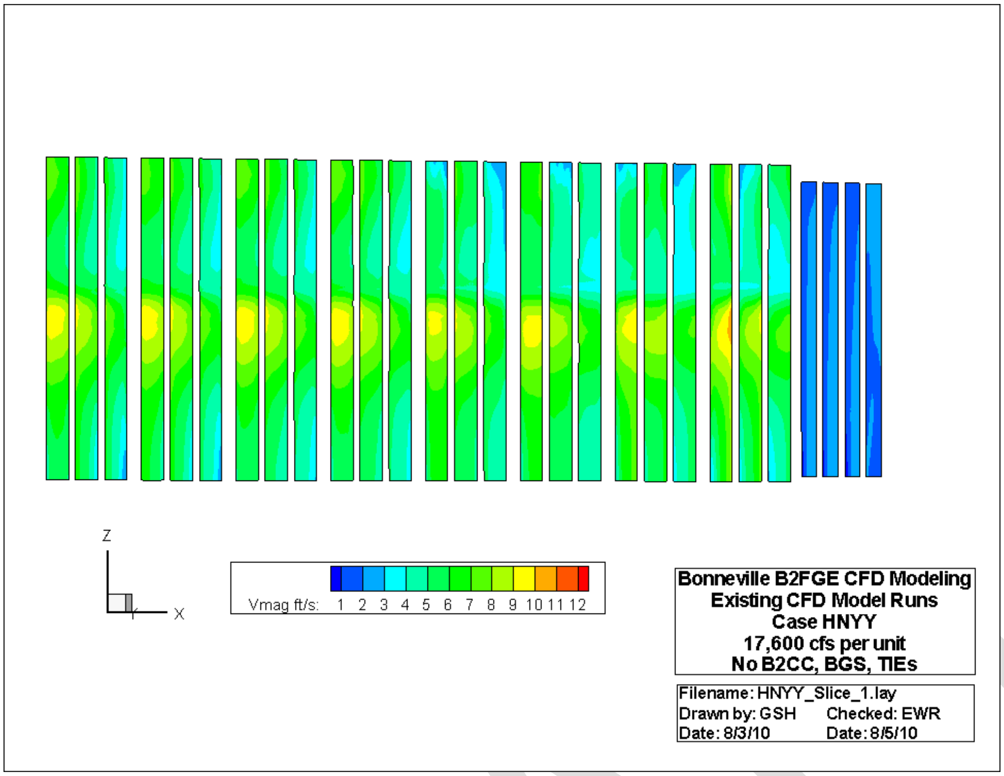


Figure 40. HNYY – Velocity Magnitude, Slice 1

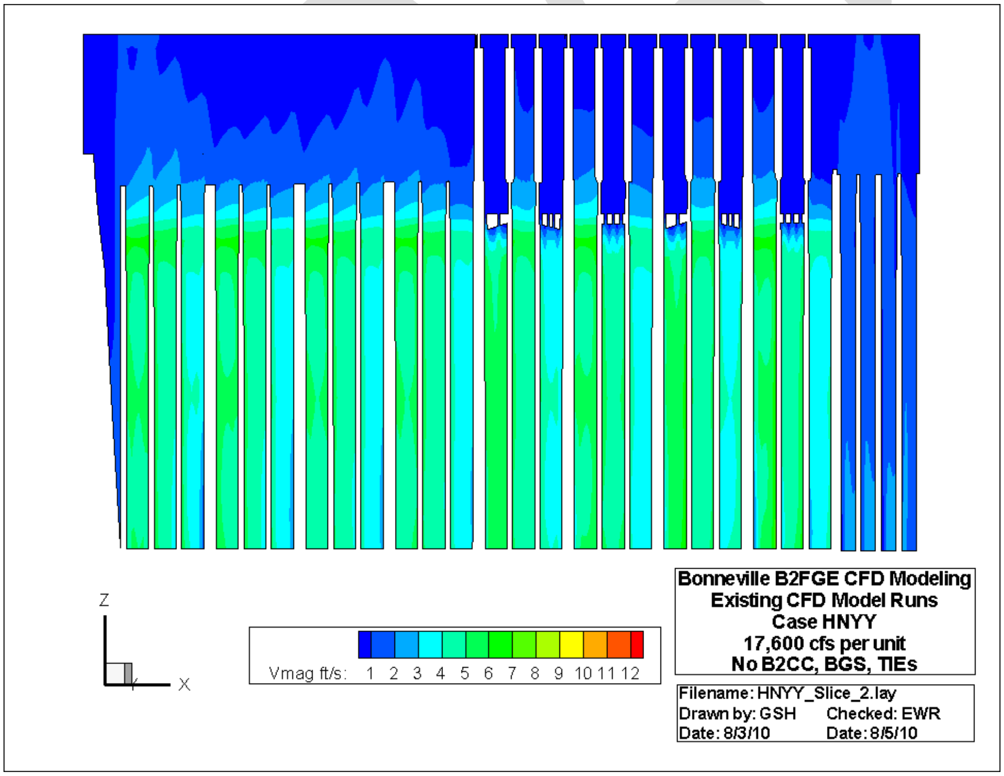


Figure 41. HNYY – Velocity Magnitude, Slice 2

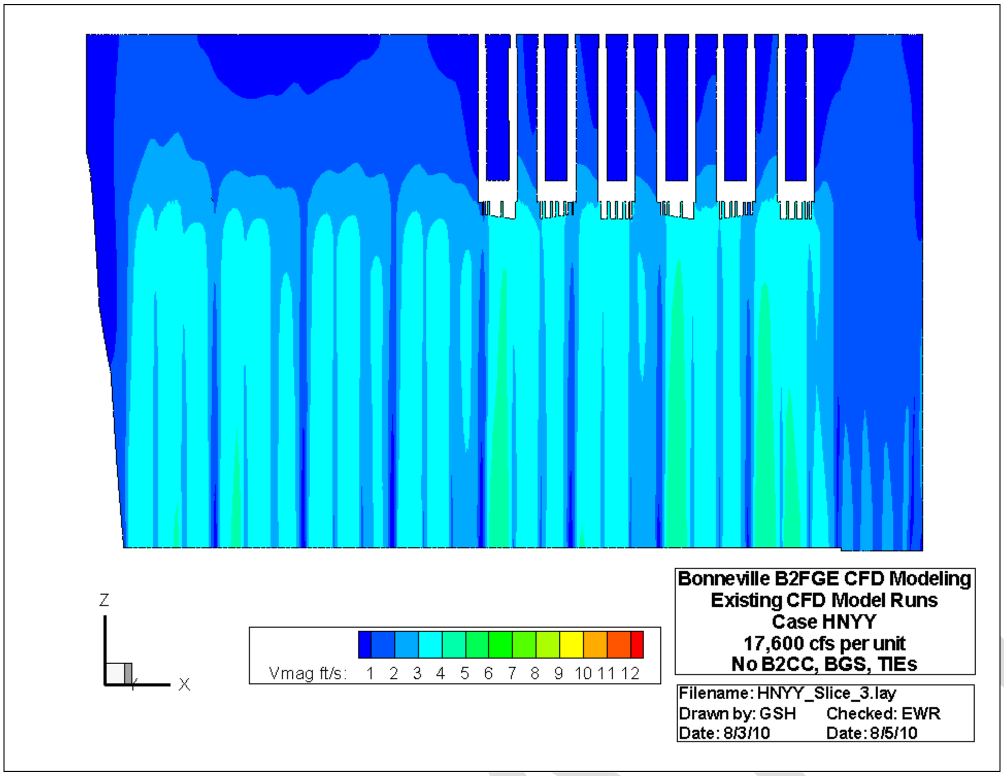


Figure 42. HNYY – Velocity Magnitude, Slice 3

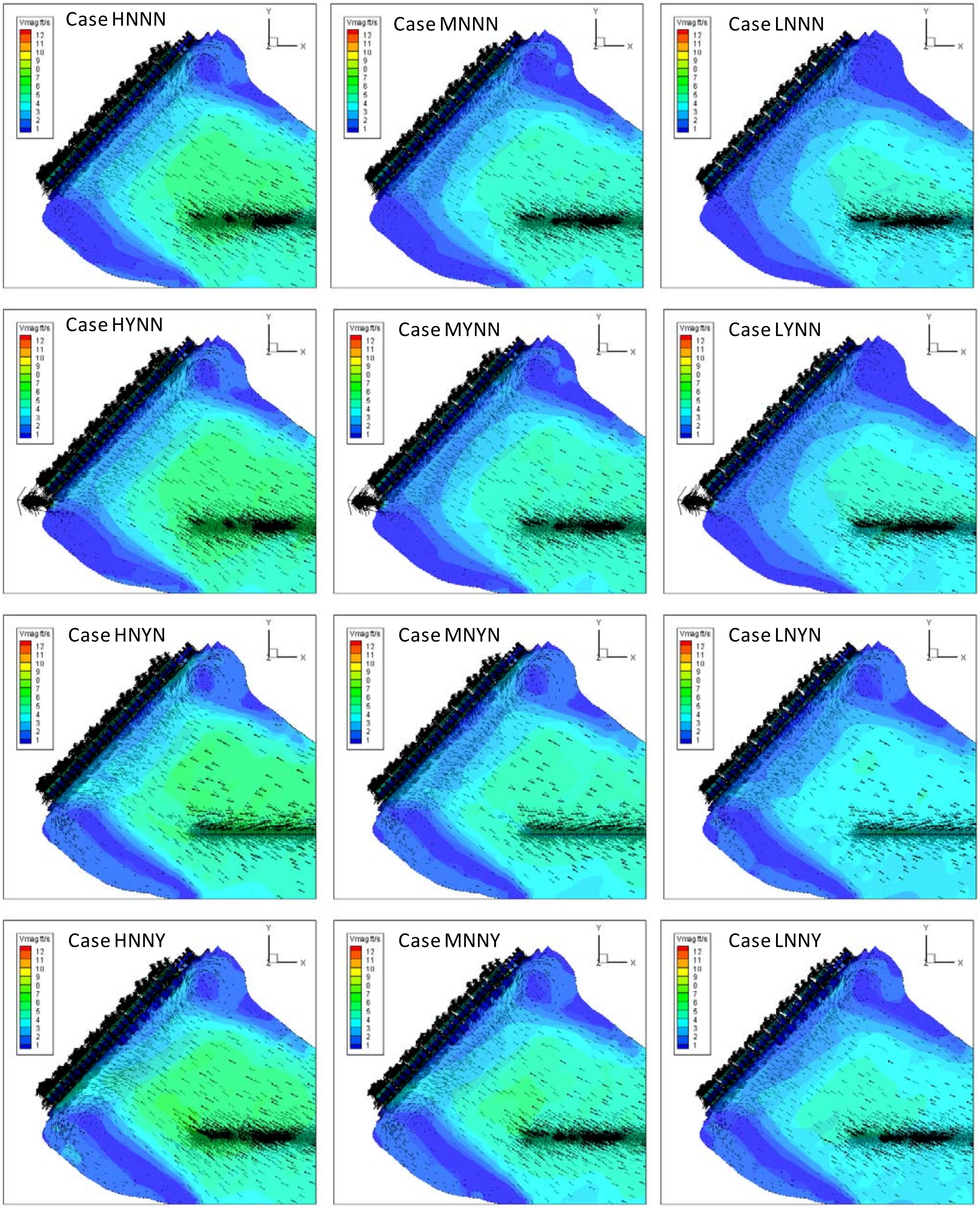


Figure 43. Comparison of Surface Velocities for High, Medium, and Low B2 Flows (1 of 2)

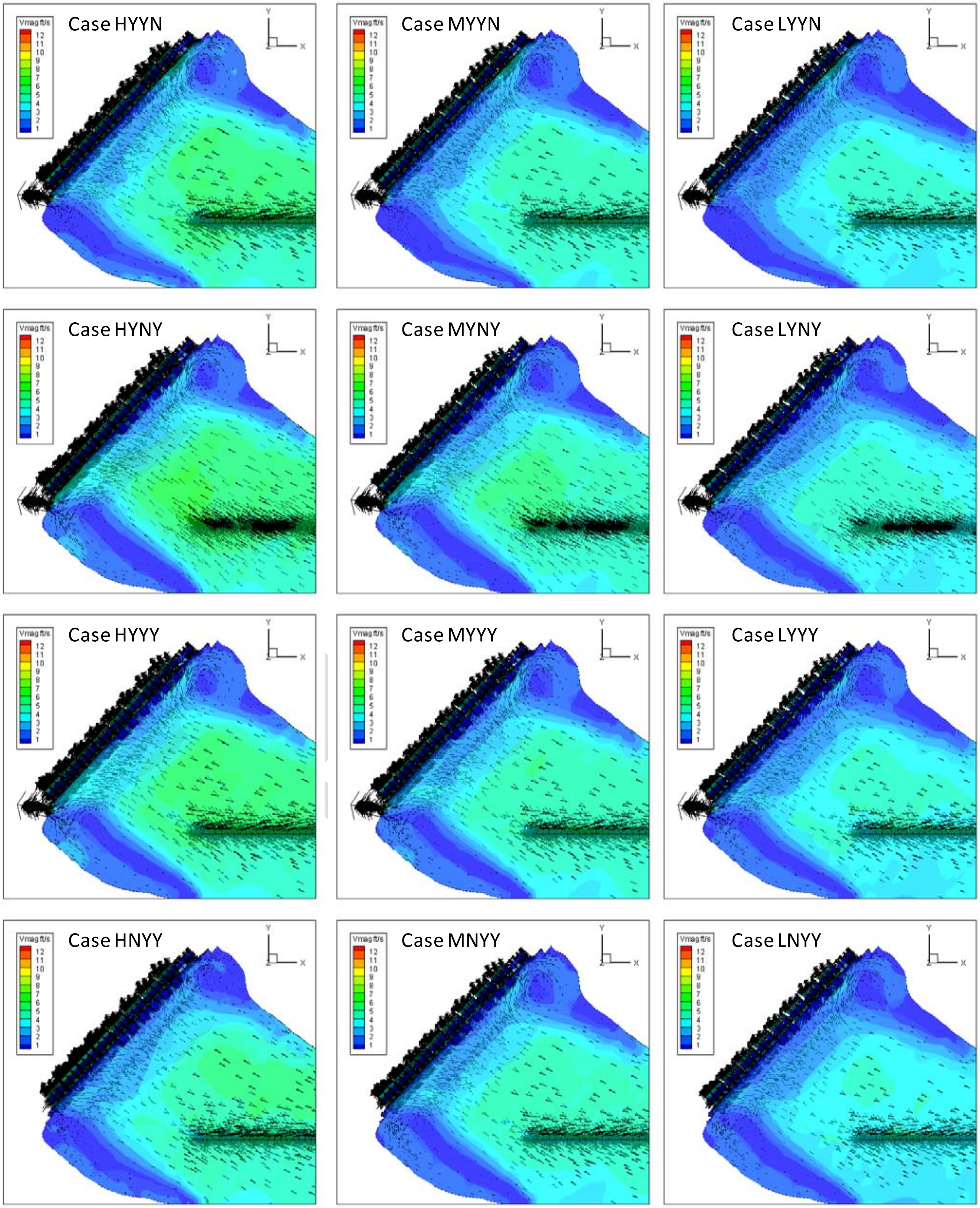


Figure 44. Comparison of Surface Velocities for High, Medium, and Low B2 Flows (2 of 2)

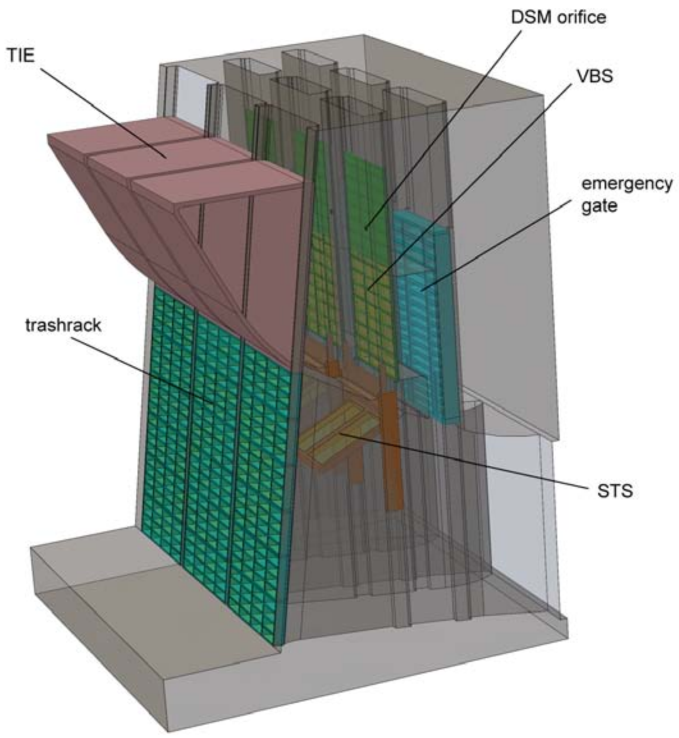


Figure 45. Isometric View of turbine unit

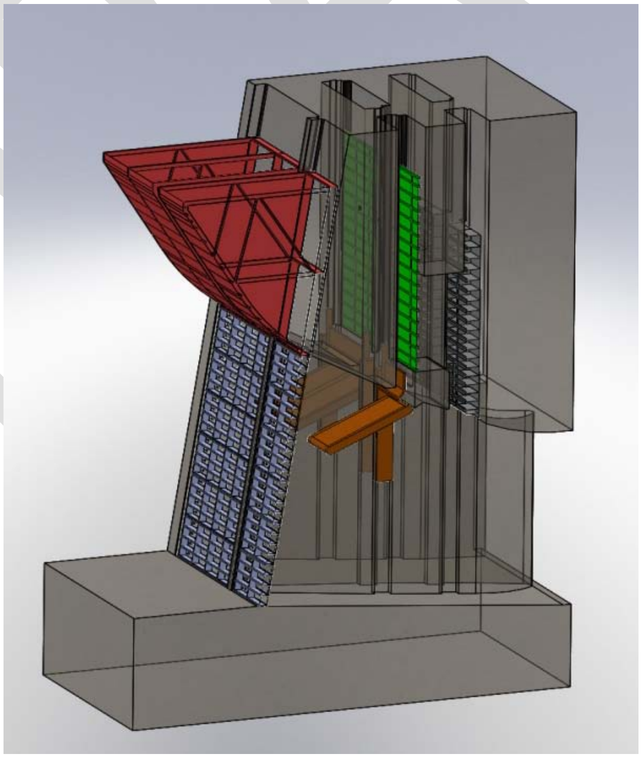


Figure 46: Section view of turbine unit

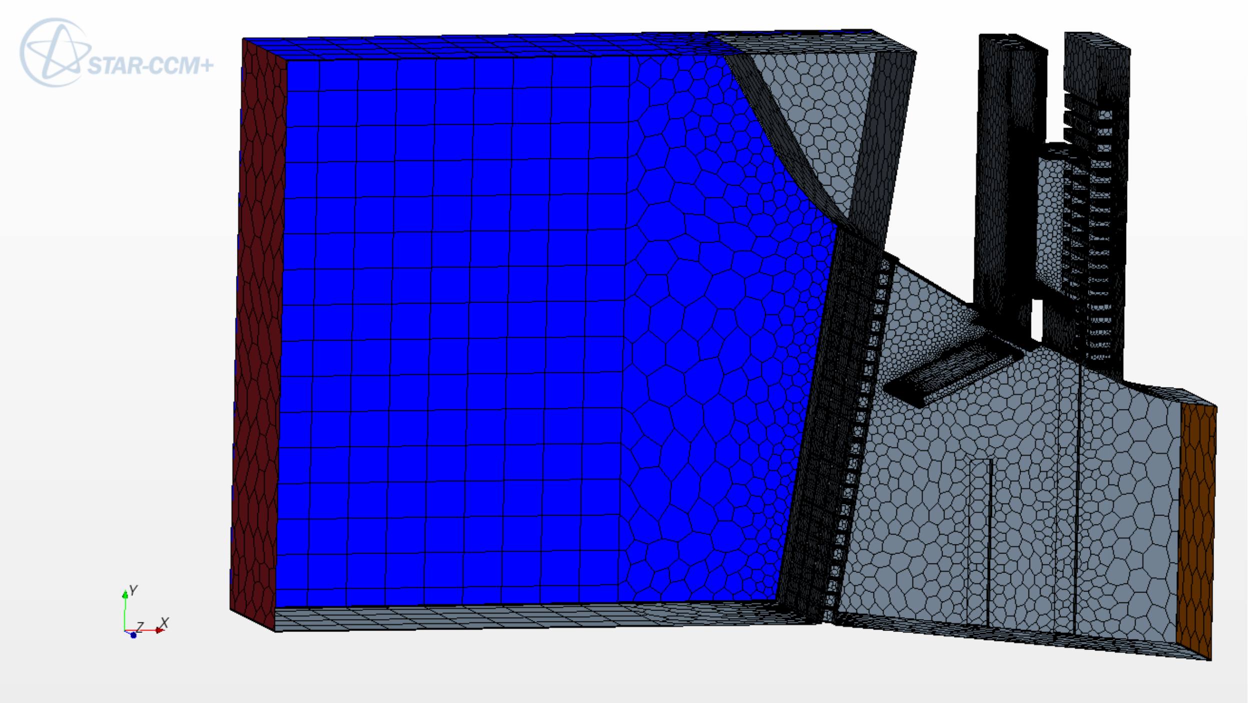


Figure 47. CFD Model Grid – Section View

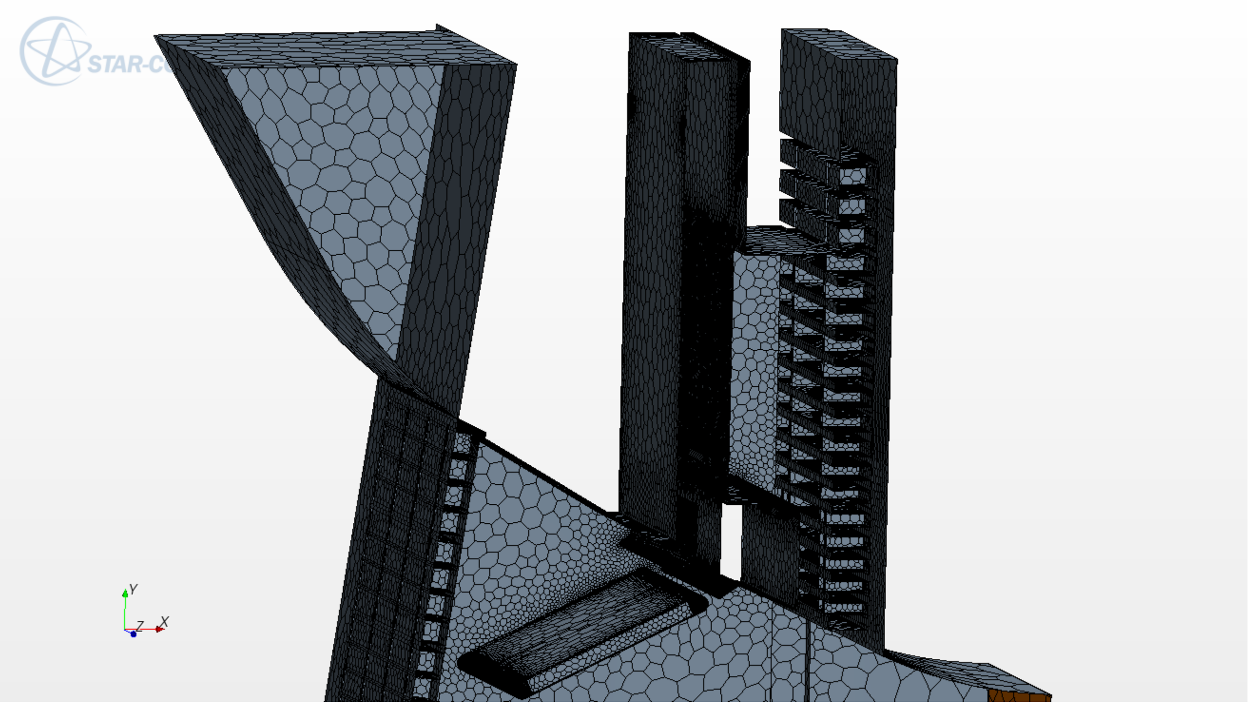


Figure 48. CFD Model Grid (Zoomed View)

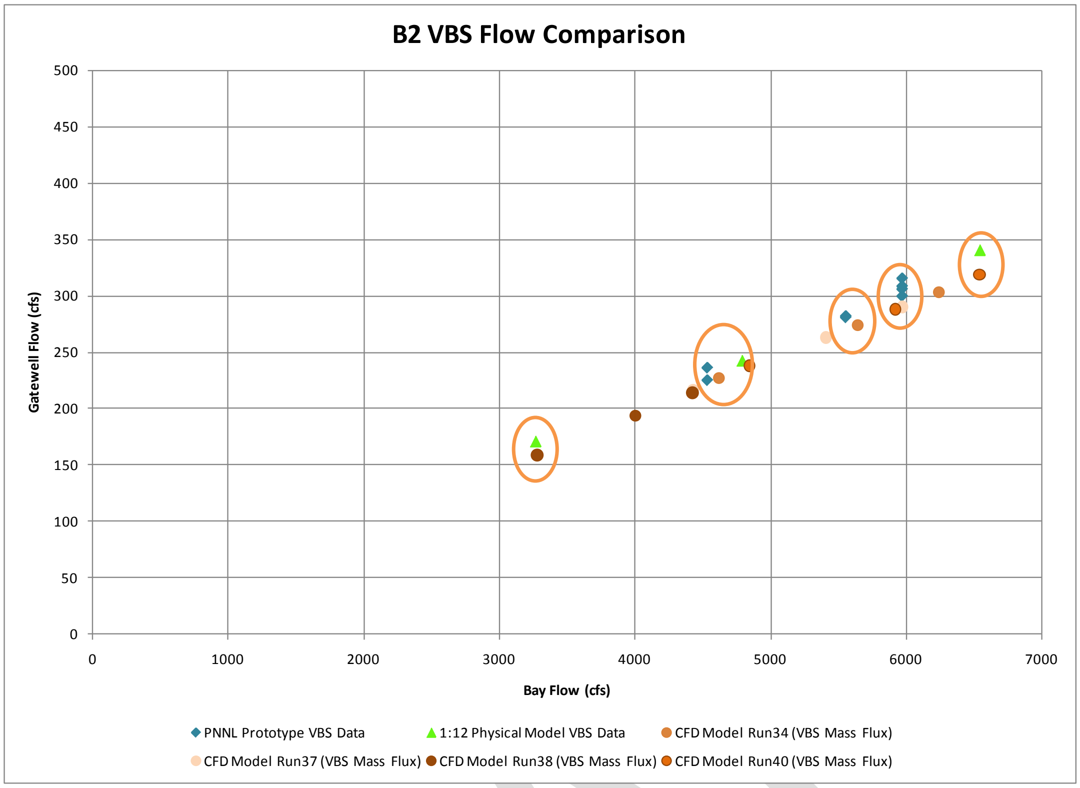


Figure 49. VBS Flow Comparison

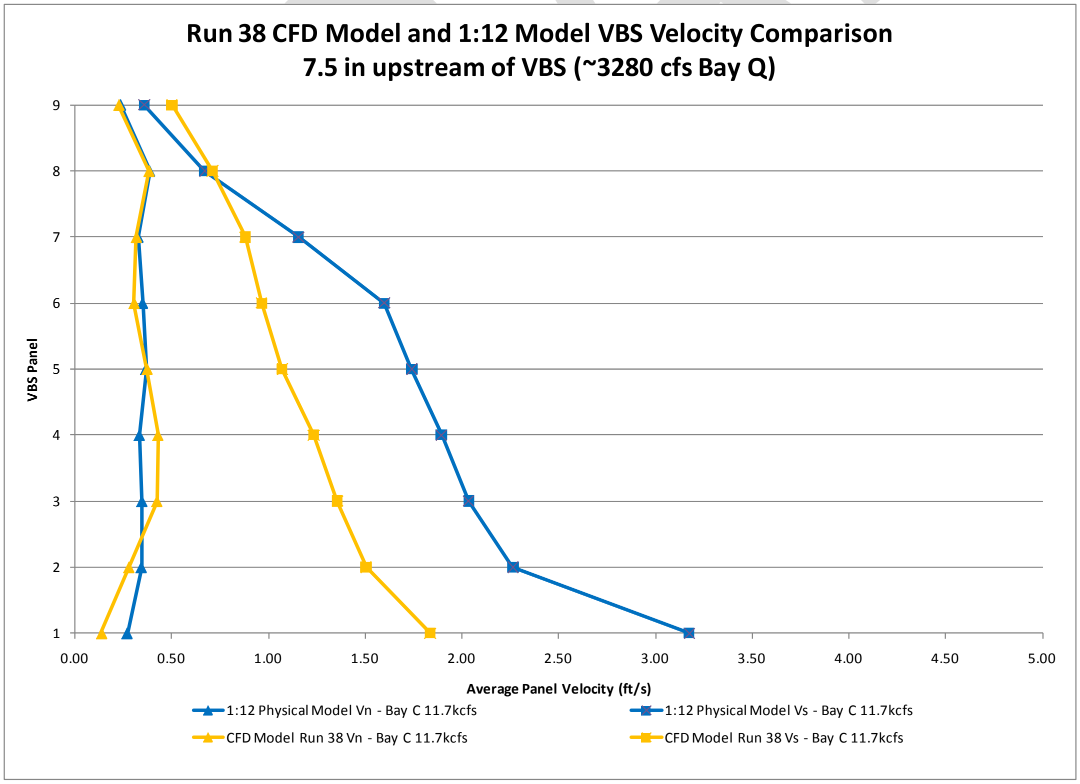


Figure 50. VBS Normal and Sweeping Velocity Comparisons (Bay Flow ~ 3,280 cfs)

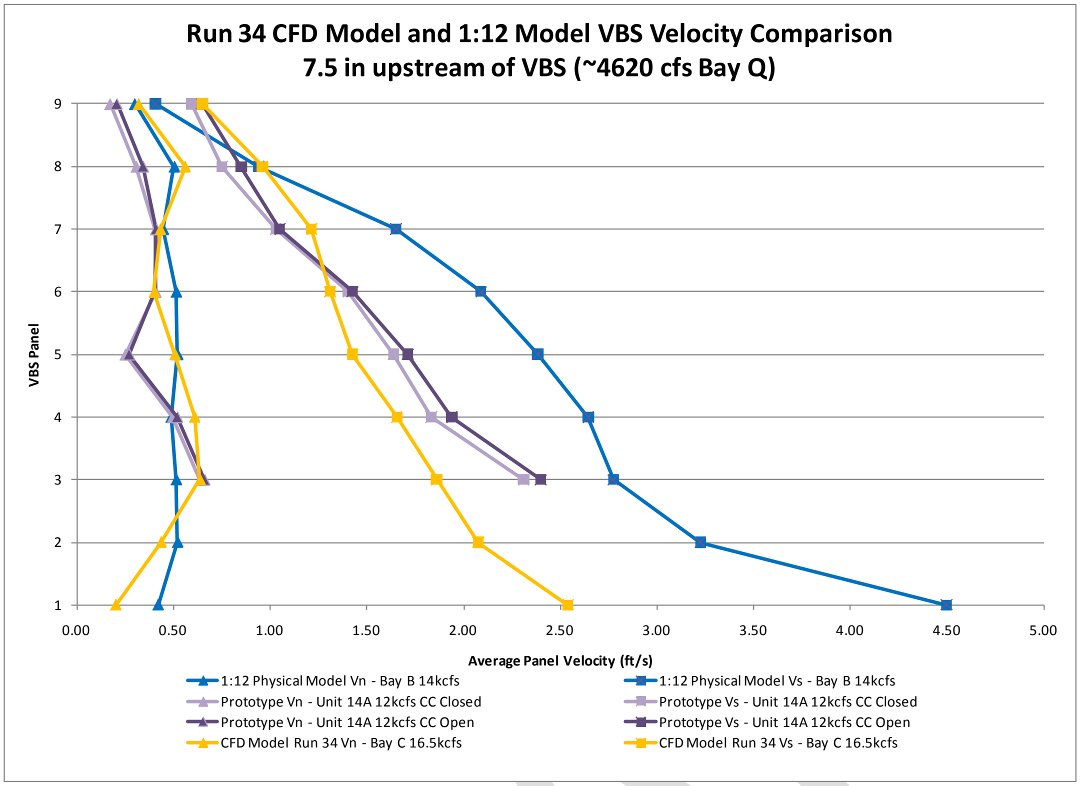


Figure 51. VBS Normal and Sweeping Velocity Comparisons (Bay Flow ~ 4,620 cfs)

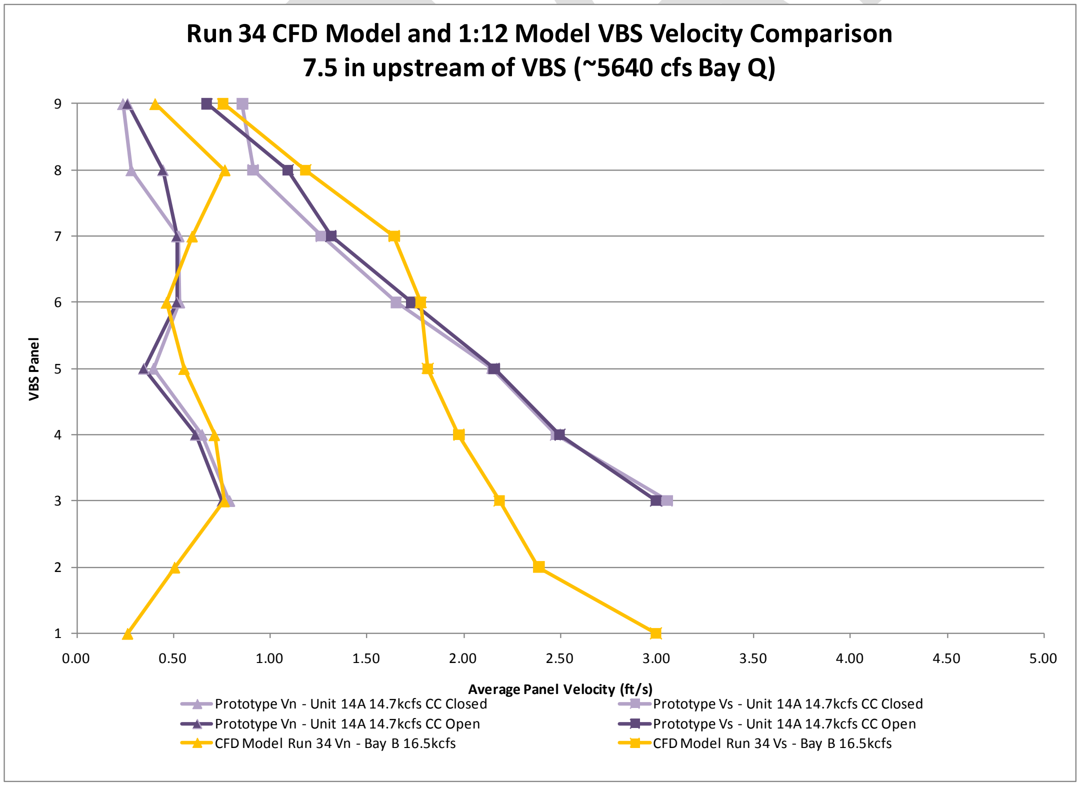


Figure 52. VBS Normal and Sweeping Velocity Comparisons (Bay Flow ~ 5,640 cfs)

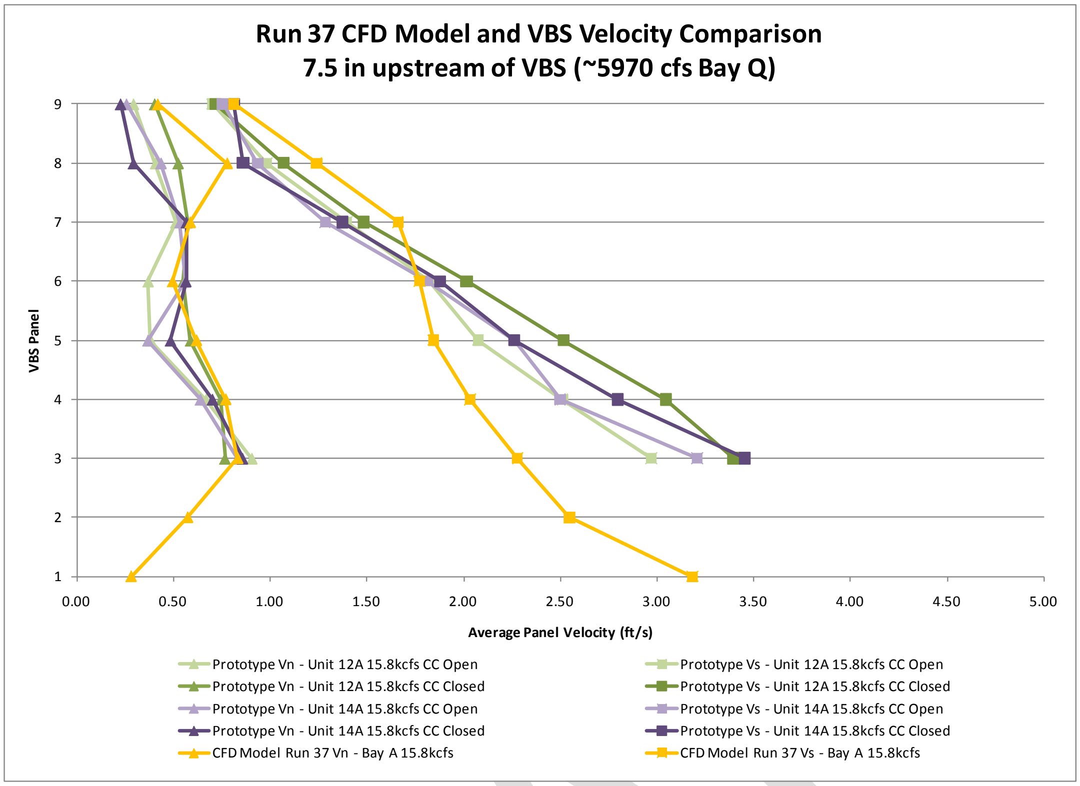


Figure 53. VBS Normal and Sweeping Velocity Comparisons (Bay Flow ~ 5,970 cfs)

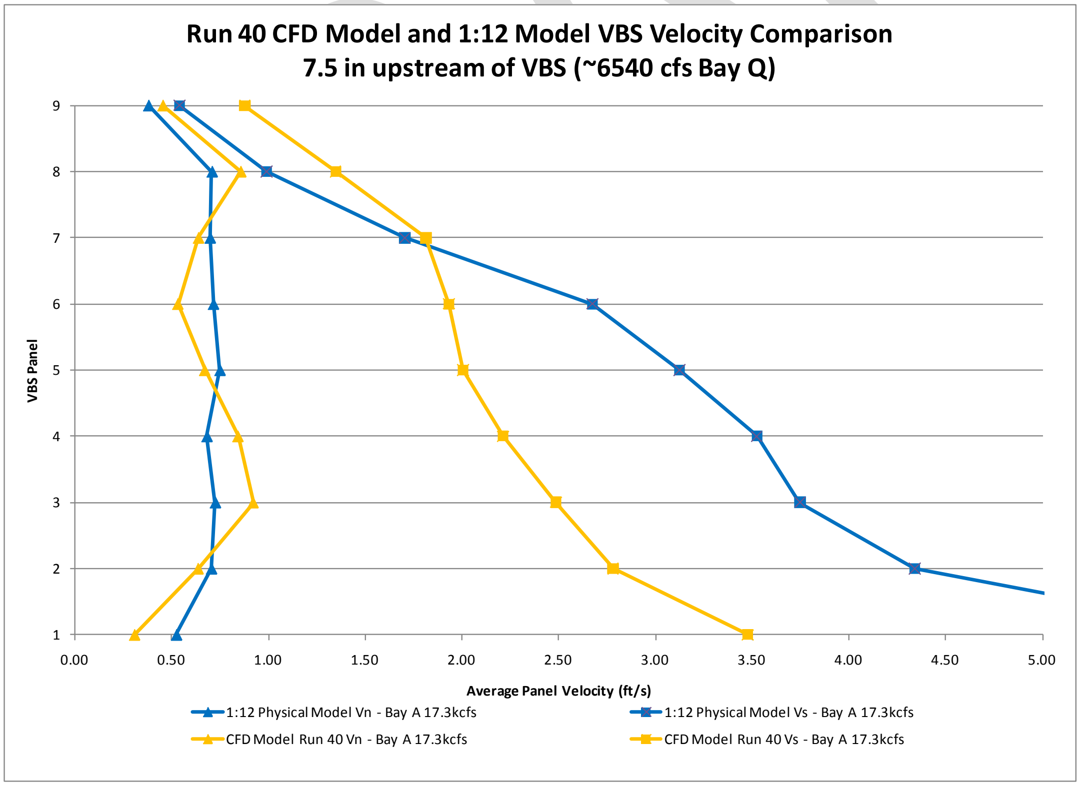


Figure 54. VBS Normal and Sweeping Velocity Comparisons (Bay Flow ~ 6,540 cfs)

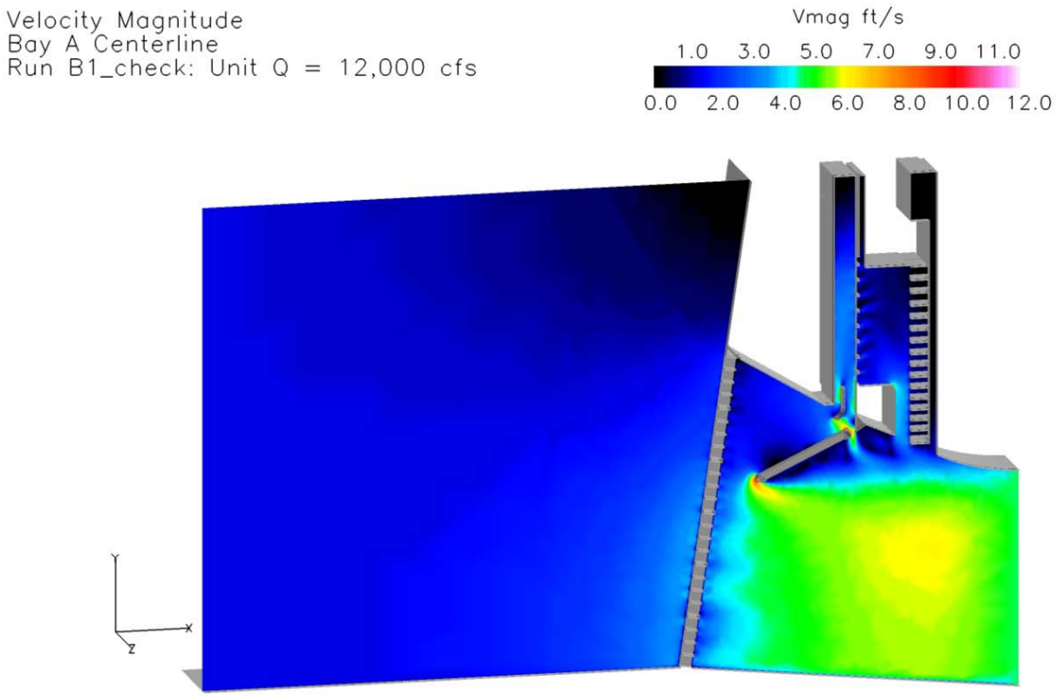


Figure 55 Baseline Conditions, Unit Q = 12,000 cfs, Bay A Centerline Velocities

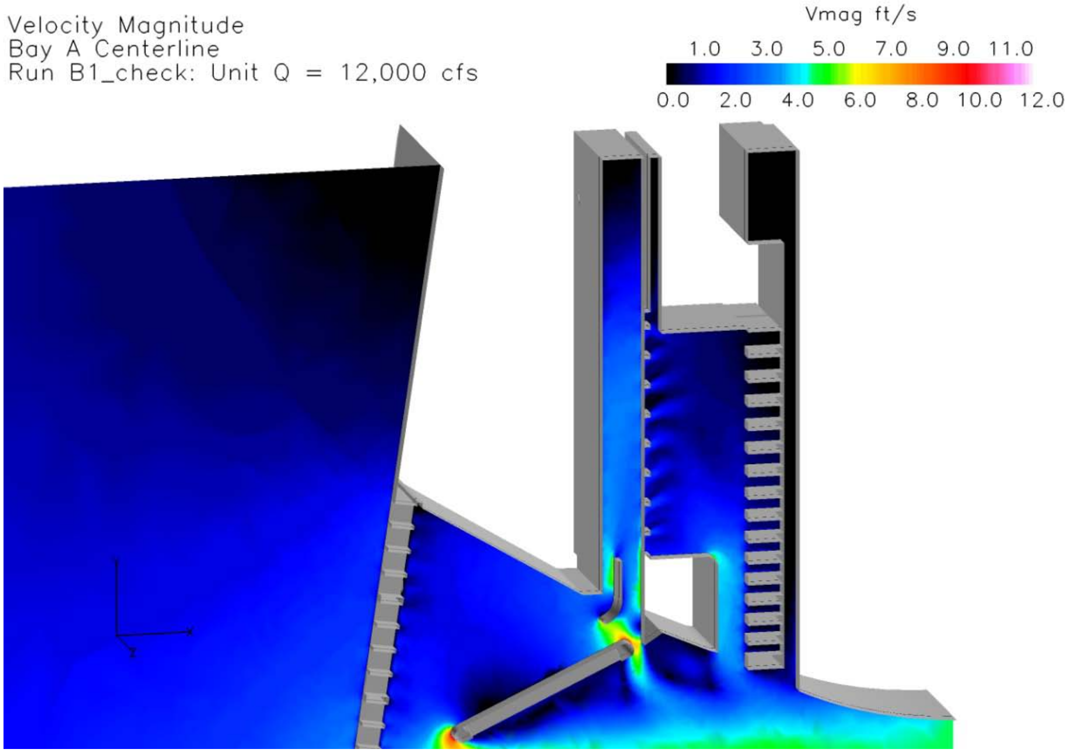


Figure 56. Baseline Conditions, Unit Q = 12,000 cfs, Bay A Centerline Velocities (zoomed)

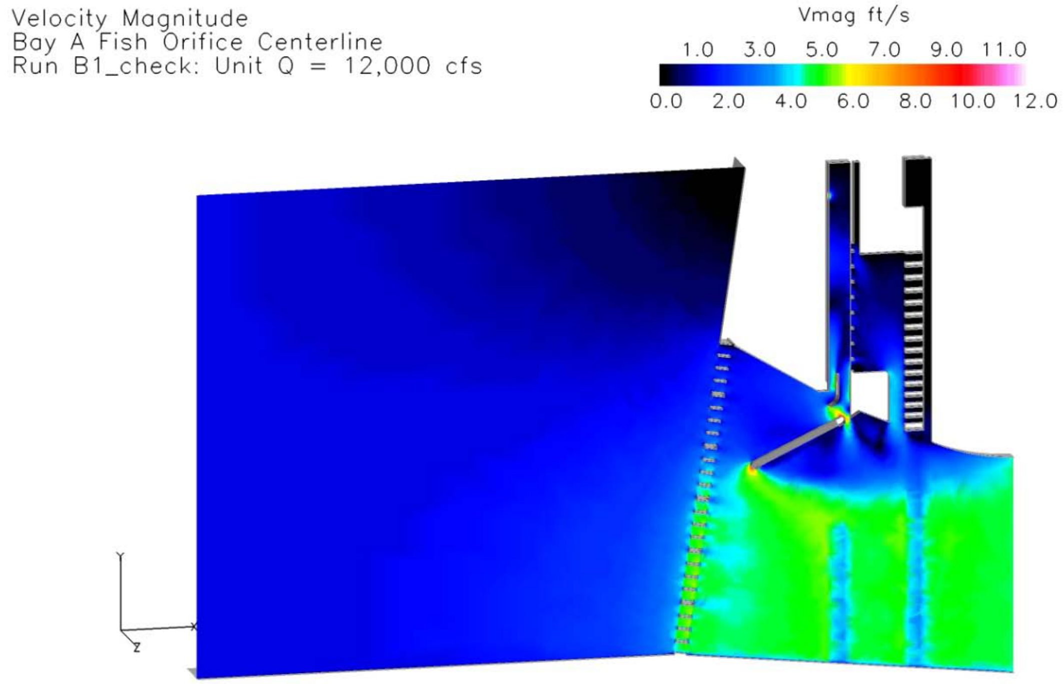


Figure 57. Baseline Conditions, Unit Q = 12,000 cfs, Bay A Fish Orifice Centerline Velocities

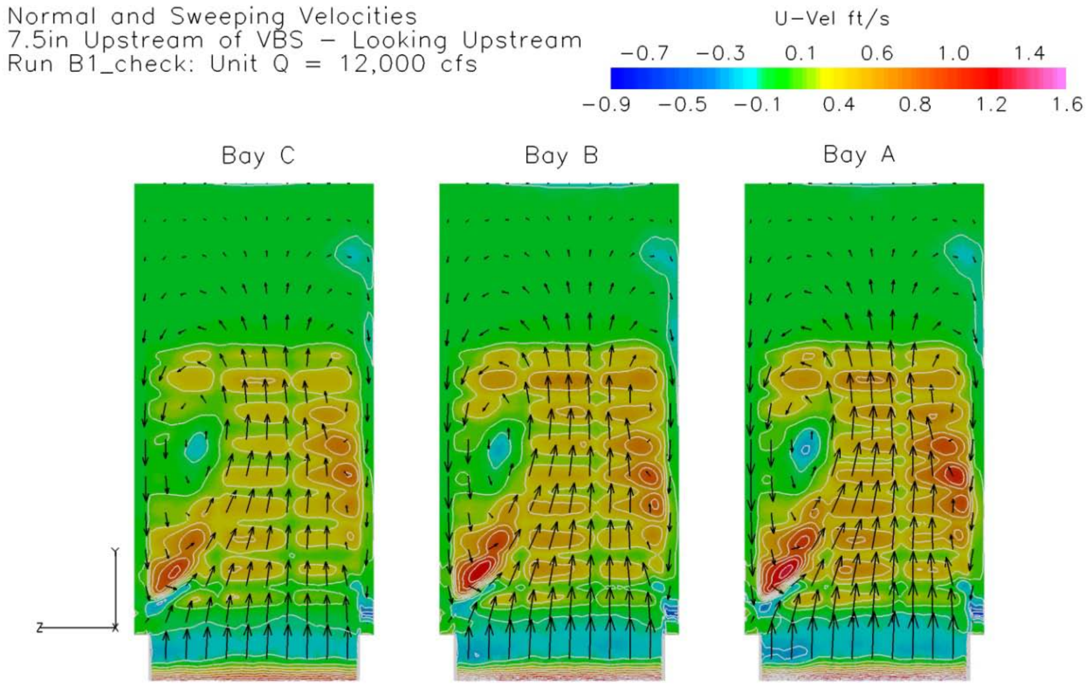


Figure 58. Baseline Conditions, Unit Q = 12,000 cfs, VBS Normal Velocities and Flow Patterns

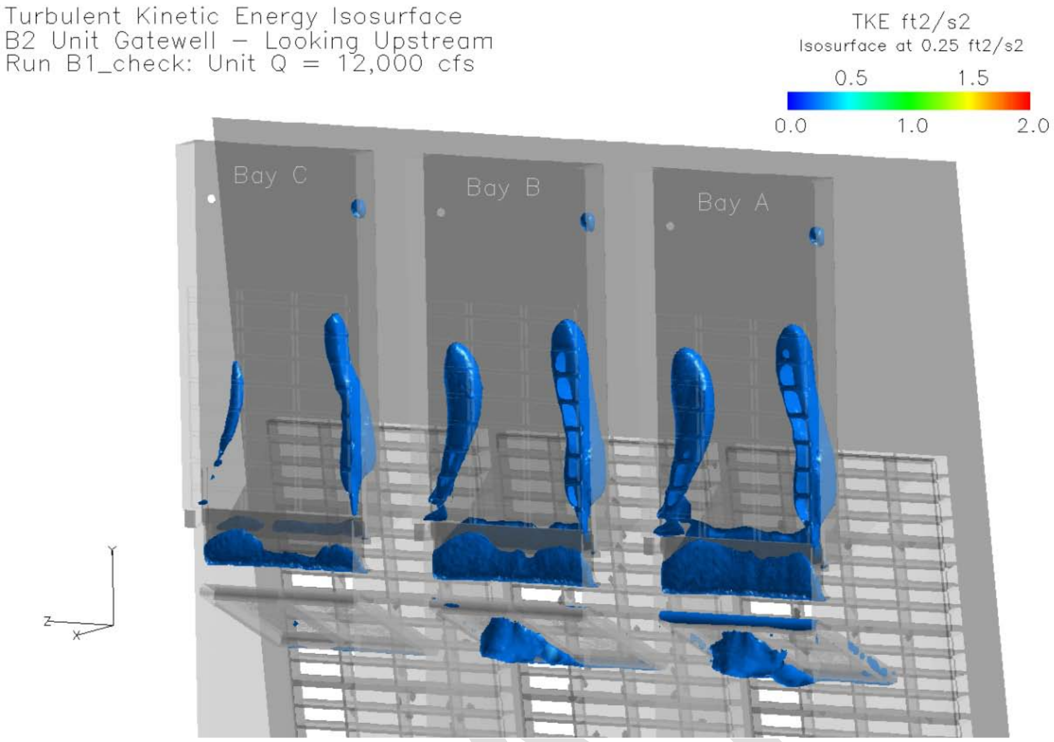


Figure 59. Baseline Conditions, Unit Q = 12,000 cfs, Turbulent Kinetic Energy Isosurface (0.25 ft2/s2)

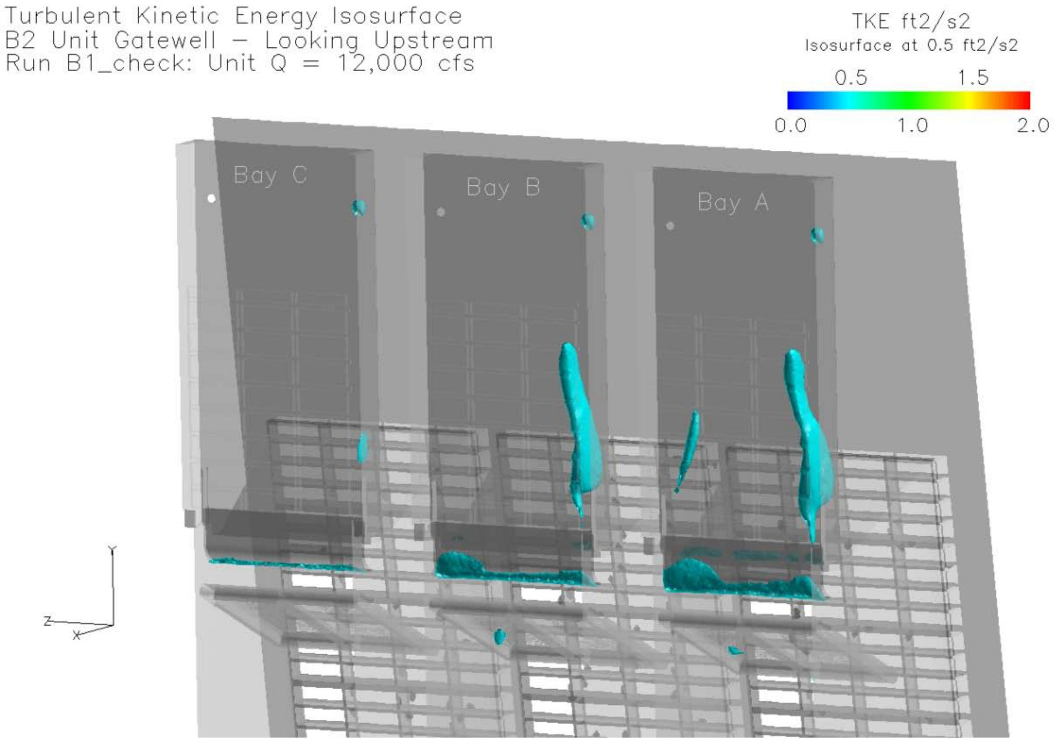


Figure 60. Baseline Conditions, Unit Q = 12,000 cfs, Turbulent Kinetic Energy Isosurface (0.5 ft2/s2)

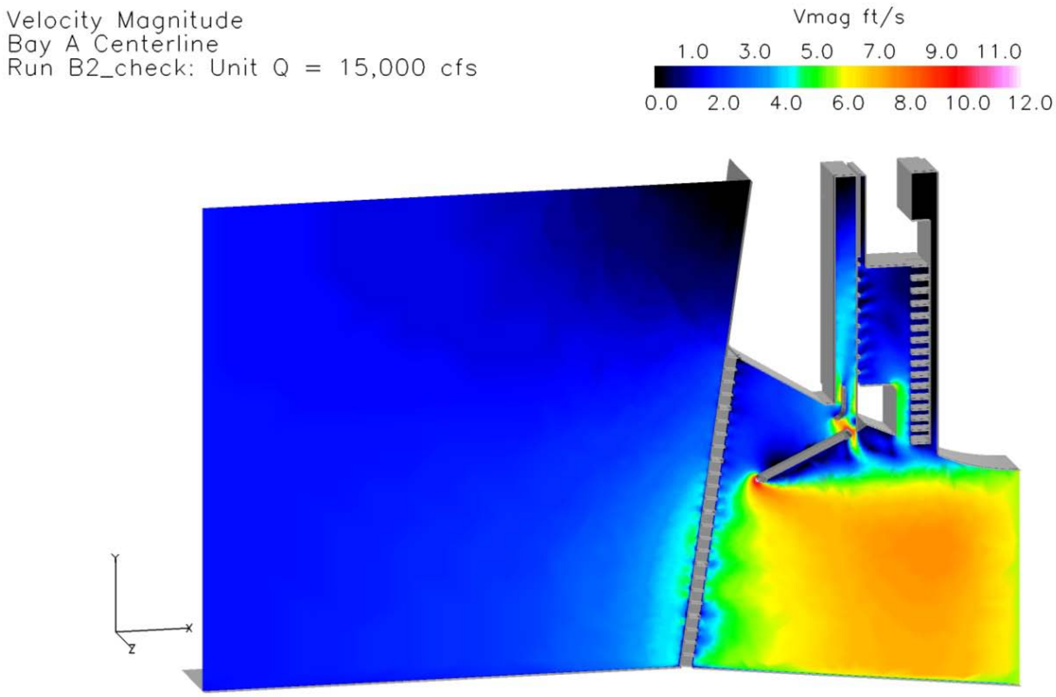


Figure 61. Baseline Conditions, Unit Q = 15,000 cfs, Bay A Centerline Velocities

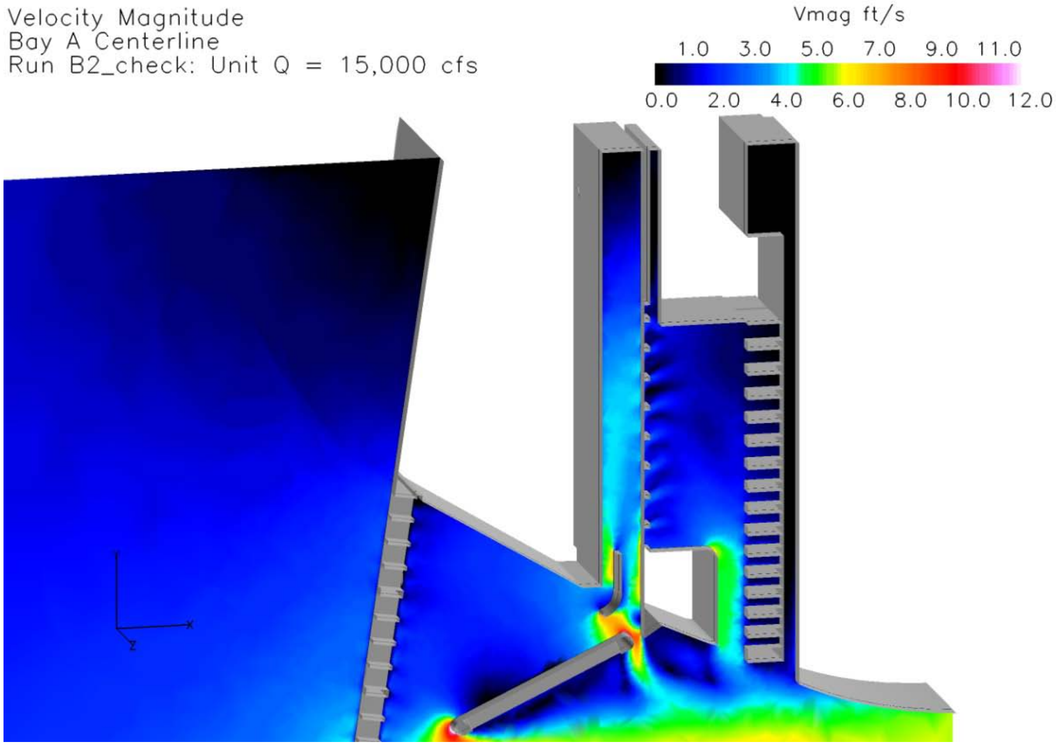


Figure 62. Baseline Conditions, Unit Q = 15,000 cfs, Bay A Centerline Velocities (zoomed)

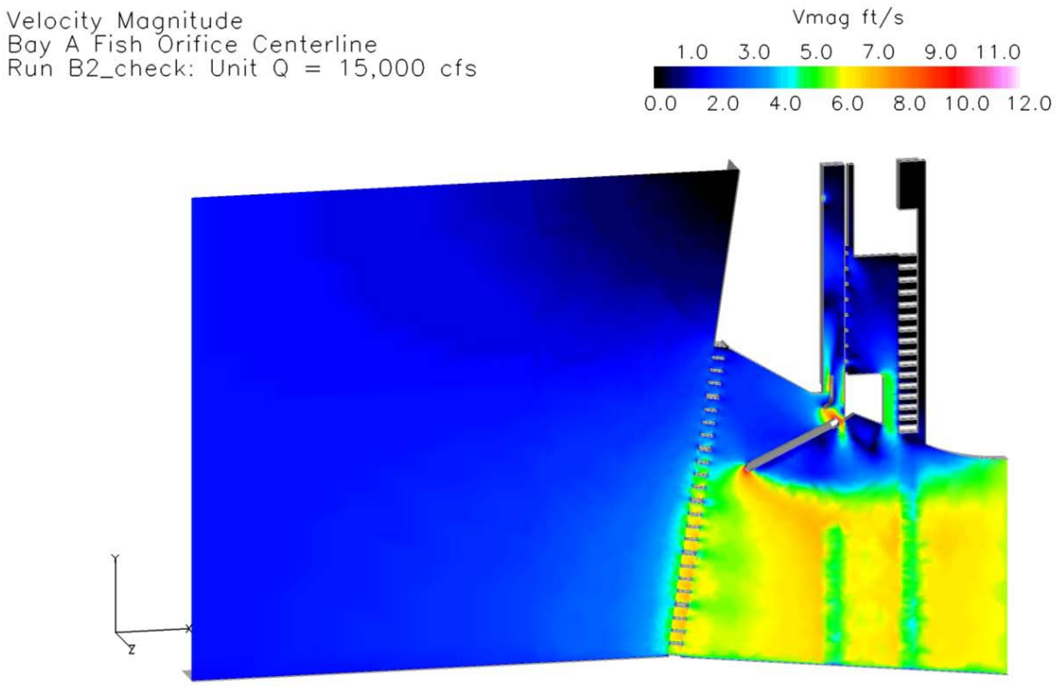


Figure 63. Baseline Conditions, Unit Q = 15,000 cfs, Bay A Fish Orifice Centerline Velocities

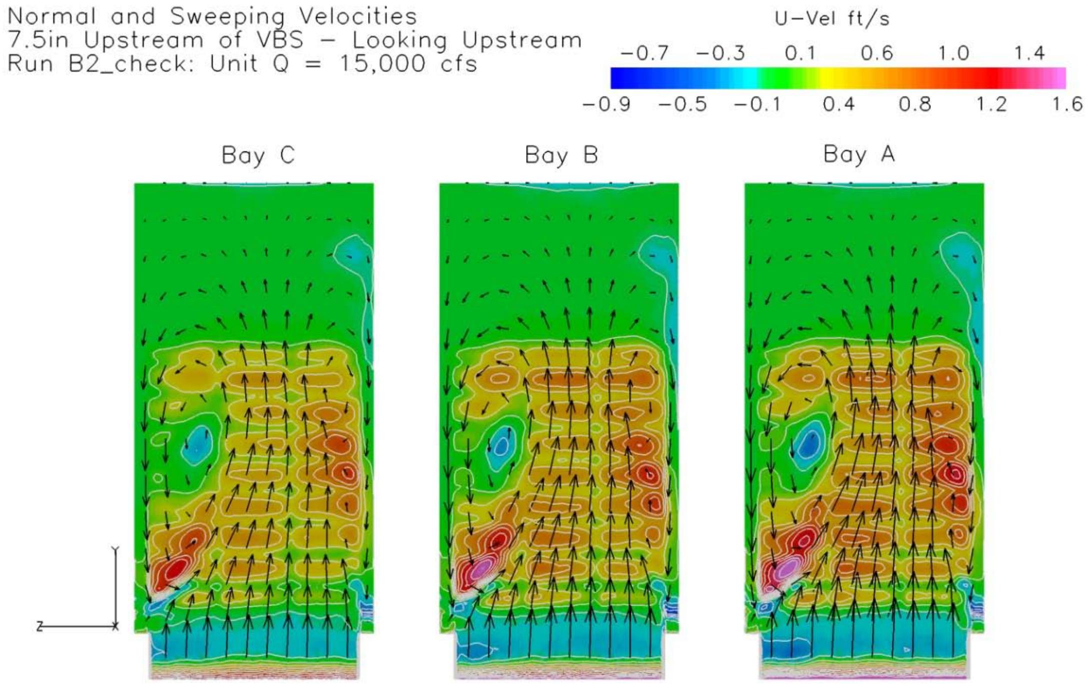


Figure 64. Baseline Conditions, Unit Q = 15,000 cfs, VBS Normal Velocities and Flow Patterns

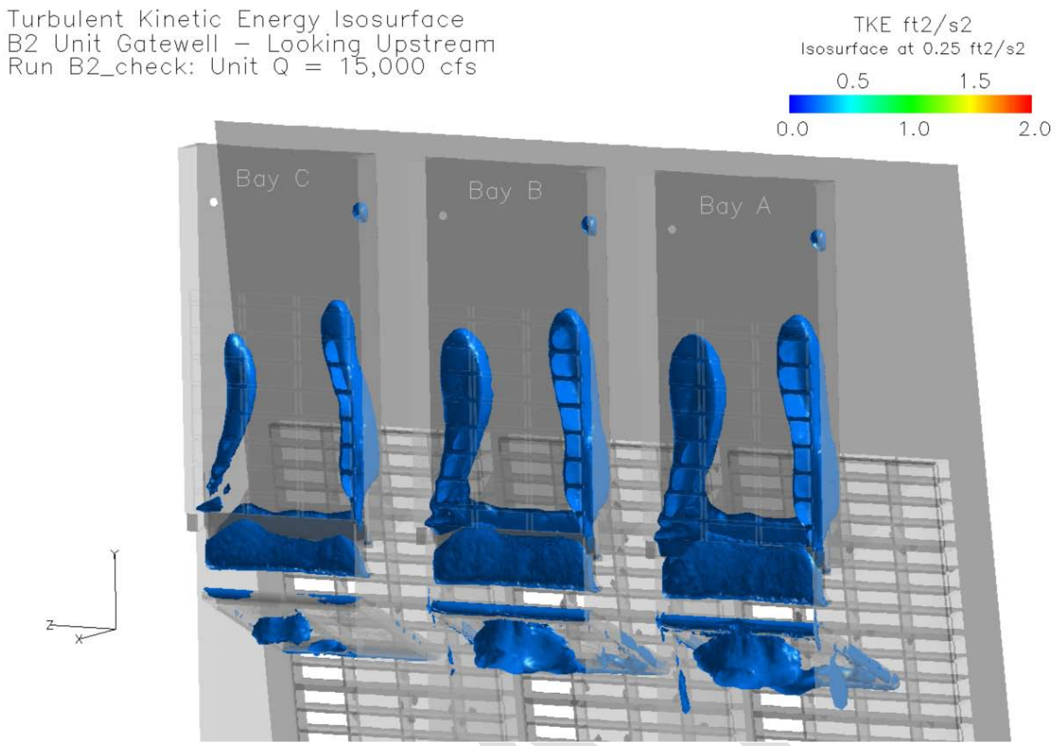


Figure 65. Baseline Conditions, Unit Q = 15,000 cfs, Turbulent Kinetic Energy Isosurface (0.25 ft2/s2)

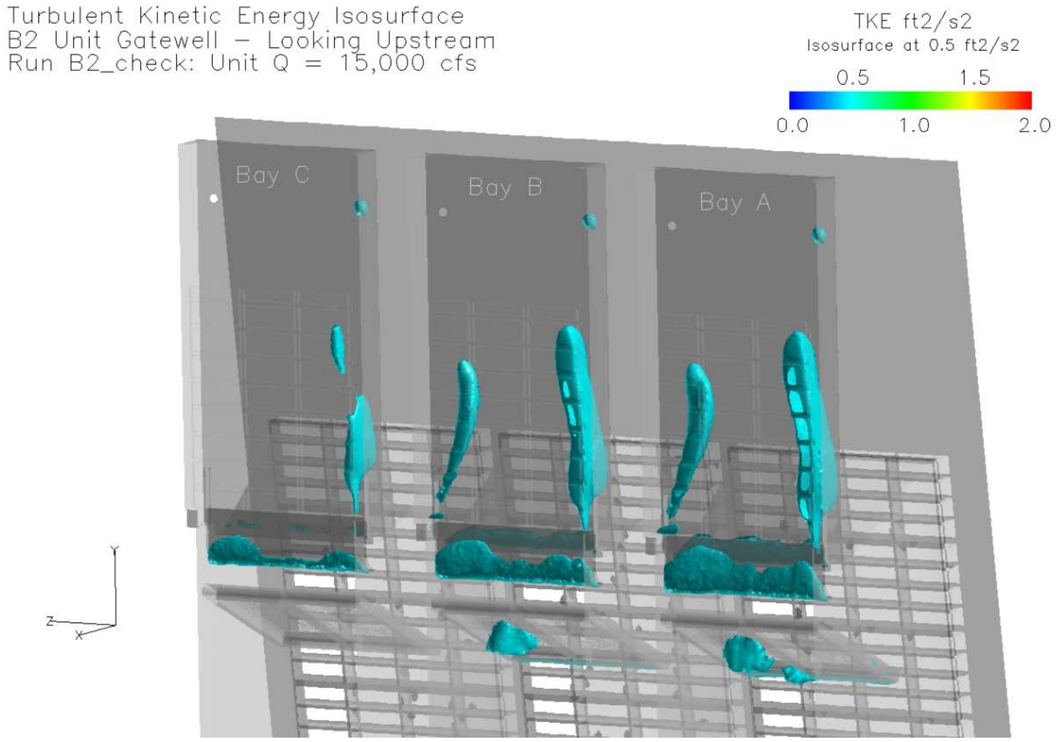


Figure 66. Baseline Conditions, Unit Q = 15,000 cfs, Turbulent Kinetic Enery Isosurface (0.5 ft2/s2)

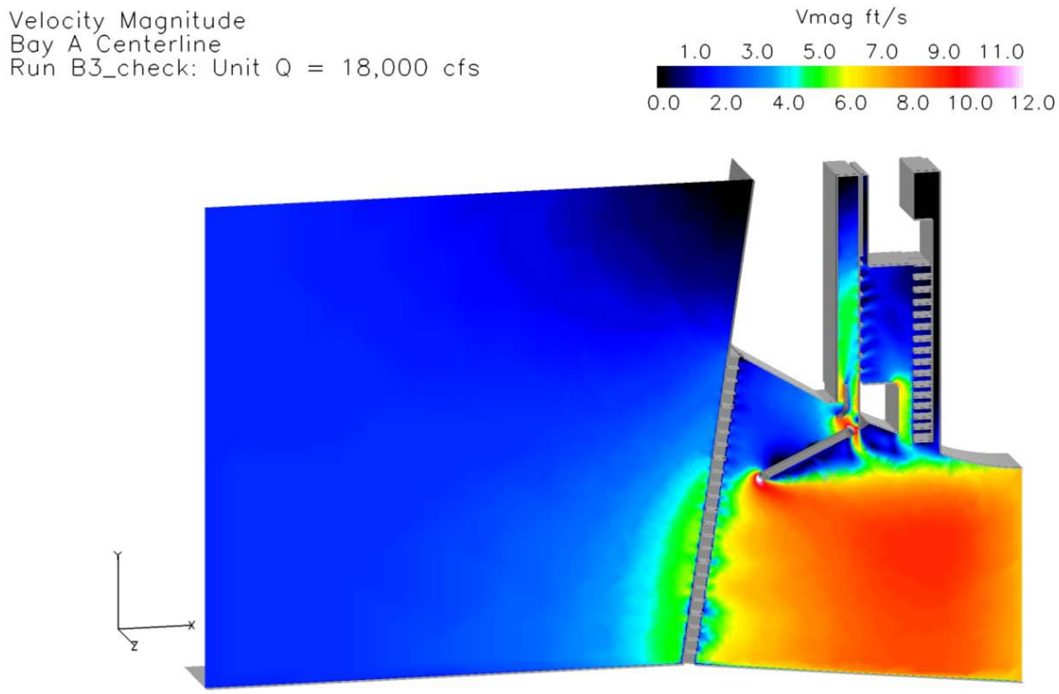


Figure 67. Baseline Conditions, Unit Q = 18,000 cfs, Bay A Centerline Velocities

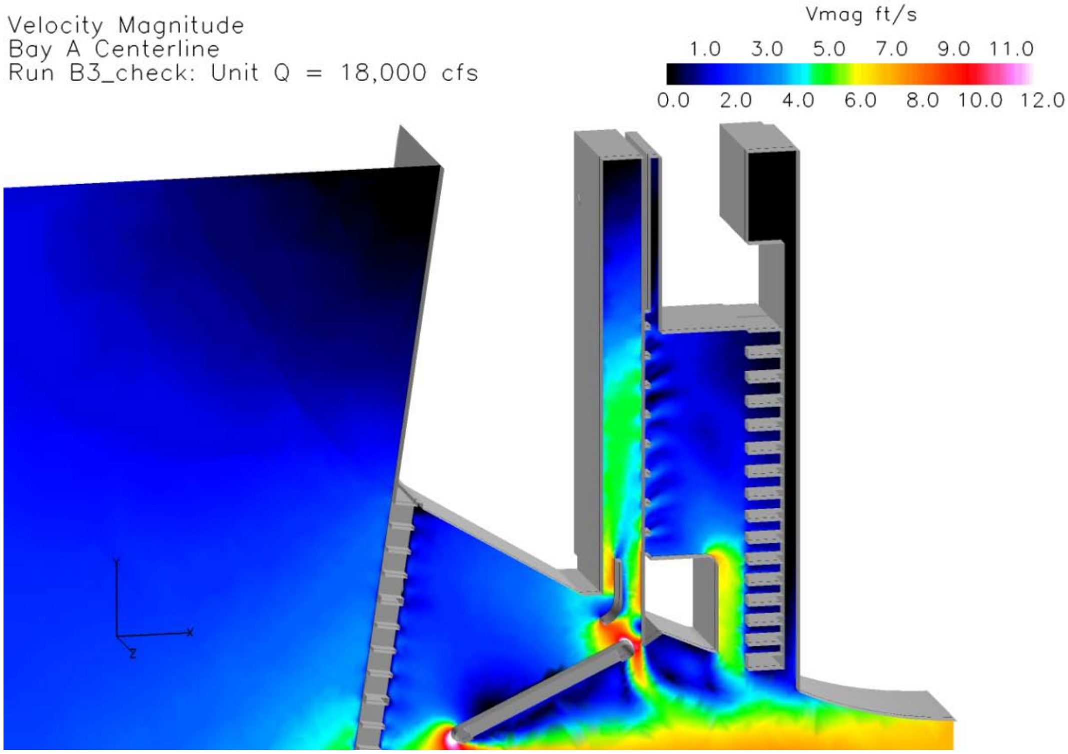


Figure 68. Baseline Conditions, Unit Q = 18,000 cfs, Bay A Centerline Velocities (zoomed)

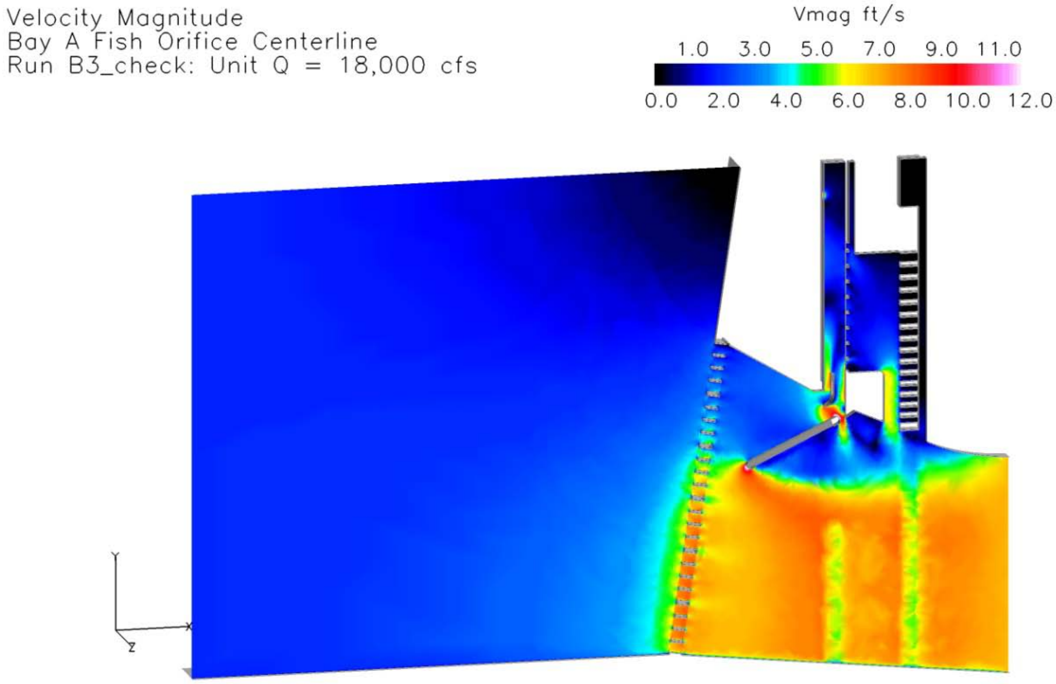


Figure 69. Baseline Conditions, Unit Q = 18,000 cfs, Bay A Fish Orifice Centerline Velocities

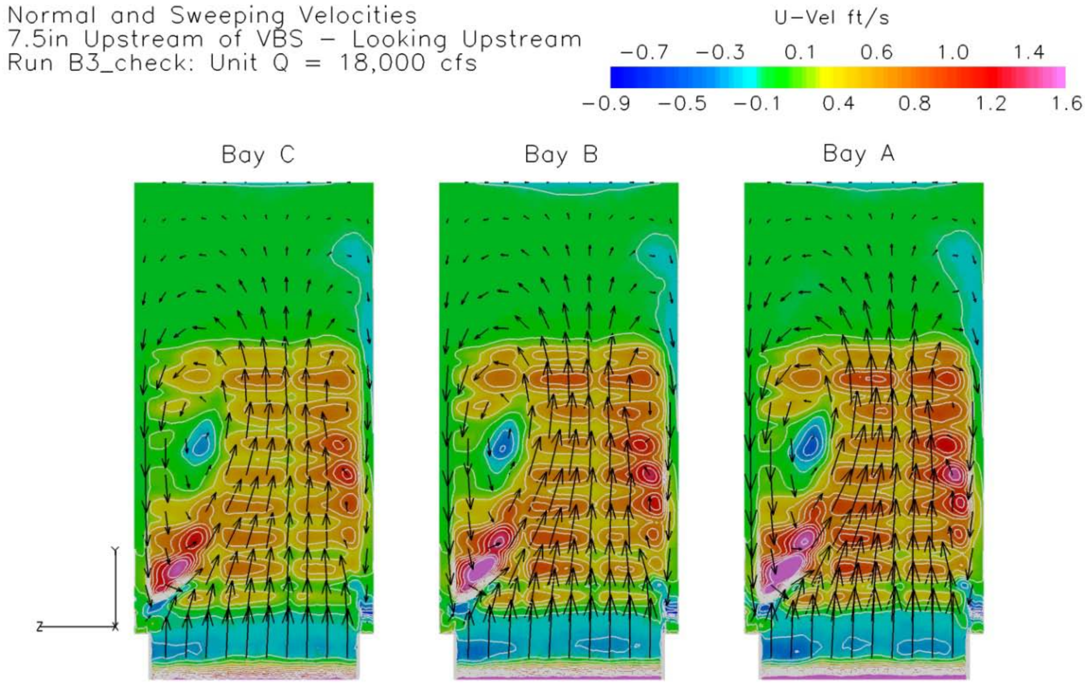


Figure 70. Baseline Conditions, Unit Q = 18,000 cfs, VBS Normal Velocities and Flow Patterns

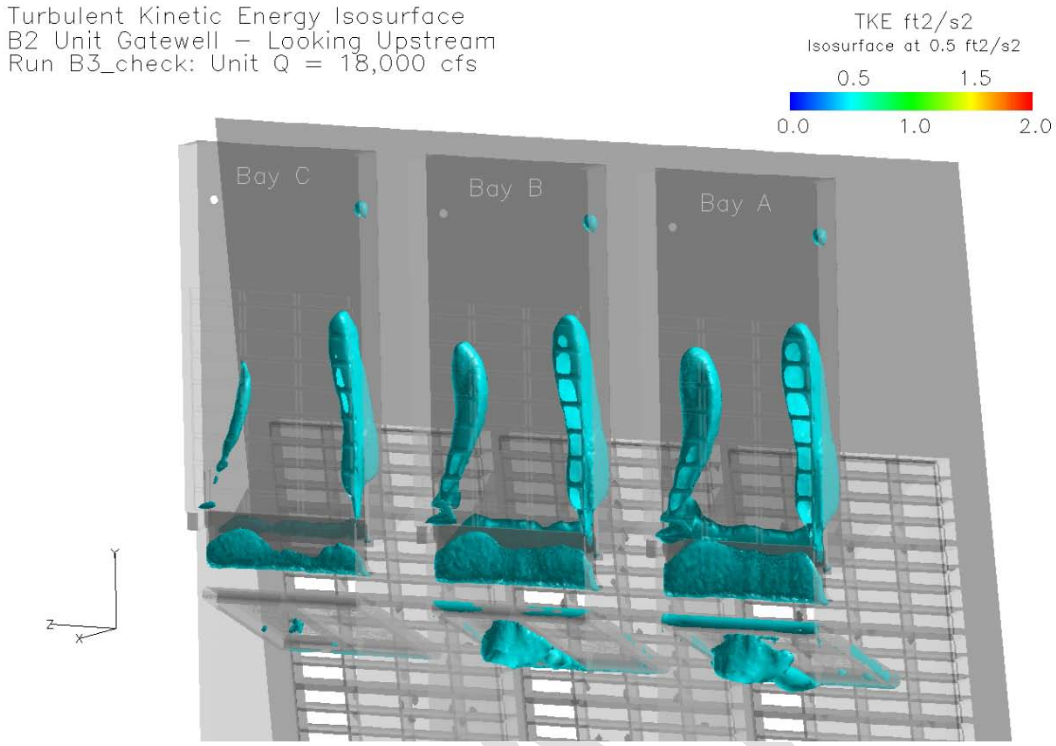


Figure 71. Baseline Conditions, Unit Q = 18,000 cfs, Turbulent Kinetic Energy Isosurface (0.25 ft2/s2)

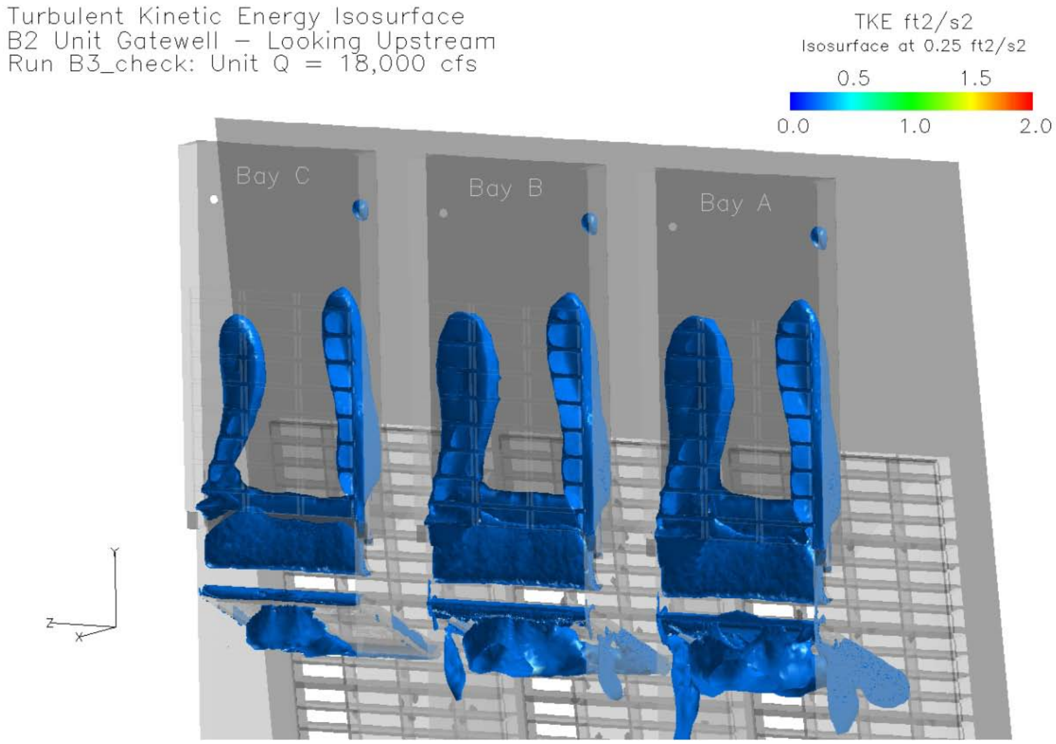


Figure 72. Baseline Conditions, Unit Q = 18,000 cfs, Turbulent Kinetic Energy Isosurface (0.5 ft2/s2)

Figure 1: Flow Control Device - Adjustable Louver Concept

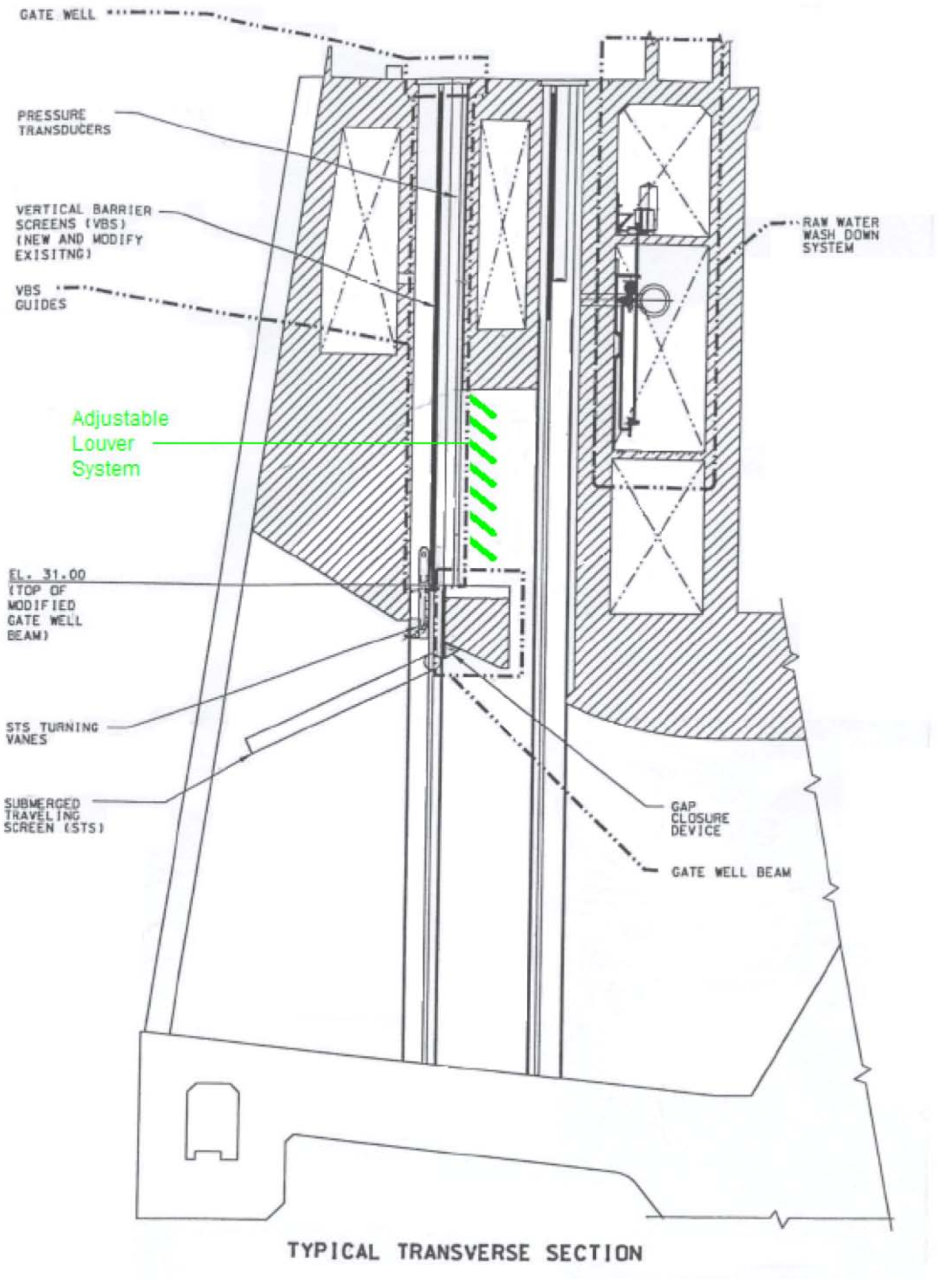


Figure 73. Alternative A1 - Adjustable Louver Flow Control Device

Figure 2: Flow Control Device - Sliding Plate Concept

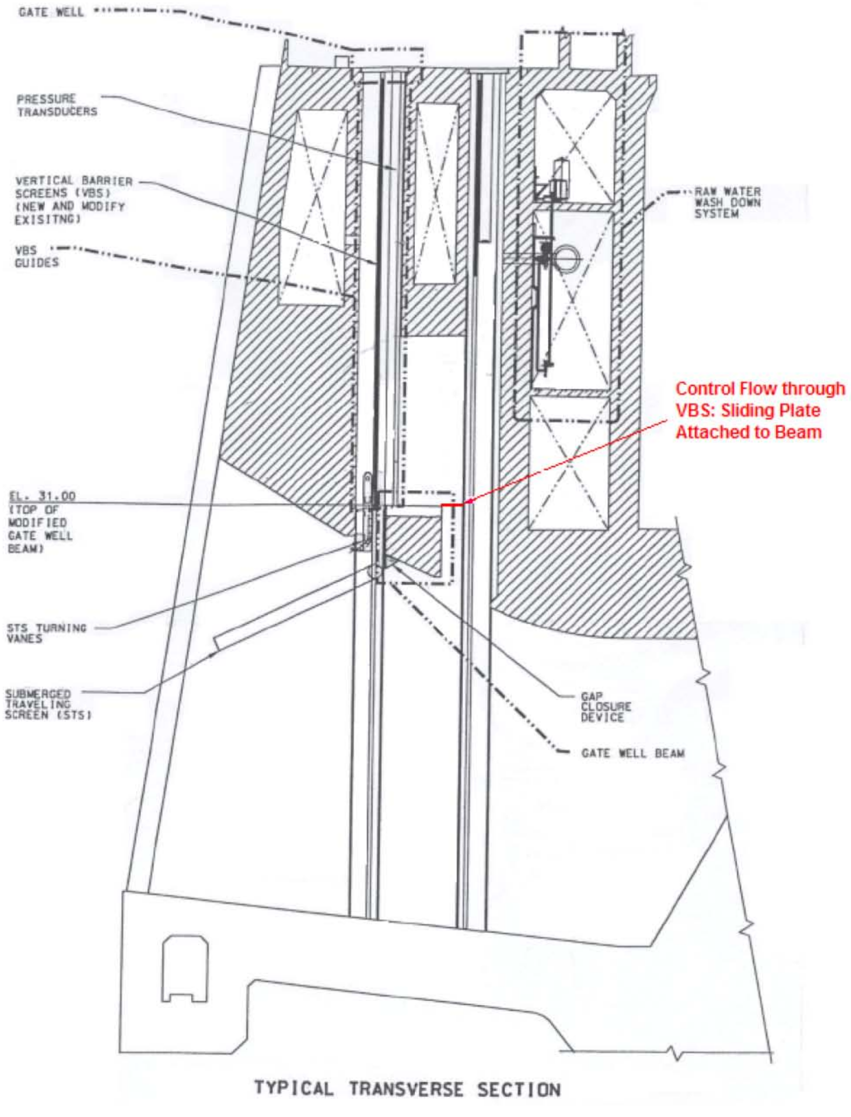


Figure 74: Alternative A2 – Sliding Plate Flow Control Device

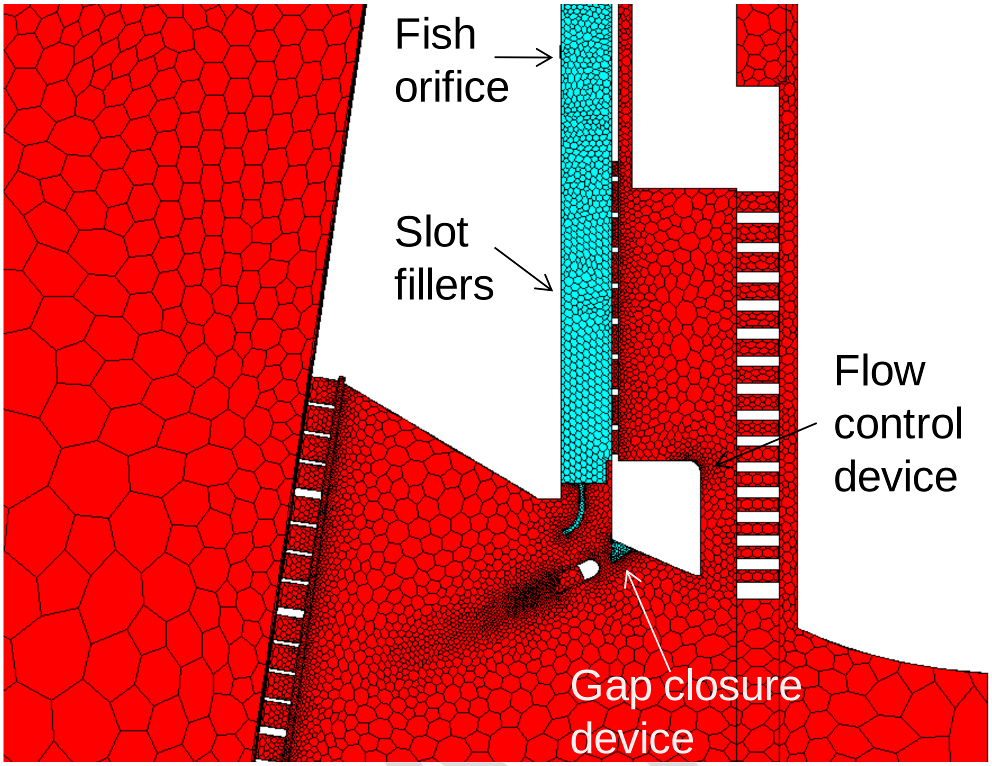


Figure 75. Alternative A2 – Sliding Plate Flow Control Device CFD Model Grid

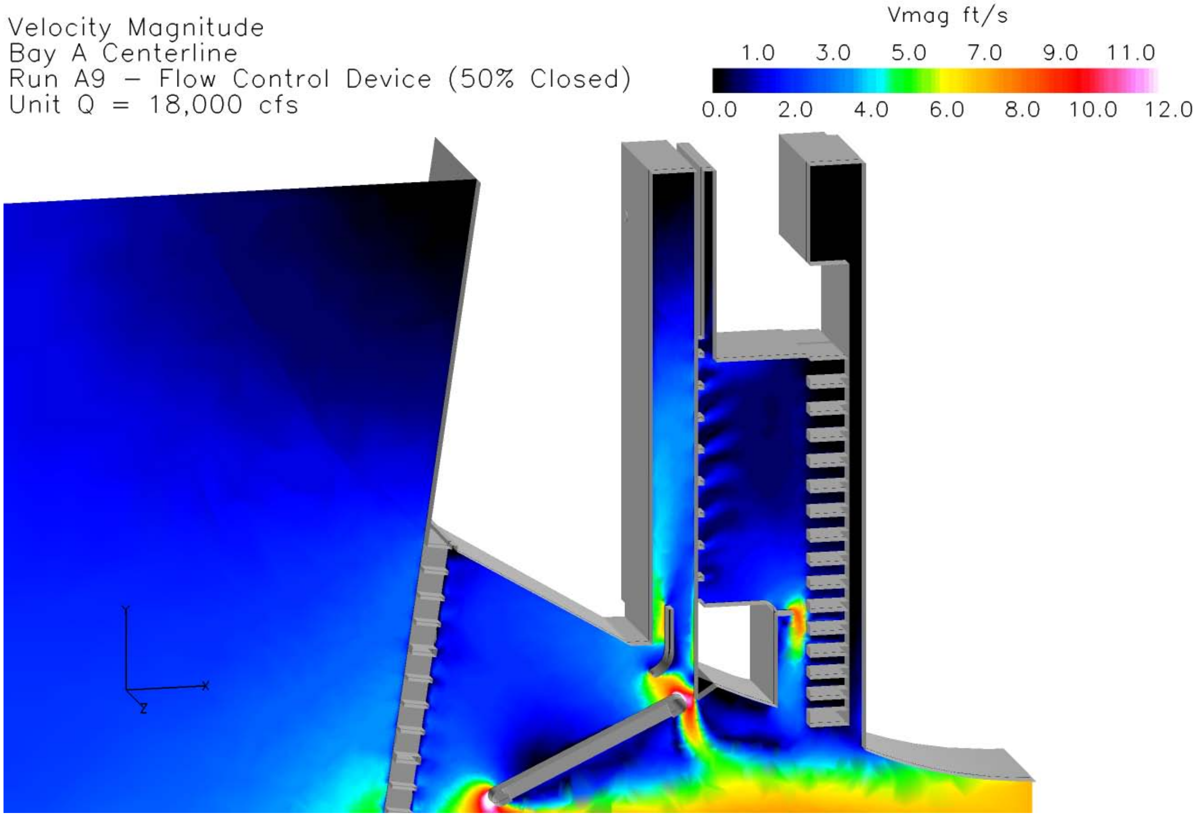


Figure 76. Alternative A2 – Bay A Centerline Velocity Magnitude

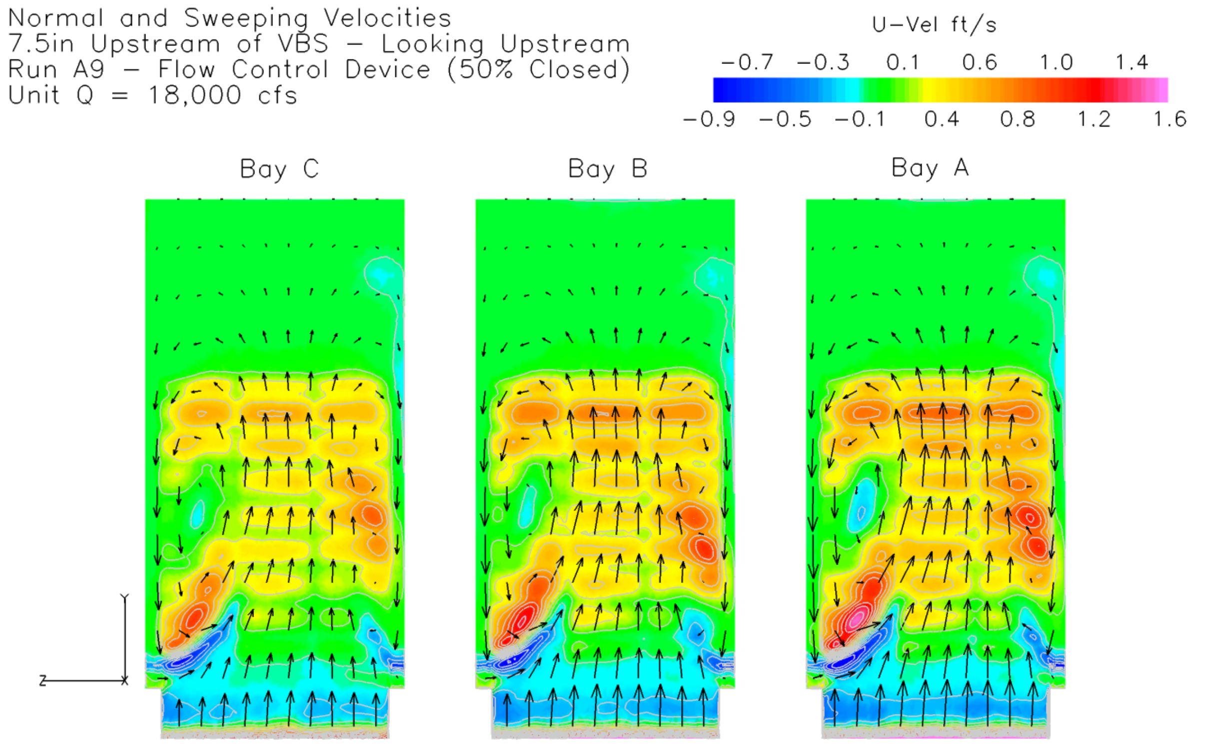


Figure 77. Alternative A2 – VBS Normal Velocities and Flow Patterns

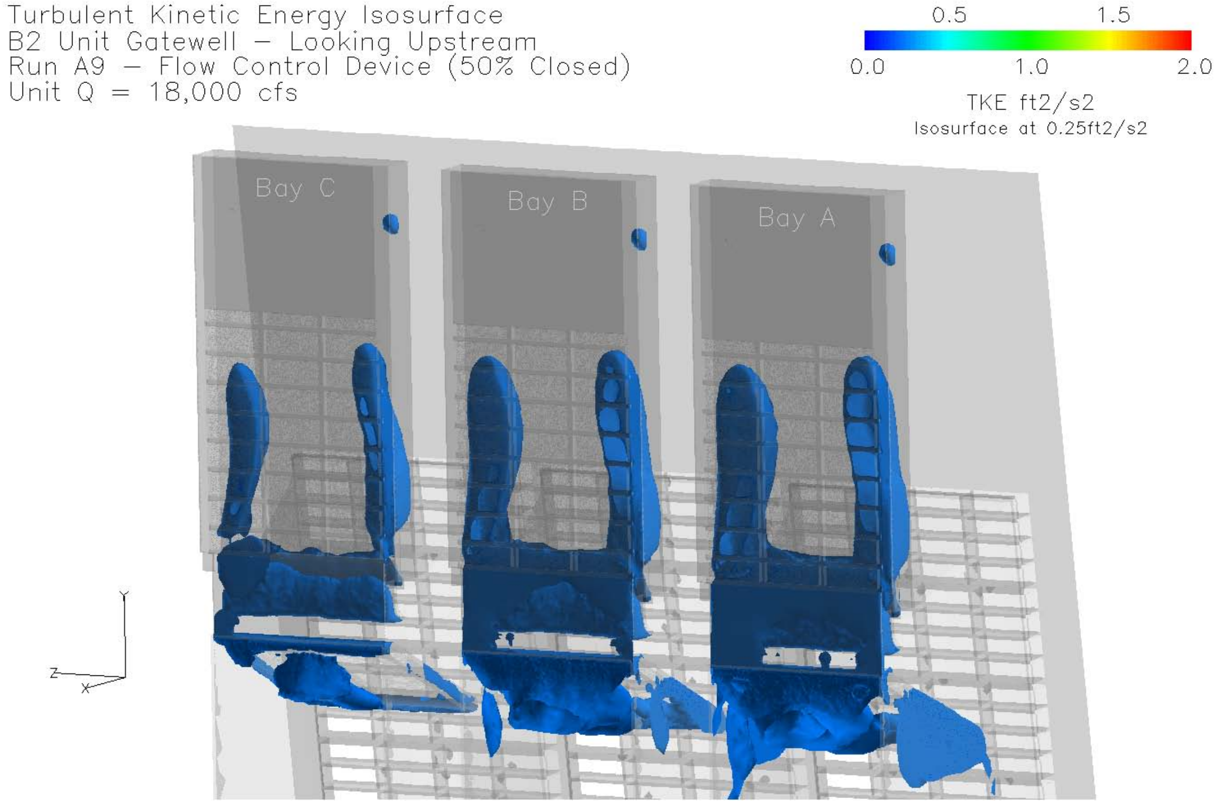


Figure 78. Alternative A2 – Turbulent Kinetic Energy Isosurface

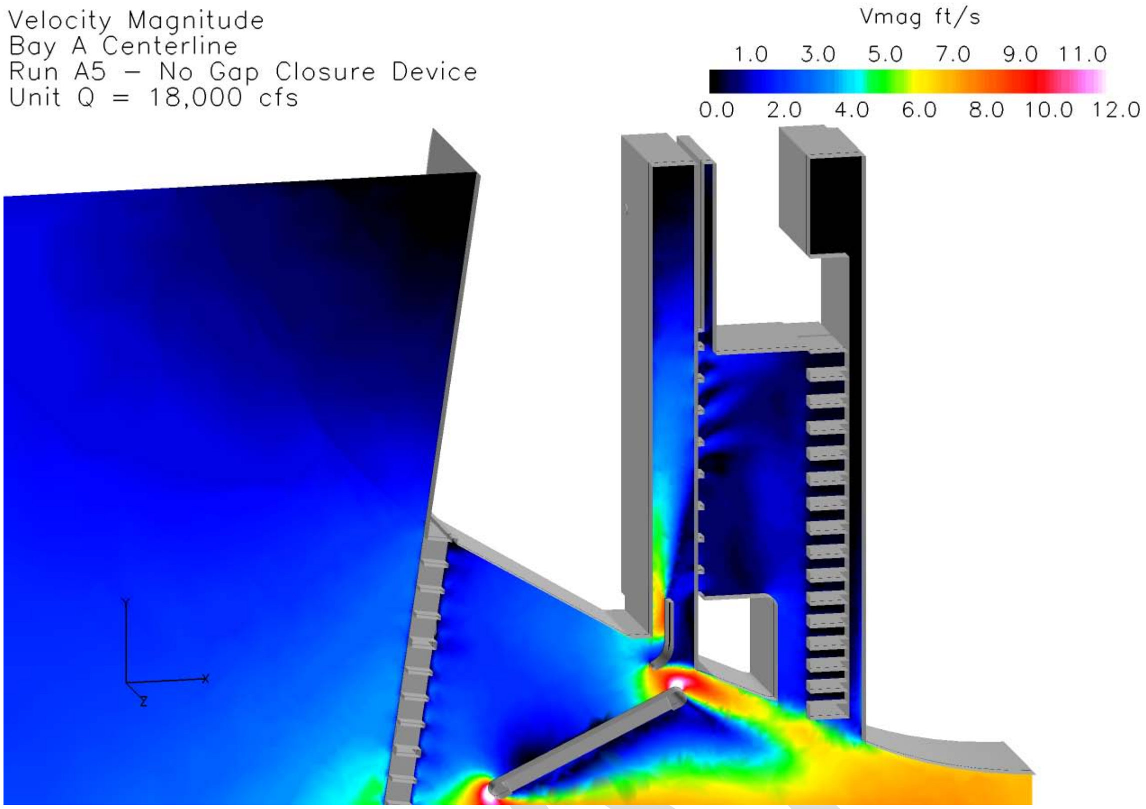


Figure 79. Alternative A4 – Bay A Centerline Velocity Magnitude

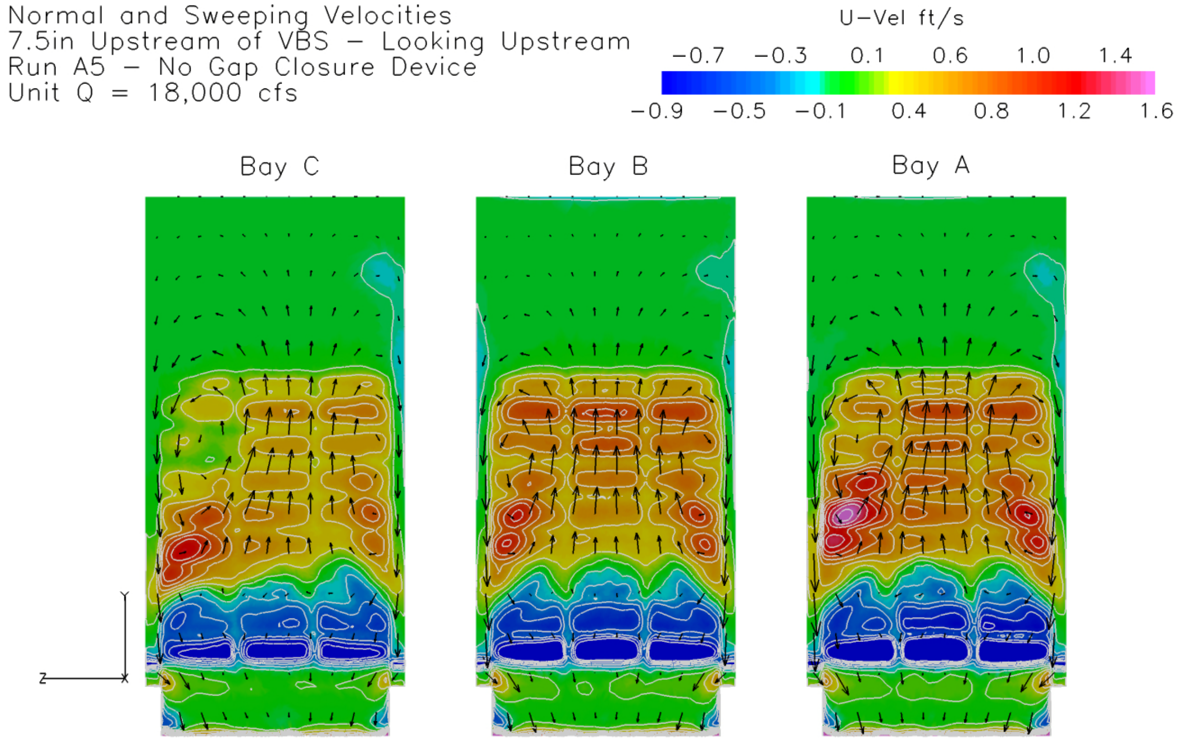


Figure 80. Alternative A4 – VBS Normal Velocities and Flow Patterns

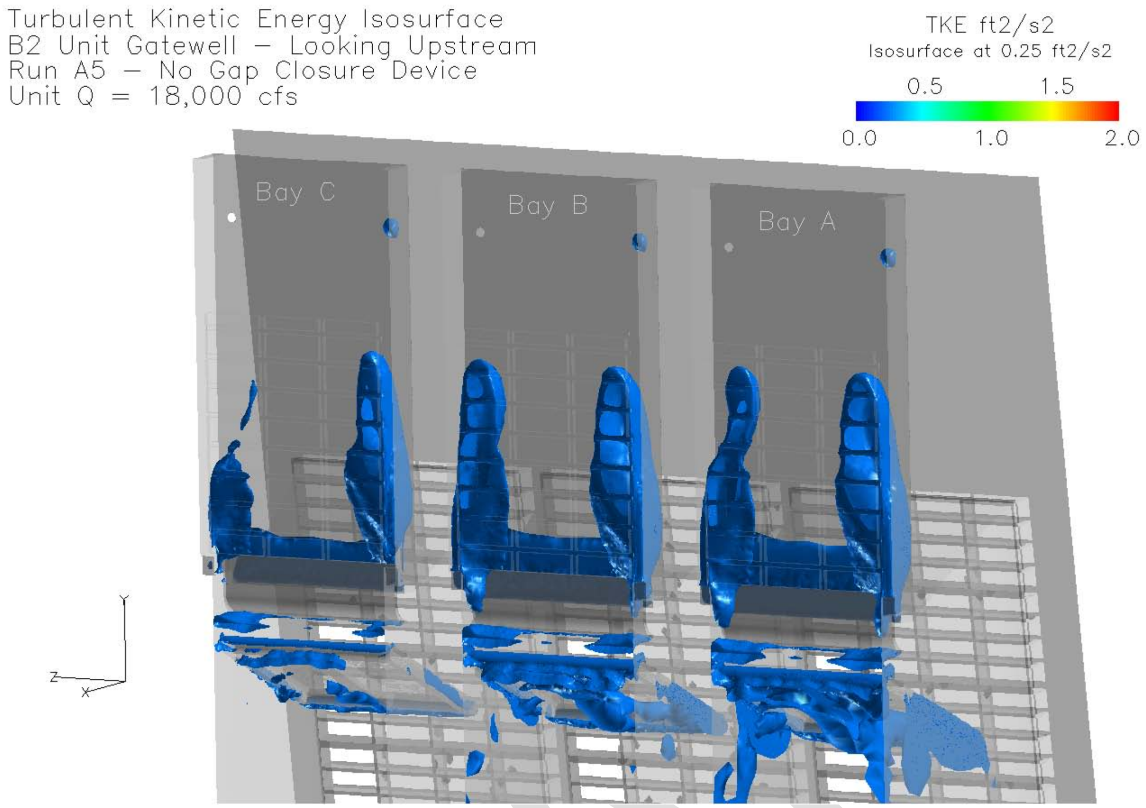


Figure 81. Alternative A4 – Turbulent Kinetic Energy Isosurface

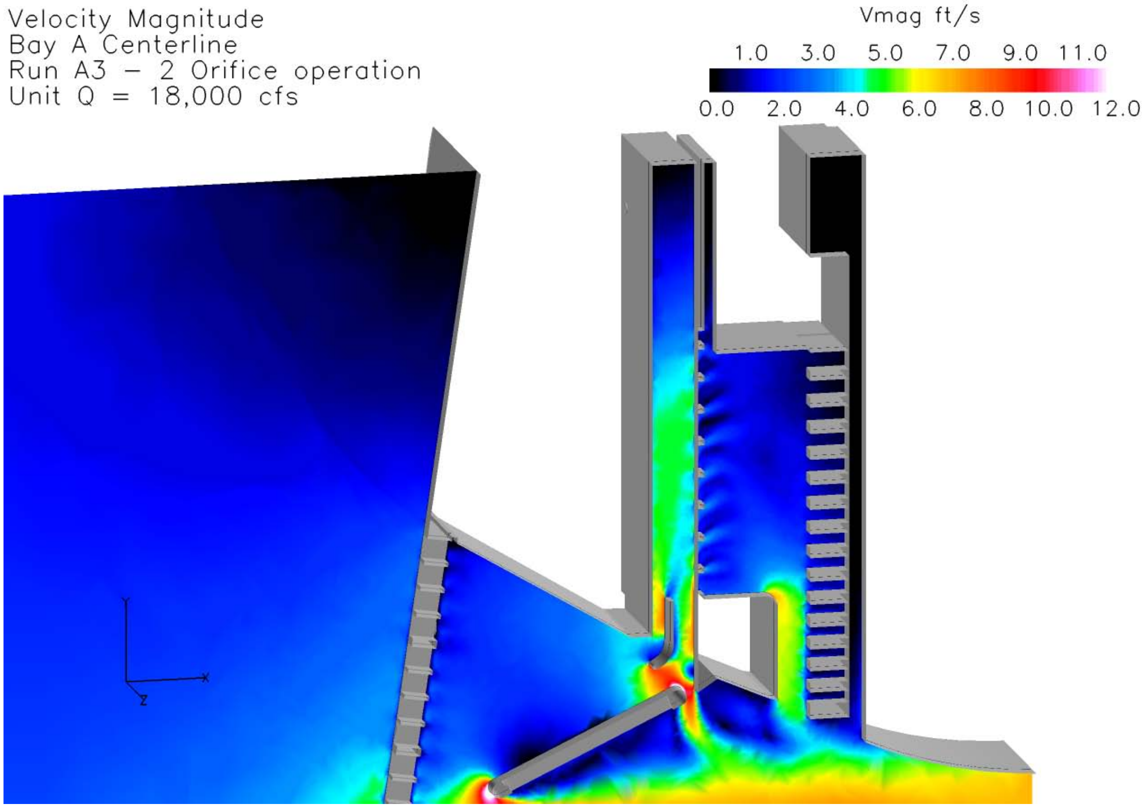


Figure 82. Alternative B2 – Bay A Centerline Velocity Magnitude

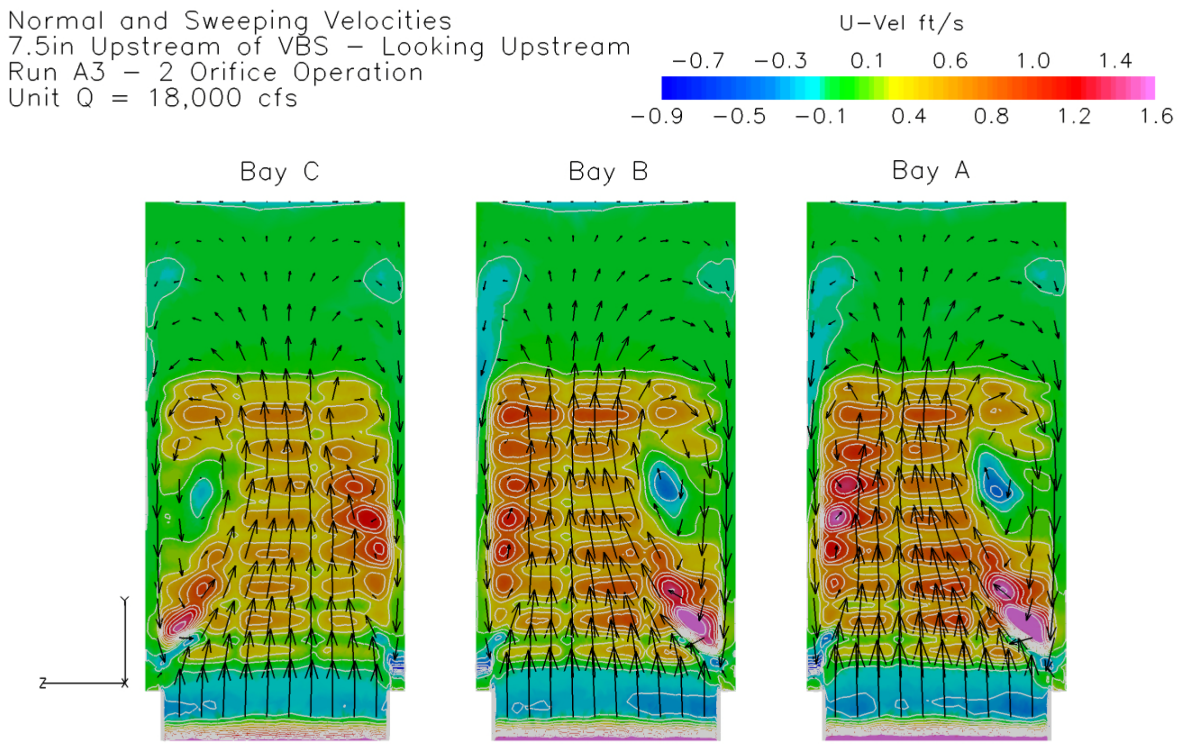


Figure 83. Alternative B2 – VBS Normal Velocities and Flow Patterns

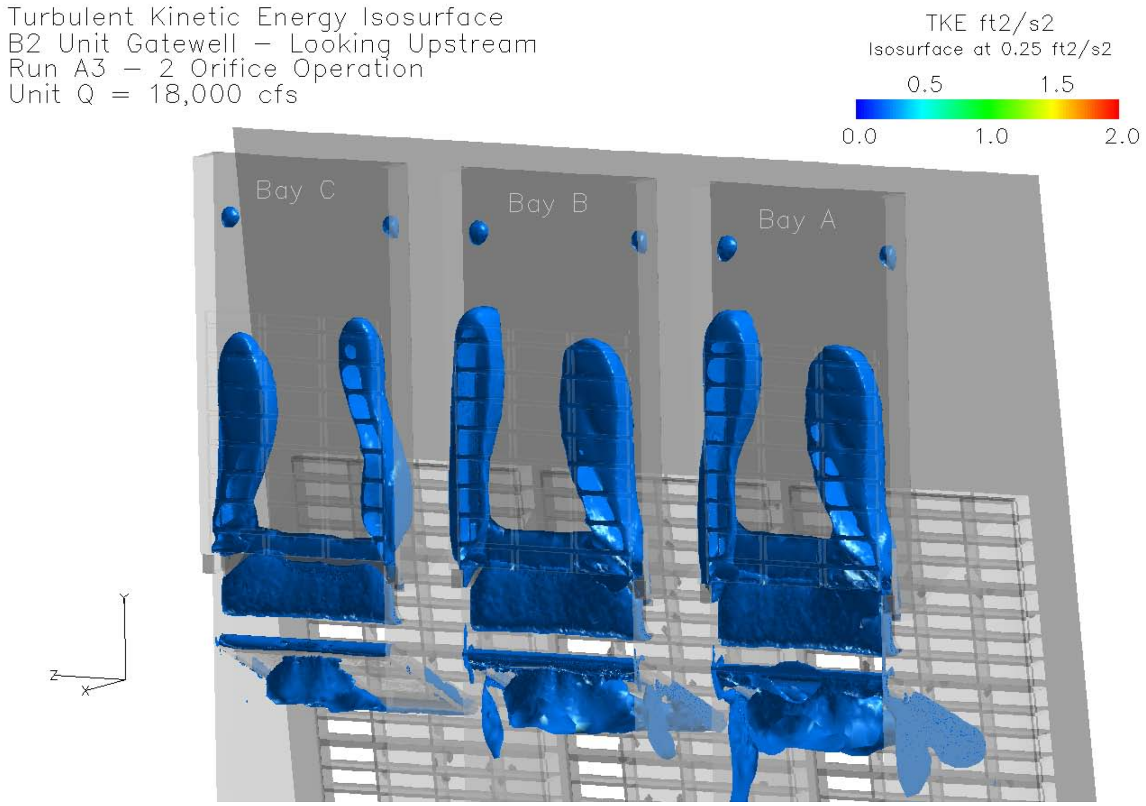


Figure 84. Alternative B2 – Turbulent Kinetic Energy Isosurface

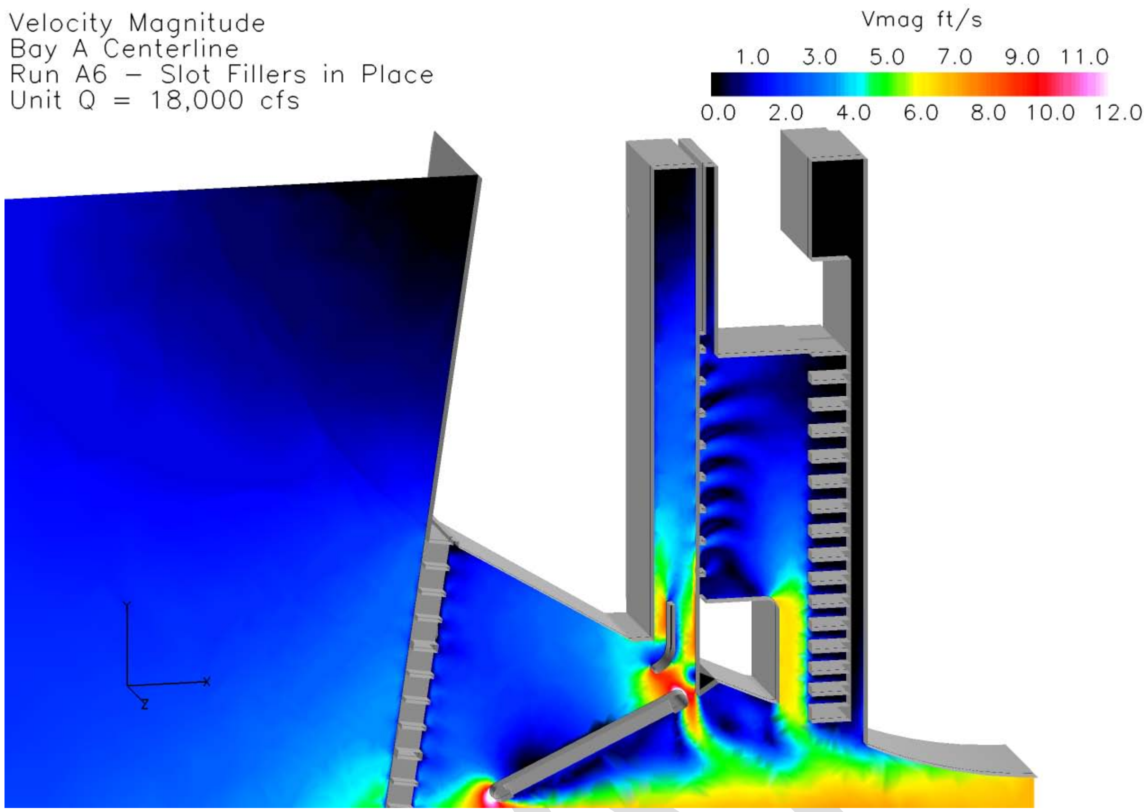


Figure 85. Alternative C1 – Bay A Centerline Velocity Magnitude

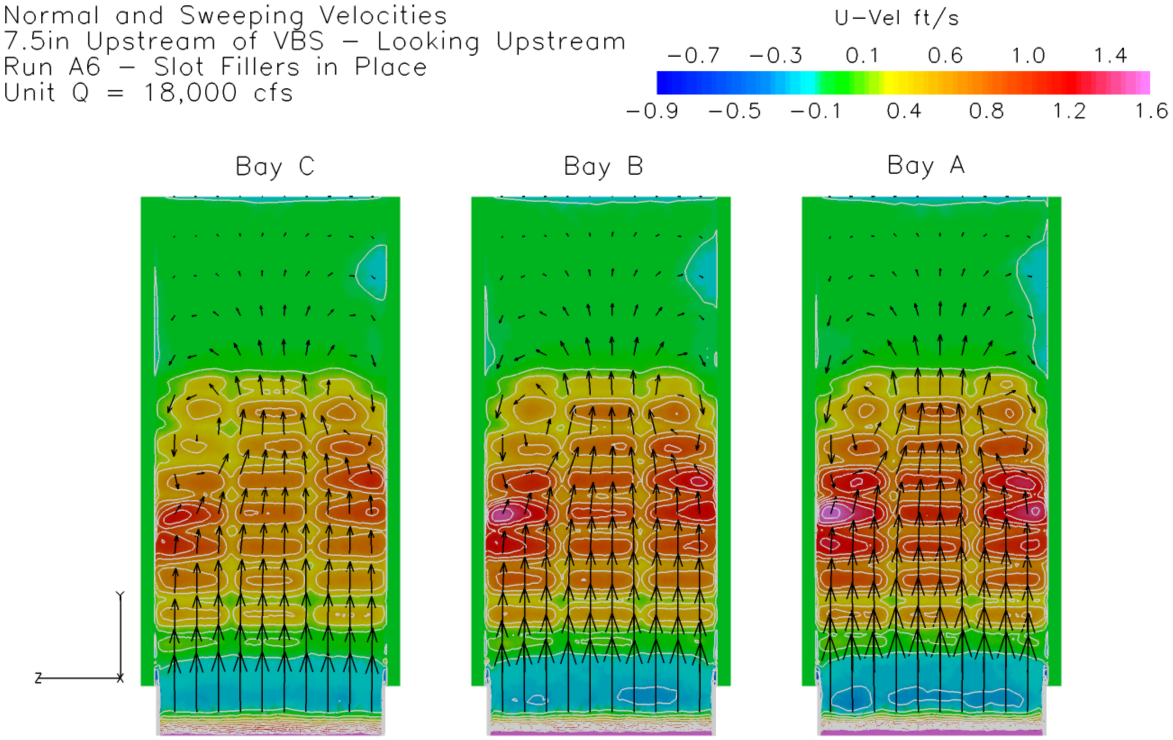


Figure 86. Alternative C1 – VBS Normal Velocities and Flow Patterns

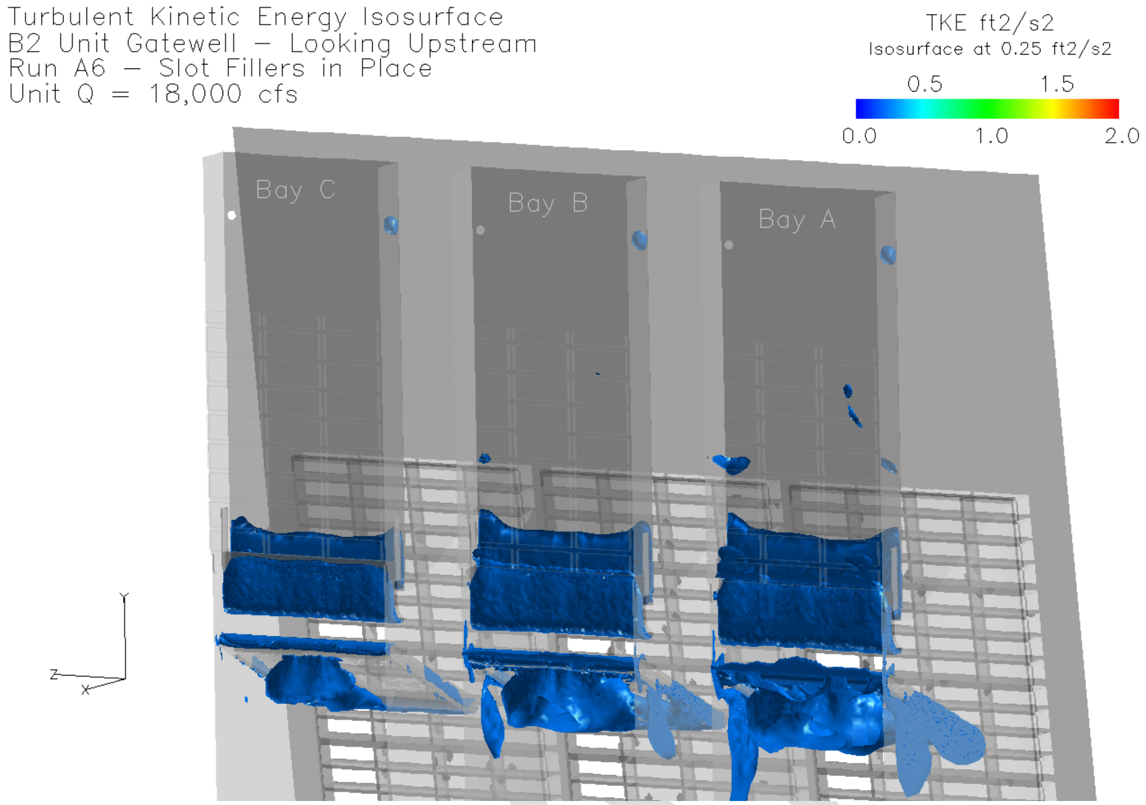


Figure 87. Alternative C1 – Turbulent Kinetic Energy Isosurface

APPENDIX D

Hydropower Impacts

Appendix D – Hydropower Impacts

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Appendix D. Hydropower Impacts

D.1. Introduction

D.1.1. Purpose and Scope

One of the alternatives (Alternative B1) under study for improving the Bonneville second powerhouse (PH2) fish guidance efficiency (FGE) during the juvenile fish passage season (March through August) involves restricting the main turbine units to operation below the upper 1% operating point (1% below peak efficiency). The purpose of this appendix is to estimate the impact to project generation output and corresponding hydropower benefits if the main turbine units are operated at peak efficiency for juvenile fish passage. These results can be used to place an upper limit on the impacts to project generation output and hydropower benefits resulting from operating the main units below the upper 1% operating point.

D.1.2. Project Description

Bonneville Dam is a run-of-river project located on the Columbia River (river mile 146.1) in the states of Oregon and Washington. Project operating purposes include hydropower, navigation, fisheries, recreation, and water quality. The first powerhouse with main turbine units 1 through 10 was completed in 1943, while PH2 with main turbine units 11 through 18 (along with two fishway units) was completed in 1982. The original per unit nameplate ratings of the main units are 43 MW for units 1-2, 54 MW for units 3-10, and 66.5 MW for units 11-18. Major rehabilitation of the first powerhouse was completed in 2010 (turbine runner replacement and generator rewind for all 10 turbine units). The per unit nameplate ratings of the rehabilitated units are 53.5 MW for units 1-2 and 62 MW for units 3-10.

D.1.3. Second Powerhouse Operation Alternatives

Analysis of the hydropower impacts of restricting PH2 turbine units to peak efficiency operation during the juvenile fish passage season involves estimating project generation output and corresponding hydropower benefits under each of two alternatives, which are briefly described below.

1. **Base Case: Second Powerhouse Turbine Units Operate to the Upper 1% Operating Point.** This alternative assumes that all first and second powerhouse turbine units operate between the peak efficiency operating point and the upper 1% operating point during the juvenile fish passage season. The project is assumed to conform to the operating requirements as summarized in the April 2009 Fish Passage Plan (FPP) and the U.S. Army Corps of Engineers (USACE) 2009-2010 Data Submittal.
2. **Alternative Case: Second Powerhouse Turbine Units Operate at the Peak Efficiency Operating Point.** This alternative assumes that all first powerhouse units operate between the peak efficiency operating point and the upper 1% operating point during the juvenile fish passage season, while all PH2 units operate at the peak efficiency operating point during this time period. The project is assumed to conform to the operating requirements as summarized in the April 2009 FPP and the USACE 2009-2010 Data Submittal.

D.1.4. Procedure

Analysis of the hydropower impacts of restricting Bonneville PH2 units to peak efficiency operation during the juvenile fish passage season included the following steps:

- Run the HYSSR model to obtain a sequential stream flow regulation for Bonneville for the period from August 1928 through July 1978. Determine weekly average releases and reservoir elevations for this 50-year hydrologic period of record.
- Input Bonneville operational data (including HYSSR flows and reservoir elevations, turbine-generator performance, unit loading orders, unit maintenance schedules, spill for fish requirements, and powerhouse minimum flow requirements) into the Turbine Energy Analysis Model (TEAM).
- Run TEAM for the Base Case in order to estimate Bonneville energy generation for each year and week in the 50-year hydrologic period of record.
- Modify the Bonneville PH2 turbine-generator performance input to TEAM to require unit operation at peak efficiency during the juvenile fish passage season under the Alternative Case.
- Run TEAM for the Alternative Case in order to estimate Bonneville energy generation for each year and week in the 50-year hydrologic period of record.
- Determine average weekly power values from BPA supplied data for super-peak (SP) hours, heavy-load hours (HLH) and light-load hours (LLH) for each week in the 50-year hydrologic period of record. This serves as input to the COMPARE spreadsheet.
- Import the Bonneville 50-year hydrologic period of record energy generation tables for the Base Case and Alternative Case into the COMPARE spreadsheet.
- Use the COMPARE spreadsheet to determine the annual value of Bonneville generation under the Base Case and Alternative Case. The difference between these generation values represents the annual hydropower benefits foregone due to the requirement that PH2 units operate at the peak efficiency operating point. The hydropower benefits foregone during the juvenile fish passage season are used in the study analysis.

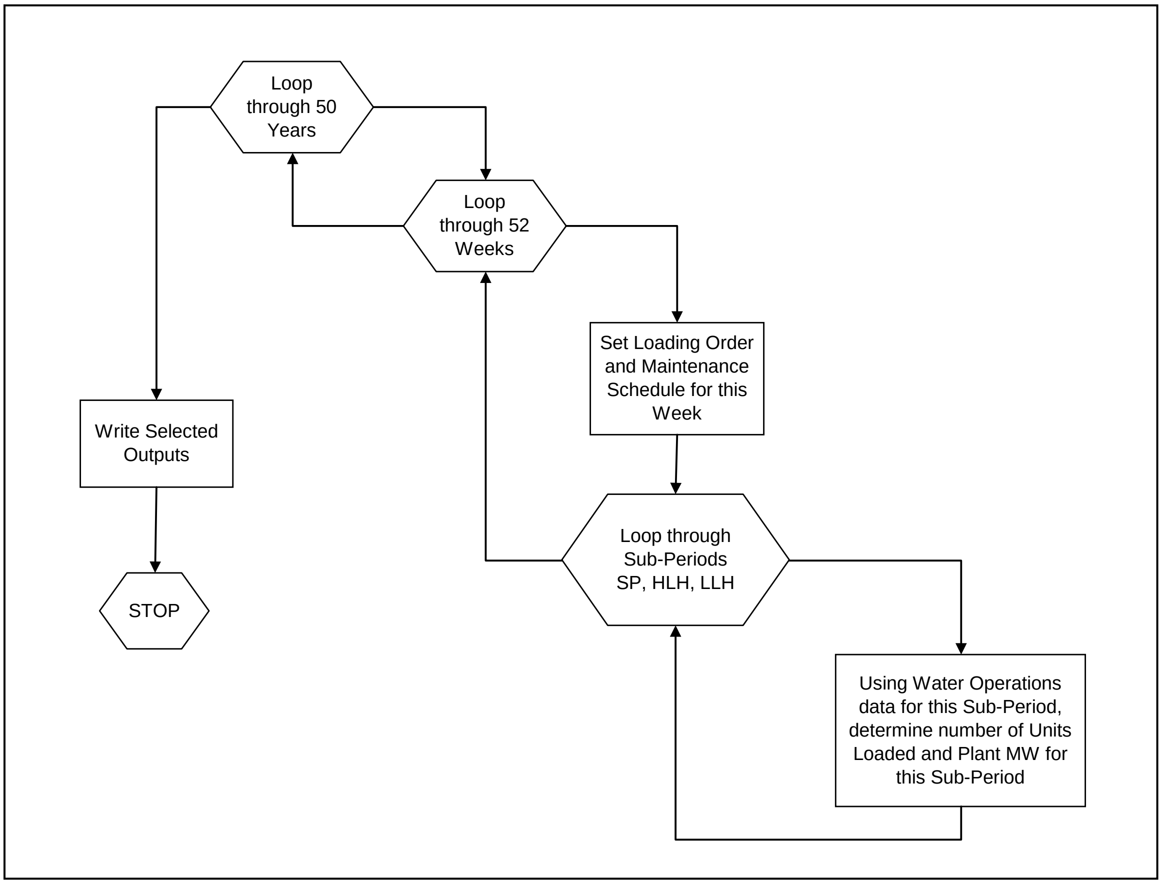
Some parts of the study analysis were performed using spreadsheet software. Arithmetic operations and totals were taken to full decimal accuracy within the spreadsheet. Tables found in this report have been rounded to a specified level of accuracy after the mathematical computations have been performed; therefore, rounded totals may not equal the summation of rounded values.

D.2. Energy Production

D.2.1. General

TEAM was used to estimate the energy generation output of Bonneville under the Base Case and Alterative Case. A simplified logic diagram for TEAM is shown in Figure D-1.

Figure D-1. TEAM Logic Flow



Briefly, TEAM is used to allocate project discharge to units at a power plant with multiple and/or different-sized generating units. When the discharge allocation has been determined for each generating unit, the power output for each unit is computed based on the head and unit efficiency specified. Using available discharges adjusted for various project flow losses, TEAM simulates the loading of generating units in a given sequence, up to the point that all discharge is utilized for generation and any excess is spilled. The unit loading order is specified for each month of the year, thereby allowing the model to reflect variations in loading order and unit availability.

D.2.2. TEAM Overview

TEAM is set up to use a weekly time step for up to a 62-year hydrologic period of record. In addition, each week is further broken into three sub-periods: (1) the 30-hour SP, the six highest value hours during 6 AM to 10 PM period on Monday through Friday; (2) the 66-hour HLH, the 6 AM to 10 PM period on Monday through Saturday (not including the SP hours); and (3) the 72-hour LLH, the remaining hours of the week. This allows energy generation output from TEAM to be valued at the appropriate price levels.

When executed, TEAM loops through all years in the long-term hydrology (50 years are used in this study); within each year TEAM then loops through each week, and within each week TEAM loops through the three sub-periods starting with SP, then HLH, and finally LLH. For each sub-period, TEAM uses the defined flow and head for that sub-period and loops through the units based on the loading order specified for that week while checking the maintenance schedule for unit availability. It loads as many units as needed to fully use the sub-period flow. Using performance curves specified for each unit, units are first loaded at their best efficiency point and if after all units are loaded there is flow remaining, units are then loaded up to their generator limit. For the first two sub-periods (SP and HLH), if flow remains after all units have been loaded up to their maximum limit, the remaining flow is moved to the next sub-period (from SP to HLH and from HLH to LLH). For the last sub-period (LLH), if flow remains, all sub-periods are set to the weekly average flow and any unused flow (spill) is assumed to occur in all sub-periods. After all the years are completed, depending on the selected output, power generation, total flow, power flow, unused power flow, gross head, tailwater, and overall efficiency are output for each sub-period to the TEAM spreadsheet. In addition, if selected, unit-specific output is available for each sub-period. A brief description of TEAM inputs and outputs is provided below.

D.2.3. TEAM Inputs

D.2.3.1. Turbine Performance Data

TEAM requires detailed information for combined turbine-generator performance for each type of unit included in the evaluation. For each unit, TEAM requires four polynomial equations (up to 3rd order) that are each a function of gross head. These are Power (MW) at Best Gate (PBG), Power (MW) at Full Gate (PFG), Efficiency (%) at Best Gate (EBG), and Efficiency (%) at Full Gate (EFG). For each unit the generator upper limit in MW is required. In addition, four values (starting head, starting MW, ending head, and ending MW) are included to define an upper cavitation limit. This data is included in the TEAM spreadsheet on worksheet “Unit Performance.” This sheet also includes the total number of units for the power plant (18 for this study) and the number of different types of units. The unit type for each unit is assigned on worksheet “Unit Operations.”

Three different sets of unit performance equations (i.e., three unit types) were required as input to TEAM in order to model Bonneville existing condition unit operation. The first unit type modeled first powerhouse unit operation under the Base Case and Alternative Case, the second unit type modeled PH2 unit operation under the Base Case, and the third unit type modeled second powerhouse unit operation under the Alternative Case. Since the interest of this study is unit operation during the juvenile fish passage season, TEAM modeled first and second powerhouse unit operation with STS fish screens in place. The three sets of unit performance equations were developed by the Hydroelectric Design Center (HDC).

For the first and second unit types, performance equations representing unit operation at the upper one percent operating point were input into TEAM in place of the full gate performance equations. For the third unit type, performance equations representing unit operation at peak efficiency (best gate) were input into TEAM in place of the full gate performance equations. This forced PH2 units to operate at peak efficiency under the Alternative Case.

D.2.3.2. Loading Order

For TEAM to load units for each sub-period, it needs to know the desired loading order. TEAM allows the input of up to 14 different loading orders, which are entered into TEAM on worksheet “Unit Operations.” The loading order assigned to each week of the year is also entered on worksheet “Unit Operations.”

As summarized in the April 2009 FPP, the predominant unit operating priorities are:

First Powerhouse Unit Priority = 1, 3, 6, 2, 4, 5, 8, 10, 7, 9
Second Powerhouse Unit Priority = 11, 18, 15, 12, 17, 14, 13, 16

where typically PH2 units are operated ahead of first powerhouse units. In order to simplify the analysis, the loading order listed below was utilized in TEAM for each week of the year.

TEAM Unit Loading Order = Second Powerhouse, First Powerhouse
= [11, 18, 15, 12, 17, 14, 13, 16] , [1, 3, 6, 2, 4, 5, 8, 10, 7, 9]

D.2.3.3. Unit Maintenance

TEAM allows up to a 5-year maintenance/unit outage cycle to be entered on a week-by-week basis specifying which units are unavailable for that week (from one to the entire plant if desired). For studies whose hydrologic period of record exceeds the number of years in the cycle (a 50-year hydrologic period of record is used in this study), TEAM repeats the cycle. The cycle data is entered into TEAM on worksheet "Unit Operations."

In order to simplify the analysis, the Bonneville study assumed a 1-year cycle so that the same cycle was applied to each of the 50 hydrologic years. The number of units to assume unavailable during each week of the cycle was determined by analyzing 10 years of Bonneville historical unit unavailability data for years 1999-2008 obtained from the USACE Operation and Maintenance Business Information Link (OMBIL). The data analyzed included both scheduled outages (categories PO, MO) and forced outages (categories U1, U2, U3, SF). Since the interest of this study was in obtaining an estimate for the average number of units unavailable by week once first powerhouse major rehabilitation is complete, most of the outages related to first powerhouse turbine runner replacements and generator rewinds were eliminated from the analysis. Based on analysis of the OMBIL data, the TEAM yearly cycle (which begins in August and ends in July) assumed the following:

TEAM weeks 01-04, 14-17	(AUG, NOV)	three units total unavailable
TEAM weeks 05-13	(SEP, OCT)	four units total unavailable
TEAM weeks 18-52	(DEC - JUL)	two units total unavailable

Units from both powerhouses were assumed to be placed on outage in the reverse of the unit loading order. To the extent possible, the units placed on outage were evenly split between the first and second powerhouse. Thus, during a week where two units were assumed unavailable, the cycle included units 9, 16; during a week where three units were assumed unavailable, the cycle included units 9, 16, 7; and during a week where four units were assumed unavailable, the cycle included units 9, 16, 7, 13.

D.2.3.4. Spill for Juvenile Fish

TEAM allows for the input of spill for fish requirements by month, which is entered into TEAM on worksheet "Water Monthly." Spill for fish is entered into TEAM using two parameters:

- Percent of project flow spilled for fish.
- Upper limit in thousands of cubic feet per second (kcfs) on project flow spilled for fish (i.e., spill cap).

The spill for fish requirements entered into TEAM are based on information contained in the April 2009 FPP and the USACE 2009-2010 Data Submittal. Based on these documents, the percent of Bonneville flow spilled for fish entered into TEAM was 100% (subject to the appropriate spill cap) over the entire fish spill season (April 10 through August 31). For some periods in the fish spill season, the documents specified separate spill caps for the daytime and nighttime spill periods. Since TEAM is not able to model separate daytime and nighttime periods, it was necessary to weight the daytime and nighttime spill caps for a given period according to the number of hours per day that each spill cap applied in order to obtain the corresponding weighted spill cap that could serve as input to TEAM for that period. Based on the spill caps specified in the documents and the weighting process just described, the upper limit on Bonneville flow spilled for fish entered into TEAM ranged from a low of 92 kcfs (during the last half of August) to a high of 98 kcfs (during the last half of April).

D.2.3.5. Water Operations/Hydrology

TEAM requires water operation data for each week for every year evaluated. The HYSSR model was used to simulate the operation of the Columbia River Basin system of projects over the 50-year hydrologic period of record from August 1928 through July 1978. The HYSSR output that served as input to TEAM for this study included Bonneville regulated flows and forebay elevations for the 50-year period. Since HYSSR uses a 14-period per year routing interval (monthly with April and August each split into two periods), TEAM converted the HYSSR monthly flows and forebay elevations into weekly equivalents. For a TEAM week that fell entirely within 1 month, TEAM used the HYSSR monthly value to represent the weekly value. For a TEAM week that crossed 2 months, TEAM used a weighted average of the two HYSSR monthly values to represent the weekly value, based on the number of days of the week that fell in each of the 2 months.

Also required as input into TEAM is data for determining the project tailwater elevation for each week for every year evaluated. This input can either be in the form of a tailwater rating table or a constant tailwater elevation to be applied to each week of each year. For this study, the Bonneville tailwater rating table that served as input to the HYSSR model was used as input to TEAM. Other project data that served as input to TEAM included:

- Project non-power discharges and flow losses such as lockages, flows through fish ladders, juvenile bypass systems, ice and trash sluiceways, the PH2 corner collector, and auxiliary water supply for fishways (not included is spill for fish requirements that are entered into TEAM separately).
- Minimum powerhouse discharge.

Project values for each of the above two data types were entered into TEAM for each of the 14 HYSSR periods. The same set of project values was used for all years evaluated by TEAM. These values are based on information contained in the April 2009 FPP and the USACE 2009-2010 Data Submittal.

The TEAM input described in this section is entered on worksheet “Water Monthly.”

D.2.3.6. Sub-Periods

Section G.2.2 notes that each TEAM week is broken into three sub-periods: the 30-hour SP, the 66-hour HLH, and the 72-hour LLH. This section describes the weekly process by which project units are loaded in each of the three sub-periods.

In order to load units in each sub-period, TEAM needs to distribute the weekly flow between the three sub-periods. This is accomplished by multiplying a weekly “shaping factor” for each sub-period by the weekly flow. The shaping factors used by TEAM are stored in worksheet “Sub Period Weekly Factors.” This worksheet contains a table of shaping factors for each of the three sub-periods. Each table contains a shaping factor for each week in the 50-year hydrologic period analyzed by TEAM. The weekly shaping factors are calculated by TEAM based on monthly shaping factors that are entered into worksheet “Sub-Period Monthly Factors.” The monthly shaping factors were developed by the Bonneville Power Administration (BPA).

D.2.3.7. Other Inputs

TEAM run execution is controlled on worksheet “Control.” The number of years included in the input data is set here, along with the number of periods (weeks in this case) in the year. The user can select the first and last year to run (anywhere from one to the total years available can be selected). The user can choose whether to run sub-periods or only use period average data. Run identifiers are also entered on this worksheet. The user can select the desired outputs here, and can also choose to have run-status messages written to this worksheet during TEAM execution. A prefix is entered for naming output worksheets. If the user decides to save the file, a unique file name based on run date and time and run identifier is created. After saving, the file name and time it was saved are written to this worksheet.

D.2.4. TEAM Outputs

Four types of output can be selected. Each type (except debug) is written to its own worksheet. Desired output and corresponding worksheet names are set in worksheet “Control.”

- Detailed Unit Output: Provides period-by-period detailed unit loading information. Only for monthly data of 10 years or less.
- Quick Unit Output: Added to the Visual Basic version as an alternative to the existing detailed unit output. This provides abbreviated period-by-period output, which is much quicker than the detailed unit output.
- Table Output: User-friendly tabular output used for investment evaluations. Available for individual sub-periods and runs based on period average flows without sub-periods. A sub-period summary table is also produced.
- Debug: These were the embedded write statements used for debugging included in the original HALLO model (which was used as the starting point for the development of TEAM). Writes to a text file.

D.2.5. Bonneville Energy Production Estimates

TEAM was used to estimate the energy generation output of Bonneville under Base Case (PH2 units operate to the upper 1% operating point) and under Alternative Case (PH2 units operate at the peak efficiency operating point). TEAM output for Base Case and Alternative Case used in the study analysis consisted of energy generation for each year and week in the 50-year hydrologic period of record. Separate tables were available for each of the three weekly sub-periods: SP, HLH and LLH. For each case, the results for the three weekly sub-periods were combined to yield the project total energy generation for each year and week in the hydrologic period. The results of this process are summarized in Table D-1 in the form of juvenile fish passage season monthly and total energy generation averages in megawatt hours (MWh) over the hydrologic period. The values shown in the last column, labeled **BC -**

AC, represent the estimate of energy generation foregone due to restricting PH2 units to peak efficiency operation during this season.

Table D-1. Bonneville 1929 to 1978 Monthly Average Energy Generation

Month	Generation (MWh)		
	Base Case	Alternative Case	BC - AC
MAR	482,580	474,690	7,890
APR	411,610	393,860	17,750
MAY	447,770	414,730	33,040
JUN	441,620	413,250	28,370
JUL	329,410	326,770	2,640
AUG	218,360	219,000	-640
Total	2,331,350	2,242,300	89,050

The main factor contributing to the results shown in Table D-1 is the relationship between the flow available for energy generation and the Bonneville hydraulic capacity (first powerhouse + second powerhouse). During the months March through July there are a number of monthly periods over the 50-year hydrologic period where the flow available for energy generation exceeds the project hydraulic capacity (thus resulting in forced spill) under both the Base Case and Alternative Case. Since the hydraulic capacity of the PH2 is less under the Alternative Case than under the Base Case, there is more forced spill under the Alternative Case than under the Base Case during these monthly periods. This results in less energy generation under the Alternative Case than under the Base Case during March through July as shown in Table D-1.

During the month of August, the flow available for energy generation is less than the project hydraulic capacity over the entire 50-year hydrologic period. Thus, the flow utilized for energy generation during August is the same under the Base Case and the Alternative Case. Since PH2 units operate more efficiently under the Alternative Case than under the Base Case, there is more energy generation under the Alternative Case than under the Base Case during August as shown in Table D-1.

D.3. Valuation of Energy Output

D.3.1. Overview

The BPA developed and provided to USACE the projected hourly market-clearing prices based on the 50 years of hydrologic data used in estimating energy production. These projections were developed using an electric energy market model called AURORA. AURORA is owned and licensed by EPIS Incorporated.

D.3.2. AURORA Production Cost Model

The hourly market-clearing price is based upon a fixed set of resources dispatched in least-cost order to meet demand. The hourly price is set equal to the variable cost of the marginal resource needed to meet the last unit of demand. A long-term resource optimization feature within the AURORA model allows generating resources to be added or retired based on economic profitability. Market-clearing price and the resource portfolio are interdependent. Market-clearing price affects the revenues any particular resource can earn and consequently will affect which resources are added or retired. Iterative solutions of resource portfolios and market-clearing prices are completed in AURORA until the difference between the last two iterations is minimal. AURORA sets the market-clearing price using assumptions of demand levels (load) and supply costs. The demand forecast implicitly includes the effect of price elasticity over time. The supply side is defined by the cost and operating characteristics of individual electric generating plants, including resource capacity, heat rate, and fuel price. AURORA incorporates the effect that transmission capacity and prices have on the system's ability to move generation output between areas. AURORA recognizes 13 areas within the Western Electricity Coordinating Council (WECC), largely defined by major transmission interconnections. For example, California is split into two market areas, north and south; Oregon, Washington, and Northern Idaho are combined while Southern Idaho is a separate market area; and British Columbia and Alberta (Canada) are combined into a single market area.

The assumptions in AURORA for determining power values include:

- Load year October 2009 - September 2010 was modeled using AURORA.
- 50 water years (August 1928 through July 1978) of regional monthly generation obtained from BPA's HYDROSIM model served as input to AURORA.
- For each of the 50 water years, monthly generation was simulated for the modeled load year.
- An hourly marginal cost for each hour of the period October 2009 - September 2010 was determined for each water year's generation.
- BPA provided 8,760 hourly marginal costs values for each of the 50 water years (leap years not considered).
- These values represent the Mid-Columbia trading prices.

To describe AURORA's methodology, it is helpful to distinguish between two main aspects of modeling the electric energy market: the short-term determination of the hourly market-clearing price and the long-term optimization of the resource portfolio.

D.3.2.1. Hourly Price Determination

As noted earlier, the hourly market-clearing price is based upon a fixed set of resources dispatched in least-cost order to meet demand. The hourly price is set equal to the variable cost of the marginal resource. AURORA places two restrictions on the hourly operation of generating plants. First, AURORA simulates the "must run" status of certain units. Second, AURORA recognizes that costs associated with ramping generation levels up and down will make the economic dispatch of plants on an hourly basis impractical. To account for this, AURORA commits generating plants to operate at weekly intervals. AURORA uses a weekly price forecast to determine plant profitability and to model the commitment decision.

D.3.2.2. Long-term Resource Optimization

The long-term resource optimization feature within AURORA allows generating resources to be added or retired based on economic profitability. Economic profitability is measured as the net present value (NPV) of revenue minus the NPV of costs. A potential new resource that is economically profitable will be added to the resource database. An existing resource that is not economically profitable will be retired from the resource database. In reality, the market-clearing price (hence the profitability of a resource) and the resource portfolio are interdependent. The market-clearing price will affect the revenues any particular resource can earn, and consequently, it will affect which resources are added and retired. In the same way, changes in the resource portfolio will change the supply cost structure, which will affect the market-clearing price. AURORA uses an iterative process to address this interdependency.

AURORA's iterative process uses a preliminary price forecast to evaluate existing and potential new resources in terms of their economic profitability. If an existing resource is not profitable, it becomes a candidate for retirement. Alternatively, if a potential new resource is economically profitable, it is a candidate to be added to the resource portfolio. In the first step of the iterative process, a small set of new resources is drawn from those with the greatest profitability and added to the resource base. Similarly, a small set of the most unprofitable existing resources is retired. This modified resource portfolio is used in the next step in the iterative process to derive a revised market-clearing price forecast. The modified price will then drive a new iteration of resource changes. AURORA will continue the iterative solution of the resources portfolio and the market-clearing price until the difference in price between the last two iterations reaches a minimum and the iterations converge on a stable solution.

D.3.3. Energy Values Used in Evaluation

The hourly AURORA energy values cannot be directly used in the evaluation since TEAM is calculating average weekly generation. To derive average weekly prices, the hourly AURORA prices were grouped into three weekly sub-periods: SP, HLH, and LLH for each of the weeks in the 50-year period of record. The following assumptions were used:

- SP will be defined as the highest price 6 hours per day during the traditional HLH period (6 AM to 10 PM or 0600 to 2200) on Monday through Friday for a total of 30 hours per week.
- HLH are usually the 16 hours per day for the period 6 AM to 10 PM (0600 to 2200) for Monday through Saturday for a total of 96 hours per week. Since this includes SP hours, which are a subset of HLH, the HLH were limited to 66 hours per week. This is based on 96 hours minus the 30 SP hours (highest 6 hours per day on Monday through Friday).
- LLH are 8 hours per day on Monday through Saturday and all day Sunday for a total of 72 hours per week. Although certain holidays are considered LLH for the entire day, they are not included in the breakdown used here.
- Holidays and Daylight Savings are not accounted for.
- Days used to break down sub-periods are based on the August 2009 through July 2010 period for all water years.
- Each week has 7 days except for week 52, which has 8 days. Based on the assumed year for prices, this extra day is a Saturday, so the last week has 192 hours, but only 30 SP hours.

Hourly prices were converted to weekly averages for each water year. The result was a 50-water year by 52-week table of power values for each sub-period. The average weekly prices are shown in Figure D-2.

D.3.4. Bonneville Energy Benefits Estimates

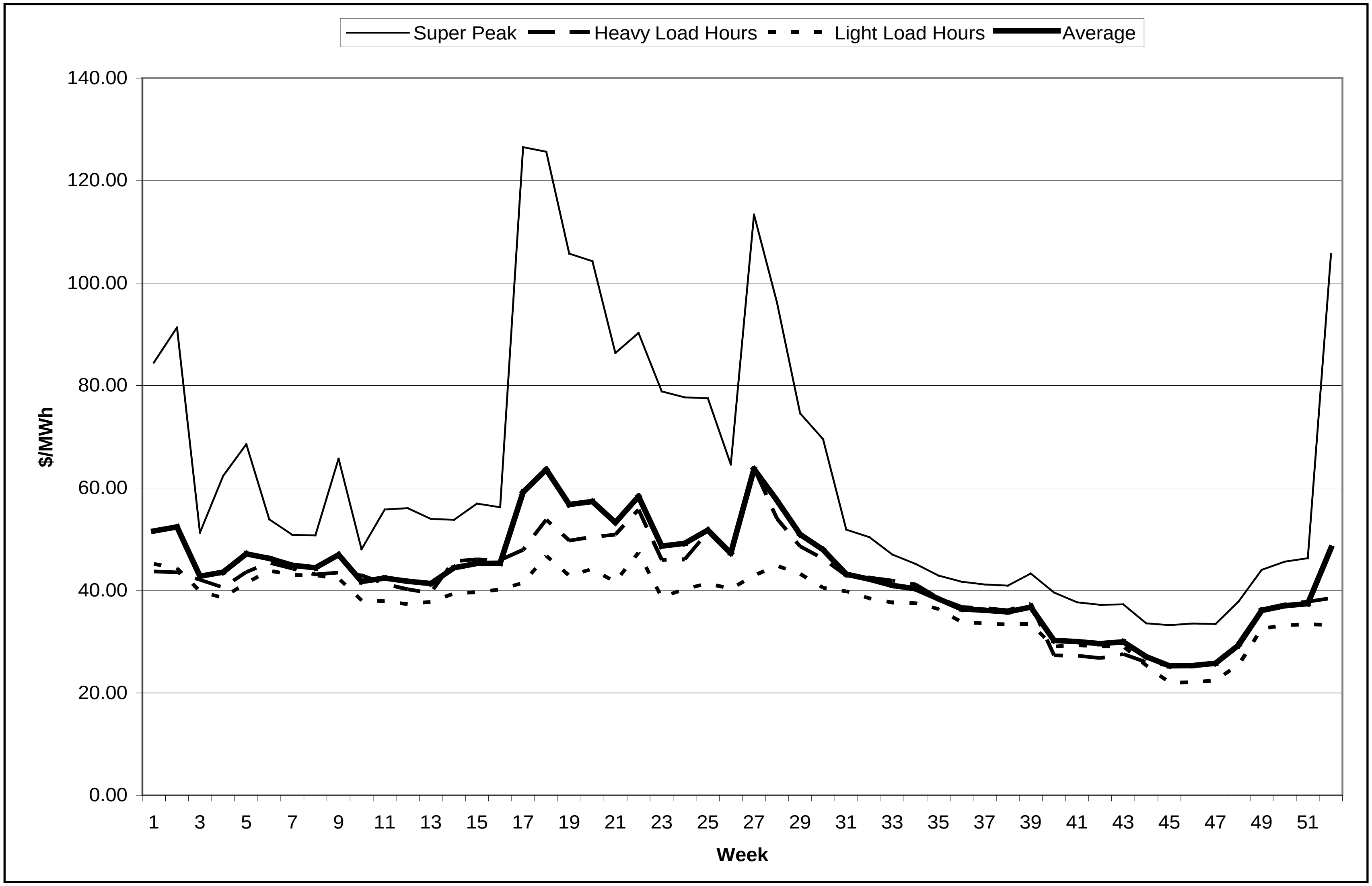
To determine the energy benefits associated with the Bonneville Base Case and Alternative Case, an Excel spreadsheet called COMPARE was developed that utilized as input TEAM output for each case, along with the weekly energy values described in Section G.3.3. The Bonneville output imported into COMPARE for each case consisted of a worksheet summarizing project weekly generation for each of the three sub-periods (SP, HLH and LLH) over the 50-year hydrologic period of record. Weekly $/MWh energy values for all years in the hydrologic period were also imported into COMPARE. With the generation worksheets and weekly energy values as input, COMPARE estimated the energy benefits for the Base Case and Alternative Case, as well as the difference in energy benefits between the two cases. The results of this process are summarized in Table D-2 in the form of juvenile fish passage season monthly and total energy benefits averages in $1,000 over the hydrologic period. The values shown in the last column, labeled BC - AC, represent the estimate of energy benefits foregone due to restricting PH2 units to peak efficiency operation during this season.

The energy benefits estimates summarized in Table D-2 are consistent with the energy generation estimates summarized in Table D-1. The last column of each table shows losses during the months March through July and gains during the month of August.

Table D-2. Bonneville 1929 to 1978 Monthly Average Energy Benefits

Month	Benefits ($1,000)		
	Base Case	Alternative Case	BC - AC
MAR	19,670	19,390	280
APR	14,670	14,090	580
MAY	12,760	11,950	810
JUN	11,170	10,650	520
JUL	12,490	12,430	60
AUG	10,770	10,800	-30
Total	81,530	79,310	2,220

Figure D-2. Average Weekly Price by Sub-Period



APPENDIX E

Construction Cost Estimate

B2 FGE Post Construction Alternative Report 2012
Preliminary Cost Estimate (Rounded to 100,000$)

Prepared by: RLR

11/27/2012

Description (costs rounded to $100k)	ALTERNATIVE **Alt B2 (open 2 orifices)**	**Alt B3 (Horz Slot)**	V2 **Alt C1 Gate Slot Filler**
Direct Costs	$28,500,000	$3,500,000	$3,390,000
Markups (Overhead, Profits, Bond, tax, OT)	$15,400,000	$1,900,000	$1,800,000
SUBTOTAL COSTS	$43,900,000	$5,400,000	$5,190,000
CONTENGENCY PERCENT	36%	27%	28%
CONTINGENCY AMOUNT	$15,900,000	$1,500,000	$1,400,000
TOTAL ESTIMATE CONSTRUCTION COST	**$59,800,000**	**$6,900,000**	**$6,590,000**

NOTES

1 Escalation & Inflation NOT included

2 Engineering, Supervision, Admin, etc costs NOT included

3 Alternative B2: Open Second DSM Orifices

4 Alternative B3: Horizontal Slot For DSM

5 Alternative C1: Gate Slot Filler

6 Markup assumptions base on experience of previous 10 yrs of estimates JOOH 20%, HOOH 15%, Profit 10%, Bond 1.5%

Assumptions for costs
B2 FGE Post Construction Alternative Report 2012
Preliminary Cost Estimate
RLR 11/27/2012

V1

12/16/2011 Only Alt B1, B2, B3, and C will be have cost estimates

Other Alternatives not studied for cost due to unfavorable biological evaluations.
Alt A1 is Adj Louver Flow Control Device Eliminated by Matrix: Thus NO Cost Estimate
Alt A2 is Sliding Plate Flow Control Device Eliminated by Matrix: Thus NO Cost Estimate
Alt A3 is Modify VBS Perf Plates Eliminated by Matrix: Thus NO Cost Estimate
Alt A4 is Modify Turning Vane Eliminated by Matrix: Thus NO Cost Estimate

Alt B1 is Operate Main Units off 1% peak No Construction costs ONLY Lost Power Costs for LCC
Alt B2 is Open Second DSM Orifices
Alt B3 is Horizontal Slot For DSM

Alt C1 is Install Gate Slot Fillers

V2

8/1/2012 Revised TRD type for C1 w/ 25ft Ht to Gateslot Filler with 60ft height

11/27/2012 Input Contingency based on Abbreviated Risk Analyses

B2 FGE Post Construction Alternative Report 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

		Prepared by: RLR	6/25/12			Labor or Crew or Sub-Bid				Material		Verified	Quantities per Item						
V1		**Direct Costs Alt B2 Open Second DSM Orifices**				Production		Rate	L-Cr-SB		Matl								
Location	**alts**	**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 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	A
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	64.0	1	GenCrew	$400	$26,000		$0		16	4				64	B
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	B
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	B
	5	Demo existing orifice tube	Ditto	hr	-	1	StruCr	$162	$0		$0							0	C = Col "Matl" only D = Col "L-Cr-SB" only
	6	Core drill for 13" dia Tube	Ditto	hr	24.0	1	Core	$1,104	$27,000		$0		6	4				24	ditto
	7	Install 13" Tube	Ditto	hr	80.0	1	StruCr	$162	$13,000		$0		2	10	4			80	ditto
	8	Matl costs for new tubes	Ditto	ea	4.0	1	n/a		$0	$ 3,600	$15,000		4					4	ditto
	9	Install New Gate	Ditto	hrs	180.0	1	MechElCr	$194	$35,000		$0		1	10	18			180	ditto
	10	Install New Actuator	Ditto	hr	216.0	1	MechElCr	$194	$42,000		$0		1	12	18			216	ditto
	11	Matl Cost for Mech	Ditto	ea	18.0	1	n/a		$0	$ 10,000.00	$180,000		18					18	ditto
	12	Modify DSM Grating	Ditto	hr	144.0	1	StruCr	$162	$24,000		$0		8	18				144	ditto
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	ditto
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	ditto
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	ditto
	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	$1,911	$344,000		$0		3	60				180	ditto
	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	ditto
	18				-	1			$0		$0							0	
Alt 13 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. A
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$400	$0		$0		0	10	10			0	B
	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	$562	$0		$0		3	10	0	3		0	B
	23	scaffolding at fish units	ditto	hr	-	1	ditto	$562	$0		$0		3	10	0			0	B
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	840.0	1	StruCr	$162	$137,000		$0		42	20				840	C = Col "Matl" only D = Col "L-Cr-SB" only
	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	ditto
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	840.0	1	MechElCr	$194	$163,000		$0		42	20				840	ditto
	27	Matl costs mech Elec	From text report	ea	42.0	1			$0	$ 1,500.00	$63,000		42					42	ditto
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	100.8	1			$0	$ 150.00	$16,000		42	2.4				100.8	ditto
	29					1			$0		$0							0	
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	$162	$69,000		$0		42	10				420	C = Col "Matl" only D = Col "L-Cr-SB" only
	32	Install Structural Frame	Assume 20 hrs ea	hr	840.0	1	StruCr	$162	$137,000		$0		42	20				840	ditto
	33	Matl cost for frame	from rpt text	ea	42.0	1	na/		$0	$ 700.00	$30,000		42					42	ditto

B2 FGE Post Construction Alternative Report 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

Prepared by: RLR 6/25/12

V1 **Direct Costs Alt B2 Open Second DSM Orifices**

Location	alts	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 Reduce Orifice	34	Redo Piping to Actuator	Assume 20 hrs to customize at each	hr	840.0	1	MechElCr	$194	$163,000		$0		42	20				840	ditto
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	168.0	1	MechElCr	$194	$33,000		$0		42	4				168	ditto
	36	Install Actuator Valve	Assume 12 hrs each	hr	504.0	1	MechElCr	$194	$98,000		$0		42	12				504	ditto
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	42.0	1	StruCr	$162	$7,000	$ 500.00	$21,000		42					42	ditto
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	ditto
	39	Mob Demob if not other alts done			-	1			$0		$0							0	A
	40				-	1			$0		$0							0	
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	100,600.0	1		$0	$0	$ 1.00	$101,000		503,000	0.2				100600	C = Col "Matl" only D = Col "L-Cr-SB" only
	43	Misc Labor etc	Say 20%	%	290,600.0	1		$1	$291,000	$ -	$0		1,453,000	0.2				290600	ditto
		Subtotal Direct Cost Added Orifices	**$2,348,000**						$1,744,000		$604,000								
		Dewatering Stage 1 Structure	See assumption text, next Tab "AltB2assum"		1.0	1		$13,100,000	$13,100,000		$0		1					1	F
		Dewatering Stage 2 Structure	See assumption text, next Tab "AltB2assum"		1.0	1		$13,100,000	$13,100,000		$0		1					1	**F**
		Subtotal Direct Cost Added Orifices	**$28,548,000**						$27,944,000		$604,000								

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 .

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

Notes: In the NOTE Columns: A to D denotes category of costs used in the Risk Analysis
"A" Denotes Mob Costs
"B" Denotes Access to Work
"C" Denotes Materials
"D" Denotes Install
"F" Denotes D/W Structures

Bonneville Second Powerhouse
Fish Guidance Efficiency (FGE) Program
Post Construction

5/30/12

Alt B2

This Alternative is to open 2 orifices in every Gate slot. It is reported from observations that the slots with 2 orifices operating seemed to have less problems. Operating 2 orifices requires significant changes in the Downstream Migrant System, DSM.

Current DSM: The dewatering screens have the capacity to dewater flows from 465 cfs to 486 cfs. This maintains velocities on the screen within criteria. (< 0.4 fps) and Channel Velocity of 2-5 fps. However the forebay elevation can change from elev. 71.5 to 76.5 feet with a corresponding change in flow from each orifice. Each orifice, 13 inch diameter opening, has a flow of 10.4 cfs to 14.7 cfs from the low to high forebay range. Therefore the number of operating orifice is adjusted to the forebay elevation to maintain the DSM flow within the capacity of the dewatering structure. Currently there are 40 operating orifices. The dewater structure is at the maximum size that can fit at its currently location in the powerhouse structure.

In addition to the criteria on the dewatering screen, the velocities along the DSM channel, where the orifices discharge, the channel flow must be between 2 to 5 fps. At the upstream end of the channel, 60 cfs add-in water provides the beginning 2 fps. As the forebay elevation lowers, additional orifices are opened starting at the upstream end to provide more flow and even channel velocities.

Cost Assumptions.

In 1997, the B2 DSM, Orifices, and Dewatering structure were improved; See "Supplement No. 6 to Design Memorandum No. 9, Bonneville Second Powerhouse Downstream Migrant System Improvements" dated August 1997. Assume for Alternative B2, a 2 stage dewatering structure. Stage 1, would be a rebuild of the existing dewatering structure to "control" the flow fluctuations in the DSM with a *dewatering capacity range* of 209 cfs to 450 cfs and a constant 433 cfs exiting to the stage 2 dewatering structure, located outside of the powerhouse. Assume each stage would have similar costs to the 1997 rehab.

The 1997 Total Project cost, which includes construction, markups, engineering, supervision, contingency of the contract was $10,813,000. Assume the contingency and markups represents the costs of details not yet determined in the 1997 DDR, reinforced by the experience that those estimates were commonly below (sometimes by a factor 1/2x the contract costs after P&S were developed and contractor bid on the project not to mention cost growth due to modifications during construction. Using EM-1110-2-1304, Civil Works Construction Cost Index System, the Cost Index Composite for Oct 1997 is 476.72. The index for June 2012 is 778.18 for an inflation factor of 1.63x. For a 2012 estimated cost of **$17,600,00 for each stage**.

Construction ONLY.
$8,018,000 x 1.63 = $13,100,000 each stage.

B2 FGE Post Construction Alternative Report 2012
Preliminary Cost Estimate (Rounded to 1000$)
Prepared by: RLR
Total costs with Markups from Summary sheet **(for Risk Analysis)**

Category for Risk Analysis Costs Alt B2 Open Second DSM Orifices

	Risk Areas	Direct Cost	Markup	Subtotal
A	Mobilization	$128,000	$70,000	$200,000
B	Access to Work	$26,000	$10,000	$40,000
C	Materials	$604,000	$330,000	$930,000
D	Install	$1,590,000	$860,000	$2,450,000
F	Dewatering Structures	$26,200,000	$14,150,000	$40,350,000
E	Rounding Adj		($20,000)	($70,000)
	total	$28,548,000	$15,400,000	$43,900,000

Note: Line "E" Rounding Adj is to remove rounding error due to rounding subtotals up to $10k

Crews
GenCrew

Green Cells are link/formula

B2 FGE Post Construction Alternative Report 2012

Preliminary Cost Estimate (Rounded to 1000$)

		Prepared by: RLR	6/25/12			Labor or Crew or Sub-Bid				Material		Verified	Quantities per Item						
V1		**Direct Costs Alt B3 Horizontal Slot for DSM**				Production		Rate	L-Cr-SB		Matl								
Location	Tag to text	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
	i	Mob Demob See MII info following	Assume trips of 8hrs Rnd for 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc, needs to be done 3 times (3 yrs)	LS	27.0	1		$4,731	$128,000		$0		9	3				27.00	A
	ii	Prep & Dewater Units	Assume 5 days (10 hrs ea) 10 units	hr	500.0	1	GenCrew	$400	$200,000		$0		5	10	10			500.00	B
	iii	Scaffolding/work platform to work on slot area	Assume 2 days to install 1 day remove at 28 gate slots	hr	840.0	1	GenCrew+ StruCr	$562	$473,000		$0		30	28				840.00	B
	1	Penetration in Gate Slot u/s wall all labor, sawcutting & removal	2' x 10' opening to install weir (historical cost from 2 proj)	CF	1,120.0	1	Hist	$75	$84,000		$0		2	2	10	28		1,120.00	C = Col "Matl" only D = Col "L-Cr-SB" only
	2	Install Track	Assume 30 hrs ea for drilling & installing ea side, and grouting	hr	1,680.0	1	StruCre	$162	$273,000		$0		30	28	2			1,680.00	ditto
		" Anchors SS 1/2" x 6.5"	Assume 22 Anchors per side. From RSM2012 05 05 23.15 adj Matl from 8.55$ for 3/4" x 9.5 to say $6 ea x 3.5 for SS	ea	1,232.0	1			$0	$ 21.00	$26,000		22	2	28			1,232.00	ditto
		" Track SS	ea side Say angle/Pls 1/2" x 12" plus HSS 2x2x1/4 all 23 ft long plus 20 misc details	lbs	34,137.6	1			$0	$ 7.00	$239,000		30.48	2	28	20		34,137.60	ditto
	3	Broad Crest weir of Polished SS	Assume 5/8" SS Plate 24" x 13' plus 30% for stiffeners, misc details, seals, etc	lbs	23,186.8	1			$0	$ 8	$186,000		31.85	2	13	28		23,186.80	ditto
		"	Assume MechElCr 8 hr to install & Fit ea crest	hr	224.0	1	MechElCr	$194	$44,000		$0		8	28				224.00	ditto
		Cover in DSM over Actuator	Assume 1/4" SS plate x 2' x 10' and 4 hrs ea to install adj etc. Or 50lbs/hr	lb	5,600.0	50	StruCr	$162	$19,000	$ 5.00	$28,000		10	2	10	28		5,600.00	ditto
	4	Lintel Beam Above Opening	Assume $500 demo & 20 hr Str Crew at ea	hr	560.0	1	StruCr	$162	$91,000	$ -	$0		20	28				560.00	ditto
		" Demo	"	ea	56.0	1		$500	$28,000		$0		2	28				56.00	ditto
		SS Beam & Misc Matl	HSS8x4x5/8 x 3' x2 at each Place 30% misc	lb	10,264.8	1			$0	$ 7.00	$72,000		47	1.3	2	3	28	10,264.80	ditto
	5	Control system	Guess $300k for Forebay sensors, 28 crest sensors & limit switches, CPU, Wiring, etc	LS	300,000.0	1		$0.67	$200,000	$ 0.33	$100,000		300,000					300,000.00	ditto
	6	Remove Existing Piping, Air, Elec at existing orifices since it is in the way	Assume 40 working orifices, 24 hrs ea for MechElcr plus $25/hr misc material to refurbish to abandon or mothball	HR	960.0	1	MechElCr	$194	$187,000	$ 25.00	$24,000		40	24				960.00	ditto
	7	Remove DSM Channel floor at Adjusting Crest for bottom of elevation 54	Say chip out 5' L x 1.5'w x 3'd into floor at 6 units x 3 weirs/unit Say 10x more difficult than demo above in #1	cf	517.0	1	Hist & judg	$750	$388,000		$0		517					517.00	ditto
	8	New Hydraulic Power system	From discussion with Mech Eng	LS	1.0	1			$0	$80,000	$80,000		1					1.00	ditto
		" Fluid for system	Say $25/gal "	gal	1,500.0	1			$0	$ 25.00	$38,000		1500					1,500.00	ditto
		Actuators say 3"dia x 11' stroke	say $5000 ea "	ea	28.0	1			$0	$ 5,000.00	$140,000		28					28.00	ditto
		Hyd Pwr System Install	Say 3 wks	hr	150.0	1	MechElCr	$194	$30,000		$0		150					150.00	ditto
	9	Modify deck grating in DSM	Say 4' all sides $50/sf demo+ $70/sf custom new matl for Labor say 10 ea loc is 0.25Hr/sf	sf	1,120.0	4	StruCr	$162	$46,000	$ 120.00	$135,000		28	40				1,120.00	ditto
	10	Shroud for flow from weir into DSM	Say 1/4" t SS 10't x 6'w ea	lb	16,800.0	1			$0	$ 5.00	$84,000		10	10	6	28		16,800.00	ditto

B2 FGE Post Construction Alternative Report 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

Prepared by: RLR 6/25/12

Location	Tag to text	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 B3 Horizontal Slot for DSM**																	
		" Install	Say 20 hrs ea	hr	560.0	1	StruCr	$162	$91,000		$0		28	20				560.00	ditto
	11	Commissioning	Say 1 week	hr	50.0	1	StruCr+MechElCr+GenCr	$756	$38,000		$0		50					50.00	ditto
		Misc			28.0	1			$0	$ 1,000.00	$28,000		28					28.00	ditto
					-	1			$0		$0							-	ditto
					-	1			$0		$0							-	
					-	1			$0		$0							-	
					-	1			$0		$0							-	
		Subtotal Direct Cost Added Orifices	**$3,500,000**						$2,320,000		$1,180,000								
					-	1			$0		$0							-	
					-	1			$0		$0							-	
		Subtotal Direct Cost Added Orifices	**$3,500,000**						$2,320,000		$1,180,000								

Notes: In the NOTE Columns: A to D denotes category of costs used in the Risk Analysis
- "A" Denotes Mob Costs
- "B" Denotes Access to Work
- "C" Denotes Materials
- "D" Denotes Install

B2 FGE Post Construction Alternative Report 2012
Preliminary Cost Estimate (Rounded to 1000$)
Prepared by: RLR
Total costs with Markups from Summary sheet **(for Risk Analysis)**

Category for Risk Analysis Costs Alt B3   Horizontal Slot for DSM

	Risk Areas	Direct Cost	Markup	Subtotal
A	Mobilization	$128,000	$70,000	$200,000
B	Access to Work	$673,000	$360,000	$1,030,000
C	Materials	$1,180,000	$640,000	$1,820,000
D	Install	$1,519,000	$820,000	$2,340,000
E	Rounding Adj		$10,000	$10,000
	total	$3,500,000	$1,900,000	$5,400,000

Note: Line "E" Rounding Adj is to remove rounding error due to rounding subtotals up to $10k

B2 FGE Post Construction Alternative Report 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew

Green Cells are link/formula

Location	Tag to text	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	$/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	X	Y	Z	T	S	Q (product xyzts)	NOTE
		Prepared by: RLR	08/01/12 V2			Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		**Direct Costs Alt C1 GateSlot Filler**				Production		Rate	L-Cr-SB		Matl								
	1	Mob Demob See MII info (altB3)	Assume trips of 8hrs Rnd for 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc, needs to be done 3 times (3 yrs)	LS	27.0	1		$4,731	$128,000		$0		9	3				27.00	A
	2	Prep & Dewater Units	Assume 5 days (10 hrs ea) 10 units	hr	500.0	1	GenCrew	$400	$200,000		$0		5	10	10			500.00	B
	3	Scaffolding/work platform to work on slot area	Assume 1 days to install 1/2 day remove at 28 gate slots	hr	420.0	1	GenCrew+ StruCr	$562	$237,000		$0		15	28				420.00	B
					-	1			$0		$0							-	
	4	Install Track	Assume 1 hr ea for anchor bolt drilling & installing ea side, and grouting. 9 per track, 4 tracks per GateSlot	hr	2,419.2	1	StruCre	$162	$392,000		$0		36	28	2.4			2,419.20	V2, C = Col "Matl" only D = Col "L-Cr-SB" only
	5	" Anchors SS 1/2" x 6.5"	From RSM2012 05 05 23.15 adj Matl from 8.55$ for 3/4" x 9.5 to say $6 ea x 3.5 for SS	ea	2,419.2	1			$0	$ 21.00	$51,000		36	28	2.4			2,419.20	V2, C = Col "Matl" only D = Col "L-Cr-SB" only
	6	Slot filler fabrication	A36 painted steel	lbs	767,200.0	1			$0	$ 3.04	$2,333,000		13700	2	28			767,200.00	V2, C = Col "Matl" only D = Col "L-Cr-SB" only
	7	Dogging	Say $200 for dogging beam & dog each side	lbs	56.0	1	guess		$0	$ 200	$12,000		28	2				56.00	C = Col "Matl" only D = Col "L-Cr-SB" only
	8	Install Fillers & Move existing cables, controls, sensers etc in the slots	Say 4 hr per Gate slot	hr	28.0	1	GenCrew+ StruCr	$562	$16,000		$0		28	1				28.00	C = Col "Matl" only D = Col "L-Cr-SB" only
					-	1			$0		$0							-	C = Col "Matl" only D = Col "L-Cr-SB" only
		Misc			21.0	1			$0	$ 1,000.00	$21,000		21					21.00	C = Col "Matl" only D = Col "L-Cr-SB" only
					-	1			$0		$0							-	
		Subtotal Direct Cost Added Orifices	**$3,390,000**						$973,000		$2,417,000								
					-	1			$0		$0							-	
					-	1			$0		$0							-	
		Subtotal Direct Cost Added Orifices	**$3,390,000**						$973,000		$2,417,000								

Notes: In the NOTE Columns: A to D denotes category of costs used in the Risk Analysis

"A" Denotes Mob Costs
"B" Denotes Access to Work
"C" Denotes Materials
"D" Denotes Install

B2 FGE Post Construction Alternative Report 2012
Preliminary Cost Estimate (Rounded to 1000$)
Prepared by: RLR
Total costs with Markups from Summary sheet **(for Risk Analysis)**

Category for Risk Analysis Costs Alt C1 GateSlot Filler

	Risk Areas	Direct Cost	Markup	Subtotal
A	Mobilization	$128,000	$70,000	$200,000
B	Access to Work	$437,000	$240,000	$680,000
C	Materials	$2,417,000	$1,310,000	$3,730,000
D	Install	$408,000	$220,000	$630,000
E	Rounding Adj		($40,000)	($50,000)
	total	$3,390,000	$1,800,000	$5,190,000

Note: Line "E" Rounding Adj is to remove rounding error due to rounding subtotals up to $10k

Costs Alt C1 GateSlot Filler

Quantity Take-off of B2 Gate Slot Filler												
Material Quantity		40.8 psf of 1"t plate										
8/1/2012												
by Rick Russell								**lbs**		**TONS**		
	TOTAL WT 1 Side of Slot Filler							**13,702**		**6.9**		
	Description	L (ft)	W (ft)	T	" x "	Quant.	Unit	*type*	Unit Wt	Subtotal WT		
	One Side of gate slot										13,702	
1	Skin plate 1/2"	60	4	1	1	1	SF		20.4	4,896		0.36
2	Side Plates	60	1.2	1	1	2	SF		20.4	2,938		
3	Top & Bottom plate	3.6	0.7	1	1	2	SF		20.4	103		
4	Long angles L2.5x2.5x3/8	60	1	1	1	2	LF		5.3	636		
5	Transvers Angles L4x4x 3/8	4	1	1	4	10	LF		9.8	1,568		
6	Backing bar 1x1/4 1/S-402	4	1	1	1	3	LF		1.06	13		
7	track section M-501 3/8" x 8"	60	0.67	1	1	3	SF		15.3	1,845		
8	Guide bar Support 1 L2.5 x 2.5 x 3/8	18	1	1	1	3	LF		5.3	286		
9	Guide Bar Support 2 Pl 2.5" x 3/8"	18	1	1	1	3	LF		3.19	172		
10										-		
11										-		
12										-		
13										-		
14										-		
15										-		
16										-		
17										-		
18										-		
19										-		
20										-		
21	Misc at 10%	1	1	12,457	0.1	1	%		1	1,246		
22							SF			-		
23										-		
24												

Assumptions for costs				
B2 FGE Post Construction Alternative Report 2012				
Preliminary Cost Estimate				
RLR 6/25/12				
	Crews_	$/hr	Cellname	NOTE
	GenCrew			GenCrew to perform Dewatering support, Scaffolding install, Demolition, General Deck Support see MII Unit cost Includes 2 oper, 3 Laborers, 1 foreman, 1 Misc pwr tools, 1 40T crane, 1 FlBd 15T truck
	Labor	277		
	Equip	123		
	Total	400	**GenCrew**	
	Coring Crew			Performs: Coring new orifices see MII unit cost. Includes 1 Skilled Worker, 1 Laborer, 1 drill (D20Z2800) and $1000/hr for diamond drill bit wear
	Labor	95		
	Equip	9		
	Wear	1000		
	Total	1104	Core	
	Structural Installers Crew			Performs: chipping/removing concrete. Gratings, etc. See MII unit costs includes: 3 Laborers, 1 PwrTools, 1 truck (3/4Ton)
	Labor	129		
	Equip	33		
	Total	162	StruCr	
	MECH ELECTRICAL INSTALLERS			MechElCr) Assumes same cost for millwright and electrician and same cost for their required equipment. Performs: Installing Valves, Actuators, SS weir, fitting, Redo Piping, sensors, power d/s "guide sheath" for water into DSM. Includes 2Millrights, 1 pwrTools, 1 truck
	Labor	149		Sub MU 15%, 10%, 10%, 0.5% excise
	Equip	45		1.40
	Total	194	MechElCr	
	Controllers			Performs: Changing programming of controls. See Calc p. 60-8
	Labor	49		
	Equip	2		
	Total	51	Ctrl	

Abbreviated Risk Analysis

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices
Alternatives Report

Meeting Date: 25-Jul-12

PDT Members

Project Management:	GJM
Technical Lead:	RTL
Structual Design	DWP
Mechanical Design	SWH
Cost Engineering:	RLR
Construction:	RLR

Note:
NWP Command Policy Memo 15 Personally Identifying Information on the District Internet Web Site
Names of Employees should NOT be published due to privacy and security policies

Abbreviated Risk Analysis

Project (less than $40M): **B2 FGE Post Constr Alt B2 – Open Second DSM Orifices**
Project Development Stage: Alternatives Report

Note: Although this Alternative is estimated greater than $40 million, the Abbreviated Risk Analysis is used because A) this report is at the alternative comparison phase and the other alternatives (less than $10 million each) use this method. B) due to this alternative's cost being many times greater than the others considered, the non-abbreviated risk analysis would not change the conclusions of the alternative study. If this alternative is recommended as the preferred alternative, the full Cost Schedule Risk Analysis would be done for that recommendation.

Total Construction Contract Cost = **$ 43,900,000**

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	**06 FISH AND WILDLIFE FACILITIES**	**Mobilization (size, equipment dura)**	**$ 200,000**		19%	$ 37,500	$ 237,500
2	**06 FISH AND WILDLIFE FACILITIES**	**Access to work (d/w schaf, etc)**	**$ 40,000**		19%	$ 7,500	$ 47,500
3	**06 FISH AND WILDLIFE FACILITIES**	**Materials**	**$ 930,000**		17%	$ 155,000	$ 1,085,000
4	**06 FISH AND WILDLIFE FACILITIES**	**Install (crews, equipment, production)**	**$ 2,450,000**		25%	$ 612,500	$ 3,062,500
5	**06 FISH AND WILDLIFE FACILITIES**	**Dewatering Structures**	**$ 40,350,000**		38%	$ 15,131,250	$ 55,481,250
6		**Item Name**	**$ -**		0%	$ -	$ -
7		**Item Name**	**$ -**		0%	$ -	$ -
8		**Item Name**	**$ -**		0%	$ -	$ -
9		**Item Name**	**$ -**		0%	$ -	$ -
10		**Item Name**	**$ -**		0%	$ -	$ -
11		**Item Name**	**$ -**		0%	$ -	$ -
12		**Remaining Construction Items**	**$ (70,000)**	*0.0%*	0%	$ -	$ (70,000)
13	**30 PLANNING, ENGINEERING, AND DESIGN**	**Planning, Engineering, & Design (15%)**	**$ 6,590,000**		25%	$ 1,647,500	$ 8,237,500
14	**31 CONSTRUCTION MANAGEMENT**	**Construction Management (10%)**	**$ 4,390,000**		19%	$ 823,125	$ 5,213,125

Totals				
Total Construction Estimate	$ 43,900,000	36%	$ 15,943,750	$ 59,843,750
Total Planning, Engineering & Design	$ 6,590,000	25%	$ 1,647,500	$ 8,237,500
Total Construction Management	$ 4,390,000	19%	$ 823,125	$ 5,213,125
Total	$ 54,880,000	34%	$ 18,414,375	$ 73,294,375

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/26/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Mobilization (size, equipment dura)	2 or 3 seasons are required as modifying/adding work on 2nd orifices needs to occur during the IWWP because the JBS must be dewatered and inoperatable durign this work, and the corresponding turbine units dewatered to below the orifices.	Since Multi mobilizations are planned the cost impact would be marginal, and it is unlikely to affect the mob as the contract can plan for 3 years on site. In additional the majority of the work and equipment will be involved in the work on the dewatering structures.	Unlikely	Marginal	1
PS-2	Access to work (d/w schaf, etc)	Ditto	Since the work involves the JBS being off line, it will be a busy worksite during the IWWP. Access will be a limiting factor so changes in the scope could have a marginal impact on costs and are likely to happen on that scale.	LIKELY	Marginal	2
PS-3	Materials	LED lights for orifices is not yet typical for all projects, and changes during design could impact the orifice work. Dewatering structures are more set in the materials needs as several of these have been operating for several years.	It is UNLIKELY the project scope would change the cost of materials, and if they did it would have a NEGLIGIBLE effect on costs.	Unlikely	Negligible	0
PS-4	Install (crews, equipment, production)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2, however the work area are tight considering the amount of work in the limited IWWP time	Similar to PS-2	LIKELY	Marginal	2
PS-5	Dewatering Structures	No design work has been done concerning adding dewatering capacity.	The assumptions of the cost estimator are likely rather broad based and there could be Significant impacts in the costs.	LIKELY	Significant	4
PS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design (15%)	Priorities could change	Design report could start over requiring additional effort, however the process is in place to minimize this, and decision are usually made before final design effort, as cost of scope change is negligible.	LIKELY	Negligible	1
PS-14	Construction Management (10%)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2	Weather and coordination with others in the work area could have impacts. Change in duration would have the greatest impact and would be similar to Mob.	Unlikely	Marginal	1
Acquisition Strategy						
AS-1	Mobilization (size, equipment dura)	Acquisition strategy will have not affect the contractor's mob costs/methods	It is very unlikely that mob costs would be impacted more than a negligible amount	Very Unlikely	Negligible	0
AS-2	Access to work (d/w schaf, etc)	Acquisition strategy will have not affect the contractor's costs/methods for this feature	It is very unlikely that these costs would be impacted more than a negligible amount	Very Unlikely	Negligible	0
AS-3	Materials	ditto	Material price not impacted	Unlikely	Negligible	0
AS-4	Install (crews, equipment, production)	ditto	The work is estimated to be large enough that small inexperience contractors would not be able to bid and whatever acquisition strategy will result in contractor's with adequate work forces.	Very Unlikely	Negligible	0
AS-5	Dewatering Structures	Since there is no design yet for this design build could be a cost risk since the COE probably has the greatest expereince in design these type features	It is likely the Acquistion strategy could impact the cost marginally.	LIKELY	Marginal	2
AS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
AS-13	Planning, Engineering, & Design (15%)	Since there is no design yet for the Dewatering structures, design build could be a cost risk since the COE probably has the greatest expereince in design these type features	The tight spaces increase the difficulty and tolerances. For this element, there is a likely likelyhood with significat cost impact to this.	LIKELY	Significant	4
AS-14	Construction Management (10%)	ditto	The tight spaces increase the difficulty and tolerances. For this element, there is a Unlikely likelyhood with Negligible cost impact to this.	Unlikely	Negligible	0

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/26/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Construction Complexity						
CC-1	Mobilization (size, equipment dura)	Normal	Good road access to the site, equipment avail in PDX area, but may need custom build platforms. Unlike to change, and if did impact marginal	Unlikely	Marginal	1
CC-2	Access to work (d/w schaf, etc)	Requires coordination of powerhouse operations, which could restrict areas of the intake deck. Potential for delays.	Access is more difficult than normal for installing (not fabrications)	Unlikely	Negligible	0
CC-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
CC-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate	Unlikely	Negligible	0
CC-5	Dewatering Structures	No design work has been done concerning adding dewatering capacity.	The assumptions of the cost estimator are likely rather broad based and there could be Marginal impacts in the costs.	LIKELY	Marginal	2
CC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CC-13	Planning, Engineering, & Design (15%)	Remodeling / remaking the dewatering structure adds a level of complixity to match with the existing	Although not as "straight forward" as design of a new struture, remodelling is typcial of this type of work	Unlikely	Negligible	0
CC-14	Construction Management (10%)	Normal, but with tight conditions and schedules considering the amount of work.	ditto, but cost impact could be marginal due to the schedule	Unlikely	Marginal	1
Volatile Commodities						
VC-1	Mobilization (size, equipment dura)	Crane Size	Required crane (<75T) is common in the are	Very Unlikely	Negligible	0
VC-2	Access to work (d/w schaf, etc)	Custom built platforms	Common construction will be used for custom builts	Very Unlikely	Negligible	0
VC-3	Materials	Prices could increase from suppliers	Standard construction materials expected. Steel, concrete anchors. Available from many suppliers. Economic situation is not changing rapidly in last 2 years.	Unlikely	Marginal	1
VC-4	Install (crews, equipment, production)	Labor rates change?	Recent Labor rates have been stable. Trades needed are not unusual	Very Unlikely	Negligible	0
VC-5	Dewatering Structures	Uses rather specialized items (wedge wire, perplate, lots of Stainless steel)	See VC-3	Unlikely	Marginal	1
VC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
VC-13	Planning, Engineering, & Design (15%)	n/a		Very Unlikely	Negligible	0
VC-14	Construction Management (10%)	n/a		Very Unlikely	Negligible	0

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/26/2012

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4
	Negligible	Marginal	Significant	Critical	Crisis

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Quantities						
Q-1	Mobilization (size, equipment dura)	Amount of Equipment? Number of Season?(see PS-1)	Similar to previous work in the slot. If add'l season would require more mob with a marginal impact on cost	Unlikely	Marginal	1
Q-2	Access to work (d/w schaf, etc)	N/a	Change in quantity would have little to no effect of access	Very Unlikely	Negligible	0
Q-3	Materials	Change in quantity has direct change on cost	Unlikely that quantities would change beyond what is already captured in Project Scope section above, but would be critical is they did	Very Unlikely	Critical	2
Q-4	Install (crews, equipment, production)	ditto	ditto	Very Unlikely	Critical	2
Q-5	Dewatering Structures	No design work has been done concerning adding dewatering capacity.	The assumptions of the cost estimator are likely rather broad based and there could be Significant impacts in the costs.	LIKELY	Significant	4
Q-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
Q-13	Planning, Engineering, & Design (15%)	Not impacted by quantities		Very Unlikely	Negligible	0
Q-14	Construction Management (10%)	ditto		Very Unlikely	Negligible	0
Fabrication & Project Installed Equipment						
FI-1	Mobilization (size, equipment dura)	Change in scope could require add'l or different equipment	different equipment would affect costs	Unlikely	Marginal	1
FI-2	Access to work (d/w schaf, etc)	Assumes units will be dewatered by project	Bulkhead is used often by Project which will perform the dewatering. Coordination required. Change here would have critical impacts	Very Unlikely	Critical	2
FI-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
FI-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate. However if The Proj is unable to d/w Ktr use of alternate methods would have critical impact. Additionally, tolerance of existing dimension be greater than expected requiring custom fitting.	Unlikely	Critical	3
FI-5	Dewatering Structures	Fabrication of rather special parts, but included in cost estimate	change from assumptions very unlikely, dewaterings parts mostly set	Very Unlikely	Negligible	0
FI-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.	n/a	Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design (15%)	No design work has been done concerning adding dewatering capacity.	The assumptions of the cost estimator are rather broad based, But the likelyhood of changed from assumed existing d/w structures is UNLIKELY with NEGLIBLE cost impact (that has not been captured in the Quantities area)	Unlikely	Negligible	0
FI-14	Construction Management (10%)	ditto	DITTO	Unlikely	Negligible	0

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/26/2012

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4
	Negligible	Marginal	Significant	Critical	Crisis

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Cost Estimating Method						
CE-1	Mobilization (size, equipment dura)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-2	Access to work (d/w schaf, etc)	Assumption base of previous work, but contract may not have same experience	Ditto and Ktr could have different better ideas or be restricted by other requirements	LIKELY	Marginal	2
CE-3	Materials	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-4	Install (crews, equipment, production)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-5	Dewatering Structures	ditto	ditto	LIKELY	Marginal	2
CE-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design (15%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
CE-14	Construction Management (10%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
External Project Risks						
EX-1	Mobilization (size, equipment dura)	Funding Priorities, Biological Focus could change	could have large impact is focus changes. Some mention that some agencies not fully agree with this approach	Unlikely	Critical	3
EX-2	Access to work (d/w schaf, etc)	Ditto	Ditto	Unlikely	Critical	3
EX-3	Materials	Ditto	Ditto	Unlikely	Critical	3
EX-4	Install (crews, equipment, production)	Ditto	Ditto	Unlikely	Critical	3
EX-5	Dewatering Structures	Ditto	Ditto	Unlikely	Critical	3
EX-12	Remaining Construction Items			Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design (15%)	Ditto	Ditto	Unlikely	Critical	3
EX-14	Construction Management (10%)	Ditto	Ditto	Unlikely	Critical	3

B2 FGE Post Constr Alt B2 – Open Second DSM Orifices

Alternatives Report

Abbreviated Risk Analysis

		Potential Risk Areas													
		Mobilization (size, equipment dura	Access to work (d/w schaf, etc)	Materials	Install (crews, equipment, productio	Dewatering Structures	Item Name	Item Name	Item Name	Item Name	Item Name	Item Name	Remaining Construction Ite	Planning, Engineering, & Design (1	Construction Management (10%)
Typical Risk Elements	**Project Scope**	1	2	-	2	4	-	-	-	-	-	-	-	1	1
	Acquisition Strategy	-	-	-	-	2	-	-	-	-	-	-	-	4	-
	Construction Complexity	1	-	-	-	2	-	-	-	-	-	-	-	-	1
	Volatile Commodities	-	-	1	-	1	-	-	-	-	-	-	-	-	-
	Quantities	1	-	2	2	4	-	-	-	-	-	-	-	-	-
	Fabrication & Project Installed Equipment	1	2	-	3	-	-	-	-	-	-	-	-	-	-
	Cost Estimating Method	2	2	2	2	2	-	-	-	-	-	-	-	4	4
	External Project Risks	3	3	3	3	3	-	-	-	-	-	-	-	3	3
	Weighted Summation	9	9	8	12	18	0	0	0	0	0	0	0	12	9
	Weighted %	18.8%	18.8%	16.7%	25.0%	37.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	18.8%

Abbreviated Risk Analysis

B2 FGE Post Constr Alt B3 Horizontal Slots
Alternatives Report

Meeting Date: 25-Jul-12

PDT Members

Project Management:	GJM
Technical Lead:	RTL
Structural Design	DWP
Mechanical Design	SWH
Cost Engineering:	RLR
Construction:	RLR

Note:
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Abbreviated Risk Analysis

Project (less than $40M): **B2 FGE Post Constr Alt B3 Horizontal Slots**
Project Development Stage: Alternatives Report

Total Construction Contract Cost = **$ 5,400,000**

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	**06 FISH AND WILDLIFE FACILITIES**	**Mobilization (size, equipment dura)**	**$ 200,000**		29%	$ 58,333	$ 258,333
2		**Access to work (d/w schaf, etc)**	**$ 1,030,000**		27%	$ 278,958	$ 1,308,958
3		**Materials**	**$ 1,820,000**		19%	$ 341,250	$ 2,161,250
4		**Install (crews, equipment, production)**	**$ 2,340,000**		33%	$ 780,000	$ 3,120,000
5		**Item Name**	**$ -**		0%	$ -	$ -
6		**Item Name**	**$ -**		0%	$ -	$ -
7		**Item Name**	**$ -**		0%	$ -	$ -
8		**Item Name**	**$ -**		0%	$ -	$ -
9		**Item Name**	**$ -**		0%	$ -	$ -
10		**Item Name**	**$ -**		0%	$ -	$ -
11		**Item Name**	**$ -**		0%	$ -	$ -
12		**Remaining Construction Items**	**$ 10,000**	*0.2%*	0%	$ -	$ 10,000
13	**30 PLANNING, ENGINEERING, AND DESIGN**	**Planning, Engineering, & Design (15%)**	**$ 810,000**		23%	$ 185,625	$ 995,625
14	**31 CONSTRUCTION MANAGEMENT**	**Construction Management (10%)**	**$ 540,000**		25%	$ 135,000	$ 675,000

Totals				
Total Construction Estimate	$ 5,400,000	27%	$ 1,458,542	$ 6,858,542
Total Planning, Engineering & Design	$ 810,000	23%	$ 185,625	$ 995,625
Total Construction Management	$ 540,000	25%	$ 135,000	$ 675,000
Total	$ 6,750,000	26%	$ 1,779,167	$ 8,529,167

B2 FGE Post Constr Alt B3 Horizontal Slots

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Mobilization (size, equipment dura)	2 or 3 seasons are required as modifying for Horz Slot needs to occur during the IWWP because the JBS must be dewatered and inoperatable during this work, and the corresponding turbine units dewatered to below the orifices.	Since Multi mobilizations are planned the cost impact would be marginal, and it is unlikely to affect the mob as the contract can plan for 3 years on site.	Unlikely	Marginal	1
PS-2	Access to work (d/w schaf, etc)	Ditto	Since the work involves the JBS being off line, it will be a busy worksite during the IWWP. Access will be a limiting factor so changes in the scope could have a marginal impact on costs and are likely to happen on that scale.	Unlikely	Marginal	1
PS-3	Materials	Materials not like to be different from the work at Lower Granite which this is based on.	It is UNLIKELY the project scope would change the cost of materials, and if they did it would have a NEGLIGIBLE effect on costs.	Unlikely	Negligible	0
PS-4	Install (crews, equipment, production)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2, however the work area are tight considering the amount of work in the limited IWWP time, and demo required	Similar to PS-2	LIKELY	Marginal	2
PS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design (15%)	Priorities could change	Design report could start over requiring additional effort, however the process is in place to minimize this, and decision are usually made before final design effort, as cost of scope change is negligible.	LIKELY	Negligible	1
PS-14	Construction Management (10%)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2	Weather and coordination with others in the work area could have impacts. Change in duration would have the greatest impact and would be similar to Mob.	Unlikely	Marginal	1
Acquisition Strategy						
AS-1	Mobilization (size, equipment dura)	8a likely which is typically smaller contractor on program to develop expertise for heavy construction. Methods may not be fully developed, more a learning curve to overcome, proficiency using or managing all equipment can improve.	Cost est can only adjust assuming higher end of ranges of typical costs, since IGE is to be fair and reasonable	LIKELY	Significant	4
AS-2	Access to work (d/w schaf, etc)	ditto	ditto	LIKELY	Significant	4
AS-3	Materials	ditto	Material price not impacted by 8a	Unlikely	Negligible	0
AS-4	Install (crews, equipment, production)	ditto	Cost est can only adjust assuming higher end of ranges of typical costs, since IGE is to be fair and reasonable, but most cost is Matl so impact here is lessened	LIKELY	Marginal	2
AS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
AS-13	Planning, Engineering, & Design (15%)	ditto	Design does not change due to likely Acquisition strategy unless it goes Design build	Very Unlikely	Negligible	0
AS-14	Construction Management (10%)	ditto	Effort to assist ktr could add some costs	LIKELY	Marginal	2

B2 FGE Post Constr Alt B3 Horizontal Slots

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Construction Complexity						
CC-1	Mobilization (size, equipment dura)	Normal	Good road access to the site, equipment avail in PDX area, but may need custom build platforms. Unlike to change, and if did impact marginal	Unlikely	Marginal	1
CC-2	Access to work (d/w schaf, etc)	Requires coordination of powerhouse operations, which could restrict areas of the intake deck. Potential for delays. Diving not planned but could be used.	Access is more difficult than normal for installing (not fabrications)	Unlikely	Negligible	0
CC-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
CC-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation. With no direct design being done, amount of work is subject to change	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate. However amount of work could impact cost marginally	Unlikely	Marginal	1
CC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CC-13	Planning, Engineering, & Design (15%)	Remodeling / remaking the slots adds a level of complexity to match with the existing	Although not as "straight forward" as new design, and remodeling is typical of this type of work, the type of demo could have some cost impact	Unlikely	Marginal	1
CC-14	Construction Management (10%)	Normal	Similar to many of projects at same location	Very Unlikely	Negligible	0
Volatile Commodities						
VC-1	Mobilization (size, equipment dura)	Crane Size	Required crane (<75T) is common in the are	Very Unlikely	Negligible	0
VC-2	Access to work (d/w schaf, etc)	Custom built platforms	Common construction will be used for custom builts	Very Unlikely	Negligible	0
VC-3	Materials	Prices could increase from suppliers	Standard construction materials expected. Steel, concrete anchors. Available from many suppliers. Economic situation is not changing rapidly in last 2 years.	Unlikely	Marginal	1
VC-4	Install (crews, equipment, production)	Labor rates change?	Recent Labor rates have been stable. Trades needed are not unusual	Very Unlikely	Negligible	0
VC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
VC-13	Planning, Engineering, & Design (15%)	n/a		Very Unlikely	Negligible	0
VC-14	Construction Management (10%)	n/a		Very Unlikely	Negligible	0

B2 FGE Post Constr Alt B3 Horizontal Slots

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Quantities						
Q-1	Mobilization (size, equipment dura)	Amount of Equipment? Number of Season?(see PS-1)	Similar to previous work in the slot. If add'l season would require more mob with a marginal impact on cost	Unlikely	Marginal	1
Q-2	Access to work (d/w schaf, etc)	N/a	Change in quantity would have little to no effect of access	Very Unlikely	Negligible	0
Q-3	Materials	Change in quantity has direct change on cost	Unlikely that quantities would change beyond what is already captured in Project Scope section above, but would be critical is they did	Very Unlikely	Critical	2
Q-4	Install (crews, equipment, production)	ditto	ditto	Very Unlikely	Critical	2
Q-5	Item Name			Very Unlikely	Negligible	0
Q-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
Q-13	Planning, Engineering, & Design (15%)	Not impacted by quantities		Very Unlikely	Negligible	0
Q-14	Construction Management (10%)	ditto		Very Unlikely	Negligible	0
Fabrication & Project Installed Equipment						
FI-1	Mobilization (size, equipment dura)	Change in scope could require add'l or different equipment	different equipment would affect costs	Unlikely	Marginal	1
FI-2	Access to work (d/w schaf, etc)	Assumes units will be dewatered by project	Bulkhead is used often by Project which will perform the dewatering. Coordination required. Change here would have critical impacts	Very Unlikely	Critical	2
FI-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
FI-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate. However if The Proj is unable to d/w Ktr use of alternate methods would have critical impact. Additionally, tolerance of existing dimension be greater than expected requiring custom fitting.	Unlikely	Critical	3
FI-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.	n/a	Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design (15%)	Normal	Assumptions based on rule of thumb	Unlikely	Marginal	1
FI-14	Construction Management (10%)	ditto	Safety requirement are always changing…	Unlikely	Marginal	1

B2 FGE Post Constr Alt B3 Horizontal Slots

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Cost Estimating Method						
CE-1	Mobilization (size, equipment dura)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-2	Access to work (d/w schaf, etc)	Assumption base of previous work, but contract may not have same experience	Ditto and Ktr could have different better ideas or be restricted by other requirements	LIKELY	Marginal	2
CE-3	Materials	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-4	Install (crews, equipment, production)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design (15%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
CE-14	Construction Management (10%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
External Project Risks						
EX-1	Mobilization (size, equipment dura)	Funding Priorities, Biological Focus could change	could have large impact is focus changes. Some mention that some agencies not fully agree with this approach	Unlikely	Crisis	4
EX-2	Access to work (d/w schaf, etc)	Ditto	Ditto	Unlikely	Crisis	4
EX-3	Materials	Ditto	Ditto	Unlikely	Crisis	4
EX-4	Install (crews, equipment, production)	Ditto	Ditto	Unlikely	Crisis	4
EX-12	Remaining Construction Items			Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design (15%)	Ditto	Ditto	Unlikely	Crisis	4
EX-14	Construction Management (10%)	Ditto	Ditto	Unlikely	Crisis	4

B2 FGE Post Constr Alt B3 Horizontal Slots

Alternatives Report

Abbreviated Risk Analysis

		Potential Risk Areas													
		Mobilization (size, equipment dura	Access to work (d/w schaf, etc)	Materials	Install (crews, equipment, productio	Item Name	Item Name	Item Name	Item Name	Item Name	Item Name	Item Name	Remaining Construction Ite	Planning, Engineering, & Design (1	Construction Management (10%
Typical Risk Elements	**Project Scope**	1	1	-	2	-	-	-	-	-	-	-	-	1	1
	Acquisition Strategy	4	4	-	2	-	-	-	-	-	-	-	-	-	2
	Construction Complexity	1	-	-	1	-	-	-	-	-	-	-	-	1	-
	Volatile Commodities	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Quantities	1	-	2	2	-	-	-	-	-	-	-	-	-	-
	Fabrication & Project Installed Equipment	1	2	-	3	-	-	-	-	-	-	-	-	1	1
	Cost Estimating Method	2	2	2	2	-	-	-	-	-	-	-	-	4	4
	External Project Risks	4	4	4	4	-	-	-	-	-	-	-	-	4	4
	Weighted Summation	14	13	9	16	0	0	0	0	0	0	0	0	11	12
	Weighted %	29.2%	27.1%	18.8%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.9%	25.0%

Abbreviated Risk Analysis

B2 FGE Post Constr Alt C1 Gateslot Filler
Alternatives Report

Meeting Date: 25-Jul-12

PDT Members

Project Management:	GJM
Technical Lead:	RTL
Structual Design	DWP
Mechanical Design	SWH
Cost Engineering:	RLR
Construction:	RLR

Note:
NWP Command Policy Memo 15 Personally Identifying Information on the District Internet Web Site
Names of Employees should NOT be published due to privacy and security policies

Abbreviated Risk Analysis

Project (less than $40M): **B2 FGE Post Constr Alt C1 Gateslot Filler**
Project Development Stage: Alternatives Report

Total Construction Contract Cost = **$ 5,190,000**

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	**06 FISH AND WILDLIFE FACILITIES**	**Mobilization (size, equipment dura)**	**$ 200,000**		33%	$ 66,667	$ 266,667
2		**Access to work (d/w schaf, etc)**	**$ 680,000**		25%	$ 170,000	$ 850,000
3		**Materials**	**$ 3,730,000**		27%	$ 1,010,208	$ 4,740,208
4		**Install (crews, equipment, production)**	**$ 630,000**		29%	$ 183,750	$ 813,750
5		**Item Name**	**$ -**		0%	$ -	$ -
6		**Item Name**	**$ -**		0%	$ -	$ -
7		**Item Name**	**$ -**		0%	$ -	$ -
8		**Item Name**	**$ -**		0%	$ -	$ -
9		**Item Name**	**$ -**		0%	$ -	$ -
10		**Item Name**	**$ -**		0%	$ -	$ -
11		**Item Name**	**$ -**		0%	$ -	$ -
12		**Remaining Construction Items**	**$ (50,000)**	*0.0%*	0%	$ -	$ (50,000)
13	**30 PLANNING, ENGINEERING, AND DESIGN**	**Planning, Engineering, & Design (15%)**	**$ 780,000**		21%	$ 162,500	$ 942,500
14	**31 CONSTRUCTION MANAGEMENT**	**Construction Management (10%)**	**$ 520,000**		29%	$ 151,667	$ 671,667

Totals				
Total Construction Estimate	$ 5,190,000	28%	$ 1,430,625	$ 6,620,625
Total Planning, Engineering & Design	$ 780,000	21%	$ 162,500	$ 942,500
Total Construction Management	$ 520,000	29%	$ 151,667	$ 671,667
Total	$ 6,490,000	27%	$ 1,744,792	$ 8,234,792

B2 FGE Post Constr Alt C1 Gateslot Filler

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Mobilization (size, equipment dura)	One Season if coordinate w/ BPA	High flow or operations constraints (unplanned outage of too many units) could limit timing of dewatering units to install devices. With 18 units at Bonneville, it is unlikely to occur since there is usual extra capacity (total of ~ 300kcfs) for the powerhouses and average flows are less than ~200kcfs?. But would double mob cost if occurred with is significant impact to the element.	Unlikely	Significant	3
PS-2	Access to work (d/w schaf, etc)	Ditto	Work can occur outside of IWWP since it is the structure. Changes of Scale of work can rather independent of access, so impact to access is negligible.	Unlikely	Negligible	0
PS-3	Materials	Material used could change, Have not specifically coordinated with agencies.	If material must be stainless steel (and there seems to be lots of SS related to fish work although not needed for engineering requirements) it would significantly impact the cost or it devices become too heavy to handle on deck,	LIKELY	Significant	4
PS-4	Install (crews, equipment, production)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2	Weather and coordination with others in the work area could have impacts	Unlikely	Marginal	1
PS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design (15%)	Priorities could change	Design report could start over requiring additional effort, however the process is in place to minimize this, and decision are usually made before final design effort, as cost of scope change is negligible.	LIKELY	Negligible	1
PS-14	Construction Management (10%)	Work is typical remod type work that has been preformed, similar to much work lately that has been performed at B2	Weather and coordination with others in the work area could have impacts. Change in duration would have the greatest impact and would be similar to Mob.	Unlikely	Significant	3
Acquisition Strategy						
AS-1	Mobilization (size, equipment dura)	8a likely which is typically smaller contractor on program to develop expertise for heavy construction. Methods may not be fully developed, more a learning curve to overcome, proficiency using or managing all equipment can improve.	Cost est can only adjust assuming higher end of ranges of typical costs, since IGE is to be fair and reasonable	LIKELY	Significant	4
AS-2	Access to work (d/w schaf, etc)	ditto	ditto	LIKELY	Significant	4
AS-3	Materials	ditto	Material price not impacted by 8a	Unlikely	Negligible	0
AS-4	Install (crews, equipment, production)	ditto	Cost est can only adjust assuming higher end of ranges of typical costs, since IGE is to be fair and reasonable, but most cost is Matl so impact here is lessened	LIKELY	Marginal	2
AS-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
AS-13	Planning, Engineering, & Design (15%)	ditto	Design does not change due to likely Acquisition strategy unless it goes Design build	Very Unlikely	Negligible	0
AS-14	Construction Management (10%)	ditto	Effort to assist ktr could add some costs	LIKELY	Marginal	2

B2 FGE Post Constr Alt C1 Gateslot Filler

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Construction Complexity						
CC-1	Mobilization (size, equipment dura)	Normal	Good road access to the site, equipment avail in PDX area, but may need custom build platforms. Unlike to change, and if did impact marginal	Unlikely	Marginal	1
CC-2	Access to work (d/w schaf, etc)	Requires coordination of powerhouse operations, which could restrict areas of the intake deck. Potential for delays. Diving not planned but could be used.	Access is more difficult than normal for installing (not fabrications)	Unlikely	Negligible	0
CC-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
CC-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate	Unlikely	Negligible	0
CC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CC-13	Planning, Engineering, & Design (15%)	Normal	Standard design	Very Unlikely	Negligible	0
CC-14	Construction Management (10%)	Normal	Similar to many of projects at same location	Very Unlikely	Negligible	0
Volatile Commodities						
VC-1	Mobilization (size, equipment dura)	Crane Size	Required crane (<75T) is common in the are	Very Unlikely	Negligible	0
VC-2	Access to work (d/w schaf, etc)	Custom built platforms	Common construction will be used for custom builts	Very Unlikely	Negligible	0
VC-3	Materials	Prices could increase from suppliers	Standard construction materials expected. Steel, concrete anchors. Available from many suppliers. Economic situation is not changing rapidly in last 2 years.	Unlikely	Marginal	1
VC-4	Install (crews, equipment, production)	Labor rates change?	Recent Labor rates have been stable. Trades needed are not unusual	Very Unlikely	Negligible	0
VC-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
VC-13	Planning, Engineering, & Design (15%)	n/a		Very Unlikely	Negligible	0
VC-14	Construction Management (10%)	n/a		Very Unlikely	Negligible	0

B2 FGE Post Constr Alt C1 Gateslot Filler

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4
	Negligible	Marginal	Significant	Critical	Crisis

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Quantities						
Q-1	Mobilization (size, equipment dura)	Amount of Equipment? One Season?(see PS-1)	Similar to previous work in the slot. If add'l season would require more mob with a marginal impact on cost	Unlikely	Marginal	1
Q-2	Access to work (d/w schaf, etc)	N/a	Change in quantity would have little to no effect of access	Very Unlikely	Negligible	0
Q-3	Materials	Change in quantity has direct change on cost	Unlikely that quantities would change beyond what is already captured in Project Scope section above, but would be critical is they did	Very Unlikely	Critical	2
Q-4	Install (crews, equipment, production)	ditto	ditto	Very Unlikely	Critical	2
Q-5	Item Name			Very Unlikely	Negligible	0
Q-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
Q-13	Planning, Engineering, & Design (15%)	Not impacted by quantities		Very Unlikely	Negligible	0
Q-14	Construction Management (10%)	ditto		Very Unlikely	Negligible	0
Fabrication & Project Installed Equipment						
FI-1	Mobilization (size, equipment dura)	Change in scope could require add'l or different equipment	different equipment would affect costs	Unlikely	Marginal	1
FI-2	Access to work (d/w schaf, etc)	Assumes units will be dewatered by project	Bulkhead is used often by Project which will perform the dewatering. Coordination required. Change here would have critical impacts	Very Unlikely	Critical	2
FI-3	Materials	Materials could change, but would still use standard methods for fabrication and installation.	construction methods would have negligible changes. Cost Impacts/Risk of materials changing captured in Project Scope Section	Very Unlikely	Negligible	0
FI-4	Install (crews, equipment, production)	Fabrication is typical but access in the slot is not an ordinary situation	Clever custom platforms and hoist could be an advantage lessening the impact. Judged unlikely since the site constraints are already considered in the estimate. However if The Proj is unable to d/w Ktr use of alternate methods would have critical impact. Additionally, tolerance of existing dimension be greater than expected requiring custom fitting.	Unlikely	Critical	3
FI-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design (15%)	Normal	Code updates could affect design time	Unlikely	Marginal	1
FI-14	Construction Management (10%)	ditto	Safety requirement are always changing…	Unlikely	Marginal	1

B2 FGE Post Constr Alt C1 Gateslot Filler

Alternatives Report
Abbreviated Risk Analysis

Meeting Date: 7/25/2012
Risk Register Date: 11/27/2012

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4
	Negligible	Marginal	Significant	Critical	Crisis

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Cost Estimating Method						
CE-1	Mobilization (size, equipment dura)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-2	Access to work (d/w schaf, etc)	Assumption base of previous work, but contract may not have same experience	Ditto and Ktr could have different better ideas or be restricted by other requirements	LIKELY	Marginal	2
CE-3	Materials	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-4	Install (crews, equipment, production)	Based on similar projects, but most concerns above would impact costs	Unrealistic to account for all elements above in cost estimate but some likely to occur	LIKELY	Marginal	2
CE-12	Remaining Construction Items	n/a balance of rounding errors vs significant digits.		Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design (15%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
CE-14	Construction Management (10%)	Percentage basis may not capture effort correctly	Project is custom heavy construction with custom type project. Range of Costs likely greater than averages based on	LIKELY	Significant	4
External Project Risks						
EX-1	Mobilization (size, equipment dura)	Funding Priorities, Biological Focus could change	could have large impact is focus changes. Some mention that some agencies not fully agree with this approach	Unlikely	Crisis	4
EX-2	Access to work (d/w schaf, etc)	Ditto	Ditto	Unlikely	Crisis	4
EX-3	Materials	Ditto	Ditto	Unlikely	Crisis	4
EX-4	Install (crews, equipment, production)	Ditto	Ditto	Unlikely	Crisis	4
EX-12	Remaining Construction Items			Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design (15%)	Ditto	Ditto	Unlikely	Crisis	4
EX-14	Construction Management (10%)	Ditto	Ditto	Unlikely	Crisis	4

B2 FGE Post Constr Alt C1 Gateslot Filler

Alternatives Report

Abbreviated Risk Analysis

		Potential Risk Areas													
		Mobilization (size, equipment dura	Access to work (d/w schaf, etc)	Materials	Install (crews, equipment, productio	Item Name	Item Name	Item Name	Item Name	Item Name	Item Name	Item Name	Remaining Construction Ite	Planning, Engineering, & Design (1	Construction Management (10%)
Typical Risk Elements	**Project Scope**	3	-	4	1	-	-	-	-	-	-	-	-	1	3
	Acquisition Strategy	4	4	-	2	-	-	-	-	-	-	-	-	-	2
	Construction Complexity	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	Volatile Commodities	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Quantities	1	-	2	2	-	-	-	-	-	-	-	-	-	-
	Fabrication & Project Installed Equipment	1	2	-	3	-	-	-	-	-	-	-	-	1	1
	Cost Estimating Method	2	2	2	2	-	-	-	-	-	-	-	-	4	4
	External Project Risks	4	4	4	4	-	-	-	-	-	-	-	-	4	4
	Weighted Summation	16	12	13	14	0	0	0	0	0	0	0	0	10	14
	Weighted %	33.3%	25.0%	27.1%	29.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.8%	29.2%

Life cycle cost Analysis
B2 Fish Guidance Efficiency (FGE) Program
Post Construction
Alternative Study
RLR 11/27/2012

CRITERIA

Requirements for Life Cycle Costs analysis is provided by ER 1110-2-8159, Life Cycle Design and Performance; and OPB Circular A-94 (revised 1992), Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.

<u>Alternative B2 2nd Orifice</u>
Assume Engineering Costs from data from Abbreviated Risk Analysis
Total Construction $59,840,000
Construction manage $5,210,000
for MidPt Const Cost of $65,050,000
Planning, Eng, Design Costs $8,240, 000
O&M Assume extra O&M for the 2nd stage Dewatering Facility of 6M crew + equip = $700/hr 80 hrs per year.

<u>Alternative B3 Horizontal Slot</u>
Assume Engineering Costs from data from Abbreviated Risk Analysis
Total Construction $6,860,000
Construction manage $680,000
for MidPt Const Cost of $7,540,000
Planning, Eng, Design Costs $1,000, 000
Assume addl O&M of 8hr of 6M crew ($700/hr) for each of 28 weirs ea year

<u>Alternative C Gate slot Fillers</u>
Assume Engineering Costs from data from Abbreviated Risk Analysis
Total Construction $6,620,000
Construction manage $670,000
for MidPt Const Cost of $7,290,000
Planning, Eng, Design Costs $940, 000
Assume Addl O&M of 6M crew ($700/hr) to remove & place back Slot Fillers an average of 2x per year for
Work on STS, dewatering units, etc. on all 28 slots. Say 4 hrs per slot each time

	B2 FGE Gate Slot Impromenent Alterntive Study		
	RLR 11/29/2012		
	AltB2 – Open Second DSM Orifice		
	AltB3 – Horizontal Slot		
	AltC – Gateslot Fillers		
		Average Annual Life Cycle Costs	
	Alternative	Expected	Factor of min. cost
	AltB2 – Open Second DSM Orifice	$2,304,478	5.761
	AltB3 – Horizontal Slot	$409,565	1.024
	AltC – Gateslot Fillers	$400,008	1.000
	Rounded to 2 sign digits		
	AltB2 – Open Second DSM Orif	**$2,300,000**	**5.80**
	AltB3 – Horizontal Slot	**$410,000**	**1.00**
	AltC – Gateslot Fillers	**$400,000**	**1.00**

B2 FGE Gate Slot Impromenent Alterntive Study
RLR 11/29/2012

AltB2 – Open Second DSM Orifice

Project Year	Description Costs	Capital Cost in 2012 dollars Costs	O&M Cost in 2012 dollars Costs	FV Factors Costs	Inflated cost to dollars year expended Costs	PV Factors	PV Present Value Total Life Cycle Cost Stream	PV Capital Cost Stream	PV O&M Cost Stream
				0.0000		**0.02000**	***(int.rate)***		
0	Engineering Costs	$8,240,000		1.0000	$8,240,000	1.0000	$8,240,000	$8,240,000	$0
1				1.0000	$0	0.9804	$0	$0	$0
2	MidPt Construction costs	$65,050,000		1.0000	$65,050,000	0.9612	$62,524,029	$62,524,029	$0
3			$56,000	1.0000	$56,000	0.9423	$52,770	$0	$52,770
4			$56,000	1.0000	$56,000	0.9238	$51,735	$0	$51,735
5			$56,000	1.0000	$56,000	0.9057	$50,721	$0	$50,721
6			$56,000	1.0000	$56,000	0.8880	$49,726	$0	$49,726
7			$56,000	1.0000	$56,000	0.8706	$48,751	$0	$48,751
8			$56,000	1.0000	$56,000	0.8535	$47,795	$0	$47,795
9			$56,000	1.0000	$56,000	0.8368	$46,858	$0	$46,858
10			$56,000	1.0000	$56,000	0.8203	$45,940	$0	$45,940
11			$56,000	1.0000	$56,000	0.8043	$45,039	$0	$45,039
12			$56,000	1.0000	$56,000	0.7885	$44,156	$0	$44,156
13			$56,000	1.0000	$56,000	0.7730	$43,290	$0	$43,290
14			$56,000	1.0000	$56,000	0.7579	$42,441	$0	$42,441
15			$56,000	1.0000	$56,000	0.7430	$41,609	$0	$41,609
16			$56,000	1.0000	$56,000	0.7284	$40,793	$0	$40,793
17			$56,000	1.0000	$56,000	0.7142	$39,993	$0	$39,993
18			$56,000	1.0000	$56,000	0.7002	$39,209	$0	$39,209
19			$56,000	1.0000	$56,000	0.6864	$38,440	$0	$38,440
20			$56,000	1.0000	$56,000	0.6730	$37,686	$0	$37,686
21			$56,000	1.0000	$56,000	0.6598	$36,947	$0	$36,947
22			$56,000	1.0000	$56,000	0.6468	$36,223	$0	$36,223
23			$56,000	1.0000	$56,000	0.6342	$35,513	$0	$35,513
24			$56,000	1.0000	$56,000	0.6217	$34,816	$0	$34,816
25			$56,000	1.0000	$56,000	0.6095	$34,134	$0	$34,134
26			$56,000	1.0000	$56,000	0.5976	$33,464	$0	$33,464
27			$56,000	1.0000	$56,000	0.5859	$32,808	$0	$32,808
28			$56,000	1.0000	$56,000	0.5744	$32,165	$0	$32,165
29			$56,000	1.0000	$56,000	0.5631	$31,534	$0	$31,534
30			$56,000	1.0000	$56,000	0.5521	$30,916	$0	$30,916
31			$56,000	1.0000	$56,000	0.5412	$30,310	$0	$30,310
32			$56,000	1.0000	$56,000	0.5306	$29,715	$0	$29,715
33			$56,000	1.0000	$56,000	0.5202	$29,133	$0	$29,133
34			$56,000	1.0000	$56,000	0.5100	$28,562	$0	$28,562
35			$56,000	1.0000	$56,000	0.5000	$28,002	$0	$28,002
36			$56,000	1.0000	$56,000	0.4902	$27,452	$0	$27,452
37			$56,000	1.0000	$56,000	0.4806	$26,914	$0	$26,914
38			$56,000	1.0000	$56,000	0.4712	$26,386	$0	$26,386
39			$56,000	1.0000	$56,000	0.4619	$25,869	$0	$25,869
40			$56,000	1.0000	$56,000	0.4529	$25,362	$0	$25,362
41			$56,000	1.0000	$56,000	0.4440	$24,865	$0	$24,865
42			$56,000	1.0000	$56,000	0.4353	$24,377	$0	$24,377
43			$56,000	1.0000	$56,000	0.4268	$23,899	$0	$23,899
44			$56,000	1.0000	$56,000	0.4184	$23,430	$0	$23,430
45			$56,000	1.0000	$56,000	0.4102	$22,971	$0	$22,971
46			$56,000	1.0000	$56,000	0.4022	$22,521	$0	$22,521
47			$56,000	1.0000	$56,000	0.3943	$22,079	$0	$22,079
48			$56,000	1.0000	$56,000	0.3865	$21,646	$0	$21,646
49			$56,000	1.0000	$56,000	0.3790	$21,222	$0	$21,222
50			$56,000	1.0000	$56,000	0.3715	$20,806	$0	$20,806
TOTAL PRESENT VALUE COST							**$72,415,024**	$70,764,029	$1,650,995
	Amort. Factor:					x	0.0318	0.0318	0.0318
Average Annual Costs						=	**$2,304,478**	$2,251,939	$52,540
							Total	**Capital**	**O&M**

NOTES

1 Assumes all alternatives compared over same time period (50 years), so if some have shorter lives, repeat sequence of costs to make equivalent comparison.
2 Assume Engineering Costs from data from Abbreviated Risk Analysis (rounded to $10,000s)
3 MidPt Construction costs from Abbreviated Risk Analysis of Construction cost plus Construction Management
4 O&M Assume extra O&M for the 2nd stage Dewatering Facility of 6M crew + equip = $700/hr 80 hrs per year.

B2 FGE Gate Slot Impromenent Alterntive Study										
RLR 11/29/2012										
AltB3 – Horizontal Slot										
								PV	PV	PV
	Project	Description	Capital Cost in 2012 dollars	O&M Cost in 2012 dollars	FV Factors	Subtotal cost to dollars year expended (PV factor includes inflation)	PV	Present Value Total Life Cycle	Capital	O&M
	Year	Costs	Costs	Costs	Costs	Costs	Factors	Cost Stream	Cost Stream	Cost Stream
							0.02000	***(int.rate)***		
	0	Engineering Costs	$1,000,000		1.0000	1,000,000	1.0000	1,000,000	1,000,000	0
	1				1.0000	0	0.9804	0	0	0
	2	MidPt Construction costs	$7,540,000		1.0000	7,540,000	0.9612	7,247,213	7,247,213	0
	3			$156,800	1.0000	156,800	0.9423	147,756	0	147,756
	4			$156,800	1.0000	156,800	0.9238	144,859	0	144,859
	5			$156,800	1.0000	156,800	0.9057	142,019	0	142,019
	6			$156,800	1.0000	156,800	0.8880	139,234	0	139,234
	7			$156,800	1.0000	156,800	0.8706	136,504	0	136,504
	8			$156,800	1.0000	156,800	0.8535	133,827	0	133,827
	9			$156,800	1.0000	156,800	0.8368	131,203	0	131,203
	10			$156,800	1.0000	156,800	0.8203	128,631	0	128,631
	11			$156,800	1.0000	156,800	0.8043	126,108	0	126,108
	12			$156,800	1.0000	156,800	0.7885	123,636	0	123,636
	13			$156,800	1.0000	156,800	0.7730	121,211	0	121,211
	14			$156,800	1.0000	156,800	0.7579	118,835	0	118,835
	15			$156,800	1.0000	156,800	0.7430	116,505	0	116,505
	16			$156,800	1.0000	156,800	0.7284	114,220	0	114,220
	17			$156,800	1.0000	156,800	0.7142	111,981	0	111,981
	18			$156,800	1.0000	156,800	0.7002	109,785	0	109,785
	19			$156,800	1.0000	156,800	0.6864	107,632	0	107,632
	20			$156,800	1.0000	156,800	0.6730	105,522	0	105,522
	21			$156,800	1.0000	156,800	0.6598	103,453	0	103,453
	22			$156,800	1.0000	156,800	0.6468	101,424	0	101,424
	23			$156,800	1.0000	156,800	0.6342	99,436	0	99,436
	24			$156,800	1.0000	156,800	0.6217	97,486	0	97,486
	25			$156,800	1.0000	156,800	0.6095	95,574	0	95,574
	26			$156,800	1.0000	156,800	0.5976	93,700	0	93,700
	27			$156,800	1.0000	156,800	0.5859	91,863	0	91,863
	28			$156,800	1.0000	156,800	0.5744	90,062	0	90,062
	29			$156,800	1.0000	156,800	0.5631	88,296	0	88,296
	30			$156,800	1.0000	156,800	0.5521	86,565	0	86,565
	31			$156,800	1.0000	156,800	0.5412	84,867	0	84,867
	32			$156,800	1.0000	156,800	0.5306	83,203	0	83,203
	33			$156,800	1.0000	156,800	0.5202	81,572	0	81,572
	34			$156,800	1.0000	156,800	0.5100	79,972	0	79,972
	35			$156,800	1.0000	156,800	0.5000	78,404	0	78,404
	36			$156,800	1.0000	156,800	0.4902	76,867	0	76,867
	37			$156,800	1.0000	156,800	0.4806	75,360	0	75,360
	38			$156,800	1.0000	156,800	0.4712	73,882	0	73,882
	39			$156,800	1.0000	156,800	0.4619	72,433	0	72,433
	40			$156,800	1.0000	156,800	0.4529	71,013	0	71,013
	41			$156,800	1.0000	156,800	0.4440	69,621	0	69,621
	42			$156,800	1.0000	156,800	0.4353	68,256	0	68,256
	43			$156,800	1.0000	156,800	0.4268	66,917	0	66,917
	44			$156,800	1.0000	156,800	0.4184	65,605	0	65,605
	45			$156,800	1.0000	156,800	0.4102	64,319	0	64,319
	46			$156,800	1.0000	156,800	0.4022	63,058	0	63,058
	47			$156,800	1.0000	156,800	0.3943	61,821	0	61,821
	48			$156,800	1.0000	156,800	0.3865	60,609	0	60,609
	49			$156,800	1.0000	156,800	0.3790	59,421	0	59,421
	50			$156,800	1.0000	156,800	0.3715	58,256	0	58,256
	TOTAL PRESENT VALUE COST							**12,869,997**	8,247,213	4,622,785
		Amort. Factor:					x	0.0318	0.0318	0.0318
	Average Annual Costs						=	**$409,565**	262,453	147,112
								Total	**Capital**	**O&M**
1	Assumes all alternatives compared over same time period (50 years), so if some have shorter lives, repeat sequence									
	of costs to make equivalent comparison.									
2	Assume Engineering Costs from data from Abbreviated Risk Analysis (rounded to $10,000s)									
3	MidPt Construction costs from Abbreviated Risk Analysis of Construction cost plus Construction Management									
4	Assume addl O&M of 8hr of 6M crew ($700/hr) for each of 28 weirs ea year									

B2 FGE Gate Slot Impromenent Alterntive Study
RLR 11/29/2012

AltC – Gateslot Fillers

Project Year	Description Costs	Capital Cost in 2012 dollars Costs	O&M Cost in 2012 dollars Costs	FV Factors Costs	Subtotal cost to dollars year expended (PV factor includes inflation) Costs	PV Factors	PV Present Value Total Life Cycle Cost Stream	PV Capital Cost Stream	PV O&M Cost Stream
						0.02000	***(int.rate)***		
0	Engineering Costs	$940,000		1.0000	940,000	1.0000	940,000	940,000	0
1				1.0000	0	0.9804	0	0	0
2	MidPt Construction costs	$7,290,000		1.0000	7,290,000	0.9612	7,006,920	7,006,920	0
3			$156,800	1.0000	156,800	0.9423	147,756	0	147,756
4			$156,800	1.0000	156,800	0.9238	144,859	0	144,859
5			$156,800	1.0000	156,800	0.9057	142,019	0	142,019
6			$156,800	1.0000	156,800	0.8880	139,234	0	139,234
7			$156,800	1.0000	156,800	0.8706	136,504	0	136,504
8			$156,800	1.0000	156,800	0.8535	133,827	0	133,827
9			$156,800	1.0000	156,800	0.8368	131,203	0	131,203
10			$156,800	1.0000	156,800	0.8203	128,631	0	128,631
11			$156,800	1.0000	156,800	0.8043	126,108	0	126,108
12			$156,800	1.0000	156,800	0.7885	123,636	0	123,636
13			$156,800	1.0000	156,800	0.7730	121,211	0	121,211
14			$156,800	1.0000	156,800	0.7579	118,835	0	118,835
15			$156,800	1.0000	156,800	0.7430	116,505	0	116,505
16			$156,800	1.0000	156,800	0.7284	114,220	0	114,220
17			$156,800	1.0000	156,800	0.7142	111,981	0	111,981
18			$156,800	1.0000	156,800	0.7002	109,785	0	109,785
19			$156,800	1.0000	156,800	0.6864	107,632	0	107,632
20			$156,800	1.0000	156,800	0.6730	105,522	0	105,522
21			$156,800	1.0000	156,800	0.6598	103,453	0	103,453
22			$156,800	1.0000	156,800	0.6468	101,424	0	101,424
23			$156,800	1.0000	156,800	0.6342	99,436	0	99,436
24			$156,800	1.0000	156,800	0.6217	97,486	0	97,486
25			$156,800	1.0000	156,800	0.6095	95,574	0	95,574
26			$156,800	1.0000	156,800	0.5976	93,700	0	93,700
27			$156,800	1.0000	156,800	0.5859	91,863	0	91,863
28			$156,800	1.0000	156,800	0.5744	90,062	0	90,062
29			$156,800	1.0000	156,800	0.5631	88,296	0	88,296
30			$156,800	1.0000	156,800	0.5521	86,565	0	86,565
31			$156,800	1.0000	156,800	0.5412	84,867	0	84,867
32			$156,800	1.0000	156,800	0.5306	83,203	0	83,203
33			$156,800	1.0000	156,800	0.5202	81,572	0	81,572
34			$156,800	1.0000	156,800	0.5100	79,972	0	79,972
35			$156,800	1.0000	156,800	0.5000	78,404	0	78,404
36			$156,800	1.0000	156,800	0.4902	76,867	0	76,867
37			$156,800	1.0000	156,800	0.4806	75,360	0	75,360
38			$156,800	1.0000	156,800	0.4712	73,882	0	73,882
39			$156,800	1.0000	156,800	0.4619	72,433	0	72,433
40			$156,800	1.0000	156,800	0.4529	71,013	0	71,013
41			$156,800	1.0000	156,800	0.4440	69,621	0	69,621
42			$156,800	1.0000	156,800	0.4353	68,256	0	68,256
43			$156,800	1.0000	156,800	0.4268	66,917	0	66,917
44			$156,800	1.0000	156,800	0.4184	65,605	0	65,605
45			$156,800	1.0000	156,800	0.4102	64,319	0	64,319
46			$156,800	1.0000	156,800	0.4022	63,058	0	63,058
47			$156,800	1.0000	156,800	0.3943	61,821	0	61,821
48			$156,800	1.0000	156,800	0.3865	60,609	0	60,609
49			$156,800	1.0000	156,800	0.3790	59,421	0	59,421
50			$156,800	1.0000	156,800	0.3715	58,256	0	58,256
TOTAL PRESENT VALUE COST							**12,569,705**	7,946,920	4,622,785
	Amort. Factor:					x	0.0318	0.0318	0.0318
Average Annual Costs						=	**$400,008**	252,897	147,112
							Total	**Capital**	**O&M**

1 Assumes all alternatives compared over same time period (50 years), so if some have shorter lives, repeat sequence of costs to make equivalent comparison.
2 Assume Engineering Costs from data from Abbreviated Risk Analysis (rounded to $10,000s)
3 MidPt Construction costs from Abbreviated Risk Analysis of Construction cost plus Construction Management
4 Assume Addl O&M of 6M crew ($700/hr) to remove & place back Slot Fillers an average of 2x per year for Work on STS, dewatering units, etc. on all 28 slots. Say 4 hrs per slot each time