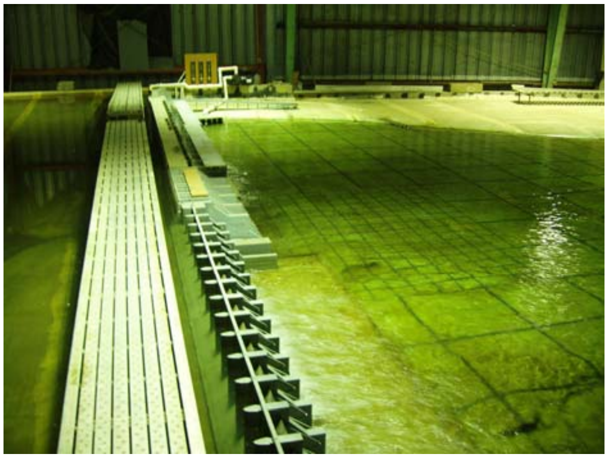
Prepared for:
USACE Portland District
Portland, Oregon



John Day Lock and Dam General Model Status Independent Technical Review Final Report

Contract No. W9127N-06-D-0004, T.O. No. 03

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Executive Summary

The U.S. Army Corps of Engineers Engineering Research and Design Center (ERDC) 1:80 scale general model of John Day Lock and Dam is the primary tool that has been used for the development of fish passage improvements and assessing the impact of structure and operational modifications on towboat and barge navigation at the project. Discrepancies between flow conditions observed by towboat operators on the model and at the prototype facilities have raised concern about the model's ability to simulate flow conditions in the John Day tailrace. ERDC has made improvements in the model to address these concerns and prepared a Model Validation Data Report comparing the improved model performance to different sets of field data.

ENSR was contracted to perform an Independent Technical Review (ITR) of the status of the model and the ERDC Model Validation Data Report. In performing the ITR, we reviewed the ERDC Model Validation Report and other technical reports and memoranda about application and calibration of the model, plus technical literature on hydrodynamic phenomena relevant to fisheries and navigation studies and the scaling requirements for simulating these phenomena in physical hydraulic models. We also drew upon our expertise and experience acquired in the course of performing hundreds of field data collection and physical and computer hydraulic model studies and consulted with other modeling experts. We supplemented this knowledge base with a site visit to the John Day general model at ERDC, where we examined the model, interviewed the ERDC project staff, and observed model operation for specific conditions which we requested.

We have determined that, in general, the model scale selection, construction, instrumentation, and operation follow accepted hydraulic modeling practices and that the model should adequately simulate conditions in the project forebay for investigation of fish passage facilities and navigation impacts. However, the tailrace flow field and velocities do not adequately match the conditions measured in the field and the model requires additional adjustment to bring this verification to field data within acceptable limits. Most significantly, the model does not appear to match the flow regime expected downstream from the spillway deflectors, the entrainment by the spillway discharge jet of the ambient flow supplied from the powerhouse tailrace area, or the velocity of flow downstream from the area of entrainment and spillway discharge. We feel that the lack of tailrace flow field similarity may be primarily driven by lack of similarity of the energy (depth of flow and velocity magnitude) of flow entering the tailrace from the spillway deflectors and a discrepancy in tailwater level caused by using a different location for setting tailwater level in the model than the location of tailwater measurement at the prototype facility. A secondary factor might be the lack of similarity of distribution and angularity of flow velocities exiting the model turbine draft tubes. Additional factors that may affect the tailrace processes are not well-documented in the literature, but our understanding of the physics of the processes and the experience of other modeling experts indicate that they may be the inability of any reduced scale model to simulate air entrainment and transport or the turbulent eddies along the spillway jet boundaries that govern the entrainment process.

We recommend a program of model checks and improvements that can address the spillway flow energy, tailwater setting discrepancy, and draft tube flow distribution issues. The program is laid out in a step-wise fashion so that if the model verification goals are met at intermediate steps the process can be shortened. If the model verification goals are met by following this program the model should properly simulate the tailrace flow field and processes for fisheries and navigation studies. If the verification goals cannot be met through the recommended program of model checks and improvements, it is likely that air entrainment and turbulent eddy formation along the spillway jet boundaries dominate the tailrace processes and a reduced scale physical hydraulic model will not be a practical tool as the scale ratio may have to be on the order of 1:5 or less to simulate the air entrainment process. The threshold physical model scale at which these processes will be correctly simulated has not been clearly delineated in the literature at this time.

1.0 Introduction

Recent work by the U.S. Army Corps of Engineers Portland District (the District) on the John Day Configuration and Operations Plan (COP) has identified and prioritized potential fish passage improvements at John Day Dam. As a result of the COP, a Configuration and Alternative Evaluation Study was initiated in the 3rd Quarter of FY 2006. Additional work to develop fish passage improvements at John Day is planned through FY 2013.

The Army Corps of Engineers' Engineering Research and Design Center (ERDC) John Day 1:80 scale general model (the model) has been used as the primary hydraulic model tool to support the biological program in the tailrace of John Day Dam. There is a concern if the model can be used to meet all the modeling requirements of future study needs. The Columbia River Towboat Association has also raised concern about the transferability of navigation conditions from the general model to the prototype in the lower Navigation Lock Approach. Specifically the model, that has been used extensively in the past to answer questions of tailrace egress, had been found to have model velocities along the North shore (near the Navigation Lock guide wall) that are consistently 30% lower than prototype velocities and was not believed to be replicating flow entrainment from the powerhouse to the spillway.

ERDC made improvements to the model intended to improve the model's ability to replicate the prototype flow features. After making the improvements, ERDC collected data for comparison of the model to field conditions and identified and quantified the discrepancies between the model and prototype data sets. ERDC has produced a Model Validation Data Report (ERDC, 2006) that details the steps taken to improve the general models' performance, identifies the differences between the model and prototype data sets, and defines the limitations on the use of the physical model use for fish passage study work.

1.1 Objective

The objective of this report is to document ENSR's Independent Technical Review (ITR) of the status of the model and the ERDC Model Validation Data Report (ERDC, 2006).

In addition to the analysis performed in support of our review, we also:

- Participated in a project kick-off meeting with District staff in Portland to clarify the scope of the review and receive a briefing on the intended uses of the model and the chronology of the model development and

- Visited the model at ERDC in Vicksburg, Mississippi to gain first hand knowledge of its construction and operation and observe model operation to assess sensitivity of tailrace flow conditions to project operations. A report documenting this visit is included as an appendix to this report.

1.2 Acknowledgments

This ITR was performed for the District under Contract No. W9127N-06-D-0004, Task Order No. 03 by Charles "Chick" Sweeney, P.E. and Elizabeth Roy, P.E. of ENSR. Sean Askelson, P.E. of the District was the technical point of contact and both Sean and Kyle McCune, P.E. of the District provided valuable technical insight and support. Don Wilson, P.E. and Dave Maggio of ERDC hosted the visit to the general model and provided valuable insight into its construction and operation.

1.3 Report Organization

The sections of our report provide:

- A statement of understanding of the desired model application that is couched not in terms of the studies or structures to be investigated, but rather simulation of the hydrodynamic phenomena that occur in the different regions of the forebay and tailrace of the John Day project and the processes that drive these phenomena;
- A definition of the model scaling and precision requirements for the John Day general model that focuses on the phenomena identified in the statement of understanding of the model application;
- A review of the pertinent literature on model scaling requirements;
- An evaluation of whether the model satisfies the model scaling and precision requirements presented in the definition;
- A comparison of the evaluation to the findings of the ERDC report; and
- Conclusions and recommendations concerning the application limitations of the model and how it might be improved and operated to increase its applicability.

2.0 John Day Lock and Dam Modeling Requirements

2.1 General Application

2.1.1 Fisheries Management Studies

The fisheries managers want a model that can be universally applied to visually, through dye plume tracking, evaluate potential fish approach to and egress from the project as affected by project operations and structural changes. There is also a desire to evaluate the impacts of project operations and structural changes on navigation. The ultimate goal of tailrace studies will be to make the tailrace “robust” for all fish egress paths, i.e. from the Juvenile Bypass System (JBS) outfall, turbines, spillway, and future surface flow outlets (SFOs).

2.1.2 Navigation Studies

The impacts of any changes in project structures and operations that are made to meet fisheries management goals must also be compatible with operation of the navigation lock at the project. The general model is the primary tool used to evaluate the impacts on navigation and must reproduce flow patterns and velocities in both the upstream and downstream approaches to the navigation lock accurately.

2.2 Model Geographic Regions

Several regions can be defined in the model for assessing hydrodynamic phenomena and processes and the performance of the physical model. The regions are defined below for the purposes of this ITR and the remainder of the ITR is divided into geographic regions for clarity.

2.2.1 Forebay

The model forebay extends from upstream of the confluence of the John Day River with the Columbia River to the John Day Dam spillway and powerhouse structures.

2.2.2 Structures

The model structures include spillway bays 1 through 20 with tainter gates, powerhouse units 1 through 16 and skeleton bays 17 through 20, the fish ladders, the outfall, and the navigation locks and lock approach wall. Future investigations may include various SFOs and appurtenant guidance structures.

2.2.3 Near-Field Tailrace

The near-field tailrace is defined as the area downstream of the powerhouse and spillway to approximately 600 feet downstream for the purposes of this ITR.

2.2.4 General Tailrace

The general tailrace extends from the near-field tailrace downstream to the boundary of the model at the weirs.

2.3 Hydrodynamic Phenomena and Processes

The hydrodynamic phenomena and processes in the model study area are important for studying fisheries, navigation, and operational issues. Hydrodynamic phenomena and processes specific to each of the geographic regions in the model are described in the following sections.

2.3.1 Forebay

The primary hydrodynamic phenomena that will affect the approach of downstream migrating juvenile fish to the project, as well as adult fish egress from the fish ladder exits, are the shape and dimension of the flow net approaching the fisheries facilities, or the so-called zone of influence of the facility, and the magnitude and rate of change, either acceleration, or gradient, of the velocities in that flow net. The flow net and velocity related phenomena must be accurately simulated in a model of a project forebay to gain insight into their potential effect on fish movement.

The zone of influence is essentially the region of the forebay flow net, within which flow streamlines, indicated by released dye, eventually enter the fish passage facility. Fish that enter the zone of influence and do not actively swim, but move as neutrally buoyant particles would eventually enter the fish facility. Fish that actively swim in this zone will have a component of their swimming velocity vector directed toward the fish facility. Velocities at the periphery of the zone of influence are quite low in the prototype forebay, less than 1 ft/s.

As flow approaches the project structures, the acceleration or velocity gradient, as well as associated fluid shear and turbulence become dominant features of importance. In this near-field zone, velocities will increase from under 1 ft/s to greater than the fish swimming capabilities, on the order of 7 ft/s, the so-called capture velocity for juvenile fish.

Flow velocity in the navigation lock approaches in the project forebay is generally very low, less than 1 ft/s, but may still affect tow boat and barge movement.

2.3.2 Structures

Study of flow through project structures has importance on two different scales and for two different purposes in the development of fisheries management facilities, operational plans, and studies of their impact on navigation:

- Flow conditions within the structures may be important to understand the potential for safe and effective passage of fish being transported in flow through the structure. Studying fish passage through structures dictates selection of a model scale that results in flow depths and velocities in the model that are large enough in a theoretical sense to accurately simulate prototype conditions and in a practical sense to be measurable and observable. These types of studies are usually not performed on a general model of a project as the physical size of the model structures will not satisfy either the theoretical or practical requirements.

- Both forebay and tailrace flow conditions will be dependent on the model structures providing the proper boundary conditions in terms of geometry, flow magnitude and energy.

Having an appropriate boundary condition of flow leaving the project forebay section of the model requires the correct geometry or opening size of the flow outlets, i.e. turbine intakes, fish ladder entrances, and spillway gate openings; and the correctly scaled flow rate. Especially in the case of the spillway, this means that the model gate discharge coefficient and rating must be the same as the prototype, otherwise the opening size and velocity will be incorrectly scaled in order to achieve the scaled discharge rate and the local approach flow field will be incorrectly simulated.

For the tailrace section of the model the inflow boundary condition requirements are similar to the outflow boundary conditions of the forebay, the geometry and magnitude of the flow must be correctly scaled. For the powerhouse flows this means that the jets exiting the model draft tubes must have the correct velocity magnitudes, distribution, and angularity or swirl.

For condition of the flow exiting a deflector-equipped spillway to be correctly simulated, the depth of flow, velocity, and air content of flow leaving the plane of the deflector must be correctly scaled. In order to have the correct depth of flow and velocity, the model gate opening or rating must be correctly scaled, as previously described, and the dissipation of flow energy through boundary friction on the spillway ogee must be correctly simulated or some other means must be developed to provide the correct flow energy (depth and velocity) leaving the plane of the deflector.

2.3.3 Near-Field Tailrace

In the near-field of the project tailrace, correct simulation of velocity magnitudes and flow patterns are extremely important in understanding the egress of juvenile fish from and approach of adult fish to fisheries facilities. The velocity magnitudes are large enough, from several feet per second to over 60 ft/s, that juvenile fish cannot very effectively resist the flow and are transported by it, while adult fish will only swim on the periphery of the higher velocity regions, while searching for a migration path. Several important flow processes take place that dictate these flow patterns and velocity magnitudes:

- Downstream from the powerhouse, the flow field is primarily governed by the decay and merging of the submerged jets from the draft tubes and the formation of a back roller above the draft tube discharge. These features will be governed by the geometry, velocity distribution, and swirling of the draft tube discharges, all of which must be properly scaled and simulated, as described in Section 2.3.2.

- Downstream from the spillway the initial condition of flow exiting the plane of the spillway deflectors must be correctly simulated as described in Section 2.3.2. Beyond the plane of the deflectors the combination of flow energy and local tailwater level will establish a flow regime, i.e. skimming, undular, plunging, etc., as described in the NHC Deflector Design Report (NHC, 1999), that will dominate the near-field flow, so this regime must be correctly simulated. The spillway flow jets off the deflector will mix with lower velocity ambient flow, decaying the jets with distance downstream from the deflectors. As the jets spread and decay they entrain ambient flow through fluid shear, turbulence, and formation of small scale eddies on the jet peripheries. The supply for the flow entrainment will be from the open boundary adjacent to the spillway tailrace formed by the region downstream from the skeleton bays and powerhouse. The amount of air entrained in the spillway jets will affect their relative density and may also have a large effect on the entrainment process. Proper simulation of all of these phenomena is essential to establishing the correct near-field flow patterns and velocities.

2.3.4 General Tailrace

Flow patterns and velocities in the general tailrace are of interest both for fisheries management and navigation. Juvenile fish discharged in the tailrace will be carried by the currents similarly to neutrally buoyant particles or a dye plume as they recover from the stress of passage until they can again actively swim. If the juvenile fish are carried into an area of recirculation or eddying, they may be delayed and/or exposed to predation by fish or birds. General flow patterns and velocities in the area downstream from and approaching the navigation lock entrance will dictate the difficulty of navigation into the lock.

The general flow patterns and eddy formation in the tailrace will be primarily driven by the dual engines of the momentum magnitude and distribution of the powerhouse and spillway discharges as they exit the near-field tailrace and as they interact with the tailrace bathymetry. The momentum magnitude and distribution of the powerhouse flows will be correctly simulated as long as the general unit operations and flow rates are correctly simulated as the draft tube jets will be fully merged and mixed upon leaving the near-field. The jet-mixing from the spillway may still be incomplete at the boundary of the near-field, so the correct simulation of the spillway flow in the near-field is still important in the general tailrace.

3.0 Evaluation of Model Scaling Requirements

The application of scaling theory to the hydrodynamic phenomena and processes in each geographic region is described in the following sections.

3.1 General Scaling Theory

For accurate modeling of prototype (actual) conditions, the hydraulic model must be dynamically similar to the prototype. Achieving dynamic similarity of fluid motions requires geometrically similar boundaries and flow patterns, and identical ratios of forces acting on the fluid elements. The dimensionless force ratios for dynamic similarity are:

Froude Number: $$F = \frac{U}{\sqrt{gL}} = \frac{\text{Inertial Force}}{\text{Gravity Force}} \qquad (3.1)$$

Euler Number: $$E = \frac{\Delta P}{\rho U^2} = \frac{\text{Pressure Force}}{\text{Inertial Force}} \qquad (3.2)$$

Reynolds Number: $$R = \frac{UL}{\nu} = \frac{\text{Inertial Force}}{\text{Viscous Force}} \qquad (3.3)$$

Weber Number: $$W = \frac{U^2}{\sigma / \rho L} = \frac{\text{Inertial Force}}{\text{Surface Tension Force}} \qquad (3.4)$$

where: U = characteristic flow velocity

g = gravitational acceleration

L = characteristic length

ρ = density of the fluid

ΔP = pressure difference

ν = kinematic viscosity of the fluid

σ = surface tension of the fluid

Complete dynamic similarity between model and prototype requires all the ratios given in Equations 3.1 through 3.4 to be identical. Only a scale of 1:1 meets these criteria. Modeling at a reduced scale involves identification of the force relationships necessary to accurately simulate critical or significant prototype flow processes.

For free surface flows, inertia and gravity forces characterize the physical conditions seen in the prototype. Therefore, the dimensionless force ratio of primary importance in modeling free-surface flows is the Froude number. The Froude numbers in the model and prototype must be equal for the hydraulic conditions in the prototype to be correctly simulated in the model:

$$\frac{F_P}{F_M} = F_R = 1 \qquad (3.5)$$

where subscripts: M = model

P = prototype

R = ratio of prototype to model values

Inertia and gravity forces are indeed dominating in free surface flow, but these forces alone are insufficient for similitude of flow resistance. Flow resistance, which is a function of the fluid viscosity and the roughness of the boundary, is important when modeling flow near a solid boundary or in an open channel where replication of flow patterns and energy losses are of concern. The resistance coefficient *f*, presented graphically by the Moody diagram in Figure 1, varies with the Reynolds number and the boundary relative roughness height and should be the same in the model and prototype to properly scale flow resistance. Since the resistance coefficient may vary over certain ranges of Reynolds number, the Reynolds number must be the same in prototype and model to achieve flow resistance similitude, assuming geometric similitude of the boundary relative roughness height:

$$\frac{R_P}{R_M} = R_R = 1 \qquad (3.6)$$

It is impossible to simultaneously satisfy both Froude number similitude criteria (Equation 3.5) and Reynolds number similitude criteria (Equation 3.6), since water will be used in both model and prototype. Based on the Moody diagram in Figure 1, the relationship between the Reynolds number and the resistance coefficient indicates that the model and prototype Reynolds numbers need not be the same, but must place the flow in the same flow regime, fully rough for example. If the lower Reynolds number at the model scale begins to transition flow from fully rough to a transitional or laminar flow, an exaggerated emphasis on viscous resistance over form resistance, changes in local flow patterns near boundaries, and an overall increase in resistance coefficients will result. Therefore, the model and prototype values of the Reynolds number should place the flow in the same flow regime.

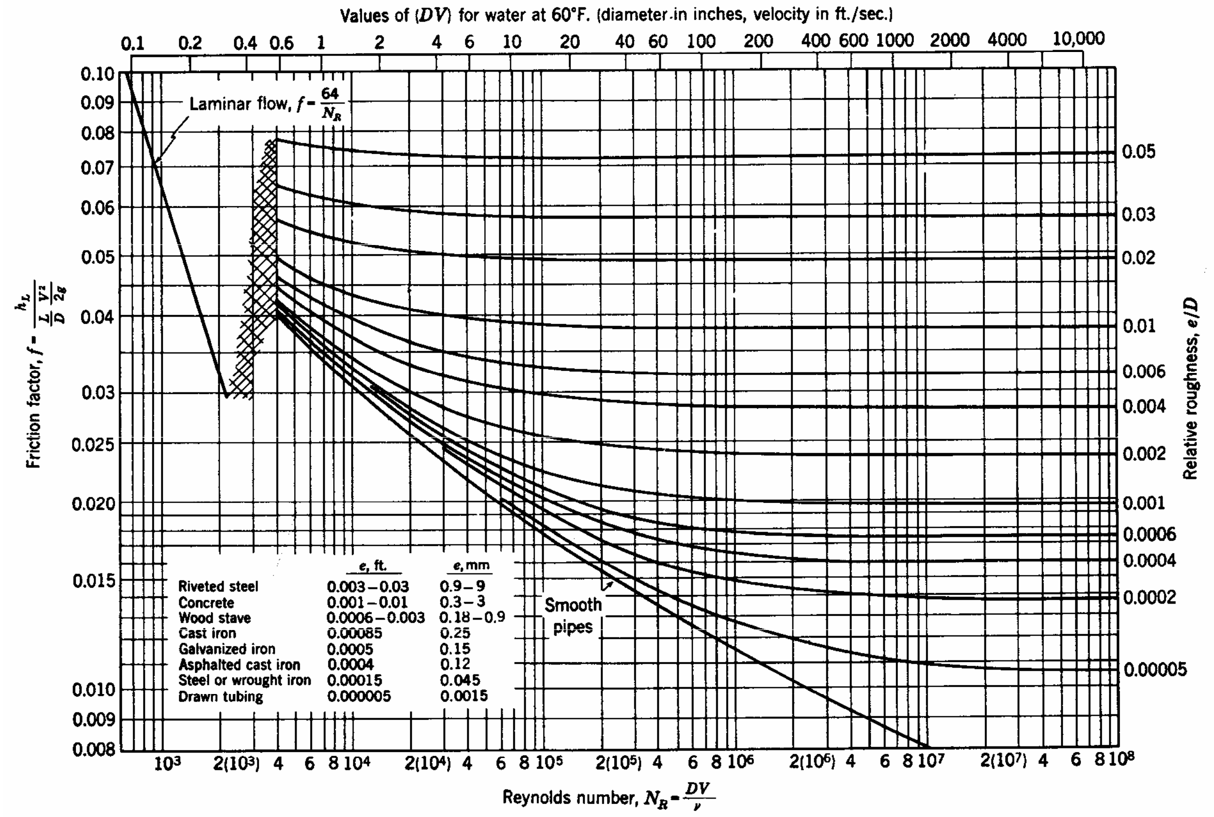

Figure 1. Moody Diagram

A discussion of the scaling requirements for the hydrodynamic phenomena and processes of interest in each geographic region of the model study area is provided in the following sections.

3.2 Forebay

In the forebay, the minimum Reynolds number required to achieve fully rough flow in the river is approximately $1x10^4$, based on flow in natural rivers and channels where form losses are also important (ASCE, 2000). In ENSR's experience forebay models with Reynolds numbers greater than 1×10^3 provide adequate scaling of flow resistance. The typical prototype forebay Reynolds number is estimated to be approximately 1.4×10^6 based on the field data from Transect 4 for April 2003. The corresponding model Reynolds numbers at several model scales are shown in Table 1.

Table 1. Forebay Reynolds Number

	Prototype	Model Scale 1:25	Model Scale 1:50	Model Scale 1:80
Reynolds Number	1.4×10^6	1.1×10^4	4.0×10^3	2.0×10^3

The 1:80 scale model is adequately scaled to provide similar regime flow as the prototype in the forebay, but the lower Reynolds numbers in the model may result in slightly exaggerated flow resistance and result in steeper vertical velocity gradients.

3.3 Structures

Appropriately modeling the structures in the model requires properly scaling the flows through the flow outlets such as the spillways, turbine intakes, and fish ladders. Especially in the case of the spillway, this means that the model gate discharge coefficient and rating must be the same as the prototype, otherwise the opening size and velocity will be incorrectly scaled in order to achieve the scaled discharge rate and the local approach flow field will be incorrectly simulated. Based on our previous experience the minimum Reynolds number required to properly scale loss coefficients is 1×10^4.

Based on available information on spillway gate setting and flows from the Model Validation Data Report (ERDC, 2006) the Reynolds numbers in the model and prototype are approximately as shown in Table 2 for a range of spillway bay flows.

Table 2. Spillway Gate Reynolds Numbers

Flow per Bay (cfs)	Reynolds Number (Prototype)	Reynolds Number (Model)
3200	4.2×10^6	4.6×10^4
4000	5.2×10^6	4.8×10^4
5333	6.9×10^6	5.2×10^4
6400	8.3×10^6	5.2×10^4
8000	1.0×10^7	5.7×10^4
10000	1.3×10^7	6.3×10^4

The Reynolds numbers for the spillway gates are sufficient based on this assessment. However, some question arose during the ERDC trip about the spillway gate settings in the model and how they compare to the prototype. In the Recommendations in Section 5, we recommend determining or confirming the relationship between model and prototype gate opening to ensure that the gate discharge coefficient is properly scaled. Any difference between model and prototype gate openings (discharge coefficients) will have a greater effect on correct simulation of spillway and tailrace flow conditions than on the forebay.

In order to minimize the effects of surface tension in free surface flows, the model should be scaled such that the minimum flow depth is 1 inch (ASCE, 2000). The flow depths observed over the spillway ogees were less than one inch. The Weber number should be greater than approximately 1×10^2 in order to minimize the scale effects of surface tension on flows in the model (ASCE, 2000). Based on estimates of the Weber number for the model ogee for the April 2003 spillway flows the Weber number is less than this threshold and the spillway may be influenced by scaling effects of surface tension.

For discharges from a deflector-equipped spillway to be correct, the depth of flow, velocity, and air content of flow leaving the plane of the deflector must be correctly scaled. Modeling air content is problematic at a reduced scale due to both surface tension effects and the fact that the velocities of flowing water and rising bubbles have different scales in a model. Air entrainment on the spillway is affected differently by viscosity, surface tension, and pressure at model and prototype scale and therefore is a challenge when using water as the modeling medium. Previous studies for spillways have indicated good agreement between model data and prototype data for spillway performance with and without deflectors at smaller scales (models scales less than 1:30) (ASCE, 2000).

Practical considerations included in model scaling of the structures include the ability to conveniently and accurately set gate operations and control flows, measure velocities and water depths, and make visual observations. At a 1:80 scale the structures in the spillway and powerhouse are too small for accurate velocity measurement and visual observation of flow patterns on the spillway ogee is difficult. The scale is adequate for use as a general model, but detailed fisheries, navigation, and operational structure design should be done on a smaller scale ratio for scaling and practical reasons.

3.4 Near-Field Tailrace

In the near-field tailrace the model must be scaled and geometrically similar to the prototype to simulate the correct flow regime (skimming, undular, plunging, etc.) of flow off the spillway deflectors. In addition, the flow path of the spillway jets as they spread, decay, and entrain ambient powerhouse flow must be modeled correctly as this drives the flow patterns in the entire tailrace.

Geometric similitude is critical to these processes, as is maintaining a Reynolds number above 1×10^4 to maintain fully turbulent flow (Dimotakis, 1993). Representative Reynolds numbers for the near-field tailrace downstream of the spillway are estimated to be 1.4×10^7 and 2.0×10^4 for the prototype and model, respectively, based on visual observations, the April 2003 field data for nearby transects, and bathymetry information available to us. Though the Reynolds numbers appear adequate to simulate the spillway jet processes, the amount of air entrained into the spillway jets may have an impact on the entrainment process. Modeling air entrainment and transport is problematic at a reduced scale due to both surface tension effects and the fact that the velocities of flowing water and rising bubbles have different scales in a model.

The powerhouse discharge exiting the model draft tubes must have correctly scaled velocity magnitudes, distribution, and angularity or swirl. In order to properly scale these phenomena, the Reynolds number should be greater than 1×10^4. A representative Reynolds number from the Transect 2, downstream of the powerhouse is estimated to be 0.9×10^4 based on the conditions for the April 2003 field data collection. The 1:80 scale may capture the exit phenomena for the draft tubes, but geometric similitude will be important for ensuring that conditions are as similar to the prototype as practically feasible in the draft tube exits. We recommend developing inserts with baffling and angled vanes for the draft tubes to aid in delivering the correct velocity distribution and swirl at the exit.

3.5 General Tailrace

As in the forebay, a Reynolds number of 1×10^3 for the tailrace flow would ensure that the model resistance is scaled properly. A spot check on the estimated tailrace Reynolds numbers based on Transect 4 data from April 10, 2003 are 7.4×10^6 and 1.0×10^4, prototype and model Reynolds numbers, respectively.

Surface tension effects may be significant in Froude scaled models for very shallow flows. Therefore, the model flow depth should be a minimum of 1 inch (ASCE, 2000). The 1:80 model flow depths should be confirmed in the tailrace areas of interest to confirm that depths are greater than 1 inch.

4.0 Evaluation of Other Model Requirements

4.1 Boundary Conditions

4.1.1 Upstream Boundary

The upstream boundary of the model should be placed far enough upstream that the effects of the headbox are minimized and that the velocity profile in the river can develop prior to the areas of interest.

The model boundary is upstream of the John Day River confluence with the main river flow and is sufficiently far upstream to minimize boundary effects on the powerhouse and spillway forebay.

4.1.2 Downstream Boundary

The downstream boundary should be placed sufficiently far downstream that the boundary condition does not influence hydrodynamic phenomena or processes in the area of concern in the model. The downstream boundary of the general model is an adequate distance from the areas of interest for model application.

4.2 Construction

The following sections describe ENSR's recommended construction methods for a scale model of the size and scope of the John Day General model. A description of our knowledge of the ERDC construction methods based on ERDC reports and the site visit follows for comparison in each section.

4.2.1 Bathymetry

The bathymetry should be formed and constructed using a combination of mortar, rocks, and wood templates. The templates should be designed from bathymetry contour data with accurate representation of vertical walls and structures. The templates should be installed perpendicular to the river at 3-4 foot intervals and at approximately 1 foot intervals in the vicinity of the spillway in the tailrace. Rocks or sand may be used as filler material between the templates to provide support for a layer of mortar to be installed flush with the top of the templates. The mortar should be hand formed between the templates to match the bathymetry contours between each template. Geometrically scaled rocks should be uniformly spaced and attached to the top of the mortar to ensure flow resistance is approximately the same in the model and prototype. The bathymetry should be constructed above the expected testing range for river flow conditions.

Based on our knowledge, ERDC generally followed the above construction methods and conducted a partial post-bathymetry survey. They made some additional changes and refinements to the bathymetry, particularly in the area immediately downstream of the spillway stilling basin. ENSR does not have adequate documentation of the post-bathymetry survey at this time to identify other specific areas that may need to be addressed.

However, based on visual observation there has been no additional roughness applied to the model bathymetry. The lack of roughness may impact the overall longitudinal water surface profile in the model, most significantly in the tailrace.

4.2.2 Structures

Model structures such as the spillway bays, piers, powerhouse, fish ladders, and navigation locks should be constructed of acrylic where possible to maintain smooth surfaces. The structures should be constructed to within +/- 0.06 in (model scale) tolerance. After installation, the tolerance on elevation of structures should be +/- 0.1 in (model scale).

During the ERDC visit, we observed the structures and identified two potential construction issues:

1. ERDC staff mentioned that the spillway structure has an elevation sag over its length of up to 1 ft prototype.

2. The spillway ogees are constructed of painted sheet metal. The ogees are significantly rougher than expected and would be improved if constructed of smooth acrylic. The roughness likely impacts velocities down the ogee and entering the tailrace.

4.3 Operation

The general model operation should include proper setting of flows and water levels for each river condition as described in the following sections. A description of the procedures used by ERDC staff follows for evaluation.

4.3.1 Flows

Flow entering the model at the upstream end should be measured in the supply line using an orifice or venturi flow meter attached to a manometer with appropriate fluid for reading the manometer differential. Flows for each spillway bay should be set based on information available from operations at the John Day Dam. A gate setting or rating curve for the spillways should be developed to determine the appropriate gate opening in the model for the tainter gates based on reported spill flow from operators. The gates should be set to a measured opening in a consistent and reproducible manner. Flows for each powerhouse bay should be set according to operator reports for powerhouse unit flows using a consistent rating curve developed for the powerhouse bays.

Procedures for setting flows for the river, spillway, powerhouse, and fish ladders are summarized in Appendix A and are consistent with the recommendations above with the exception of the spillway flows. At the time of the ERDC site visit, while a satisfactory tool was being employed to consistently set gate openings, the relationship between the model spillway gate opening and the prototype gate opening was not available.

4.3.2 Water Levels

The forebay and tailrace water levels should be measured for each river condition by measuring the water level in a stilling basin attached to a piezometer tap. The water level should be measured with a point gage and the piezometer tap should be appropriately located to reproduce the measurement location in the field. The forebay velocities are generally lower than the tailrace and forebay water surface variation will be minimal so the piezometer location in the forebay is not critical. The water surface measurement at the tailrace piezometer location may be more highly influenced by local velocity head. Prototype tailrace water surface elevation is currently measured near the powerhouse draft tube outlets (Personal Conversation with Sean Askelson, USACE Portland District, 2006). Therefore, the piezometer tap used to measure tailrace water surface elevation in the model should be located in the vicinity of the powerhouse outlets. Tailrace water levels should be adjusted by weir or other control at the downstream model boundary.

During the ERDC site visit, ERDC personnel confirmed that these procedures are generally followed with the exception that the tailrace water surface elevation is set using the piezometer tap that is downstream of the spillway (see Appendix A for details). It is estimated that the local velocity head difference between the powerhouse tailrace and spillway tailrace tap locations could be as much as 2-5 ft, depending on spillway operations. This discrepancy could greatly impact the deflector flow regime and resulting spillway jet decay and entrainment characteristics.

4.4 Calibration and Verification

After model construction and initial startup testing, the model should be calibrated and verified to field water surface elevation and velocity data to ensure that the model adequately reproduces hydrodynamic conditions. ENSR collected field data in April 2003 (ENSR, 2003) for model calibration and PNNL collected a second data set in 2005 (PNNL, 2006). River flows, spillway flows, powerhouse, flows, and water levels should be reproduced in the model for the April 2003 data collection conditions. The overall water surface profile in the model should be matched to measured water surface during the field data collection period. Adjustments to the model bottom roughness should be made to in an iterative process match the field measured water surface profile over the model reach.

After the water surface profile is calibrated, velocity measurements should be made at the same locations in the model using an ADV to obtain velocity magnitude and direction for comparison to the field data. At each measurement location, the model velocity should generally lie within one standard deviation of the average magnitude and within 10 degrees of the direction measured in the field for adequate calibration. This calibration standard has been applied by ENSR in tailrace models used for juvenile fish passage outfall site selection studies (ENSR, 1998).

The 1:80 model calibration was checked as part of recalibration efforts in the Model Validation Data Report (ERDC, 2006). It is not clear from the Model Validation Data Report whether the model water surface profile has been calibrated over the tailrace reach. After reviewing the report, we feel that the velocity calibration to the April 2003 data is not satisfactory with regards to the above standards at the following locations:

- Transect 1: The prototype flow along Transect 1 is more directed towards the spillway than that in the model. Additional discussion of Transect 1 velocities can be found in the ERDC Trip Report in Appendix A. The discrepancies along this transect indicate that the spillway entrainment is not being modeled adequately in the near-field tailrace.
- Transect 2: Along the powerhouse at Transect 2, the model flow angles for stations 2-1 through 2-4. are satisfactory, but those for stations 2-5 through 2-9 may be improved if the powerhouse turbine velocity distribution and spillway entrainment can be improved as recommended in Section 5.
- Transect 3 and 4 along the Right Bank and Navigation Lock wall: the prototype velocities along the navigation lock wall and right bank downstream of the wall are as much as 3 ft/s higher than in the model.
- Transect 4: at measurement stations 4-5 and 4-7 the velocity magnitudes are representative of prototype conditions, but the model flow angles vary from the prototype angles by –15 and –28 degrees, respectively.

The presentation of velocity data would be improved by presenting the average model velocity magnitude graphically with respect to the prototype average velocity magnitude and standard deviation. This method or similar method would show visually whether the model velocity magnitude is within a satisfactory “window” around the average prototype velocity.

The model velocity data were also compared to the 2005 velocity data (PNNL, 2006) and similar trends were observed and reported in the Model Validation Data Report.

5.0 Conclusions and Recommendations

5.1 Conclusions

In general, the operational calibration performed for the 2006 Model Validation Data Report (ERDC, 2006) of the model boundary conditions, model continuity, and instrumentation was a thorough and sound investigation of model operations. Based on our review of this report, other available model reports, literature, and our site visit we have developed conclusions about the applicability of the model for studying fisheries management and navigation in each region of the model study area.

5.1.1 Forebay

The model is a satisfactory tool for performing fisheries management and navigation studies in the project forebay, with the following observations:

- Velocities and in the far field forebay are generally less than 1 ft/s and as a result the fisheries and navigation implications of structures will be negligible.

- In the mid-field, downstream of the navigation lock guide wall and navigation concerns, the approach flow net of interest in fish management appears to be reasonably simulated. The zone of influence of any SFO and flow paths approaching the SFO will be driven primarily by flow magnitude and not velocities.

5.1.2 Structures

The model is a satisfactory tool for simulating the contribution of flows through the powerhouse, spillway, fish ladder, and navigation structures as part of the general model. However, the scaling issues described in the following comments prevent adequate simulation of the flow field and velocities for developing design details of fisheries and navigation structures:

- The model scale is too small to simulate the flow conditions in an SFO or to practically measure and observe such conditions.

- A model scale on the order of 1:20-1:25 would be more adequate for detailed design investigations.

5.1.3 Near-Field Tailrace

The model may potentially be a satisfactory tool for conducting fisheries management and navigation studies in the near-field tailrace after addressing the following concerns with the existing model:

- The model calibration in the near-field tailrace is not satisfactory along Transect 1;

- Based on our literature review and site visit, the model is not adequately simulating the spillway jet energy and momentum and entrainment of powerhouse flow;

- The distribution of flow leaving the powerhouse draft tubes is not simulated adequately.

A step-wise plan for improving the spillway jet energy, momentum, and entrainment, powerhouse draft tube flow, and model calibration is provided in Section 5.2 Recommendations.

5.1.4 General Tailrace

If the corrections recommended for the near-field tailrace improve the spillway/powerhouse jet momentum and entrainment and the model calibration, the model scale is satisfactory for investigating navigation and fisheries management projects in the general tailrace. However, the bottom roughness in the tailrace is not represented and the water surface profile in the tailrace has not been calibrated to our knowledge.

5.2 Recommendations

Based on our conclusions, ENSR has developed a series of recommendations for improving the model for future fisheries management and navigation studies.

5.2.1 Forebay

No changes are required in the forebay.

5.2.2 Structures

ENSR recommends developing separate models at smaller scale (1:20 or 1:25) for development of the design details of fisheries management structures. Structures in a general model should be designed to provide appropriate boundary conditions for the forebay and tailrace as described in Section 2.3.2. This requires considerations other than simulating the scaled geometry of the structures. The following section describes how the structures might be modified to improve the tailrace inflow boundary conditions.

5.2.3 Near-Field Tailrace

The following plan has been developed based on our literature review, observations of the model during the field visit, and professional knowledge of modeling practices. The plan is presented in a step-wise fashion in the order of the items that we feel may have the largest impact on the correct simulation of the tailrace flow field. Some or all of the steps will be required to reach adequate calibration. The model calibration should be checked after each step or series of steps to confirm the impact of the changes.

1. Set the tailrace water surface elevation based on the piezometer tap located downstream of the powerhouse rather than the spillway as described in the ERDC Trip Report in Appendix A to minimize the influence of the higher spillway velocities on the tailrace water surface elevation. The powerhouse piezometer tap will allow for a tailwater elevation that is more closely set to that measured in the field. This change alone may result in the spillway deflector flow being of the correct regime and entrainment being better simulated.

2. Compare the water surface elevation profile in tailrace over the length of the model to known field measurements as available. Add bottom roughness if needed to calibrate the water surface profile in the tailrace through an iterative process.

3. Confirm or compare the calibration rating curve for the model spillway gate opening as compared to the prototype gate opening.

4. Confirm that the model spillway ogee is providing adequate velocity at the end of the deflector by measuring the depth of flow on the ogee using a point gage. Use the spillway flow and depth of flow to calculate the velocity at the end of the deflector and compare to CFD model results or water surface profile calculations for the prototype spillway.

5. Conduct CFD or water surface profile calculations to determine if one or a combination of smoothing the spillway crest and ogee, steepening the ogee slope, increasing head, or changing gate setting practices will deliver the correct flow depth and velocity on the deflectors.

6. If calculations show this approach will work, add extensions to the spillway gates to allow forebay water surface elevation increase and re-calibrate the powerhouse for higher forebay so spillway jet energy and momentum is appropriately simulated.

7. If calculations show that the velocities leaving the deflectors will still not be adequately scaled, modify the piers to install downstream slide gates to set required deflector flow depth and velocity; and

8. Develop draft tube inserts that deliver the correct distribution for simulation of different turbine settings and confirm against field velocity data. An additional set of velocity data may need to be collected at a flow condition different than the one for the Battelle data set (PNNL, 2006).

Discussions with Larry Weber of Iowa Institute of Hydraulic Research (IIHR) (Personal Conversation, ENSR, 2006) about preliminary studies of physical and CFD modeling of jet entrainment indicate that there is a potential for continued difficulty with adequately representing the spillway jet entrainment in the physical model due to the influences of air entrainment and content and turbulence scaling on entrainment. The threshold physical model scale at which these processes will be correctly simulated has not been clearly delineated in the literature at this time.

5.2.4 General Tailrace

We recommend following the process of model adjustment and verification described in Section 5.2.3 Near-Field Tailrace before using the model for fisheries or navigation studies in the general tailrace.

6.0 References

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Dimotakis, Paul E., 1993. Some issues on turbulent mixing and turbulence. Distributed as GALCIT Report FM93-1 (17 March 1993). Updated as FM93-1a (23 August 1993). Acrobat Read PDF version distributed 12 November 1998. Copyright 199301998 P.E. Dimotakis, Graduate Aeronautical Laboratories, California Institute of Technology, Pasadena, CA.

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Appendix A

ERDC Trip Report September 13, 2006

ENSR | AECOM

ENSR
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T 425.881.7700   F 425.883.4473 www.ensr.aecom.com

Memorandum

Date: September 28, 2006

To: Sean Askelson, Kyle McCune – USACE Portland District

From: Liza Roy, Chick Sweeney - ENSR

Subject: John Day ITR ERDC Trip Report (September 13, 2006)   Contract No. W9127N-06-D-0004, T.O. No. 03

Distribution: ENSR Project File: 09000-406

Introduction

Chick Sweeney and Liza Roy of ENSR traveled to the USACE Engineering Research and Development Center (ERDC) to view the John Day 1:80 scale general model in operation as part of ENSR's Independent Technical Review (ITR) of the John Day general model status. Sean Askelson and Kyle McCune of the USACE Portland District attended and Don Wilson and Dave Maggio of ERDC hosted the visit. This trip report summarizes the goals of and observations made during the ERDC trip and will be included in the John Day general model status ITR report as an appendix.

The goals for the trip included the following:

1. Observe the general layout of the 1:80 scale general model;
2. Understand the model construction methods;
3. Understand the model operation and calibration methods;
4. Observe the model operation during at least two flow conditions, one of which represents flow conditions during the April 2003 field data collection
5. Assess the flow patterns near the spillway and powerhouse in the area near Transect 1

1:80 General Model Layout and Construction

Principal Investigator Don Wilson and Testing Technician David Maggio described the 1:80 scale model layout, construction, and operation during our field visit to ERDC on September 13, 2006. The following sections summarize their description.

Model Layout and Construction

The 1:80 scale model encompasses 7 miles of the Columbia River from River Mile (RM) 212.5 to RM 219.5, approximately the region shown in Figure 1. A single pump provides flow from the sump to the upstream end of the model where it enters through a perforated supply line along the length of the headbox (Figure 2) and passes through a concrete block baffle to the forebay reach (Figure 3). The bathymetry was constructed of trowel-finished mortar over sand using templates at approximately 4-foot (model scale) intervals in the forebay and tailrace (template lines are visible in the model), except in the area downstream of the spillways where greater resolution was achieved. No roughness elements are applied to the bathymetry surface. Piezometer taps provide water surface elevations at approximately one-quarter mile intervals along the model through a group of stilling basins read with point gages.

Figure 1. Approximate John Day Dam Model Study Area (photo provided by Sean Askelson, USACE Portland District)

Figure 2. Headbox (Looking from Right Bank)

Figure 3. Forebay (Looking Downstream from Headbox)

The spillways were constructed of a combination of acrylic and metal (Figure 4). The piers, spillway walls, and deflector walls were constructed of painted acrylic. The tainter gates and spillway ogee are painted sheet metal and the surfaces are significantly rougher than the painted acrylic surfaces. The powerhouse units were constructed of acrylic with metal control gates (Figure 5).

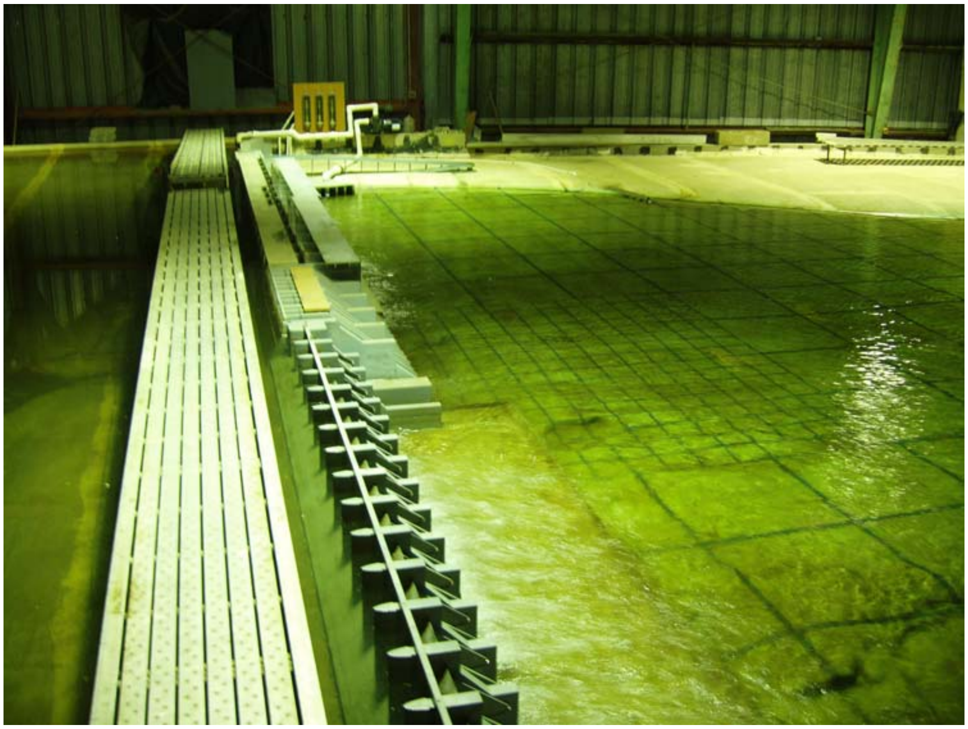

Figure 4. Spillway (Looking from Right Bank)

Figure 5. Powerhouse Units

A view of the tailrace looking downstream from the powerhouse is shown in Figure 6. Flow passes over a pair of weirs at the downstream end of the model into a tailbox and returns to the sump by gravity.

Figure 6. Tailrace (Looking Downstream from Right Bank)

Model Operation

Total river flow to the model is controlled by a recently recalibrated venturi meter with a mercury manometer. The recalibration process was described in the Model Status Report[1] (ERDC, July 2006).

Spillway flow is set using a tool, which was demonstrated by Dave. He has developed a rating curve that relates the tool setting to the spillway bay flow for the operating forebay level. The tool fits into the spillway bay so that the tool reading plus the thickness of the tool base (0.0735 inches model scale) is the elevation difference between the crest and the gate lip. The tool has a vernier gauge that reads in model feet to the nearest 0.001 feet. At the time of the trip, the direct relationship between the setting on the tool and prototype gate opening in stops was not known.

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[1] ERDC, July 2006. John Day Model Validation Data Report. Donald C. Wilson and David Maggio, USACE Coastal and Hydraulics Laboratory.

Powerhouse flows are set by adjusting the opening height on each powerhouse bay. Tailwater elevation is measured at the piezometer tap located approximately 500 feet downstream of spillway bay 11. The tailwater elevation can be changed by adjusting the weirs at the downstream end of the model. A point gage is used to measure the weir elevation.

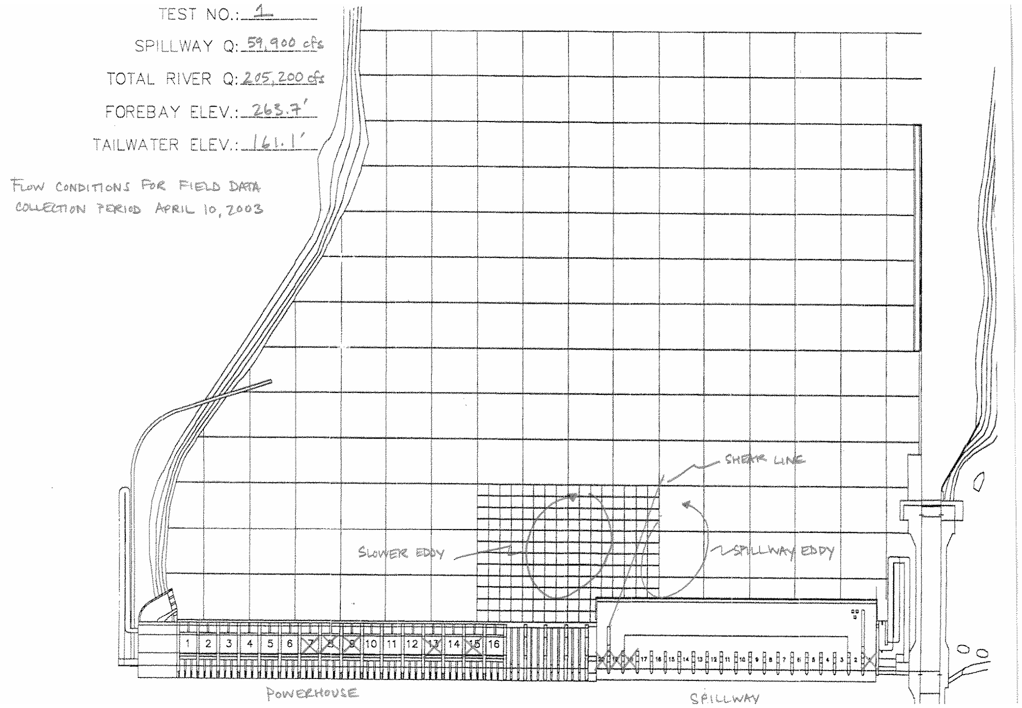
1:80 Model Observations

We observed the model operations for six different flow conditions as summarized in Table 1. The first flow condition was observed in the morning and Tests 2 through 5 were observed in the afternoon. Visual observations and observation of dye injections were made for each test.

Test 1

The initial flow condition was set prior to our arrival and represented the flow conditions during the field data collection on April 10, 2003. Observations during this flow condition included the following:

- Two large eddies form downstream of spillway bays 13 through 20 and the skeleton powerhouse bays as shown in Figure 7. A shear line between eddies extends downstream from the spillway 19/20 deflector wall approximately 15 degrees clockwise from due downstream. The eddy to the right bank of the shear line rotates counterclockwise and extends across spillway bays 13 through 20. The eddy to the left bank of the shear line rotates clockwise and more slowly and extends along all four powerhouse skeleton bays. The left eddy crosses the Transect 1 measurement points from the 2003 field velocity collection period.


TEST NO.: 1
SPILLWAY Q: 59,900 cfs
TOTAL RIVER Q: 205,200 cfs
FOREBAY ELEV.: 263.7'
TAILWATER ELEV.: 161.1'

FLOW CONDITIONS FOR FIELD DATA COLLECTION PERIOD APRIL 10, 2003

Figure 7. Eddy Location

- The majority of flow entrainment into the spillway flow occurs in the stilling basin just downstream of bay 17, not further downstream.

- Flow off the spillway deflectors appeared to be in the undular regime, not skimming jet flow regime, as expected for the spillway bay discharge and tailwater elevation conditions.

- Dye injected upstream of the tainter gate for spillway bay 12 was entrained into the spillway flow. Some of the dye passed downstream immediately, but a majority of the dye passed along the spillway stilling basin to bays 4 and 5 and then traveled downstream along the thalweg as shown in Figures 8, 9, and 10.

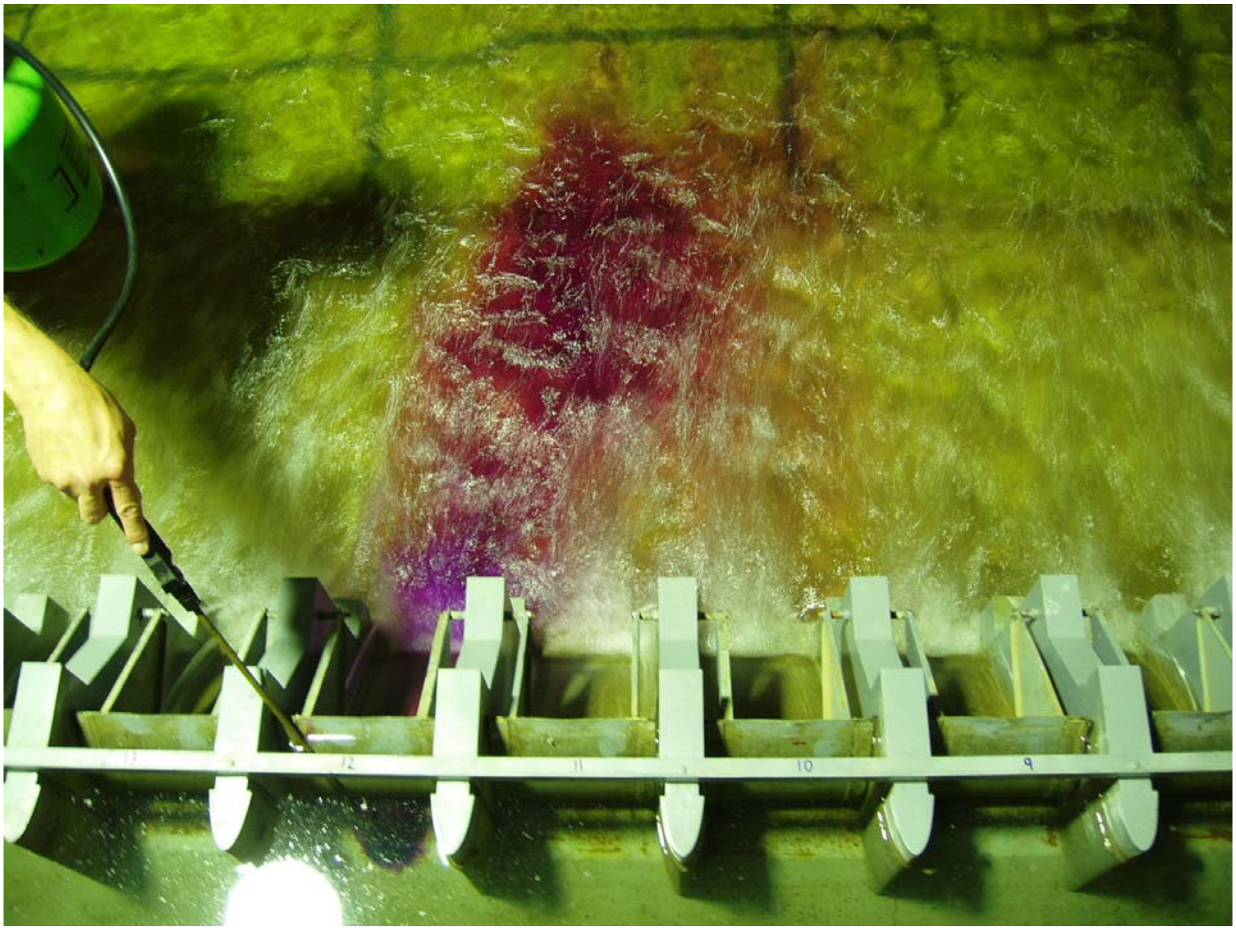


Figure 8. Dye Injected Upstream of Spillway Bay 12

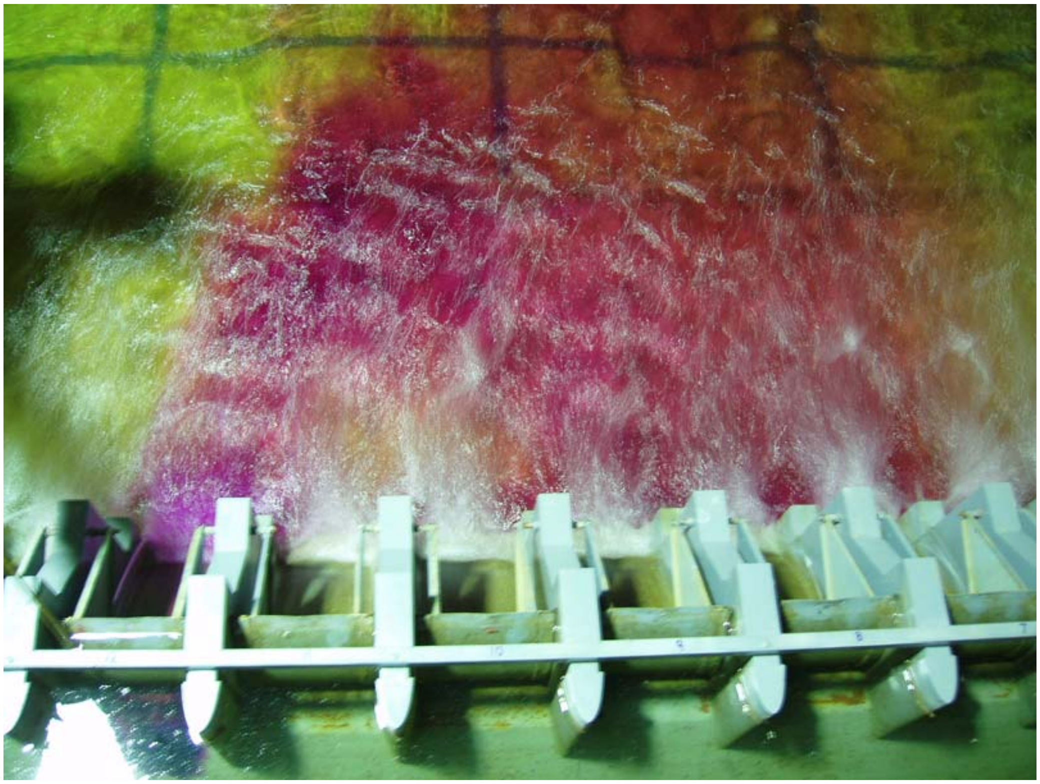


Figure 9. Dye Entrained in Spill Flow Passes Along Spillway Stilling Basin Towards Right Bank

Figure 10. Entrained Dye Near Spillway Bays 4 and 5.

Test 2

The first test represented a spill flow of approximately 30% of the total river flow. During Test 2 the spill flow was increased to 60% of the total river flow to try to achieve a skimming jet flow off the deflectors, using the same total river flow. Flows in each spillway bay were doubled. Observations during Test 2 included the following:

- Dye injected immediately downstream of spillway bays 16 and 17 was entrained into the spillway flow. Some of the dye passed downstream immediately, but a majority of the dye passed along the spillway stilling basin to bays 4 and 5 and then traveled downstream along the thalweg.
- The flow off the deflectors was more like a skimming jet than in Test 1.
- The two eddies were still present at the same location as in Figure 7 for Test 1.

Test 3

Spillway flows were set in Test 3 to try to achieve a skimming jet deflector flow regime. Flow for each spillway bay was set to 9,000 cfs beginning at spillway bay 2 to a maximum spillway flow of 119,800 cfs, approximately 60% of total river flow. Observations during Test 3 included the following:

- Flow off the spillway deflectors appeared to be in skimming jet regime.
- The double eddy flow pattern seen in the two previous tests was eliminated and flow along Transect 1 passed toward the spillway. Dye injected along the surface at Transect 1 was entrained into the spillway flow, with the exception of a small portion of the dye immediately downstream of the skeleton bays.
- Dye injected at depth along Transect 1 moved more slowly than at the surface and was directed more immediately toward the spillway.
- Dye injected along Transect 1 appeared to have a similar flow pattern to the velocity vectors measured during the field data collection on April 10, 2003, both at the surface and at depth.
- A small, very slow moving eddy developed just downstream of the skeleton bays, in a region extending approximately 150 feet downstream from the skeleton bays.

Test 4

In Test 4, we maintained the 9,000 cfs per spillway bay to maintain the skimming jets, but reduced the total spill flow to approximately 30% of the total river flow by loading the spill to bays 11 through 17. This test investigated the effects of the spill in the bays near the powerhouse and the impacts on the flow patterns between the spillway and powerhouse. Flow conditions observed during Test 4 were similar to those seen in Test 3.

Test 5

In Test 5, the spill flow was reduced to approximately 30% of the total river flow, with 5,000 cfs per spillway bay in bays 6 through 17. This test investigated the effects of spill in the bays near the powerhouse and the impacts on the flow patterns between the spillway and powerhouse. We were testing whether the two-eddy flow pattern in Tests 1 and 2 would result from spillway bay flows of 5,000 cfs during a 30% spill condition. Observations during this test include the following:

- Flow patterns were similar to Tests 3 and 4, with dye injected at Transect 1 entrained into the spill flow in the stilling basin and downstream of the basin. Flow patterns appeared similar to those represented by the velocity vectors from the field data for Transect 1 (Figures 11 through 13) and Transect 2 (Figures 14 and 15). The field data collection points on each transect are visible on the bottom of the model as red painted dots in the photos for reference.

- A very slow eddy set up downstream of the skeleton bays to a distance of approximately 150 feet downstream of the skeleton bays.

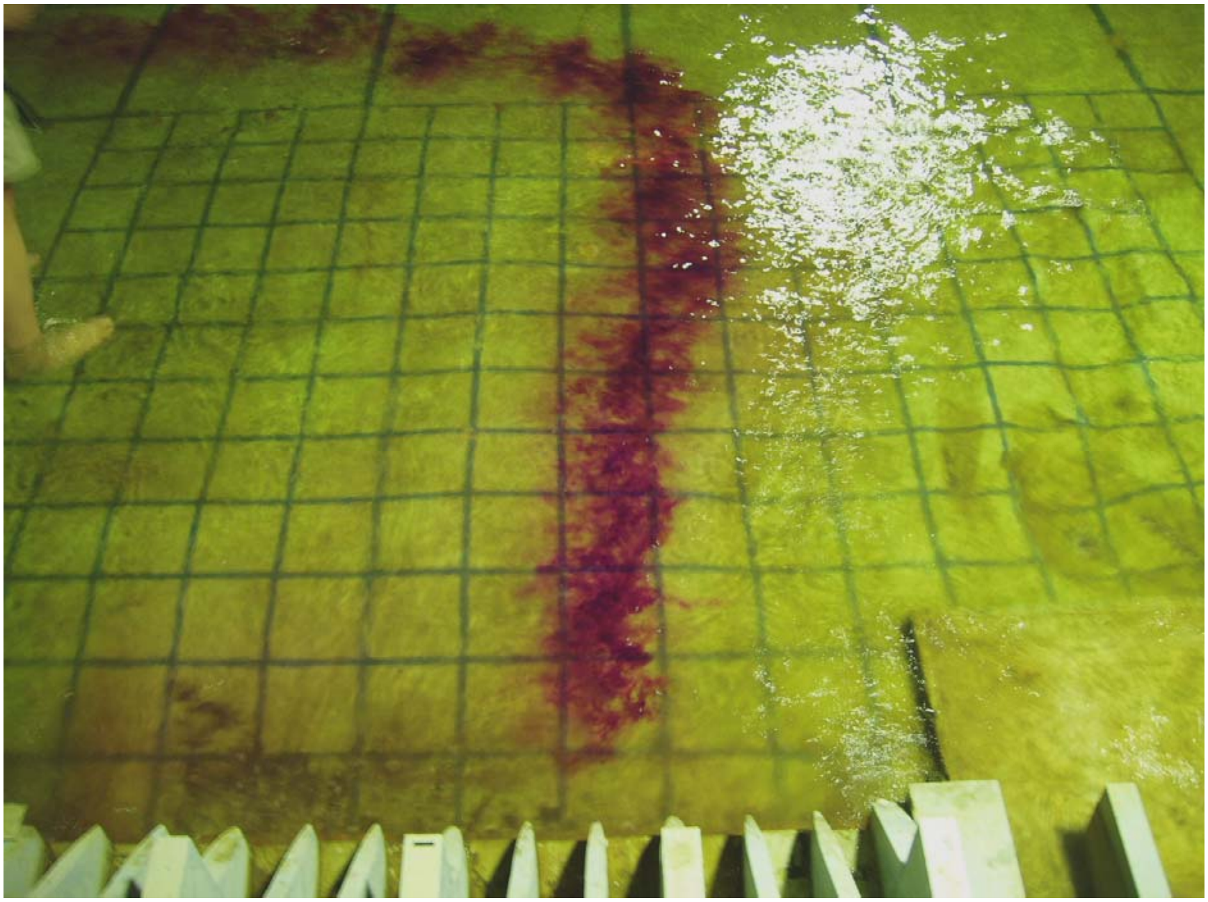


Figure 11. Dye Release at Surface Along Transect 1

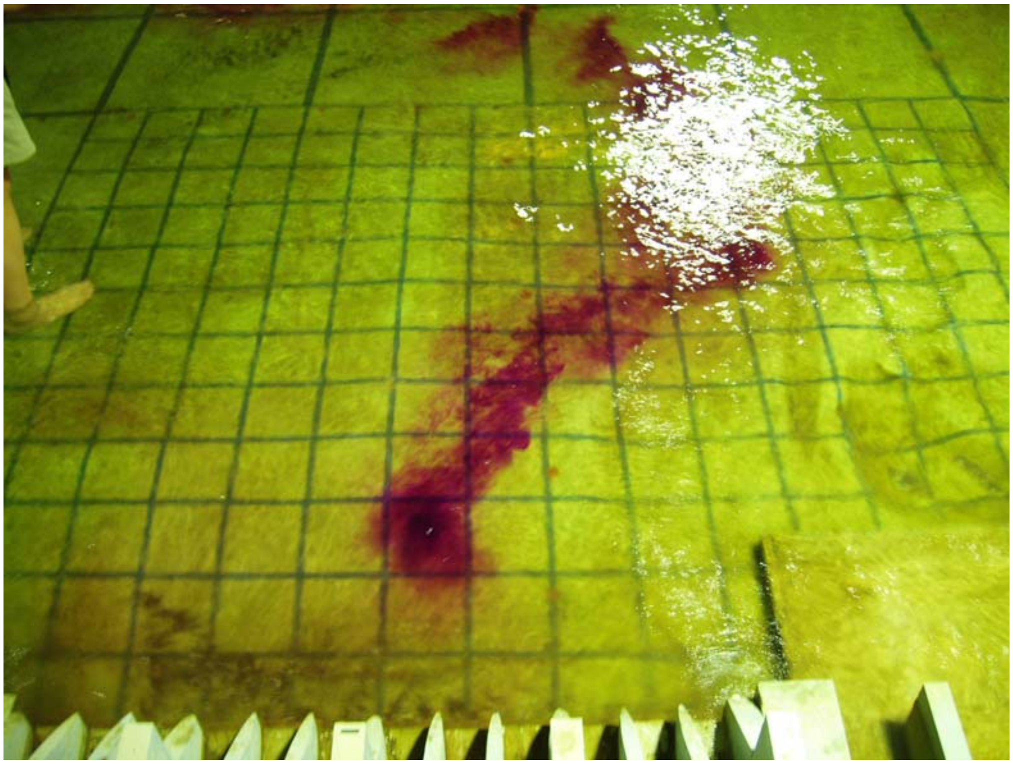


Figure 12. Progression of Dye Released at Transect 1

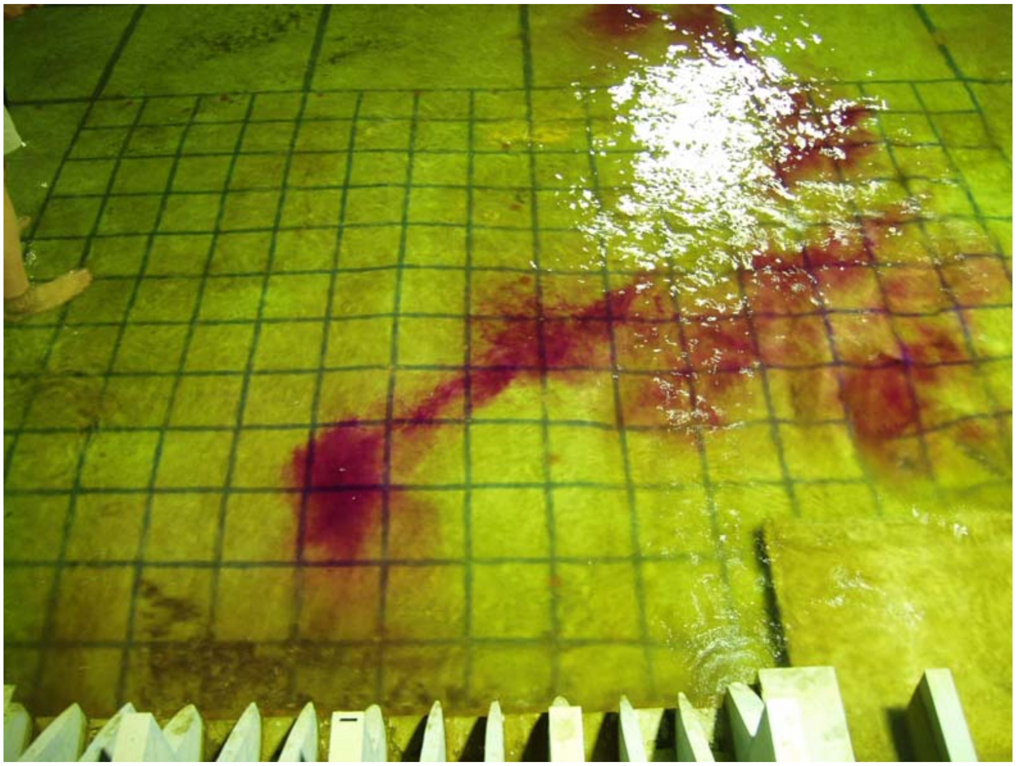


Figure 13. Progression of Dye Released at Transect 1

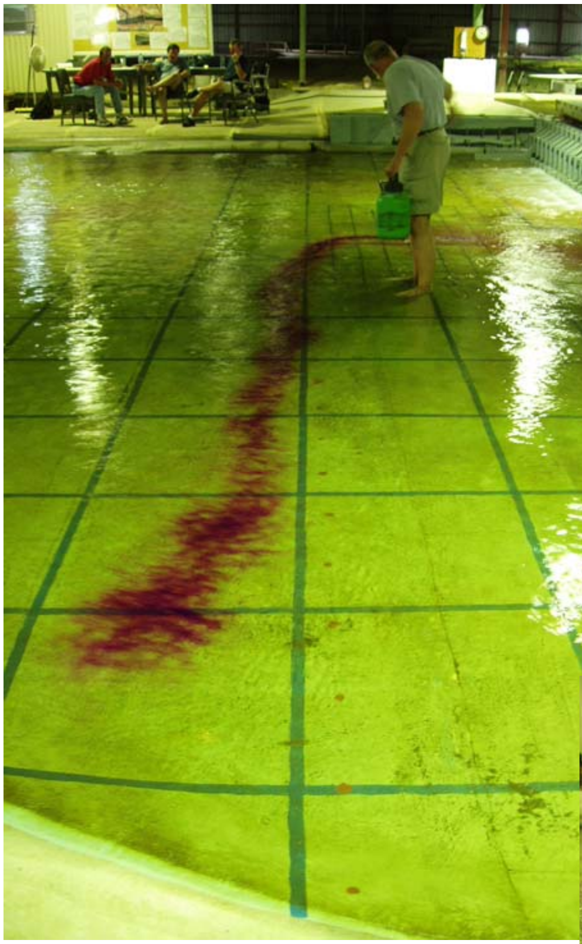


Figure 14. Dye Released Along Transect 2

Figure 15. Progression of Dye Released Along Transect 2

Test 6

Test 6 was conducted to observe the potential to reverse flow patterns downstream of the powerhouse during a 60% spill condition. This test was the same as Test 2, but we put 30% more spill in each of the spill bays nearest the powerhouse until the spill flow totaled 119,800 cfs or 60% of total river flow. Observations during Test 6 included the following:

1. Dye injected along Transect 1 was entrained into the spill flow as in Tests 3 through 5.
2. A large counterclockwise eddy developed between the outfall on the left bank and the powerhouse units 1 through 6. Dye injected along Transect 2 parallel to the powerhouse traveled in an upstream direction downstream from powerhouse units 7 through 20 and in the downstream direction near units 1 through 6.

Summary of Observations

1. General model flow supply, bathymetry construction, and tailwater control systems appeared to follow standard laboratory practice.
2. No roughness elements were applied to the model bathymetry. Based on our experience in calibrating tailrace models, the need for roughness elements should be further investigated.
3. The spillway crest and ogee surfaces were rougher than expected and the potential impact of this on spillway flow depth and velocity should be further investigated.
4. The relationship between model and prototype spillway gate calibrations should be further investigated.
5. The difference between tailwater levels set in the model at the spillway tap location and the measurements in the field at the powerhouse should be further investigated.
6. The spillway deflector flow regime appeared undular, rather than the skimming regime expected for the April 10, 2003 field data collection conditions (Test 1).
7. A clockwise eddy crossed the Transect 1 measurement points from the April 10, 2003 field data collection with the majority of the entrainment into the spillway flow occurring in the stilling basin downstream from Bay 17, not further downstream as indicated by the field data (Test 1).
8. It was possible to change flow to the expected skimming regime by increasing the unit discharge of the operating spillway bays by approximately 30% (Tests 2-6). Similar results might be achieved by setting the tailwater level at the powerhouse tap rather than the spillway tap due to dynamic depression of the water level above the spillway tap by the spillway flow, but this was not tested due to time required for the model to stabilize after a water level setting.
9. Changing the deflector flow regime to skimming by increasing spillway bay discharges also entrained powerhouse flow into the spillway discharge for a greater distance downstream and changed the direction of flow at the Transect 1 measurement points to that observed during the April 10, 2003 field data collection (Tests 2-6).

Appendix B

Comment Report

Comment Report: All Comments
Project: John Day General Model
Review: ITR
Displaying 24 comments.
297 ms to run this page

<table>
<tr><th>Id ▲</th><th>Discipline</th><th>DocType</th><th>Spec</th><th>Sheet</th><th>Detail</th></tr>
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<tr><td colspan="6">Well written document.

Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
Thank you!

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td></td><td colspan="5">*Backcheck not conducted*</td></tr>
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<tr><td colspan="6">(Document Reference: Cover Page) Appears to have two cover pages, one with signature and one without. Do we need both?

Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
We used the new standard ENSR report template and part of the style is to have separate cover and title/signature page. I suggest we use this format, but also add photos of John Day prototype and model above the title on the cover to diffrentiate it.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td></td><td colspan="5">*Backcheck not conducted*</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Open**</td></tr>
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<tr><td colspan="6">(Document Reference: ES-1) - last sentence. We will get asked what scale do we need to build the model at to not have these issues? I am not sure they have an answer but I don't think we can get enough pump capacity to make it affordable.

Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
I suggest we change the last sentence to read, " . . .hydraulic model will not be a practical tool as the scale ratio would have to be on the order of 1:5 or less to simulate the air entrainment process." I will check with John Gulliver for a reference on this or provide a personal communication reference.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
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<tr><td colspan="6">(Document Reference: Page 2-2, section 2.3.1) 2-2, section 2.3.1 first paragraph. Not sure what the first sentence is saying "as well as adult fish egress from the fish ladder exits are the form of the approach flow net to the fisheries facilities". I am confused by "the form" in this sentence.

Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**</td></tr>
</table>

	We will revise the sentence to read, " . . as well as adult egress from the fish ladder exits, are the shape and dimension of the flow net approaching the fisheries facilities . . ." Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
1284110	Hydraulics	Other	n/a	n/a	n/a
(Document Reference: Page 2-2, section 2.3.1) 2-2, section 2.3.1 last paragraph. I am not sure that we will have a scaling issue but large SFOs and BGS can negatively impact navigation in the forebay even though velocities are low. Small changes in dead zones or cross current across an entrance can make safe navigation impossible. Thus I agree the model can model navigation issues in the forebay it doesn't mean a design would have negligible influence on navigation. TDA BGS case in point. Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06					
1-0	Evaluation **Concurred** The final paragraph will be re-written to say, "Flow velocity in the navigation lock approaches in the project forebay are generally very low, under 1 ft/s, but may still affect tow boat and barge movemehnt." Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
1284111	Hydraulics	Other	n/a	n/a	n/a
(Document Reference: Page 3-5, section 3.4) 3-5, section 3.4. Not sure how you inject swirl into the draft tube exit. Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06					
1-0	Evaluation **Concurred** We will clarify this in the report by changing the last sentence in thes section to read, "We recommend developing inserts with baffling and vanes for the draft tubes to aid in delivering the correct velocity distribution and swirl at the exits." Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
1284112	Hydraulics	Other	n/a	n/a	n/a
(Document Reference: Page 4-1, section 4.2.1) 4-1, section 4.2.1. Not important to this ITR but I am curious the authors thoughts on using 3-D routered Plexiglas for bathymetry? Submitted By: Laurie Ebner ((503) 808-4880). Submitted On: 01-Oct-06					
1-0	Evaluation **For Information Only** I think routering Plexiglas would be an extremely expensive undertaking over a very large area or with much relief because ot eh number of sheets that would have to be laminated and the overall material expense. However, I have seen routered high-density foam used to make architectural models and this could be applied to model bathymetry. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
1288398	Hydraulics	Other	n/a	ES-1	n/a
(Document Reference: Last line in the last paragraph) "if the verification goals cannot be met, it is likely that an air entrainment..." possibly clarify with the following: if the verification goals cannot be met through the system of model checks and improvements, it is likely that an air entrainment					

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06

1-0	Evaluation **Concurred** The sentence will be changed to read, "If the verification goals cannot be met through the recommended program of model checks and improvements, it is likely that air entrainment and . . ." Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06
	Current Comment Status: **Comment Closed**

1288399	Hydraulics	Other	n/a	3-4	n/a

(Document Reference: 3.3 paragraph 3) Is it "safe" to say that any difference between the model gate opening (difference in discharge coefficient) will have a greater effect on the tailrace and not the forebay?

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06

1-0	Evaluation **Concurred** A sentence will be added to the end of the paragraph stating, "Any difference between model and prototype gate openings (discharge coefficients) wil have a greater effect on correct simulation of spillway and tailrace flow conditions thatn on the forebay." Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06
	Current Comment Status: **Comment Closed**

1288400	Hydraulics	Other	n/a	3-4	n/a

(Document Reference: 3.3 paragraph 4) mentioning air entrainment on the spillway is affected by viscosity and surface tension... from previous calculations, I though the Weber number on the spillway ogee was close to the "transition zone" where surface tension may have an influence on the flow... would this make the air entrainment problem worse?.

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06

1-0	Evaluation **Check and Resolve** We have not performed these calculations, but will do so and address this comment in the final report. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06
	Backcheck not conducted
	Current Comment Status: **Comment Open**

1288401	Hydraulics	Other	n/a	3-4	n/a

(Document Reference: 3.3 paragraph 5) The "all encompasing model" is not intended to provide information on the spillway ogee or inside the powerhouse, although the fisheries managers would like to model flow into and out of the structure. For instance, we do not intend on designing the approach to an RSW in the 1:80 general model. Maybe I'm just splitting hairs...

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06

1-0	Evaluation **Concurred** We concur that the "all encompassing model" is not the appropriate tool to use for detailed studies of the spillway ogee or powerhouse and that a smaller scale ratio (larger model) should be used for these studies and that is what the final sentence of the paragraph states. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06
1-1	Backcheck Recommendation **Close Comment**

<table>
<tr><td></td><td colspan="5">The text is sufficient, I just didn't want the text to give the impression that the agencies "want" to use the general model for every study, they understand some of the scale limitations

Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
<tr><td>1288403</td><td>Hydraulics</td><td>Other</td><td>n/a</td><td>4.2.1</td><td>n/a</td></tr>
<tr><td colspan="6">(Document Reference: last paragraph) the lack of added roughness is probably a better indicator that the model has never been calibrated to prototype water surface elevations... the calibration and verification process is probably incomplete

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
We concur, but chose to cover this under the discussion of calibration and verification in section 4.4

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
<tr><td>1288406</td><td>Hydraulics</td><td>Other</td><td>n/a</td><td>5.1.2</td><td>n/a</td></tr>
<tr><td colspan="6">similar to previous comment, the model is not intended to make decisions on Surface Flow designs, ogee shape, draft tube configurations, etc, although some would like to measure "right up to" and "right off of" these types of structures in the model.

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Check and Resolve**
We may be stating the obvious in this section, but felt it important to comment on the use of the structures in a general model versus the use of larger scale models for design purposes. Is there a need to change the report text?

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
I do not mind stating the obvious, it is probably a good idea to state the obvious in this section. Just didn't want to give the impression that we (or anyone else) intends on using the model for detail design through structures. I think the text is acceptable as is.

Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
<tr><td>1288407</td><td>Hydraulics</td><td>Other</td><td>n/a</td><td>5.2.3</td><td>n/a</td></tr>
<tr><td colspan="6">if the roughness on the ogee proves to be a problem in obtaining the correct energy at the deflector and we chose to replace the spillway with a plexiglas model, could making the ogee steeper be a viable solution?

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
Steepening the ogee may be an additional adjustment that can increase the energy and will be added to the list of options.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
</table>

<table>
<tr><td>1288408</td><td>Hydraulics</td><td>Other</td><td>n/a</td><td>5.2.3</td><td>n/a</td></tr>
<tr><td colspan="6">discussion with Larry Weber... the difficulty with adequately representing the spillway jet entrainment in the physical model... is there an identified scale where this starts being a problem? From the information I've heard, this is a relatively "new" problem identified since the recent move towards spillway flow deflectors.

Submitted By: Sean Askelson ((503) 808-4882). Submitted On: 04-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
This is a new problem that has been identified since the advent of spillway deflector studies and, to our knowledge, there has not been a scale identified at which this starts to be a problem. We will consult further with Larry and John Gulliver at University of Minnesota to see if we can bring further clarification to this issue.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Sean Askelson ((503) 808-4882) Submitted On: 10-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
<tr><td>1290235</td><td>Hydraulics</td><td>Technical Report</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td colspan="6">Section 1.0, Paragraph 2: You state that the model, "was not replicating flow entrainment from the powerhouse to the spillway." You might change to, "was not believed to be..." Because we didn't actually know at the time we just suspected. The purpose of subsequent reports, including this report, is to determine the problem.

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
The suggested change will be made to the text to read, " . . and was not believed to be replicating flow entrainment . . . "

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: **Comment Closed**</td></tr>
<tr><td>1290236</td><td>Hydraulics</td><td>Technical Report</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td colspan="6">Section 2.3.2, 3rd Paragraph: Report states that for powerhouse discharges to be correct the model must produce the correct velocity magnitudes, distribution, and angularity. I don't know that this is the case, and doesn't seem to be the current practice. The discharge is a known and is provided by the overflow weir. Therefore the discharge as set (within measurement error) is correct. The velocity magnitude, distribution and angularity are important factors in modeling the powerhouse jet dynamics but not to getting the flow rate correct. Maybe you are using discharge in a larger sense of the word but I think of discharge simply as flow rate. In addition, I'm not sure they "must" all be correct to get the adequate jet dynamics. It depends of the significance of each in dissipating energy (at the general model scale) balanced against scale effects on the same by, in effect, dealing with a more viscous fluid (a function of scale) in the model. I would be concerned that people would read this literally (as maybe I did) and start to think that we need to put scaled turbines and all of the other accoutrements in the powerhouse to adequately model the powerhouse jet. We aren't looking for exact in the model; just enough to adequately replicate the processes we feel need to be modeled to get to the bottom of the problem we are looking at.

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-0**</td><td colspan="5">Evaluation **Concurred**
The term "discharge" will be removed from the text as it causes the confusion. What is meant is that as a boundary condition for the tailrace, the flow exiting the turbine draft tubes should adequately simulate the velocity magnitude, distribution, and swirl. What is adequate? For studies in the near field, these are important. In the far field they are not.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>**1-1**</td><td colspan="5">Backcheck Recommendation **Close Comment**
Closed without comment.</td></tr>
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Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06

Current Comment Status: **Comment Closed**

1290237	Hydraulics	Technical Report	n/a	n/a	n/a

Section 2.3.2, 4rd Paragraph: Similar to the comment above. I read discharge and think flow rate (cubic feet per second) and don't see that depth off of the deflector, velocity, or air entrainment drive that at all (the discharge is controlled at the gate not off of the deflector). Maybe we need to use jet dynamics (in terms of the general model these would include energy dissipation, momentum, and or entrainment characteristics) or some other word rather than discharge.

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06

1-0 Evaluation **Concurred**
Instead of discharge, the text will be revised to read, "For conditions of flow exiting a deflector-equipped spillway to be correctly simulated, the depth of flow, . . . "

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06

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

Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06

Current Comment Status: **Comment Closed**

1290238	Hydraulics	Technical Report	n/a	n/a	n/a

Section 2.3.4: State that the larger tailrace eddy is predominantly driven by dual engines of momentum magnitude and distribution. No discussion of the larger bathymetric features on the general tailrace hydraulics (beyond getting the correct roughness later). Do you feel that the necking down of the river right after the project into to distinctly separated thalwegs might contribute to the eddy formation as well?

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06

1-0 Evaluation **Concurred**
You are of course correct that the bathymetry is important. Having the bathymetry correct is an underlying need for correct simulation of the flow patterns in all areas of the model. The sentence will be revised to read, ". . . discharges as the exit the near-field tailrace and how they interact with the tailrace bathymetry."

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06

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

Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06

Current Comment Status: **Comment Closed**

1290239	Hydraulics	Technical Report	n/a	n/a	n/a

3.1 General Scaling Theory: When you are describing scaling theory after the dimensionless for ratios are presented you explain modeling at reduced scales in terms of finding the force relationships necessarily to, "accurately simulate prototype conditions." I think it would be helpful to make the distinction between prototype conditions in the all encompassing sense of the word and prototype conditions specific to what you are trying to model. We are obviously missing many prototype conditions in the all encompassing sense but we are capturing the more significant processes and therefore can depend on the model to accurately replicate conditions driven predominately by those processes.

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06

1-0 Evaluation **Concurred**
The final sentence of the second paragraph of this section will be revised to read, "indentification of the force relationships necessary to accurately simulate the critical or significant prototype flow processes."

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06

1-1 Backcheck Recommendation **Close Comment**

	Closed without comment. Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06				
	Current Comment Status: **Comment Closed**				
1290240	Hydraulics	Technical Report	n/a	n/a	n/a
Section 3.3 Structures: When you discuss the scaling effects on the structures you discuss the structures primarily as inlets and outlets for the forebay and tailrace model but the model tries to replicate the conveyances of flow as well (the ogees for example). It would be helpful to also discuss scale effects of the ogee and other features in this section. Does the fact that we are running the spillway discharge over a scaled down ogee in a thin layer explain (partially of fully) the fact that we are not getting the correct depth and velocity off of the end of the deflector and that may carry into tailrace issues. Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06					
1-0	Evaluation **Concurred** We will expand this discussion to include the simulation of the flow profile and boundary layer development down the ogee and how this affects the flow coming off the deflectors. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06				
	Current Comment Status: **Comment Closed**				
1290241	Hydraulics	Technical Report	n/a	n/a	n/a
Section 3.5 General Tailrace: States that surface tension is not significant as long as you have 1 inch of depth. Does the model meet this for all tailraces? I would suspect at the lower tailraces we are getting pretty close in large areas of the model. Is it possible to provide a graphic that confirms this? This is just a suggestion if it can readily be done. Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06					
1-0	Evaluation **Concurred** This depth of flow issue will be also included in the discussion of flow on the ogee per one of Sean Askelson's comments. We will examine the tailrace bathymetry and see if we can develop an inundation map that shows the areas that are too shallow, or, at the least, comment on this in the text. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06				
	Current Comment Status: **Comment Closed**				
1290242	Hydraulics	Technical Report	n/a	n/a	n/a
Section 4.2.2: In discussing the spillway ogee no mention of the impact of surface tension on the ogee. Do you think it has a significant impact as well? If so should we add it to the list because I could someone smoothing out the ogee and not necessarily fishing the problem because you have a significant portion of your jet sticking to the side of the bay and launching off of the downstream pier nose. I can't really quantify the significance but any discussion you could offer at this point might help. Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06					
1-0	Evaluation **Concurred** This will be addressed in an expanded discussion of the scaling requirements on the ogee in Section 3.3 and a new Section 4.3 Scaling following Section 4.2 Construction. Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06				
1-1	Backcheck Recommendation **Close Comment** Closed without comment.				

<table>
<tr><td></td><td colspan="5">Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: Comment Closed</td></tr>
<tr><td>1290243</td><td>Hydraulics</td><td>Technical Report</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td colspan="6">Section 5.2.2 Structures: Would you go further and say that not only should we model structures at larger scales but that we shouldn't be trying to replicate structural features in the general scale model (besides those that directly affect the inlet or outlet like draft tube dimensions at the point where is empties into the tailrace). Instead we should be looking at the dam structure in terms as inlets and outlets only and build the dam structure around getting those inlets and outlet conditions correct with regard to velocity and other characteristics.

Submitted By: Kyle McCune ((503) 808-4835). Submitted On: 06-Oct-06</td></tr>
<tr><td>1-0</td><td colspan="5">Evaluation Concurred
A paragraph will be added to the end of the section introducing this concept and the program of improvements described in Section 5.2.3.

Submitted By: Charles Sweeney (425-881-7700) Submitted On: 06-Oct-06</td></tr>
<tr><td>1-1</td><td colspan="5">Backcheck Recommendation Close Comment
Closed without comment.

Submitted By: Kyle McCune ((503) 808-4835) Submitted On: 13-Oct-06</td></tr>
<tr><td></td><td colspan="5">Current Comment Status: Comment Closed</td></tr>
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