Appendices

Appendix A – List of Revisions

Appendix B – References

Appendix C – Technical Review Documentation

Appendix D – Coordination and Correspondence

List of items

1. REGION
    a. NMFS
        i. NMFS Physical Model Trip Report (Nov 2007)

2. PROJECT
    a. Proposed Count Station Modifications Project, prepared by the Project Fisheries, The Dalles and John Day Projects, USACE, April 2002

November 21, 2007 F/NWO3

MEMO FOR: Hydro Files

FROM: Gary Fredricks

SUBJECT: ENSR Trip Report – JDA North Ladder

Ed Meyer and I attended a model investigation at the ENSR hydraulic lab in Redmond, WA, on November 19 and 20. The trip was specifically to review the latest changes to the new design of the John Day Dam North Ladder flow control section. On our previous model trip in August, we identified a some areas of concern regarding the design of the exit section, the position of the weir orifices and the design of the fish count section. The Corps and the ENSR folks had addressed these concerns and we were to review the results of these changes in the model.

Exit Section. We had previously expressed concern with the sluggish hydraulics in the last section of the ladder. To address this, the Corps and ENSR had developed two new designs for review on this trip. The first design involved some fairly simple changes to the existing section while the second design was more complex and would involve installing additional walls in the existing section. When we looked at the first design we were so satisfied with the hydraulics that we didn't even install the second design.

Orifice Placement: The previous design incorporated weir orifices that were placed on the floor against the south wall of the ladder. During our last trip, we noticed that the flow through these orifices tended to shoot downstream through several orifices very quickly, mainly because of the efficiencies gained from flow adhering to both the wall and the floor. The new design moved the orifices away from the wall. This design was much better at dissipating energy and the flow from one orifice would dissipate well in one or two pools.

Fish Counting Section: Our previous concerns in this area related to the ramp in the floor of the count slot and the lack of streamlined approach and exit to and from the count slot. New changes to this area included raising the entire floor of this pool to the level of the count window and adding streamlined fairings to the approach and exit of the count window.

New Issues

Two new issues came up as we conducted our model investigations. The first issue arose when we noticed that the pools that did not have vertical slot sills installed (pools 1 – 9) had erratic slot flow hydraulics. The flow from these slots would wander around the pool and sometimes "short circuit" through the pool to the next slot. Pools with sills (pools 10 on up) had very stable slot hydraulics with good energy dissipation in the pools. We were concerned that the mid ladder change in pool hydraulics might cause some fish to delay in the area of the change. New 1’ sills were added to the lower nine weir slots in the model. This worked well to stabilize the slot hydraulics and solved the potential problem. Now this section of the ladder will be operated either with sills in all the pools or none at all (at the lowest forebays) to provide uniform hydraulics from pool to pool.

The second issue we observed was a strong transient hydraulic roller at the upstream (exit) portion of the count window slot. We were concerned that this hydraulic condition could cause some fish to abort passage through the count slot and cause delays. There were several possible solutions to the problem but what we ended up with was the simple addition of some horizontal flow vanes attached to the non-porous panel that forms the transition into this area of the count slot. These vanes greatly reduced the size of the turbulence cells in this area and should result in a smoother hydraulic transition from the count slot.

The fairly simple resolution of these problems allowed the project to stay on schedule for a 2009 installation.

PROPOSED COUNT STATION MODIFICATIONS

By
Project Fisheries
The Dalles and John Day Projects
U.S. Army Corps of Engineers

INTRODUCTION

Construction of The Dalles Lock and Dam was authorized by the Flood Control Act of 17 May 1950. The first hydroelectric power went on line in September 1957 and the project was dedicated on October of 1959. Construction of the John Day Lock and Dam was also authorized by the Flood Control Act of 17 May 1950 and construction began in July 1958 and was completed in 1968-71-73.

This is a proposal by project fisheries, for the upgrade of fish counting stations at The Dalles Dam north and east fish ladders, and John Day Dam north and south fish ladders. The proposed modifications presented in this report are to improve species identification, counting, and fish passage , as well as routine maintenance capabilities.

THE DALLES COUNT STATIONS

HISTORY

There have been fish counts at The Dalles since 1957 when a flashboard counting station was used and located just downstream from the non-overflow dam section where the fish exited the fish ladder.
The north count station consisted of a v-trap with horizontal board, which was painted white. The white background enabled the counter to identify the species of fish passing through the ladder. The depth of submergence of the board varied depending on the turbidity of the water and was located above the exit water control section. The counting house for the fish counter and the board had to be adjusted as the pool elevation varied between different elevations. The present design of the north count station was constructed in the late 1980's. There are two orifices per weir. The dimensions were changed from 25" by 26" to 18" by 18" during 1984 ladder modifications.
The east count station was located at the fish ladder exit through the non-overflow dam and was the older counting board design. Fish leads were used to guide the upstream migrants to pass over a 3 foot wide counting board, which was submerged at about 1 foot below the surface in the center of the ladder. The counting house was positioned above the water surface level on the south side of the fish ladder exit to allow the fish counter to view the counting board through the water surface. The counting board and counting house were raised and lowered as the forebay fluctuated. The present design of the east count station and weir modifications, was constructed in 1989. The east count station modifications required moving six fish ladder flow control weirs to new locations in order to provide space for the counting station. There are two orifices per weir. The dimensions were changed from 25" by 26" to 18" by 18" during 1984 ladder modifications.

PRESENT

Present *similarities* between north and east count stations.

- Slot width variable with crowder (1'-3')
- Picketed leads for fish guidance into the count slot.
- Flow vanes inside the picketed leads to adjust count slot velocity. Maximum volume with vanes closed is 113cfs.
- The crowder and window cleaning brush system have the same design.
- Overflow weirs downstream of the count station have the same design.
- Located in the weir transition area between the flow control weir section and the overflow weir section.
- Viewing window is located on the north side of the ladder and the picketed leads are located on the south side.
- Floor is slightly raised from the floor of the fish ladder on the downstream side of the slot (1.3')
- Slot is approximately 3 feet wide and approximately 6' long.
- Picketed leads are symmetrical and angled approximately 50 degrees to the ladder flow.
- Picketed leads can rotate to clear debris. They are not rotated during fish passage season due to potential fish entrapment.

Present *differences* between north and east count stations;

- The north count station has auxiliary water input from floor diffuser immediately upstream of the count slot. The intake for this water is immediately downstream of the fishladder exit, which takes water from within the fishladder.
- The north count station has flow control, static weirs immediately upstream consisting of a center slot and orifice. The east count station has 6 flow control, removable weirs immediately upstream. Weirs 154-157 remove from the water with specific forebay elevation ranges. Weirs 158 and 159 remain in the water and change elevation with forebay fluctuations to provide flow control downstream of the count station.
- The east count station is located in the center of the ladder, the north count slot is skewed to the north side of the ladder.

The Dalles north count station looking downstream

The Dalles east count station looking upstream

JOHN DAY DAM COUNT STATIONS

HISTORY

At the John Day Project there has been fish counting since 1969.
The south ladder count station went through modifications in the PIES project improvements for endangered species program at in '93. These changes consisted of demolition of weir 194 (first weir upstream of the count slot), modification of weirs 195 thru 206, installation of miter perforated plate in first pool upstream of count slot, installation of new crowder and installation of new window brush system.
The north count station consists of original equipment.

PRESENT

Present *similarities* between north and south count stations.

- Slot width variable with crowder.
- Crowder position does not significantly affect the flow conditions through the counting slot. Designed to allow flow behind the crowder board and the total slot cross-sectional flow area will remain constant as the crowder position is adjusted.
- Picketed leads create guidance of fish into the count slot.
- Flow control gate inside the picketed leads can be used to adjust flow volume through this area, thus changing flow velocities through the count slot. The maximum slot velocity will occur when the bypass is closed at 113 cfs.
- The overflow weirs downstream of the count station have the same design.

Present *differences* between north and south count stations;

- The north count station has auxiliary water from floor diffuser immediately upstream of the count slot. The intake for this diffuser is from the forebay. There is no auxiliary water input near the south count station.
- The north count station is located at the weir transition area (floor elevation 242'), with flow control weirs upstream and overflow weirs downstream. The south count station is located in the lower section (floor elevation 188') of ladder with overflow weirs upstream and downstream.
- South count station window has less viewing width than the north count station window.
- North picketed leads can be hoisted during non-count season. New frame and pulley system installed '00. South must be raised by crane.
- Slot floor for the north is raised approximately 2'. Slot floor for the south is level with ladder floor.

John Day north count station looking upstream

John Day south count station looking upstream

FISH PASSAGE / RADIOTRACKING INFORMATION

Analysis of adult passage fallback through the count stations, from fish count data;

	TD East	TD North	JD South	JD North
Chinook Adult	0.42%	1.85%	5.70%	24.95%
Chinook Jack	0.04%	0.82%	7.21%	19.71%
Steelhead	0.39%	7.07%	14.07%	72.71%
Sockeye	0.08%	0.82%	8.06%	35.17%
Shad	0.27%	19.84%	10.83%	0.36%

This data shows a much higher frequency of fallback behavior at JD north respective to other count stations, especially for steelhead and sockeye. This has potential of affecting the accuracy of fish counts.

University of Idaho has conducted adult salmonid radio-tracking since 1997, from fish tagged at Bonneville dam. Antennae arrays throughout the fish ladders indicated no passage delays at TD north, TD east or JD south. Additional antennae were installed at JD north for higher resolution to determine if the fallback behavior results in passage delays. This data was collected for 2 years. The overall assessment showed no evidence of a passage problem for Chinook, but minor problems for steelhead. However, the data does not define whether the problem is at the count window, or something upstream of the count window. A majority of the holding behavior of steelhead is during the fall and winter.

RECOMMENDATIONS

The Dalles North and East Count Station

- Remove upstream picketed leads. Install protective rack in front of crowder assembly. Downstream pickets can be rotated to clear debris. No fish entrapment potential. Drawback, fish may hold in this area.
- Replace all mechanical assemblies with greaseless bushings. Low maintenance and no petroleum products near fishway.
- Make slot floor level with surrounding ladder floor.
- Control station needs upgrades to the control light box, crowder, and window washer. Beneficial for maintenance and fish counting accuracy.
- The heating, ventilation and air conditioning systems need upgrades.

John Day North Count Station

- Remove upstream picketed leads. Install protective rack in front of crowder assembly. Downstream pickets can be rotated to clear debris. No fish entrapment potential. Drawback, fish may hold in this area. Fisheries regional approval required.
- Improve access to lighting panel in crowder. Use longer lasting lighting.
- Replace all mechanical assemblies with greaseless bushings. Low maintenance and no petroleum products near fishway.
- Make slot floor level with surrounding ladder floor. Eliminate possible slack water in count window due to upwelling. Recommend flow vector analysis respective to other count stations.
- The entire crowder assembly is old and unreliable, should be replaced with south design specifications.
- Replace crowder limit switches and timers. Improve reliability. Set count slot minimum limit width 18”. Exception only when operating brush system.
- Brush assembly should be replaced or modified to improve reliability. The south brush has proven to be the best design. Bristle length should be increased to provide contact to lower portion of window.
- The entire count station should be moved to ground level to alleviate the fall back problem associated with the change of slope, change of weir design and avoid diffuser input area. Fisheries regional approval required.
- Change design of first weir upstream of count station. May attribute to fallback.

John Day South Count Station

- Window is too small, needs to be enlarged for fish identification accuracy.
- Remove upstream picketed leads. Install protective rack in front of crowder assembly. Downstream pickets can be rotated to clear debris. No fish entrapment potential. Drawback, fish may hold in this area.
- Replace all mechanical assemblies with greaseless bushings. Low maintenance and no petroleum products near fishway.
- Install easier access to crowder lighting for maintenance.

DISCUSSION AND CONCLUSION

The Dalles count stations problems are maintenance related. The recommendations above should address them.

The John Day south count station is the least problematic for maintenance and fish passage.

The John Day north count station is most problematic for maintenance, fish species identification, counting, and fish fallback through the count slot. The present count station is located at the transitional zone where the slope changes, the weir design changes, a diffuser adds water and the first weir upstream of the count slot is has a unique design with a 1’ step raise in the floor. One or all of these attributes may cause the fallback problem through the count slot. Essentially the entire station should be moved to ground level from its present location, similar to the south count station.

Moving the count station may be cost prohibitive, therefore, an alternative may be to change the attributes mentioned above.

There are plans to reconstruct the upper weirs of the south count station in ’02/’03. If plans continue for reconstructing the north upper weirs, the fallback problem may be solved. This modification, if used for the north ladder, may address some of the fallback problems.

Appendix E – Value Engineering Studies

Appendix F – Cost Estimate

1. Project Cost Summary Table (Placeholder only)

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

THIS COST IS BASED ON THE **DDR** DATED ___ 2008

PROJECT: **EXIT SECTION** MODIFICATIONS JDAN

LOCATION: JOHN DAY LOCK AND DAM

DISTRICT: PORTLAND

DATE: FEB 22, 2008

P.O.C.: PAT JONES, CHIEF, CONSTRUCTION AND COST ENGINEERING

CURRENT COST ESTIMATE PREPARED: Mar-08

EFFECTIVE PRICING LEVEL: Oct-08

AUTHORIZ./BUDGET YEAR: 2008

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
05---	DAMS AND LOCKS	-	-	25%	-	0%	-	-	-	Oct-09	2.2%	-	-	-
06---	FISH AND WILDLIFE FACILITIES	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0	Jan-10	2.7%	1,027.2	513.6	1,540.8
	TOTAL CONSTRUCTION COSTS ===>	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0			1,027.2	513.6	1,540.8
01---	LANDS AND DAMAGES	-	-	25%	-	0%	-	-	-	Jan-11	5%	-	-	-
18---	CULTURAL RESOURCES PRESERVATION	-	-	25%	-	0%	-	-	-	Jan-11	5%	-	-	-
30---	PLANNING, ENGINEERING AND DESIGN	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0	Jul-09	2%	1,017.0	508.5	1,525.6
31---	CONSTRUCTION MANAGEMENT	1,000.0	350.0	35%	1,350.0	0%	1,000.0	350.0	1,350.0	Jan-11	5%	1,047.9	366.8	1,414.6
33---	HTRW	-	-	25%	-	0%	-	-	-	Jan-11	5%	-	-	-
	TOTAL PROJECT COSTS ======>	3,000.0	1,350.0	45%	4,350.0		3,000.0	1,350.0	4,350.0			3,092.1	1,388.9	4,481.0

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

THIS COST IS BASED ON THE **DDR** DATED ___ 2008

PROJECT: **COUNT STATION** MODIFICATIONS JDAN — DISTRICT: PORTLAND — DATE: FEB 22, 2008

LOCATION: JOHN DAY LOCK AND DAM — P.O.C.: PAT JONES, CHIEF, CONSTRUCTION AND COST ENGINEERING

CURRENT COST ESTIMATE PREPARED: Mar-08 — AUTHORIZ./BUDGET YEAR: 2008

EFFECTIVE PRICING LEVEL: Oct-08

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
05---	DAMS AND LOCKS	-	-	25%	-	0%	-	-	-	Oct-09	2.2%	-	-	-
06---	FISH AND WILDLIFE FACILITIES	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0	Jan-10	2.7%	1,027.2	513.6	1,540.8
	TOTAL CONSTRUCTION COSTS ===>	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0			1,027.2	513.6	1,540.8
01---	LANDS AND DAMAGES	-	-	25%	-	0%	-	-	-	Jan-11	5%	-	-	-
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30---	PLANNING, ENGINEERING AND DESIGN	1,000.0	500.0	50%	1,500.0	0%	1,000.0	500.0	1,500.0	Jul-09	2%	1,017.0	508.5	1,525.6
31---	CONSTRUCTION MANAGEMENT	1,000.0	350.0	35%	1,350.0	0%	1,000.0	350.0	1,350.0	Jan-11	5%	1,047.9	366.8	1,414.6
33---	HTRW	-	-	25%	-	0%	-	-	-	Jan-11	5%	-	-	-
	TOTAL PROJECT COSTS ======>	3,000.0	1,350.0	45%	4,350.0		3,000.0	1,350.0	4,350.0			3,092.1	1,388.9	4,481.0

Appendix G – Hydraulics

List of Items:

1. Draft Model Report, ENSR Corporation, Feb 27, 2008

    a. *John Day North Ladder Physical Hydraulic Model Study Draft Report Vol. I of II –Report Text*

    b. *John Day North Ladder Physical Hydraulic Model Study Draft Report Vol. II of II –Photos, Figures, Appendices*

2. CENWP Model Site Visit Reports:

    a. Trip Report for July 5-6, 2007 PDT site Visit
    b. Trip Report for August 13-15, 2007 Agency Site Visit
    c. Trip Report for October 23-24, 2007 PDT site Visit
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3. CENWP-EC-HD-One Dimensional Model Results

    a. Insurance Tests Simulations for High Sills
        i. Simulations 1 - 9, Forebay Levels 261 - 268

    b. Insurance Tests Simulations for Low Sills
        i. Simulations 1 - 10, Forebay Levels 257 - 265

    c. Insurance Tests Simulations for No Sills
        i. Simulations 1 - 9, Forebay Levels 257 - 264

Prepared for:
USACE Portland District
Portland, OR

John Day North Ladder Physical Hydraulic Model Study Final Report

Contract No. W9127N-06-D-0004, Task Order No. 0006

Volume I of II – Report Text

ENSR Corporation
April 15, 2008
Document No.: 09000-419-702

ENSR | AECOM

Prepared for:
USACE Portland District
Portland, OR

John Day North Ladder Physical Hydraulic Model Study Final Report

Contract No. W9127N-06-D-0004, Task Order No. 0006

Volume I of II – Report Text

Prepared By
Elizabeth W. Roy, P.E., Project Manager

Reviewed By
Chick Sweeney, P.E., Technical Advisor

ENSR Corporation
April 15, 2008
Document No.: 09000-419-702

Executive Summary

There are two adult fish ladders at John Day Dam, John Day North (JDAN) and John Day South (JDAS). John Day Dam is operated by the U.S. Army Corps of Engineers, Portland District (USACE). Regional priority for the improvement of adult fish passage is to modify the JDAN ladder on the north shore side of the John Day Dam, redesigning the ladder exit and counting station as well as other possible improvements, with the goal of improving adult fish passage. USACE recently modified the JDAS ladder exit section and considered utilizing the 2003 JDAS exit section weir design in the JDAN ladder with potential modification to include lamprey-friendly features.

Previous studies have provided documentation and understanding of the JDAN ladder existing exit section, consisting of serpentine weirs and a Holey Wall (multiple-orifice weir) upstream of the count station. However, the hydraulic and biological conditions that contributed to salmon delay upstream of the existing count station were not well understood and required viewing to help understand the nature of the problems in this area. ENSR constructed a 1:5 scale physical hydraulic model of the JDAN exit channel to the forebay, exit section, count station, and four of the two-overflow/two-orifice weirs to develop improvements for the JDAN ladder. The overall objective of ENSR's study was to develop a physical hydraulic scale model of the JDAN ladder exit section and count station, and use the model as a tool to assess, document, and improve the hydraulics in the exit section and count station for a series of weir configurations and potential modifications. The ladder modifications were developed based on operational, fisheries, and hydraulic guidelines and criteria established at the start of the study to improve salmon and lamprey passage in the exit section of the ladder.

ENSR completed the study through a series of Baseline Testing, iterative Modifications Testing, and Documentation Testing in the 1:5 scale physical model in conjunction with USACE and Agency witness tests to view the model in the laboratory. The final JDAN ladder exit section design included modifications that met the objectives and alleviated potential hydraulic issues with the baseline configuration as documented in detail in the full report and summarized below:

- The hydraulics in the exit channel to the forebay were improved by removing the sills in the existing slotted weirs and the upstream-most slotted weir to increase the flow capacity of the exit channel during low forebay conditions. The existing sills and weir restricted flows at low forebay and resulted in relatively low flow depths over the sills. The downstream stub wall in the exit channel to the forebay was moved upstream to stabilize the hydraulics in the pool upstream of the exit section.

- The final exit channel weir design included a lamprey-friendly slotted-weir design with a single orifice in the left baffle (looking downstream). Rounded edges and corners were incorporated into the weir design to potentially improve passage conditions for lamprey. However, the rounded weirs and orifice openings increased the hydraulic efficiency of the exit section. Weir slot sills are used to supplement flow control in the exit channel and the increased hydraulic efficiency required refinement of the weir sill elevations through iterative testing. In addition, the rounded slot diffused the weir jet, and resulted in short-circuiting during some flow conditions in the lower pools.

- Three weir sill elevation settings were developed to accommodate required exit section flows for the full forebay operating range. In general, having the sills in place in the slots focused the jets slightly and minimized short-circuiting (passage of the jet directly to the next downstream slot) in the pools and improved energy dissipation in the pools.

- The final weir design was refined to improve energy dissipation and provide consistent pool hydraulics, including adjusting the location of the triangular fin on the right weir baffle and locating the orifice away from the left ladder wall.

- In the count station, the hydraulic conditions were improved and streamlined by eliminating the count station ramp, raising the floor, installing a lamprey “sidewalk” over the diffuser grating for attachment during passage, and adding fairings and horizontal flow vanes to the crowder.

In general, the JDAN ladder final design exhibited no major sloshing, problems with energy dissipation, or seiching. A series of documentation tests completed over the full range of expected forebay operating conditions confirmed that the water levels in the pools were relatively stable over the entire forebay operating range and that there is considerable flexibility in ladder operation over the three sill settings developed in the model study. ENSR documented the final design in the 1:5 scale physical model with photos, video, velocity measurements, notes of visual observations, and sketches of flow patterns as presented in the John Day North Ladder Physical Hydraulic Model Study Final Report.

Contents

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1.0 Introduction

1.1 Project Background

There are two adult fish ladders at John Day Dam, John Day North (JDAN) and John Day South (JDAS). John Day Dam is operated by the U.S. Army Corps of Engineers, Portland District (USACE). Regional priority for the improvement of adult fish passage is to modify the JDAN ladder, redesigning the ladder exit and counting station as well as other possible improvements, with the goal of improving adult fish passage. USACE recently modified the JDAS ladder exit section and considered utilizing the 2003 JDAS exit section weir design in the JDAN ladder with potential modification to include lamprey friendly features.

The JDAN ladder is on the north shore side of the John Day Dam as shown in Photo 1-1. An overall drawing of the existing ladder is provided in Figure 1-1 for reference. Flow enters the 24-foot (ft) wide ladder from the forebay through a trashrack into the exit channel to the forebay. Flow through the ladder is regulated with a combination of exit section weirs and supplemental flow from Diffuser No. 16 at the downstream end of the exit section, just upstream of the count station. The count station and crowder are downstream of the exit section and are operated to maximize fish counting. A series of two-overflow/two-orifice weirs make up the remainder of the ladder downstream to the ladder entrance. The exit section is operated to maintain head on the two-overflow/two-orifice weirs at 1.0 ft for normal operations and 1.3 ft for shad passage, corresponding to ladder flows of 85 cubic feet per second (cfs) and 113 cfs, respectively. The total ladder flow consists of flow through the exit section and the diffuser and the flow split depends on the forebay elevation. The forebay operating pool ranges from 257 ft, Minimum Operating Pool (MOP) to 268 ft, with 262.5 ft being the Minimum Irrigation Pool (MIP).

ENSR constructed a 1:5 scale physical hydraulic model of the JDAN exit channel to the forebay, exit section, count station, and four of the two-overflow/two-orifice weirs to study the improvements to the JDAN ladder. Previous studies have provided documentation and understanding of the JDAN ladder existing exit section, consisting of serpentine weirs and a Holey Wall (multiple-orifice weir) upstream of the count station[1]. A true baseline for of the complete existing JDAN exit section was not constructed in the physical model as the existing hydraulic conditions were already known to cause biological issues at both John Day North and John Day South fish ladders. The 1984 CENWD 1:10 model study also addressed the count station, but later alterations were made beyond the scope of the study. The hydraulic and biological conditions that contributed to salmon delay at the existing Holey Wall and count station were not well understood and required viewing to help understand the nature of the problems in this area. Rather than install the existing JDAN serpentine weirs, the new JDAS weirs were instead installed in their place along with the existing Holey Wall and count station to expedite schedule and help the USACE technical team determine whether the JDAS exit section weirs would potentially improve hydraulic/biologic conditions in the JDAN ladder exit section.

[1] Modification of Fish Ladders at John Day Dam Columbia River, Oregon and Washington Technical Report No. 103-2 Hydraulic Model Investigation, Corps of Engineers, Northwest Division, Bonneville Hydraulic Laboratory 1984; John Day Dam South Fish Ladder Control Section, Hydraulic Model Study, Northwest Hydraulic Consultants, August 2002.

The JDAN ladder exit section design was modeled and developed with respect to the following operating parameters, criteria, and guidelines:

Adult Salmon:

- The hydraulic drop per pool shall be between 0.5 and 1.0 ft in the exit channel section (0.2 ft of head drop is permitted during low Forebay conditions).
- Minimum pool depth should be 5.0 ft.
- Ladder head should be 1.0 ft (+/- 0.1 ft). If the shad fish numbers exceed 5000 fish per day at the count station, then the ladder head should be raised to 1.3 ft (+/- 0.1 ft). A combined exit section and diffuser flow of 85 cfs is required for 1.0-ft weir head operations, and 113 cfs is required for 1.3-ft weir head operations for shad passage.
- Channel velocities should be between 1.5 and 4.0 ft/s, 2.0 ft/s optimum.
- Diffuser efflux velocities should be ≤ 0.5 ft/s.

Lampreys:

- There should be a 4-in minimum radius rounding on all outside corners (> 180 degree change in bearing in any surface) of fish passage openings, wherever a weir opening is not flush with sidewall or an orifice opening is not flush with floor. The rounding was intended to eliminate sharp corners in high velocity areas that may impede lamprey passage and provide potential attachment points for lamprey as they lunge and attach through higher velocity areas during passage. Details about the development of lamprey guidelines will be discussed by USACE in their Design Development Report for the JDAN Ladder improvements.
- Ramping to raised orifice openings or along side wall to indented weirs may be needed to assure lamprey or salmon passage.
- Diffuser gratings should have a maximum ¾ inch opening to prevent trapping lampreys in the openings.[2]

In general, the modifications to the ladder were developed to provide stable and consistent hydraulic conditions through the exit channel to the forebay, exit section pools, and count station. The model was used to observe the stability, or tendency to change over time or space, of hydraulic conditions such as water surface elevation and flow patterns. Stable water level conditions were achieved by minimizing seiching, or sloshing of the water surface within the pools, and ensuring effective dissipation of energy along the ladder weirs. Short-circuiting, or the tendency of a weir slot jet to pass through the weir pool nearly directly to the next slot downstream, can result in sloshing in lower pools. If short-circuiting occurs in only some pools but not in others, an inconsistent flow pattern can develop in the ladder pools that may prove confusing to fish. Therefore, attempts were made to minimize short-circuiting in the ladder pools and maintain consistent flow patterns throughout the exit section. Stable exit channel to the forebay and weir pool circulation patterns were achieved by observing the sensitivity of the weir jet to slot configuration, sill settings, and weir geometry and modifying the ladder design accordingly.

[2] USACE Portland District, Draft John Day North Fish Ladder: Nov 19-20 2007 ENSR 1:5 Model Agency Trip Report, January 31, 2008.

1.2 Study Objectives

The overall objective of ENSR's study was to develop a physical hydraulic scale model of the JDAN ladder exit section and count station, and use the model as a tool to assess, document, and improve the hydraulics in the exit section and count station for a series of weir configurations and potential modifications. Individual objectives included:

- Document hydraulic conditions in the ladder exit channel to the forebay, exit section, and count station with the JDAS Modified Baseline weirs in place.
- If necessary, develop modifications to the count station and weirs necessary to improve hydraulic conditions for adult fish and lamprey passage based on the guidelines described in Section 1.1. Implement those changes in the physical model and assess hydraulic conditions in the ladder exit channel to the forebay, exit section, and count station.
- Conduct model witness tests to demonstrate the hydraulic performance of the ladder to USACE staff and Agency personnel.
- Document the hydraulic conditions in the final design configuration of the ladder exit channel to the forebay, exit section, and count station using photos and video, velocity data, and water level data for a range of operating conditions.
- Document the ladder final design performance over a range of expected forebay operating conditions using water level fluctuation as an indicator of hydraulic stability.

2.0 Physical Model Development

2.1 Physical Modeling Considerations

ENSR developed a physical scale model of the JDAN exit section and counting station in order to meet the objectives described in Section 1.2. The model was designed in accordance with the following considerations:

- Model scale was selected such that the flow conditions and losses at the ladder weirs, baffle slots, and orifice openings were adequately represented in the model.
- Model scale and design provided adequate space and clearance for instrumentation for measuring velocities and water surface elevations in the ladder pools, orifice openings, and the count station crowder.
- Model design provided visibility for visual observations with dye release through the weir slots, orifice openings, crowder, and exit section to the forebay.
- The above considerations were balanced with reasonable construction cost and laboratory space and pumping requirement limitations in determining the model scale.

The following sections describe the theoretical model scaling relationships used to select the scale for the JDAN Ladder Physical Model.

2.2 Model Scale Relationships

The design and operation of hydraulic models and the interpretation of data from such models requires that dynamic similarity of fluid motions between the model and prototype (actual) be maintained. Dynamic similarity is achieved when the ratios of forces acting on the fluid elements are the same in the model and prototype. The primary forces influencing incompressible flow are gravity, pressure, viscosity and surface tension. The vector sum of these primary forces is the inertial force. Dimensionless parameters are used to relate the inertial force to each of the four primary forces as follows:

Froude Number: $$F = \frac{U}{\sqrt{gL}} = \frac{\text{Inertial Force}}{\text{Gravity Force}} \tag{2.1}$$

Euler Number: $$E = \frac{\Delta P}{\rho U^2} = \frac{\text{Pressure Force}}{\text{Inertial Force}} \tag{2.2}$$

Reynolds Number: $$R = \frac{UL}{\nu} = \frac{\text{Inertial Force}}{\text{Viscous Force}} \tag{2.3}$$

Weber Number: $$W = \frac{U}{\sqrt{\frac{\sigma}{\rho L}}} = \frac{\text{Inertial Force}}{\text{Surface Tension Force}} \tag{2.4}$$

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 2.1 through 2.4 to be identical. Only a scale of 1:1 meets these criteria if water is used as the model fluid. Modeling at a reduced scale involves identification of the force relationships necessary to accurately simulate prototype conditions.

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:

$$\frac{F_P}{F_M} = F_R = 1 \qquad (2.5)$$

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 2-1, 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 the Reynolds number, the Reynolds number must be the same in the prototype and model to achieve flow resistance similitude, assuming geometric similitude of the boundary relative roughness height:

$$\frac{R_P}{R_M} = R_R = 1 \qquad (2.6)$$

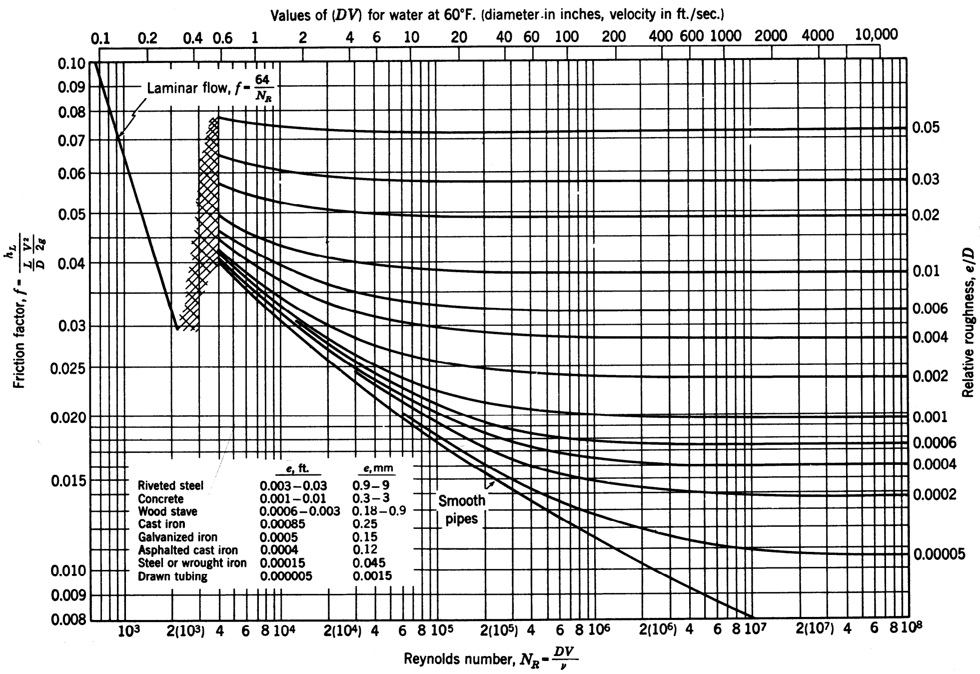

Figure 2-1 Moody Diagram

It is impossible to simultaneously satisfy both Froude number similitude criteria (equation 2.5) and Reynolds number similitude criteria (equation 2.6), since water is used in both model and prototype. However, as shown in the Moody diagram, the relationship between the Reynolds number and the resistance coefficient indicates that a change in Reynolds number does not necessarily affect the boundary resistance if the flow is fully turbulent in both the model and prototype. It is sufficient that model and prototype values of the Reynolds number place the flows in the same flow regime, such as fully turbulent.

2.3 Model Scale Selection

With respect to flow resistance, the flow conditions at the weirs and baffles are the main consideration when choosing the model scale for the JDAN ladder. Flow resistance over the overflow weirs is a combination of form losses and boundary roughness. The minimum Reynolds number required to achieve fully turbulent flow at the weirs and baffles is approximately 1×10^4, based on flow in natural rivers and channels where form losses are also important (ASCE, 2000)[3].

The energy losses through the weir orifices will be correctly simulated when the loss coefficients are the same in the model and prototype. The head loss coefficient of a sharp edged orifice varies with Reynolds number and takes a form similar to the Moody diagram. However, the head loss coefficient of a sharp edged orifice will vary only marginally above the Reynolds number threshold of 1×10^3 (Miller, 1978)[4]. Therefore, above this threshold, the influence of fluid viscosity will not affect the nature of flow through the model weir orifices.

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[3] ASCE. 2000. Hydraulic Modeling, Concepts and Practice. ASCE Manuals and Reports on Engineering Practice No. 97. American Society of Civil Engineers. Reston, Virginia.

[4] Miller, D.S., 1978. Internal Flow Systems. British Hydromechanics Research Association.

Surface tension effects may be significant in Froude scaled models for very shallow flows. Therefore, the minimum recommended model flow depth is 1.0 in (ASCE 2000).

The minimum required parameter values and the calculated parameter values for various model scales and for the critical locations to be simulated, assuming Froude number similitude, are presented in Table 2-1. Based on this analysis, model to prototype scales of up to 1:10 would satisfy the applicable Reynolds threshold for accurate fluid flow simulation.

Table 2-1 Model Scale Analysis

	Weir Flow (1)	**Orifice Loss Coefficient(2)**	**Surface Tension Effects(3)**
Critical Parameter	Reynolds Number	Reynolds Number	Flow Depth (in.)
Minimum Required Parameter Value	$1x10^4$	$1x10^3$	1.0
Scale	**Calculated Parameter Value at Corresponding Scale**		
1:1	$4.9x10^5$	$4.0x10^5$	12.00
1:2.5	$1.5x10^5$	$1.0x10^5$	4.89
1:5	$4.4x10^4$	$3.6x10^4$	2.45
1:7.5	$2.4x10^4$	$1.9x10^4$	1.63
1:10	$1.3x10^4$	$1.5x10^4$	1.22

(1) Based on an overflow weir flow rate of 35 cfs per weir.
(2) Based on orifice flow rate of 7.2 cfs per orifice.
(3) Based on flow depth of 1.0 feet at overflow weirs.

The scaling relationships derived from Froude number similitude criteria were appropriate with the length scale (L_R) specified by USACE in the Request for Proposal of 1:5 for model operation and extrapolation of model results to prototype scale. At the model scale ratio, L_R, of 1:5, the scale ratios for area, velocity, time, discharge, and pressure are:

$$A_R = L_R^2 = 25 \tag{2.7}$$
$$U_R = L_R^{0.5} = 2.24 \tag{2.8}$$
$$t_R = L_R^{0.5} = 2.24 \tag{2.9}$$
$$Q_R = L_R^{2.5} = 55.9 \tag{2.10}$$
$$P_R = L_R = 5 \tag{2.11}$$

The choice of model scale was also driven by several practical considerations such as construction tolerance requirements, flow visibility and instrumentation access, and cost of construction. As shown in Table 2-1, the minimum model scale that will accurately simulate the prototype discharge characteristics for the full range of anticipated test discharges is approximately 1:10. Based upon the overall requirements of the study, ENSR constructed the model at a scale of 1:5. A 1:5 scale model allowed for adequate viewing of flow phenomenon, adequate working space in the model for data collection, minimized the impacts of construction tolerance, surface tension, and viscous effects, while keeping construction costs reasonable. At this scale, the model footprint covered an area approximately 4.8 ft by 100 ft, with a total height of approximately 10 ft, and required 2.7 cfs of discharge capacity to simulate the maximum ladder flow.

3.0 Model Fabrication and Limits

3.1 Model Limits

The model layout is presented in Figure 3-1 in plan and profile. The physical model extended from the upstream end of the transition structure, through the exit section and count station, and included four two-overflow/two-orifice weirs downstream of the count station to establish the downstream boundary condition.

Flow entered the model through a headbox upstream of the transition structure from the forebay. In addition, Diffuser No. 16 just upstream of the count station provided flow to the physical model. The simulated prototype discharge capacity ranged from 70 cfs to 150 cfs. Flow was split between the forebay exit section and the diffuser with the possibility of the forebay exit section discharging up to the maximum discharge. The model accommodated a range of forebay elevations from 257 to 268 ft.

ENSR conducted a site visit to the John Day Dam North and South fish ladders on May 11, 2007 to field verify construction drawings of the JDAS exit section weirs, and confirm the location, configuration, and operation of the JDAN count station, Diffuser No. 16, Holey Wall, the bulkhead knife gate, the crowder, and the 2-overflow/2-orifice weirs downstream of the count station. The site visit trip report is provided in Appendix A. The information obtained during the site visit was incorporated into the model design along with information from ladder construction drawings provided by USACE[5].

3.2 Construction Methods, Materials, and Accuracy

The model was initially fabricated as shown in Photos 3-1 through 3-2 and Figures 3-1 through 3-13. The base, headbox, and tailbox portions of the model basin were constructed of waterproofed wood and supported off the laboratory floor using a post and beam support system. The model side walls were constructed of clear acrylic to facilitate viewing of flow conditions in each pool and at each weir. All support beams and other non-transparent structural members were placed to allow viewing of critical areas wherever possible. The accuracies of construction dimensions and elevations are presented in Table 3-1.

The transition structure, count station, crowder, bulkhead knife gate, count station ramp, and weirs were constructed of acrylic. The picket leads for the count station were simulated by matching the porosity and aspect ratio (bar depth: bar spacing) and were constructed of 1/8” acrylic.

A headbox at the upstream end of the model introduced flow to the model. Perforated plate baffles were installed to establish a nearly uniform velocity field at the upstream boundary of the model and prevent surging. Diffuser No. 16 just upstream of the count station was modeled with a supply pipe and perforated plate distribution baffle at the model floor. Several layers of perforated plate were added between the supply pipe and the diffuser after the initial model quality control (QC) check to ensure even flow distribution from the diffuser to the count station.

[5] As-built drawings: JDD-1-4-2/1 through 2/3, JDF-1-4-2/37 through 2/46, Walla Walla District, Corps of Engineers1959; As-built drawings: JDF-1-5-2/17 through 2/31, Walla Walla District, Corps of Engineers 1971; As-built drawings: John Day South Shore Fish Ladder Modifications: JDF-2-18/6 through 18/9.

Table 3-1 Estimated Measurement Accuracies and Probable Errors

Measurement Variable	Measurement Instrument or Method	Estimated Measurement Accuracy and Probable Error			
		Model Value	Prototype Equivalent	Typical Prototype Value	Probable Error
Structural Dimension (ft)	-	0.008	0.04	---	---
Structural Elevation (ft)	-	0.010	0.05	---	---
Model Discharge (Max) (cfs)	Calibrated Orifice Plate	0.08	4.5	150	+/-3%
Model Discharge (Min) (cfs)	Calibrated Orifice Plate	0.04	2.3	70	+/-3%
Water Level (ft)	Precision Point Gauge	0.004	0.02	---	---
Velocity (fps)	Acoustic Doppler Velocimeter	0.029	0.065	7	0.9%
Velocity (fps)	Nixon Rotor Velocimeter	0.100	0.224	7	3.2%

3.3 Equipment and Instrumentation

The estimated accuracies and probable errors for available instruments and methods are presented in Table 3-1 based on manufacturer's specifications where applicable. The following sections describe in detail the equipment and instrumentation proposed for flow supply, water level, velocity; flow visualization; and data acquisition and recording.

3.3.1 Flow Supply and Measurement

A 3 cfs pump was used to supply flows ranging from the 70 prototype cfs (1.3 model cfs at a scale of 1:5), to 150 prototype cfs (2.7 model cfs at a scale of 1:5). Valves were used to control the laboratory pump flow rate. Calibrated orifice flow meters were installed in parallel on the discharge side of the pump to measure the range of modeled flows. Figure 3-1 shows the layout of pump and supply lines to the headbox and diffuser.

3.3.2 Water Level and Velocity Measurements

Water level measurements were made using precision point gauges. The gauges measured the water levels in stilling wells connected to piezometric taps in the model floor via flexible tubing. The taps were installed at appropriate locations, such as the forebay headbox. In addition piezometric taps were installed in the center of the floor of each of the exit section weir pools and connected to a manometer board for measuring the water levels in each pool.

Velocity measurements were made in Pool 8 and in the count station using a 3-dimensional acoustic Doppler velocimeter (ADV).

3.3.3 Flow Visualization

The side walls, exit channel to the forebay, count station, crowder, and bulkhead knife gate were constructed of clear acrylic to facilitate observation of flow phenomena. The exit section and two-overflow/two-orifice weirs were constructed of white acrylic to provide a solid background for viewing of dye. Dye (a potassium permanganate solution) was used to aid in observing flow patterns. The potassium permanganate was removed from the water prior to discharge into the sanitary sewer using hydrogen peroxide as neutralizing fluid. The overall flow patterns in the ladder weirs and count station were visible from above and through the sides of the model.

3.4 Model Shakedown

ENSR performed a check of the completed model prior to the first model site visit and before beginning the baseline testing, including the following:

- Checked model flow rates to the transition structure and diffuser
- Checked corresponding head on weirs for high and low flows
- Checked all instrumentation for proper operation
- Conducted a leak test using dye at the joint between each weir and the wall and floor
- Remedied any significant leaks
- Checked for adequate baffling in the forebay head box and diffuser
- Tested operation of the knife gate at the count station
- Checked for unsafe or hazardous conditions on the working and viewing platforms

In addition a construction QC review was performed by the Project Engineer to ensure that the model construction was performed according to the model design and within allowable tolerance.

4.0 Model Testing and Results

The model test program was conducted by ENSR in several progressive phases of laboratory tests in conjunction with model witness tests for USACE and Agency personnel. The phases consisted of Baseline, Modification, and Documentation testing as described in the following sections. Table 4-1 summarizes the model configurations tested during each phase, including the ladder configuration (weir, exit channel to forebay, and count station configuration), type of testing conducted, and whether the configuration was viewed during a witness test. Additional details of the model configurations and test results are provided in the following sections.

Table 4-1 Model Testing Program

No.	Testing Phase	Ladder Configuration				Tests Conducted
		Weirs	**Sills**	**Exit Channel to Forebay**	**Count Station**	
1	Baseline	JDAS Modified Baseline with Holey Wall	Existing JDAS Sills	Existing	Existing	Model QC, Viewed during July 5-6, and Aug 13-15, 2007 witness tests, dye, photos, video, velocities in count station
2	Baseline	JDAS Modified Baseline	Existing JDAS Sills	Existing	Existing	Dye, photos, video, velocities in count station and Pool 8
3	Modification	JDAS Modified Baseline	Existing JDAS Sills	Existing	Lowered count station ramp and sloped diffuser	Viewed during Aug 13-15, 2007 witness test
4	Modification	Alternative 1 – modified weir design with lamprey friendly features	Existing JDAS Sills	Existing	Same as config. No. 3	Viewed during Aug 13-15, 2007 witness test
5	Modification	Alternative 2 – same as Alt 1 with Weir 2-23 orifice moved to JDAS location, adjusted right baffle triangular fin location	Sill Revision No. 1	Elliptical transition – 5 ft wide channel	Raised entire count station floor by 1 ft, removed crowder ramp, developed fairings for crowder, lamprey “sidewalk” on diffuser	Water level testing for sill revision, viewed during October 23-24, 2007 witness test 1st day
6	Modification	Alternative 3 – same as Alt 2 with triangular fin 1/3 of distance from slot to right wall (looking downstream) from right wall	Sill Revision No. 2	Elliptical transition – 5 ft wide channel	Same as config. No. 5	Viewed during October 23-24, 2007 witness test 2nd day
7	Modification	Alternative 3	Sill Revision No. 2	Angled transition	Same as config. No. 5	Viewed during November 8-9, 2007 witness test 1st day

Table 4-1 Model Testing Program

No.	Testing Phase	Ladder Configuration				Tests Conducted
		Weirs	**Sills**	**Exit Channel to Forebay**	**Count Station**	
8	Modification	Alternative 4 – same as Alt 3, but moved triangular fins on Weirs 2 through 18 to halfway point between slot and right wall	Sill Revision No. 2	Modified existing transition – single slotted baffle with orifice and stub wall, triangular vortex splitter on left wall	Same as config. No. 5	Viewed during November 8-9, 2007 witness test 2nd day
9	Modification	Alternative 5 – same as Alt 4, but widened slots in Weirs 18-20, moved triangular fins to final location near slot	Sill Revision No. 2	Same as config. No. 8	Same as config. No. 5, but developed initial version of crowder flow vane during witness test	Viewed during November 19-20, 2007 witness test
10	Modification	Alternative 5	Sill Revision No. 3	Same as config. No. 8	Same as config. No. 5, but developed modifications to upstream crowder fairing	Developed modifications to upstream crowder fairing through iterative testing, water level testing for sill revision.
11	Documentation	Alternative 5 – Final Configuration	Sill Revision No. 3 – Final Sills	Same as config. No. 8	Same as config. No. 5 with fairing flow vane	Dye, photos, video, velocity data in count station and Pool 8, water level variation documentation tests

4.1 Baseline Model Testing (JDAS Modified Baseline)

After completion of the model construction and initial QC, the first model witness test was hosted on July 5 through 6, 2007. USACE personnel attended the witness test to conduct model QC and observe hydraulic conditions in the model for the JDAS Modified Baseline with Holey Wall (Configuration No. 1 in Table 4-1) with the existing count station in place. Minutes for the witness tests with additional details are provided in Appendix A.

Following the initial witness test, a series of baseline tests were conducted to document hydraulic conditions in the JDAS Modified Baseline with Holey Wall (Configuration No. 1). ENSR removed the Holey Wall, installed the JDAS Weir No. 1, and documented the JDAS Modified Baseline (Configuration No. 2). The majority of the baseline tests were conducted prior to the second witness test on August 13-15, 2007.

4.1.1 Baseline Model Test Program

The baseline model testing consisted of ladder Configurations Nos. 1 and 2 in Table 4-1. The baseline weir configuration for the JDAN ladder model testing is referred to as the JDAS Modified Baseline weir configuration (Figures 3-1 through 3-10) and consists of the weir design in the existing JDAS ladder, with the weirs mirror imaged about the ladder centerline. ENSR constructed the physical model and installed Configuration No. 1, the JDAS Modified Baseline Weirs Nos. 2 through 23, with the existing Holey Wall in place at Weir No. 1 (JDAS Modified Baseline with Holey Wall), prior to the first USACE witness test. In addition, Configuration No. 1 included the details in Figures 3-1 through 3-10 for the existing exit channel to the forebay, count station, diffuser, and count station ramp. Configuration No. 2 was the same as Configuration No. 1, except the Holey Wall was removed and replaced with a JDAS Modified Baseline weir per Figure 3-3.

The slot elevations in the existing JDAS exit section weirs are controlled by flap gates with single or double sill elevation settings controlled by actuators mounted on a grated deck above the ladder. In the existing JDAS ladder, Weirs No. 17 through 23 have two flap gates and Weirs No.12 through 16 have a single flap gate. The resulting slot sill elevations were modeled in the JDAN ladder model with fixed acrylic sills rather than movable flap gates for simplicity. There were three sill elevation combinations for the exit section, depending on the forebay range. The weir slot sill elevations used for the Baseline Testing are provided in Table 4-2.

Table 4-2 JDAS Sill Settings (Installed for Model Test Configurations 1 through 4)

	Low Forebay Range		Medium Forebay Range		High Forebay Range	
Weir	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)
23	1.50	0	1.25	4.5	1.25	7
22	1.50	0	1.25	4	1.25	6.15
21	1.50	0	1.25	3	1.25	5.5
20	1.25	0	1.25	2.75	1.25	4.9
19	1.25	0	1.25	2.5	1.25	4.3
18	1.25	0	1.25	2.5	1.25	3.8
17	1.25	0	1.25	2.5	1.25	3.25
16	1.25	0	1.25	2	1.25	2
15	1.25	0	1.25	1.75	1.25	1.75
14	1.25	0	1.25	1.5	1.25	1.5
13	1.25	0	1.25	1.5	1.25	1.5
12	1.25	0	1.25	1.25	1.25	1.25
11	1.25	0.75	1.25	0.75	1.25	0.75
10	1.25	0.75	1.25	0.75	1.25	0.75
9	1.25	0.75	1.25	0.75	1.25	0.75
8	1.25	0.5	1.25	0.5	1.25	0.5
7	1.25	0.25	1.25	0.25	1.25	0.25
6	1.25	0	1.25	0	1.25	0
5	1.25	0	1.25	0	1.25	0
4	1.25	0	1.25	0	1.25	0
3	1.50	0	1.50	0	1.50	0
2	1.50	0	1.50	0	1.50	0
1	1.50	0	1.50	0	1.50	0

ENSR documented hydraulic conditions in the ladder for baseline Configuration Nos. 1 and 2 as summarized in Table 4-3. Ladder flows, diffuser flows, forebay elevation, weir pool elevations, and water surface elevation in the count station were documented for each test. For each forebay elevation and ladder operating head, USACE provided estimated exit section, diffuser, and total ladder flows based on a one-dimensional spreadsheet model developed by their staff. ENSR used these flow estimates as a starting point for the test program. For each test the desired flows for the exit section and diffuser were set, the model was allowed to stabilize, and the water surface elevation in the model forebay was recorded.

Velocity measurements were made in the count station and in Pool 8 (upstream of Weir No. 8) at the locations shown in Figures 4-1 and 4-2 at approximately depths of 0.2d, 0.6d, and 0.8d with an ADV for approximately three minute time series. Velocities were measured in the count station only for the Configuration No. 1 tests as the flow conditions in Pool 8 were the same as in Configuration No. 2.

Table 4-3 Baseline Test Program

Config. No.	Test	Weirs	Sills	Target Forebay Elev. (ft)	Actual Forebay Elev. (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
1	A	JDAS Modified Baseline w/ Holey Wall	Med	264.0	264.4	1.0	61.9	23.0	84.9
1	B	JDAS Modified Baseline w/ Holey Wall	Med	264.0	264.4	1.3	61.8	51.5	113.3
2	A	JDAS Modified Baseline	Low	257.0	258.2	1.0	32.5	52.5	85.0
2	B	JDAS Modified Baseline	Low	257.0	258.4	1.3	32.8	80.4	113.2
2	C	JDAS Modified Baseline	Med	264.0	264.4	1.0	61.8	23.0	84.8
2	D	JDAS Modified Baseline	Med	264.0	264.5	1.3	61.9	50.7	112.6
2	E	JDAS Modified Baseline	High	268.0	267.9	1.0	79.7	5.2	84.9
2	F	JDAS Modified Baseline	High	268.0	268.0	1.3	79.7	33.6	113.3

4.1.2 Baseline Test Results

4.1.2.1 JDAS Modified Baseline with Holey Wall (Configuration No. 1)

Configuration No.1 Test A

The water surface elevations recorded in the ladder for Test Configuration No. 1A are in Table 4-4. A sketch of the flow patterns near the Holey Wall and in the count station is provided in Figure 4-3. The sketch is typical of those provided for each test condition and shows flow patterns at the surface in solid arrows, subsurface flow patterns in dashed arrows, stagnation areas and upwelling with “clouds”, and the extent of the weir slot jets with dashed lines. Velocity vectors representing the flow conditions in the count station are shown in Figure 4-4. Photos for this test are shown in Photos 4-1 through 4-3. Video for this test is provided in Appendix B.

Turbulent flow approached the orifice openings in Holey Wall except orifice at bottom left. Flow from the Weir No. 2 orifice progressed from orifice to orifice, exhibiting some turbulence but directionally stable. A general plan view counterclockwise circulation cell developed upstream of the Holey Wall. The jet from the Weir No. 2 slot was directed towards the right wall (looking downstream), centered between Weir No. 2 and Holey Wall. The direction of the jet was relatively stable, oscillating between impacting the ¼ and ¾ points of the right wall.

Flow exiting the diffuser appeared uniformly distributed. Diffuser flow was generally directed upward, swept downstream near the projected width of the Holey Wall orifices, and recirculated upstream near the center of the ladder. Flow through upper orifices in the Holey Wall was parallel to the channel walls. Flow through lower Holey Wall orifices was directed toward the left wall/picket lead. Jets exiting the Holey Wall orifices produced two sets of opposing circulation cells. A large zone of stagnant recirculating flow developed near the floor upstream of the count station ramp.

Flow progressing up the count station ramp was split between the crowder and trash rack. Upwelling was present on the right vertical face of the count station ramp upstream of the fish crowder. Some minimal flow separation developed at the break in wall angle on the upstream side of the fish crowder, as well as on the downstream side. Flow exiting the fish crowder was drawn to the right hand overflow/orifice. Flow exiting the picket lead was drawn to the left hand overflow/orifice. This suggested a more or less even split of flow passing through fish crowder and knife gate.

There was a significant flow recirculation present downstream of the fish crowder on the left hand side. There was flow separation and eddy shedding on the upstream floor slope break of the count station ramp.

Table 4-4 Water Surface Elevation Data, Configuration No. 1A

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	264.35	N/A	N/A	N/A	N/A	0.50
Exit Channel	0.50	263.85	250.50	253.50	13.35	2.00	0.33
23	0.84	263.52	250.50	255.00	13.02	1.50	0.43
22	1.26	263.09	250.50	254.50	12.59	1.50	0.40
21	1.66	262.69	250.50	253.50	12.19	1.50	0.32
20	1.99	262.37	250.50	253.25	11.87	1.25	0.52
19	2.51	261.84	250.50	253.00	11.34	1.25	0.63
18	3.14	261.21	250.25	252.75	10.84	1.25	0.53
17	3.67	260.69	249.86	252.36	10.63	1.25	0.69
16	4.36	260.00	249.46	251.46	10.34	1.25	0.75
15	5.11	259.25	249.07	250.82	9.98	1.25	0.62
14	5.72	258.63	248.68	250.18	9.76	1.25	0.69
13	6.42	257.94	248.27	249.77	9.46	1.25	0.71
12	7.13	257.22	247.86	249.11	9.16	1.25	0.63
11	7.77	256.59	247.45	248.20	8.93	1.25	0.64
10	8.40	255.95	247.03	247.78	8.71	1.25	0.67
9	9.08	255.28	246.61	247.36	8.46	1.25	0.73
8	9.80	254.55	246.19	246.69	8.16	1.25	0.74
7	10.54	253.81	245.76	246.01	7.84	1.25	0.72
6	11.26	253.09	245.32	245.32	7.55	1.25	0.69
5	11.95	252.41	244.88	244.88	7.31	1.25	0.75
4	12.69	251.66	244.43	244.43	7.01	1.25	0.81
3	13.51	250.85	243.97	243.97	6.65	1.50	0.72
2	14.22	250.13	243.51	243.51	6.39	1.50	0.69
1	14.92	249.44	243.04	243.04	6.16	1.50	
247	16.30	248.06	241.00	247.00	N/A	6.00	1.01
246	17.31	247.05	240.00	246.00	6.55	6.00	1.16
245	18.47	245.89	239.00	245.00	6.39	6.00	N/A

Configuration No.1 Test B

The water surface elevations in the ladder for Test Configuration No. 1B are in Table 4-5. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-5. Velocity vectors representing the flow conditions in the count station are shown in Figure 4-6. Photo 4-4 shows dye released at the base of the count station ramp during this test condition. Video for this test is provided in Appendix B.

Flow conditions for this test were generally similar to those for Configuration No. 1 Test A. Only one circulation cell set up downstream of the Holey Wall to the right hand side of the channel centerline. Flow approaching the count station ramp was directed more toward the picket lead than for the previous test condition (1.0 ladder head), likely due to the higher diffuser flow.

Table 4-5 Water Level Data, Configuration No. 1B

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	264.39	N/A	N/A	N/A	N/A	0.49
Exit Channel	0.49	263.90	250.50	253.50	13.40	2.00	0.34
23	0.83	263.56	250.50	255.00	13.06	1.50	0.40
22	1.23	263.16	250.50	254.50	12.66	1.50	0.41
21	1.64	262.75	250.50	253.50	12.25	1.50	0.28
20	1.91	262.48	250.50	253.25	11.98	1.25	0.51
19	2.42	261.97	250.50	253.00	11.47	1.25	0.61
18	3.03	261.36	250.25	252.75	10.98	1.25	0.61
17	3.64	260.75	249.86	252.36	10.69	1.25	0.67
16	4.31	260.08	249.46	251.46	10.42	1.25	0.75
15	5.06	259.33	249.07	250.82	10.06	1.25	0.62
14	5.68	258.71	248.68	250.18	9.84	1.25	0.69
13	6.37	258.02	248.27	249.77	9.55	1.25	0.66
12	7.03	257.36	247.86	249.11	9.29	1.25	0.64
11	7.67	256.72	247.45	248.20	9.06	1.25	0.60
10	8.27	256.12	247.03	247.78	8.88	1.25	0.65
9	8.92	255.47	246.61	247.36	8.65	1.25	0.73
8	9.65	254.74	246.19	246.69	8.34	1.25	0.67
7	10.32	254.07	245.76	246.01	8.09	1.25	0.71
6	11.03	253.36	245.32	245.32	7.81	1.25	0.66
5	11.69	252.70	244.88	244.88	7.59	1.25	0.71
4	12.40	251.99	244.43	244.43	7.34	1.25	0.73
3	13.13	251.26	243.97	243.97	7.06	1.50	0.66
2	13.79	250.60	243.51	243.51	6.86	1.50	0.64
1	14.43	249.96	243.04	243.04	6.68	1.50	
247	16.17	248.22	241.00	247.00	N/A	6.00	1.00
246	17.17	247.22	240.00	246.00	6.72	6.00	1.10
245	18.26	246.13	239.00	245.00	6.63	6.00	N/A

4.1.2.2 JDAS Modified Baseline (Configuration No. 2)

Configuration No. 2 Test A

The water surface elevations in the ladder for Test Configuration No. 2A are in Table 4-6. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-7. Velocity vectors representing the flow conditions in the count station and Pool 8 are not provided for this test, as data quality control checks showed that the signal quality on the ADV was not within acceptable limits during this test. Photos for this test are shown in Photos 4-5 through 4-7. Video for this test is provided in Appendix B.

The jet from the slot in Weir No. 2 had a strong tendency to short circuit to the downstream weir slot. The jet was occasionally directed toward the downstream right corner of the pool, but did not impinge on the wall due to low momentum and the influence of the flow through the downstream slot.

There was a slight upward velocity from the diffuser and a large stagnant area on the surface above the diffuser. Flow from the slot in Weir No. 1 progressed along the right wall of the count station with the majority passing through the crowder. The majority of the flow from the orifice in Weir No. 1 and a small amount of the flow from the slot in Weir No. 1 passed through the trashrack. The trashrack approach velocity vectors were oriented slightly left of the longitudinal axis of the channel.

The flow in Pool 8 alternated between two flow patterns over a reasonably long time period (15 minutes model time scale), with the first flow pattern existing predominantly. The first and predominant flow pattern consisted of the Weir No. 9 slot jet impacting the right wall between the midpoint and the right downstream corner. Flow recirculated counterclockwise on the right side of the pool and then clockwise around the baffle block to the slot. A clockwise circulation cell set up on the left side of the pool, with flow from the Weir No. 9 orifice passing generally through to the next orifice. The second, intermittent circulation pattern resulted when the Weir No. 9 jet shifted to the left slightly and impacted the upstream side of the right baffle for Weir No. 8. Flow passed clockwise around the baffle block, but the resulting circulation cell on the left half of the pool was counterclockwise instead of clockwise. In both cases a vertical circulation cell developed in line with the orifice openings, with flow downstream along the bottom and upstream at the surface.

During low forebay conditions, the sills in the exit channel to the forebay restricted the flow to the ladder, and resulted in the need for a higher forebay elevation (258.2 ft) to pass the desired exit channel flow (32.5 cfs). Revision of the sills during the modifications phase was recommended to allow passage of required flow with a low forebay elevation of 257 ft.

Table 4-6 Water Level Data, Configuration No. 2A

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	258.17	N/A	N/A	N/A	N/A	0.65
Exit Channel	0.65	257.52	250.50	253.50	7.02	2.00	0.87
23	1.52	256.65	250.50	250.50	6.15	1.50	0.16
22	1.67	256.50	250.50	250.50	6.00	1.50	0.19
21	1.86	256.31	250.50	250.50	5.81	1.50	0.20
20	2.07	256.10	250.50	250.50	5.60	1.25	0.30
19	2.37	255.80	250.50	250.50	5.30	1.25	0.36
18	2.73	255.44	250.25	250.25	5.06	1.25	0.36
17	3.09	255.08	249.86	249.86	5.03	1.25	0.37

Table 4-6 Water Level Data, Configuration No. 2A

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
16	3.46	254.71	249.46	249.46	5.05	1.25	0.35
15	3.81	254.36	249.07	249.07	5.10	1.25	0.33
14	4.14	254.03	248.68	248.68	5.15	1.25	0.40
13	4.54	253.63	248.27	248.27	5.15	1.25	0.36
12	4.90	253.27	247.86	247.86	5.21	1.25	0.33
11	5.23	252.94	247.45	248.20	5.28	1.25	0.43
10	5.66	252.51	247.03	247.78	5.27	1.25	0.46
9	6.12	252.05	246.61	247.36	5.23	1.25	0.44
8	6.55	251.62	246.19	246.69	5.22	1.25	0.48
7	7.03	251.14	245.76	246.01	5.17	1.25	0.32
6	7.36	250.81	245.32	245.32	5.27	1.25	0.34
5	7.70	250.47	244.88	244.88	5.37	1.25	0.33
4	8.03	250.14	244.43	244.43	5.49	1.25	0.29
3	8.32	249.85	243.97	243.97	5.66	1.50	0.25
2	8.56	249.61	243.51	243.51	5.87	1.50	0.22
1	8.79	249.38	243.04	243.04	6.11	1.50	
247	16.17	248.22	241.00	247.00	N/A	6.00	1.00
246	17.17	247.22	240.00	246.00	6.57	6.00	1.10
245	18.26	246.13	239.00	245.00	6.40	6.00	N/A

Configuration No. 2 Test B

The water surface elevations in the ladder for Test Configuration No. 2B are in Table 4-7. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-8. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-9 and 4-10, respectively. Photos for this test are shown in Photos 4-8 and 4-9. Video for this test is provided in Appendix B.

The hydraulic conditions and flow patterns observed in Configuration No. 2 Test B were similar to those for Configuration No. 1 Test A. A similar flow restriction in the exit channel to the forebay was apparent during this low forebay test, with a forebay elevation of 258.4 ft required to pass the exit section flow (32.8 cfs).

Table 4-7 Water Level Data, Configuration No. 2B

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	258.40	N/A	N/A	N/A	N/A	0.64
Exit Channel	0.64	257.76	250.50	253.50	7.26	2.00	0.80
23	1.44	256.96	250.50	250.50	6.46	1.50	0.17
22	1.61	256.79	250.50	250.50	6.29	1.50	0.19

Table 4-7 Water Level Data, Configuration No. 2B

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
21	1.79	256.61	250.50	250.50	6.11	1.50	0.21
20	2.00	256.40	250.50	250.50	5.90	1.25	0.31
19	2.32	256.08	250.50	250.50	5.58	1.25	0.36
18	2.68	255.72	250.25	250.25	5.35	1.25	0.34
17	3.02	255.38	249.86	249.86	5.33	1.25	0.36
16	3.38	255.02	249.46	249.46	5.36	1.25	0.34
15	3.72	254.68	249.07	249.07	5.42	1.25	0.36
14	4.08	254.32	248.68	248.68	5.45	1.25	0.39
13	4.46	253.94	248.27	248.27	5.46	1.25	0.32
12	4.78	253.62	247.86	247.86	5.55	1.25	0.34
11	5.12	253.28	247.45	248.20	5.63	1.25	0.42
10	5.54	252.86	247.03	247.78	5.62	1.25	0.43
9	5.97	252.43	246.61	247.36	5.61	1.25	0.44
8	6.41	251.99	246.19	246.69	5.59	1.25	0.41
7	6.82	251.58	245.76	246.01	5.61	1.25	0.34
6	7.16	251.24	245.32	245.32	5.70	1.25	0.31
5	7.47	250.93	244.88	244.88	5.83	1.25	0.30
4	7.77	250.63	244.43	244.43	5.97	1.25	0.28
3	8.06	250.34	243.97	243.97	6.15	1.50	0.22
2	8.28	250.12	243.51	243.51	6.38	1.50	0.21
1	8.49	249.91	243.04	243.04	6.64	1.50	
247	10.16	248.24	241.00	247.00	N/A	6.00	0.97
246	11.14	247.26	240.00	246.00	6.76	6.00	1.08
245	12.22	246.18	239.00	245.00	6.68	6.00	N/A

Configuration No. 2 Test C

The water surface elevations in the ladder for Test Configuration No. 2C are in Table 4-8. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-11. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-12 and 4-13, respectively. Photos for this test are shown in Photos 4-10 through 4-11. Video for this test is provided in Appendix B.

The jet from the Weir No. 2 slot was generally directed toward the mid point of the Weir No. 1 right baffle. There was some oscillation in the jet direction and a slight tendency for short circuiting through the Weir No. 1 slot. A vertical circulation cell was generated by the orifice flow in Pool 1, with some minimal boiling.

The jet from the Weir No. 1 slot was directed toward the mid point of the count station wall along the length of the diffuser and was directionally stable. The Weir No. 1 orifice flow proceeded through the trash rack. Flow from the Weir No. 1 slot progressed along the right wall with the majority passing through the crowder. Flow near the floor crossed the count station floor laterally toward the trash rack, with some slight upwelling along the right side of the trash rack. A portion of the flow along the right side of the trash rack recirculated upstream. A slight counter-clockwise circulation cell developed above the center of the diffuser with low velocity. Uniform flow exited the diffuser and was overpowered by flow patterns associated with the slot and orifice jets. Flow from the crowder suggested a nearly even flow split between the crowder and the bulkhead knife gate.

Table 4-8 Water Level Data, Configuration No. 2C

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	264.40	N/A	N/A	N/A	N/A	0.42
Exit Channel	0.42	263.99	250.50	253.50	13.49	2.00	0.35
23	0.77	263.63	250.50	255.00	13.13	1.50	0.40
22	1.17	263.24	250.50	254.50	12.74	1.50	0.39
21	1.56	262.84	250.50	253.50	12.34	1.50	0.40
20	1.97	262.44	250.50	253.25	11.94	1.25	0.48
19	2.44	261.96	250.50	253.00	11.46	1.25	0.61
18	3.05	261.36	250.25	252.75	10.98	1.25	0.65
17	3.70	260.71	249.86	252.36	10.65	1.25	0.75
16	4.44	259.96	249.46	251.46	10.30	1.25	0.60
15	5.04	259.36	249.07	250.82	10.09	1.25	0.69
14	5.74	258.67	248.68	250.18	9.79	1.25	0.69
13	6.42	257.98	248.27	249.77	9.51	1.25	0.69
12	7.11	257.30	247.86	249.11	9.23	1.25	0.63
11	7.74	256.66	247.45	248.20	9.01	1.25	0.62
10	8.36	256.04	247.03	247.78	8.80	1.25	0.64
9	9.01	255.40	246.61	247.36	8.58	1.25	0.73
8	9.74	254.67	246.19	246.69	8.27	1.25	0.70
7	10.44	253.96	245.76	246.01	7.99	1.25	0.69
6	11.13	253.28	245.32	245.32	7.74	1.25	0.72
5	11.84	252.56	244.88	244.88	7.46	1.25	0.66
4	12.51	251.90	244.43	244.43	7.24	1.25	0.76
3	13.27	251.14	243.97	243.97	6.94	1.50	0.68
2	13.94	250.46	243.51	243.51	6.72	1.50	0.71
1	14.65	249.75	243.04	243.04	6.48	1.50	
247	10.16	248.24	241.00	247.00	N/A	6.00	0.97
246	11.14	247.26	240.00	246.00	6.54	6.00	1.08
245	12.22	246.18	239.00	245.00	6.37	6.00	N/A

Configuration No. 2 Test D

The water surface elevations in the ladder for Test Configuration No. 2D are in Table 4-9. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-14. Velocity vectors representing the flow conditions in the count station are shown in Figures 4-15 and 4-16, respectively. Photos for this test are shown in Photos 4-12 through 4-13. Video for this test is provided in Appendix B.

The flow patterns for Configuration No. 2D were similar to those observed for Configuration No. 2C with the following exceptions. The area above the center of the diffuser was near stagnant with only a loosely organized counter-clockwise low velocity circulation present. A portion of the flow approaching the crowder floor crossed the count station ramp and approached the trash rack. There was not an apparent upstream recirculation of flow along the trash rack as in Configuration No. 2C and no visible upwelling at the trash rack.

Table 4-9 Water Level Data, Configuration No. 2D

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	264.47	N/A	N/A	N/A	N/A	0.39
Exit Channel	0.40	264.07	250.50	253.50	13.57	2.00	0.36
23	0.75	263.72	250.50	255.00	13.22	1.50	0.40
22	1.16	263.31	250.50	254.50	12.81	1.50	0.40
21	1.56	262.91	250.50	253.50	12.41	1.50	0.37
20	1.92	262.55	250.50	253.25	12.05	1.25	0.51
19	2.44	262.03	250.50	253.00	11.53	1.25	0.58
18	3.02	261.45	250.25	252.75	11.07	1.25	0.62
17	3.64	260.83	249.86	252.36	10.77	1.25	0.73
16	4.37	260.10	249.46	251.46	10.44	1.25	0.63
15	5.00	259.47	249.07	250.82	10.20	1.25	0.69
14	5.69	258.78	248.68	250.18	9.90	1.25	0.66
13	6.35	258.12	248.27	249.77	9.65	1.25	0.67
12	7.02	257.45	247.86	249.11	9.39	1.25	0.63
11	7.64	256.83	247.45	248.20	9.17	1.25	0.61
10	8.25	256.22	247.03	247.78	8.98	1.25	0.63
9	8.89	255.58	246.61	247.36	8.76	1.25	0.72
8	9.61	254.86	246.19	246.69	8.47	1.25	0.66
7	10.27	254.20	245.76	246.01	8.23	1.25	0.71
6	10.97	253.50	245.32	245.32	7.96	1.25	0.63
5	11.61	252.86	244.88	244.88	7.76	1.25	0.70
4	12.30	252.17	244.43	244.43	7.51	1.25	0.67
3	12.98	251.49	243.97	243.97	7.30	1.50	0.63
2	13.61	250.86	243.51	243.51	7.12	1.50	0.63
1	14.24	250.23	243.04	243.04	6.96	1.50	
247	16.22	248.25	241.00	247.00	N/A	6.00	0.98
246	17.21	247.26	240.00	246.00	6.76	6.00	1.11
245	18.32	246.15	239.00	245.00	6.65	6.00	N/A

Configuration No. 2 Test E

The water surface elevations in the ladder for Test Configuration No. 2D are in Table 4-10. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-17. Velocity vectors representing the flow conditions in the count station are shown in Figures 4-18 and 4-19, respectively. Photos for this test are shown in Photos 4-14 through 4-16. Video for this test is provided in Appendix B.

Some short circuiting was observed between Weirs Nos. 1 and 2. The jet exiting the slot in Weir No. 1 impacted the right wall approximately mid-way along the diffuser with some slight upwelling. A large counterclockwise horizontal circulation cell developed above the diffuser with a stagnant/undefined flow region in the center. The surface flow circulated past the trash rack with only a small portion passing through the rack. Flow from the orifice continued along the diffuser and passed through the trash rack. Recirculation and eddy shedding was present downstream of the count station and suggested that a larger portion of the flow passed through the count station crowder than with the Holey Wall in Configuration No. 1.

Some short circuiting in Pool 8 was observed, with the jet from Weir No. 9 alternating slowly between impacting in the right corner upstream of Weir No. 8 and short circuiting through the slot in Weir No. 8. There was a general counterclockwise circulation cell observed upstream of Weir No. 8 at the surface on the left side of the pool. Flow from the orifice in Weir No. 9 continued in a sporadic and turbulent path to the orifice in Weir No. 8. There was minimal to no upwelling noted in Pool 8 during the test.

In general, the stub walls in the exit channel to the forebay effectively deflected flow off the channel wall. There was no short circuiting observed upstream of Weirs No. 16 through 23. The jet from the slot in Weirs No. 16 through 23 was generally directed toward the right downstream corner of each pool. The jets occasionally impacted near the center of the pool, but with minimal upwelling. The tendency for short-circuiting increased from Pool 15 to Pool 10, with the jet direction from the slots variable, but generally impacting at or left of the midpoint of the right downstream weir baffle. There was a less prominent tendency for short circuiting in Pools 1 through 9 with the jet oscillating between impacting the right downstream corner and impacting the upstream face of the right weir baffle.

Table 4-10 Water Level Data, Configuration No. 2E

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	267.93	N/A	N/A	N/A	N/A	0.38
Exit Channel	0.38	267.55	250.50	253.50	17.05	2.00	0.31
23	0.69	267.24	250.50	257.50	16.74	1.50	0.55
22	1.24	266.69	250.50	256.65	16.19	1.50	0.56
21	1.79	266.14	250.50	256.00	15.64	1.50	0.52
20	2.32	265.61	250.50	255.40	15.11	1.25	0.69
19	3.01	264.92	250.50	254.80	14.42	1.25	0.81
18	3.82	264.11	250.25	254.05	13.74	1.25	0.76
17	4.58	263.35	249.86	253.11	13.30	1.25	0.75
16	5.34	262.59	249.46	251.46	12.93	1.25	0.77
15	6.11	261.82	249.07	250.82	12.56	1.25	0.60
14	6.71	261.22	248.68	250.18	12.34	1.25	0.81
13	7.52	260.41	248.27	249.77	11.94	1.25	0.77
12	8.29	259.64	247.86	249.11	11.58	1.25	0.74
11	9.03	258.90	247.45	248.20	11.25	1.25	0.81
10	9.84	258.09	247.03	247.78	10.85	1.25	0.70
9	10.54	257.39	246.61	247.36	10.58	1.25	0.90
8	11.44	256.49	246.19	246.69	10.10	1.25	0.82
7	12.26	255.67	245.76	246.01	9.70	1.25	0.89
6	13.15	254.78	245.32	245.32	9.24	1.25	0.83
5	13.98	253.95	244.88	244.88	8.85	1.25	0.94
4	14.91	253.02	244.43	244.43	8.37	1.25	0.97
3	15.88	252.05	243.97	243.97	7.85	1.50	0.93

Table 4-10 Water Level Data, Configuration No. 2E

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
2	16.81	251.12	243.51	243.51	7.38	1.50	1.03
1	17.84	250.09	243.04	243.04	6.81	1.50	
247	19.85	248.08	241.00	247.00	N/A	6.00	1.03
246	20.88	247.05	240.00	246.00	6.55	6.00	1.10
245	21.98	245.95	239.00	245.00	6.45	6.00	N/A

Configuration No. 2 Test F

The water surface elevations in the ladder for Test Configuration No. 2F are in Table 4-11. Sketches of the flow patterns observed in the count station and in Pool 8 are provided in Figure 4-20. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-21 and 4-22, respectively. Video for this test is provided in Appendix B.

There was some tendency for short circuiting observed in Pool 1. The jet from Weir No. 1 impacted the right wall approximately halfway down the length of the diffuser and was generally directionally stable. In general, the flow conditions in the count station were similar to those observed for Configuration No. 2E.

In Pool 8, the Weir No. 9 slot jet direction was generally stable and the jet impacted Weir No. 8 near the right downstream corner. The jet occasionally oscillated toward the slot in Weir No. 8, causing minimal short-circuiting. A vertical circulation cell developed near the left wall as a result of the orifice flow. The triangular fin on the downstream side of the right weir baffle appeared to prohibit flow from progressing along the right downstream side of Weir No. 9. Some upwelling was present at the downstream left corner of the pool due to the vertical circulation cell from the orifice flow.

In general, the slot jets were directed toward the downstream right corner of respective pools for Weirs No. 16 through 23. The jets were directionally stable in Pools 19 through 22 and oscillated toward the upstream side of the corner along the right wall in Pools 15 through 18. Pools 8, 9, 13, and 14 had some occasional tendency for short-circuiting, with a greater variation in jet direction. Pools 10 through 12 had a high tendency for short-circuiting, with the slot jet oscillating between short circuiting to the next slot and impacting the midpoint of the right weir baffle. The remaining weir jets were directed just right of the baffle block with oscillation between short-circuiting and the right downstream corner of the pool.

Table 4-11 Water Level Data, Configuration No. 2F

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	267.98	N/A	N/A	N/A	N/A	267.98	0.37
Exit Channel	267.61	250.50	253.50	14.11	17.11	267.61	0.32
23	267.28	250.50	257.50	9.78	16.78	267.28	0.54
22	266.74	250.50	256.65	10.09	16.24	266.74	0.54
21	266.20	250.50	256.00	10.20	15.70	266.20	0.58

Table 4-11 Water Level Data, Configuration No. 2F

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
20	265.63	250.50	255.40	10.23	15.13	265.63	0.67
19	264.95	250.50	254.80	10.15	14.45	264.95	0.79
18	264.16	250.25	254.05	10.11	13.79	264.16	0.79
17	263.38	249.86	253.11	10.27	13.33	263.38	0.75
16	262.63	249.46	251.46	11.17	12.97	262.63	0.73
15	261.90	249.07	250.82	11.08	12.64	261.90	0.65
14	261.26	248.68	250.18	11.08	12.38	261.26	0.81
13	260.44	248.27	249.77	10.67	11.97	260.44	0.73
12	259.71	247.86	249.11	10.60	11.64	259.71	0.72
11	258.99	247.45	248.20	10.79	11.34	258.99	0.77
10	258.22	247.03	247.78	10.44	10.98	258.22	0.72
9	257.50	246.61	247.36	10.14	10.68	257.50	0.88
8	256.61	246.19	246.69	9.93	10.22	256.61	0.77
7	255.84	245.76	246.01	9.83	9.87	255.84	0.90
6	254.95	245.32	245.32	9.63	9.41	254.95	0.77
5	254.18	244.88	244.88	9.30	9.08	254.18	0.90
4	253.27	244.43	244.43	8.85	8.62	253.27	0.95
3	252.32	243.97	243.97	8.35	8.13	252.32	0.89
2	251.43	243.51	243.51	7.92	7.69	251.43	0.93
1	250.50	243.04	243.04	7.46	7.23	250.50	
247	248.23	241.00	247.00	1.23	N/A	248.23	1.01
246	247.23	240.00	246.00	1.23	6.73	247.23	1.13
245	246.10	239.00	245.00	1.10	6.60	246.10	N/A

4.2 Modifications Model Testing

After Baseline testing, a series of modifications were made to the JDAN Ladder model configuration to improve hydraulic conditions in the count station, ladder pools, and the exit channel to the forebay. The following sections describe the stepwise process for the modifications.

4.2.1 Configuration No. 3

USACE initially defined several modifications to the ladder that were expected to improve hydraulic conditions based on their knowledge of the ladder performance, previous testing for JDAS, and potential improvements for lamprey passage. Configuration No. 3 was the same as Configuration No. 2, with the JDAS Modified Baseline Weirs, but included modifications to the count station defined by USACE during the model design phase. The modifications to the count station are shown in Figures 4-23 through 4-25 and included sloping the diffuser floor up to the base of Weir No. 1 to eliminate the step from the diffuser to the orifice and slot in Weir No. 1. In addition the count station ramp was lowered. Configuration No. 3 was viewed during the witness test on August 13-15, 2007, by Agency and USACE staff. Observations on the flow patterns were made during the witness test with dye, but no additional model tests were conducted.

4.2.2 Configuration No. 4

For the second day of the August 13-15, 2007 witness test, the JDAS Modified Baseline weirs were removed and the Alternative 1 weirs with lamprey-friendly rounding shown in Figures 4-26 and 4-27 were installed along with the same count station ramp revisions (Figures 4-23 through 4-25) for Configuration No. 3. The primary features of the Alternative 1 weirs included 4-in rounded corners and placement of the orifice along the wall with the intention of encouraging and aiding lamprey passage.

As the flows for each test condition were set, it was noted that the forebay elevation was lower than measured with the JDAS Modified Baseline weirs in place. The rounding of the weirs for lamprey passage resulted in greater hydraulic efficiency and prompted revision of the weir slot sill settings in a later configuration to modulate ladder flows over the entire forebay operating range. As observed during Baseline Testing, during low forebay operation the two slotted baffles in the exit channel to the forebay had a significant head drop over the fixed sills and that the depth on the sills was approximately equal to the sill elevation (~2.5 ft). For high forebay conditions (268 ft) dye was observed at the ladder pools and count station, changes to the triangular fin position on the downstream face of the right weir baffle were investigated, and the stability of the weir jet in the ladder pools and the flow through the orifice in the left baffle were observed. Some short-circuiting was observed in the lower pools. Hydraulic conditions in the ladder were observed during the witness test, but no additional model tests were conducted for this configuration.

During the witness test, it was determined that the count station might be improved by removing the count station ramp and raising the entire count station floor by 1.0 ft to accommodate the count station window without having fish encounter multiple sloping ramps. In addition, a decision was made to improve hydraulic conditions between the orifice openings and attempt to decrease orifice-to-orifice flow velocities by moving the orifice away from the wall to the JDAS Modified Baseline location for Weirs No. 2 through 23. Plans were made to add a lamprey “sidewalk”, a solid plate, along the edge of the diffuser floor to provide an attachment path for lamprey passing across the diffuser to the orifice in Weir No. 1. These modifications are described in detail in Configuration No. 5.

4.2.3 Configuration No. 5

Following the August 13-15, 2007 witness test, ENSR modified the exit section weirs, count station, and exit channel to the forebay for Configuration No. 5. The Alternative 1 exit section weirs with lamprey-friendly features were modified to move the center of the orifice 4.0 ft away from the left wall to minimize the pattern of high velocity orifice-to-orifice through flow that was apparent in Configuration No. 4 with the orifice against the left ladder wall. The Alternative 2 exit section weirs are shown in Figures 4-28 and 4-29.

The count station was modified by:

a. Raising the floor of the count station by 1.0 ft and eliminating the crowder ramp and sloped diffuser;

b. Adding a solid lamprey “sidewalk” over the diffuser (12 in wide to 18 in wide at the orifice opening in Weir No. 1);

c. Reducing the crowder length to 4 ft-7 in per correction from USACE; and

d. Designing and installing fairings for the upstream and downstream side of the crowder for 24-in and 18-in opening positions. The fairings were designed with a straight section and rounded ends for smooth transition to the crowder. The straight sections were intended for fabrication in the prototype with sliding panels to allow for adjustment of the fairing length as the crowder opening is changed from 18 in to 24 in.

The details of the count station modifications are shown in Figure 4-30.

The exit channel to the forebay was modified in an attempt to reduce the losses through the exit channel and minimize the flow restriction during low forebay conditions that was observed during the baseline tests with the exit channel slot sills in place. The exit channel to the forebay was modified as shown in Figure 4-31 to narrow the channel to increase velocities, while eliminating the head losses through the existing slotted baffles. The exit channel modifications consisted of removing the existing slotted baffles and stub walls, installing a false wall to narrow the channel width to 5.0 ft and adding an elliptical transition to the ladder walls near Weir No. 23.

ENSR conducted water level testing for weir sill revisions as described in the following section. The model was demonstrated with Configuration No. 5 in place during the first day of the October 23-24, 2007 witness test for USACE staff. Dye was observed in the count station and Pool 10. Flow approach to the crowder appeared reasonably smooth with the crowder fairings in place with minimal separation on the downstream side as flow expanded to the overflow weirs. A standing wave formed in the crowder during some flow conditions.

Dye injected in the Weir No. 11 slot dispersed over the entire pool, with a slight upwelling on the right side wall. Dye in the orifice did not shoot through to the next orifice as it did when the orifice openings were against the wall in the previous weir configuration. Moving the orifice away from the wall improved hydraulic conditions for the orifice openings and reduced orifice to orifice high velocities. Upwelling was observed in the pools upstream of Weirs No. 22 and 23, but the upper weir sills were adjusted for the next configuration and this upwelling was alleviated.

Flow from the revised exit channel to the forebay came through the narrowed exit channel and expanded to the pool upstream of Weir No. 23. As it expanded along the left angled transition wall, the flow separated from the angled wall and a recirculation zone set up on the left side above the orifice. In general for the higher forebay elevations and higher ladder flows demonstrated, a vortex with an observable dye core formed off the left angled transition wall below the surface and extended through the Weir No. 23 slot. Attempts were made to break up the recirculation and prevent the vortex formation using a triangular cross section flow splitter (a piece mounted vertically on the wall and with a cross section consisting of a right isosceles triangle with the right angle apex projecting away from the wall, and a side length of 3.5 in model scale). The splitter was found to be reasonably effective at some but not all forebay elevations.

In general, the upper pools with weir slot sills tended to have a slightly plunging jet with less tendency for short-circuiting to the next weir slot. The lower pools with no slot sills had higher tendency for short-circuiting.

4.2.3.1 Sill Modification Testing, Revision 1

After the August 13-25, 2007 witness test, it was apparent that the weirs with lamprey-friendly rounded slots and orifice openings were more hydraulically efficient than the JDAS Modified Baseline weirs and adjustment to the sill settings for the forebay operating range was required. ENSR provided USACE with preliminary forebay elevations and flows observed in the model during the August 13-15, 2007 witness test and USACE used the information in their 1-D spreadsheet model to estimate new sill settings. ENSR installed the revised sills as shown in Table 4-12 as part of Configuration No. 5. ENSR conducted a series of tests for Configuration No. 5 to provide water level information to USACE for further refinement of the weir slot sill elevations and determination of the estimated operating flow ranges for each sill setting. Flows, forebay elevation, and water surface elevations at the piezometric tap in the center of each ladder pool were recorded for the tests summarized in Table 4-13.

Table 4-12 Sill Setting Revision No. 1 (Installed for Model Test Configuration No. 5)

	Low Forebay Range		Medium Forebay Range		High Forebay Range	
Weir	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)
23	1.50	0	1.25	5.75	1.25	8.5
22	1.50	0	1.25	5.25	1.25	7.75
21	1.50	0	1.25	4.5	1.25	6.75
20	1.25	0	1.25	4	1.25	6
19	1.25	0	1.25	3.25	1.25	5
18	1.25	0	1.25	3	1.25	4.5
17	1.25	0	1.25	2.75	1.25	4
16	1.25	0	1.25	2.5	1.25	3.5
15	1.25	0	1.25	2.25	1.25	3
14	1.25	0	1.25	2	1.25	2.5
13	1.25	0	1.25	1.75	1.25	2.25
12	1.25	0	1.25	1.5	1.25	1.75
11	1.25	0	1.25	1.25	1.25	1.5
10	1.25	0	1.25	1	1.25	1
9	1.25	0	1.25	0	1.25	0
8	1.25	0	1.25	0	1.25	0
7	1.25	0	1.25	0	1.25	0
6	1.25	0	1.25	0	1.25	0
5	1.25	0	1.25	0	1.25	0
4	1.25	0	1.25	0	1.25	0
3	1.50	0	1.50	0	1.50	0
2	1.50	0	1.50	0	1.50	0
1	1.50	0	1.50	0	1.50	0

Table 4-13 Configuration No. 5, Sill Modification Test Results Summary

Config. No.	Test	Weirs	Sills	Forebay Elevation (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
5	A	Alternative 2	High	268.0	1.0	85.0	0.0	85.0
5	B	Alternative 2	High	268.0	1.0	85.0	0.0	85.0
5	C	Alternative 2	Med	264.1	1.0	65.4	19.6	85.0
5	D	Alternative 2	Med	261.5	1.0	45.0	40.0	85.0
5	E	Alternative 2	Low	257.0	1.0	35.5	49.6	85.1
5	F	Alternative 2	Low	264.4	1.0	85.2	0.0	85.2
5	G	Alternative 2	High	265.7	1.0	62.0	23.0	85.0

USACE provided a target set of flows and forebay elevations for several of the tests based on previous test results and their 1-D spreadsheet model of the ladder exit section. ENSR set the flows for Tests 5A, 5B, 5C, and 5E and then checked the forebay to ensure it was within +/- 0.3 ft of the target forebay elevation for the test. If the forebay was not within this tolerance, minor adjustments to the flows were made until the forebay reached the target. For Tests 5D, 5F, and 5G, the flows were simply set and the resulting forebay elevation was recorded after the model equilibrated. Tests 5A and 5B were duplicate tests, except that the triangular fins on the downstream side of the right weir baffle on Weirs No. 2 through 23 were in two different locations for each test to determine whether they have any significant effect on the slot loss coefficient. In Test 5A, the triangular fin was located 6 in further away from the slot than shown in Figure 4-28. For Tests 5B through 5G the triangular fins were moved half the distance to the right wall from the Test 5A position. The fin position did not have a measureable effect on the weir loss coefficient. USACE used the resulting forebay elevations and flows in Table 4-13 to revise the weir loss coefficients in their spreadsheet model and provided ENSR with a new set of sill elevations for use in Configuration No. 6.

4.2.4 Configuration No. 6

The Alternative 3 weirs were the same as Alternative 2, but the triangular fins were moved 1/3 of the distance from the slot to the right wall from the right wall to determine the impact on the slot jet direction and stability. Sill Revision No. 2 (Table 4-14) was installed as provided by USACE based on the water level tests conducted with Configuration No. 5 in the model. Configuration No. 6 was viewed during the second day of the October 22-23, 2007 witness test.

Table 4-14 Weir Sill Elevation Revision No. 2

	Low Forebay Range		Medium Forebay Range		High Forebay Range	
Weir	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)
23	1.50	0	1.25	5.75	1.25	7.5
22	1.50	0	1.25	5.25	1.25	7.0
21	1.50	0	1.25	4.5	1.25	6.5
20	1.25	0	1.25	4	1.25	6.0
19	1.25	0	1.25	3.25	1.25	5.5
18	1.25	0	1.25	3	1.25	4.75
17	1.25	0	1.25	2.75	1.25	4.25
16	1.25	0	1.25	2.5	1.25	4.0
15	1.25	0	1.25	2.25	1.25	3.75
14	1.25	0	1.25	2	1.25	3.25
13	1.25	0	1.25	1.75	1.25	2.5
12	1.25	0	1.25	1.5	1.25	2.0
11	1.25	0	1.25	1.25	1.25	1.5
10	1.25	0	1.25	1	1.25	1
9	1.25	0	1.25	0	1.25	0
8	1.25	0	1.25	0	1.25	0
7	1.25	0	1.25	0	1.25	0
6	1.25	0	1.25	0	1.25	0
5	1.25	0	1.25	0	1.25	0
4	1.25	0	1.25	0	1.25	0
3	1.50	0	1.50	0	1.50	0
2	1.50	0	1.50	0	1.50	0
1	1.50	0	1.50	0	1.50	0

During the witness test, a slight standing wave was observed in the 18-in open crowder, but dye released into the crowder appeared to flow through the crowder relatively smoothly. Some short-circuiting was observed in the lower ladder pools. At Pool 9 and upstream to Pool 17 (pools with sills in place), the flow dove down slightly through the slot and upwelled slightly at the right wall. Dye released in the slot dispersed over slightly more than 2/3 of the pool. The vortex observed in the exit channel with Configuration No. 5 was observed as described previously for higher flow conditions. A variety of fillets, triangular splitter shapes, blocking off the right hand dead area upstream of the right Weir No. 23 baffle, and streamlining the exit channel approach to the slot were investigated in attempts to eliminate the vortex.

4.2.5 Configuration No. 7

After observing the vortex and flow patterns in the exit channel to the forebay during the October 23-24, 2007 site visit, the exit channel to the forebay was modified with an angled transition to attempt to streamline flow to the Weir No. 23 slot. Details of the angled transition for the exit channel to the forebay are shown in Figure 4-32. Configuration No. 7 was the same as Configuration No. 6, but included the angled transition in the exit channel to the forebay. Configuration No. 7 was viewed by USACE staff during the first day of the November 8-9, 2007 site visit. Minor modifications were made to the angled transition, including developing a fillet to train flow along the left wall and turn it to the slot above the orifice opening. Hydraulic conditions were favorable in the exit channel to the forebay with this configuration in place, but it required a significant modification to the existing exit channel for implementation and was a significant deviation from the existing condition.

4.2.6 Configuration No. 8

For the second day of the November 8-9, 2008 witness test, the angled transition from the exit channel to the forebay was removed and a modified version of the existing JDAN slotted baffle structures was developed as shown in Figure 4-33. The exit channel to the forebay was modified from existing conditions by removing the upstream slotted baffle and sill and the upstream stub wall, leaving the downstream slotted baffle and stub wall in place. To improve conditions for lamprey passage through the exit channel to the forebay, an 18-in by 18-in orifice was cut in the left side of the remaining slotted baffle against the wall. Hydraulic conditions in the exit channel to the forebay appeared favorable, and a few minor modifications were made to the configuration as follows:

- The stub wall was moved upstream by 4.5 ft (final location is shown on Figure 4-33) to stabilize the jet deflection off the stub wall.
- During higher flow conditions a slight swirling was observed off the left angled wall just upstream of Weir No. 23. A triangular flow splitter was installed along the angled wall as shown in Figure 4-33 to eliminate the swirling tendency.
- During the witness test, the stub wall and triangular splitter had sharp edges. These edges were rounded as shown in Figure 4-33 after the witness test to finalize the modifications to the exit channel to the forebay.

In addition, the triangular fins on the downstream side of the right baffles on Weirs No. 2 through 18 were moved to the halfway point between the weir slot and the right ladder wall to further optimize their position relative to the slot jet.

4.2.7 Configuration No. 9

Configuration No. 9 was the same as Configuration No. 8, but Weirs No. 18 through 20 were modified with wider slots to accommodate flows during low forebay elevations. The left baffles for Weirs 18 through 20 were shortened to change the slot width and the right baffles remained in position. In addition, the triangular fins were moved to their final position near the slot as shown in Figures 4-34 and 4-35. This configuration was viewed at the November 19-20, 2007 witness test with USACE and Agency staff.

During the witness test, flow patterns were observed for a range of operating conditions in the ladder pools and count station using dye. Some short-circuiting was observed in the lower ladder pools, typically those pools downstream of weirs with slots without sills. During the witness, test 1-ft sills were added to Weirs No. 1 through 9 for the medium and high sill settings in an attempt to alleviate the short-circuiting and assure more consistent flow patterns in all pools. The hydraulic conditions and jet stability in the pools improved with the 1-ft sills in place. During the witness, test the possibility of operating with three sill combinations (no sills, 1-ft sills in all weirs, and high sills) was discussed and ENSR investigated this further following the meeting.

Flow conditions in the count station were generally favorable, however, swirling was observed in the crowder. Flow from the Weir No. 1 slot jet passed across the crowder opening and upwelled along the base of the upstream crowder fairing, rotated, and resulted in swirling through the crowder. During the witness, test an initial version of a flow vane modification for the upstream crowder fairing was developed to minimize swirling in the crowder. ENSR developed the flow vane further during modification testing after the meeting as described in the following section.

4.2.8 Configuration No. 10

Configuration 10 was the same as Configuration 9, but included revised sills (Sill Revision No. 3) as described in Section 4.2.8.2. With this configuration in place, modifications to the crowder upstream fairing were developed to alleviate swirling flow observed during the November 19-20, 2007 witness test. In addition, water level testing was conducted to develop the final sill settings and operating ranges for the ladder.

4.2.8.1 Crowder Vane Modification Testing

ENSR conducted modification testing to develop a flow guide vane to minimize swirling through the crowder. The details of the modification tests and a series of photos are provided in our memorandum to USACE on December 11, 2008 in Appendix A.

All of the flow guide vane modification tests were performed under the following conditions:

- Q_{TOTAL} = 85 cfs
- $Q_{DIFFUSER}$ = 0 cfs
- Knife gate 40-in open
- 24-in crowder opening
- 1-ft sills installed in Weirs No. 1 through 4, (except for the first modification)

The final flow guide vane design is shown in Figure 4-36 and consisted of horizontal flow vanes attached to the face of the upstream crowder fairing. The edge of each vane was rounded in plan view to limit protrusion into the flow path through the crowder, while maintaining adequate surface area to straighten the flow. The edges of the vanes were rounded to minimize the potential for fish injury. The flow vanes were designed to attach to the straight portion of the crowder fairing in the prototype.

4.2.8.2 Sill Modification Testing, Revision 3

Following the November 19-20, 2007 witness test, sill modification tests were conducted to confirm whether the 1-ft sills installed during the witness test could be operated over a wide enough range of forebay elevations and ladder flows to replace the previous medium sill settings with some adjustment to the high sills. Flows, forebay elevation, and water surface elevations at the piezometric tap in the center of each ladder pool were recorded for the tests summarized in Table 4-15.

Table 4-15 Configuration No. 10, Sill Modification Test Results Summary

Config. No.	Test	Weirs	Sills	Forebay Elevation (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
10	A	Alternative 5	No Sills	264.17	1.0	85.0	0.0	85.0
10	B	Alternative 5	No Sills	257.07	1.0	38.4	46.0	85.0
10	C	Alternative 5	1-ft	264.57	1.0	85.0	0.0	85.0
10	D	Alternative 5	1-ft	257.07	1.0	31.7	53.3	85.0
10	E	Alternative 5	High	268.14	1.0	85.0	0.0	85.0
10	F	Alternative 5	High	261.11	1.0	33.8	51.2	85.0

The tests were conducted with the sill settings provided by USACE based on their spreadsheet model as shown in Table 4-16. USACE provided a target set of flows and forebay elevations for several of the tests based on previous test results and their 1-D spreadsheet model of the ladder exit section. ENSR set the flows for Tests 10B and 10E and then checked the forebay to ensure it was within +/- 0.3 ft of the target forebay elevation for the test. If the forebay was not within this tolerance, minor adjustments to the flows were made until the forebay reached the target. For Tests 10A, 10C, and 10D the flows were simply set and the resulting forebay elevation was recorded after the model equilibrated. The intent of the tests were to identify the upper and lower end of the operating range for each set of sills and ensure that the operating ranges overlapped adequately. USACE used the resulting forebay elevations and flows in Table 4-14 to confirm the weir loss coefficients in their spreadsheet model and confirmed that the weir settings for Configuration No. 10 were the final sill settings. Note that after initial testing for the 1-ft sill setting, the 1-ft sill in Weir No. 1 was removed to avoid violation of the 1.0-ft weir head criteria at Weir No. 1.

Table 4-16 Weir Sill Setting Revision No. 3 (Final Sill Settings)

	Low Forebay Range		Medium Forebay Range		High Forebay Range	
Weir	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)
23	1.50	0	1.50	1.00	1.25	6
22	1.50	0	1.50	1.00	1.25	5.75
21	1.50	0	1.50	1.00	1.25	5.5
20	1.50	0	1.50	1.00	1.25	5.25
19	1.50	0	1.50	1.00	1.25	4.75
18	1.50	0	1.50	1.00	1.25	4.25
17	1.25	0	1.25	1.00	1.25	4
16	1.25	0	1.25	1.00	1.25	3.75
15	1.25	0	1.25	1.00	1.25	3.5
14	1.25	0	1.25	1.00	1.25	3.25

Table 4-16 Weir Sill Setting Revision No. 3 (Final Sill Settings)

	Low Forebay Range		Medium Forebay Range		High Forebay Range	
Weir	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)
13	1.25	0	1.25	1.00	1.25	3
12	1.25	0	1.25	1.00	1.25	2.75
11	1.25	0	1.25	1.00	1.25	2.5
10	1.25	0	1.25	1.00	1.25	2.25
9	1.25	0	1.25	1.00	1.25	1.75
8	1.25	0	1.25	1.00	1.25	1
7	1.25	0	1.25	1.00	1.25	1
6	1.25	0	1.25	1.00	1.25	1
5	1.25	0	1.25	1.00	1.25	1
4	1.25	0	1.25	1.00	1.25	1
3	1.50	0	1.50	1.00	1.50	1
2	1.50	0	1.50	1.00	1.50	1
1	1.50	0	1.50	0.00	1.50	0

4.3 Documentation Testing

After the modification testing was complete, ENSR documented the hydraulic conditions for the final design for a range of operating conditions as described in the following sections. All of the documentation tests were conducted for Configuration No. 11, the final design (Figure 4-37). The features of the final design Configuration No. 11 are summarized as follows:

- Pools:
  - o The JDAN exit section design incorporated the pool spacing shown on the final model layout (Figure 4-37). Prototype pool spacings are provided in Section 5.2,
  - o A tapered filler piece was added to Pool 18 to fill the existing tapered section on the right sidewall per testing performed during the second site visit on August 13-15, 2007.
- Weirs: Alternative 5 – Final configuration weirs with lamprey rounding were employed. Other details included:
  - o 18-in by 18-in orifices with centers 4.0 ft from the left ladder wall were installed in Weirs No. 2 through 23 (Weir No. 1 orifice is flush against the left wall);
  - o Triangular fins were installed on downstream side of right baffles placed near the slot with accommodation for the slot flap actuator; and
  - o Weirs No. 18-23 were wider than the remaining weirs with L-shaped sill flaps to accommodate flows at lower forebay elevations (Figure 4-34 and 4-35).
- Sills:

- o Sills were set to the final sill settings developed during the modification testing for Configuration No. 10. (Table 4-16).
- o The three sill settings for the low, medium, and high forebay operating ranges are referred to as no-sills, 1-ft sills, and high sills, respectively.

- Exit channel to forebay (Figure 4-33):
  - o Removed the existing upstream baffle and stub wall;
  - o Modified the remaining downstream baffle wall to remove the sill and added an 18-in by 18-in orifice along the left wall flush with the bottom;
  - o Moved the remaining downstream stub wall upstream by 4.5 ft and rounded the end of the stub wall;
  - o Added a triangular flow splitter with a rounded edge to the downstream edge of the transition wall on the left side of the exit channel to the forebay; and
  - o Removed the 8-in baffle on the upstream side of the left baffle of Weir No. 23.
- Count Station (Figure 4-30 and 4-36):
  - o Raised the entire count station floor by 1.0 ft to match the elevation at the base of Weir No. 1 and sloped the floor downstream of the crowder to the base of Weir No. 248;
  - o Added an 18-in to 12-in wide solid lamprey "sidewalk" along the left side of the diffuser floor from the Weir No. 1 orifice to the count station;
  - o Added fairings to the upstream and downstream side of the count station crowder; and
  - o Added a horizontal flow guide vane to the upstream fairing on the crowder. The vane details are in Figure 4-36.

4.3.1 Documentation Test Program

ENSR documented hydraulic conditions in the ladder for documentation testing Configuration No. 11 as summarized in Table 4-17. For each test dye was released upstream and downstream of the exit section weirs in Pool 8 and at the count station and conditions were documented with video and photographs. Ladder flows, diffuser flows, forebay elevation, weir pool elevations, and water surface elevation in the count station were documented for each test. Velocity measurements were made with an ADV in the count station and in Pool 8 at the locations shown in Figures 4-38 and 4-39 respectively, at approximate depths of 0.2d, 0.6d, and 0.8d.

Table 4-17 Documentation Test Program

Config. No.	Test	Weirs	Sills	Target Forebay Elev. (ft)	Actual Forebay Elev. (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
11	A	Final Design	High	268.0	268.2	1.0	84.5	0.48	85.0
11	B	Final Design	High	262.5	262.3	1.3	44.6	68.3	112.9
11	C	Final Design	High	262.5	262.8	1.0	45.7	39.3	85.0

Table 4-17 Documentation Test Program

Config. No.	Test	Weirs	Sills	Target Forebay Elev. (ft)	Actual Forebay Elev. (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
11	D	Final Design	1-ft	262.5	262.7	1.0	67.0	18.0	85.0
11	E	Final Design	No Sills	262.5	262.5	1.0	72.0	13.0	85.0
11	F	Final Design	No Sills	257.0	257.3	1.3	37.5	75.4	112.9

4.3.2 Documentation Test Results

4.3.2.1 Documentation Test, Configuration No. 11 Test A

The water surface elevations recorded in the ladder for Test Configuration No. 11A are in Table 4-18. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-40. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-41 and 4-42, respectively. Photos for this test are shown in Photos 4-17 through 4-19. Video for this test is provided in Appendix B.

The jet from Weir No. 2 impacted the right wall about a third to halfway along the wall between Weir No. 2 and Weir No. 1, causing upwelling along that portion of the wall. A small recirculation cell formed above the jet in the upstream right corner of Pool No. 1. Following impact with the right wall, the jet passed around the baffle block on Weir No. 1, and exited Weir No. 1 at a slightly more acute angle, impacting the right wall of the count station about 1/3 of the way to the fish crowder approach wall. An intermittent vortex formed on the upstream edge of the baffle block on Weir No. 1, and broke off into the center of the pool. Orifice flow passed straight across the lower left side of the pool from the orifice in Weir No. 2 to Weir No. 1, causing upwelling along Weir No. 1 between the vertical baffle and the left wall. A portion of the surface flow reversed direction along the left wall, while the majority flowed counterclockwise to enter the Weir No. 1 slot and join the main jet. There was a significant stagnant area in the upstream left half of the pool along Weir No. 2 from the slot to just before the orifice.

A similar stagnant area occurred in the diffuser, extending slightly farther downstream than that in Pool 1 due to the slow clockwise flow pattern in the left half of the pool. The stagnant area was caused by the interaction between the left side of the slot flow and the orifice flow as it reached the trash rack. The flow from the left side of the diffuser joined the main jet to track along the angled wall into the crowder. A small portion was diverted around the flow vane into the trash rack, along with the flow from the orifice in Weir No. 1. There was a recirculation area causing an intermittent surface vortex in the upstream right corner of the diffuser.

Flow through the fish crowder was relatively smooth, with intermittent vertical velocity variation at approximately 2/3 depth. Flow exited the crowder evenly along both walls and straight downstream, with minor upwelling on the wall downstream of the fish crowder. Flow impacting Weir No. 248 proceeded smoothly around the left and right corners and through the slots.

In Pool 8, the jet from Weir No. 9 impacted the right wall about halfway between Weir No. 9 and Weir No. 8, causing upwelling along the length of the wall. There was a narrow area of recirculation on the right side of Weir No. 9. After impacting the right wall, the jet passed around the baffle block on Weir No. 8 and through the slot, forming a small vortex on the upstream edge of the baffle block and slight upwelling and turbulence on the right face of the baffle block. The orifice flow from Weir No. 9 caused slight upwelling on Weir No. 8, resulting in surface flows in three directions: upstream along the left wall; upstream towards the center of the pool; and directly towards the slot in Weir No. 8, where the flow interacted with the flow around the baffle block to cause an intermittent area of vertical recirculation that resulted in horizontal swirling.

The jets into Pools 3 through 6 adhered to the downstream side and triangular fin of the previous weir and impacted the right wall near the weir. No short circuiting was noted in these pools. Pools 1 through 12 had upwelling where the jet impacted the right wall, and Pools 13 through 16 as well as Pools 21 and 22 displayed slightly less upwelling in the same location. The jets into Pools 17, 18, and 19 impacted the downstream right corner of the pool creating upwelling along both the wall and the downstream weir. The jet in Pool 20 oscillated between the above two patterns.

In the exit channel to the forebay, flow entered the baffle slot smoothly, was deflected by the stub wall to the left wall, moved across the downstream angle of the left wall and was directed towards the slot area by the triangular flow splitter. Stagnant areas occurred on the right side of the exit channel to the forebay at the widest area just upstream of Weir No. 23 and in the area directly above the orifice. There was a small recirculation area upstream of the slotted baffle.

Table 4-18 Water Level Data, Configuration No. 11A

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	268.19	N/A	N/A	N/A	N/A	0.03
Exit Channel	0.03	268.16	250.50	250.50	17.66	2.00	0.20
23	0.23	267.97	250.50	256.50	17.47	1.25	0.56
22	0.79	267.41	250.50	256.25	16.91	1.25	0.67
21	1.46	266.73	250.50	256.00	16.23	1.25	0.58
20	2.04	266.16	250.50	255.75	15.66	1.25	0.85
19	2.89	265.30	250.50	255.25	14.80	1.25	0.88
18	3.77	264.42	250.25	254.50	14.05	1.25	1.02
17	4.79	263.40	249.86	253.86	13.35	1.25	0.68
16	5.47	262.72	249.46	253.21	13.06	1.25	0.70
15	6.18	262.02	249.07	252.57	12.75	1.25	0.76
14	6.94	261.25	248.68	251.93	12.38	1.25	0.71
13	7.65	260.54	248.27	251.27	12.07	1.25	0.81
12	8.46	259.73	247.86	250.61	11.67	1.25	0.81
11	9.28	258.92	247.45	249.95	11.26	1.25	0.89
10	10.17	258.03	247.03	249.28	10.79	1.25	0.83
9	11.00	257.19	246.61	248.36	10.37	1.25	0.78
8	11.78	256.41	246.19	247.19	10.01	1.25	0.83
7	12.61	255.59	245.76	246.76	9.61	1.25	0.73
6	13.33	254.86	245.32	246.32	9.32	1.25	0.79
5	14.12	254.07	244.88	245.88	8.97	1.25	0.91
4	15.03	253.16	244.43	245.43	8.51	1.25	1.02
3	16.05	252.14	243.97	244.97	7.94	1.50	1.10
2	17.15	251.04	243.51	244.51	7.30	1.50	1.07
1	18.22	249.97	243.04	243.04	6.70	1.50	0.88
Count Station	19.10	249.10	243.00	243.00	N/A	12.00	
248	19.10	249.10	242.00	248.00	6.60	6.00	1.16
247	20.25	247.94	241.00	247.00	6.44	6.00	0.93
246	21.18	247.02	240.00	246.00	6.52	6.00	1.05

Table 4-18 Water Level Data, Configuration No. 11A

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
245	22.23	245.97	239.00	245.00	6.47	6.00	N/A

4.3.2.2 Documentation Test, Configuration No. 11 Test B

The water surface elevations recorded in the ladder for Test Configuration No. 11B are in Table 4-19. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-43. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-44 and 4-45, respectively. Photos for this test are shown in Photos 4-20 through 4-23. Video for this test is provided in Appendix B.

In Pool 1, the jet from the Weir No. 2 slot impacted the right wall midway between Weir No. 2 and Weir No. 1 then continued along Weir No. 1 around the baffle block and through the slot. A portion of the flow through the slot in Weir No. 2 followed the face of Weir No. 2 to the right wall, causing constant swirling flow with an intermittent loosely formed vortex in the upstream right corner. The orifice flow impacted Weir No. 1 and upwelled between the vertical baffle on Weir No. 1 and the left wall. A portion of the surface flow from the upwelling reversed direction upstream along the left wall, and the remainder entered the slot on Weir No. 1 directly. An area of stagnation resulted in the upstream left side of the pool.

In the count station, the jet from the slot on Weir No. 1 impacted the right wall halfway between Weir No. 1 and the angled wall to the fish crowder and flowed towards the fish crowder. The majority of the flow from the main jet entered the crowder smoothly and about a quarter of the flow was diverted past the flow vane into the trash rack. The orifice flow mainly proceeded straight across the count station into the trash rack, with some flow diffusing towards the center of the pool. There was a large area of stagnation encompassing much of the left half of the diffuser.

Flow through the fish crowder was relatively smooth with intermittent flow undulation at about half depth. The flow along the floor of the crowder impacted Weir No. 248 and created an area of upwelling on the upstream face of the weir between the two vertical fins, while the remainder of the flow from the crowder split around the upwelling. A small area of stagnation was present along the angled count station walls downstream of the crowder.

In Pool 8, the jet from the slot in Weir No. 9 impacted the right wall midway between Weir No. 9 and Weir No. 8, forming an intermittent vortex in the upstream right corner. The jet then continued along Weir No. 8 around the baffle block and through the slot, creating a small area of recirculation on the right face of the baffle block. An area of stagnation was present in the upstream left side of the pool along Weir No. 9 from the slot to about 2/3 of the way to the left wall and extending into the center of the pool halfway to Weir No. 8. The orifice flow impacted Weir No. 8 and caused upwelling along the weir between the vertical baffle and the left wall. The majority of the upwelled surface water passed upstream along the wall, while about a third entered the slot on Weir No. 8 directly.

In Pools 2 and 3, the jet intermittently attached to the upstream weir. Pools 4 through 10 displayed minor upwelling where the jet impacted the right wall. The upwelling was constant in Pools 11 through 16. The jet was aimed at or just upstream of the midpoint of the right wall between the weirs in Pools 2 through 13 and 18 through 20; at the downstream right corner in Pools 14 through 16 and Pools 21 and 22; and near the center of the right portion of Weir No. 16 in Pool 17.

Flow patterns in the exit channel to the forebay were similar to those seen for Configuration No. 11 Test A.

Table 4-19 Water Level Data, Configuration No. 11B

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	262.30	N/A	N/A	N/A	N/A	0.02
Exit Channel	0.03	262.28	250.50	250.50	11.78	2.00	0.11
23	0.13	262.17	250.50	256.50	11.67	1.25	0.44
22	0.57	261.73	250.50	256.25	11.23	1.25	0.47
21	1.04	261.26	250.50	256.00	10.76	1.25	0.48
20	1.53	260.78	250.50	255.75	10.28	1.25	0.66
19	2.19	260.12	250.50	255.25	9.62	1.25	0.68
18	2.86	259.44	250.25	254.50	9.07	1.25	0.91
17	3.78	258.53	249.86	253.86	8.47	1.25	0.67
16	4.44	257.86	249.46	253.21	8.20	1.25	0.67
15	5.11	257.20	249.07	252.57	7.93	1.25	0.66
14	5.77	256.53	248.68	251.93	7.66	1.25	0.70
13	6.47	255.83	248.27	251.27	7.36	1.25	0.69
12	7.16	255.14	247.86	250.61	7.08	1.25	0.62
11	7.78	254.53	247.45	249.95	6.87	1.25	0.72
10	8.49	253.81	247.03	249.28	6.57	1.25	0.63
9	9.13	253.18	246.61	248.36	6.36	1.25	0.59
8	9.72	252.59	246.19	247.19	6.19	1.25	0.45
7	10.17	252.14	245.76	246.76	6.16	1.25	0.50
6	10.67	251.64	245.32	246.32	6.10	1.25	0.44
5	11.10	251.20	244.88	245.88	6.10	1.25	0.45
4	11.55	250.75	244.43	245.43	6.10	1.25	0.48
3	12.04	250.27	243.97	244.97	6.07	1.50	0.43
2	12.46	249.84	243.51	244.51	6.10	1.50	0.36
1	12.83	249.48	243.04	243.04	6.20	1.50	0.34
Count Station	13.17	249.14	243.00	243.00	N/A	12.00	
248	13.17	249.14	242.00	248.00	6.64	6.00	1.32
247	14.48	247.82	241.00	247.00	6.32	6.00	0.98
246	15.46	246.85	240.00	246.00	6.35	6.00	1.12
245	16.58	245.72	239.00	245.00	6.22	6.00	N/A

4.3.2.3 Documentation Test, Configuration No. 11 Test C

The water surface elevations recorded in the ladder for Test Configuration No. 11C are in Table 4-20. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-46. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-47 and 4-48, respectively. Photos for this test are shown in Photos 4-24 through 4-27. Video for this test is provided in Appendix B.

The jet from the slot in Weir No. 2 was directed towards the right wall midway between Weir No. 2 and Weir No. 1, creating minor vertical circulation along the length of the right wall. The flow left the right wall along Weir No. 1 and around the baffle block, creating a vortex on the left face of the baffle block before entering the slot. Orifice flow impacted Weir No. 1 and caused minor upwelling, most of which passed upstream along the left wall while the remainder flowed towards the slot in Weir No. 1 and interacted with the main jet to cause counterclockwise recirculation throughout the left side of Pool 1.

The jet entering the count station impacted the right wall about 1/3 of the way between Weir No. 1 and the angled wall to the fish crowder, where it caused similar vertical recirculation along the wall. Surface flow tracked along the angled wall to the crowder and was split by the flow vane, with the majority of the flow entering the fish crowder and about a third redirected through the trash rack. Orifice flow passed straight across the diffuser to the trash rack. There was a large area of stagnation located over the center of the diffuser.

Flow through the fish crowder was stable with little or no swirling action inside the crowder area. The flow exiting the crowder passed directly into the face of Weir No. 248, and was then drawn equally to either side of the weir. Flow from the trash rack passed to the left opening in Weir No. 248.

In Pool 8, the jet from the slot on Weir No. 9 was directed evenly towards the right hand wall resulting in minor upwelling along the length of the wall. Flow continued to track the wall to Weir No. 8 and around the baffle block to the slot. Orifice flow passed mainly to the next orifice, with a portion of the flow directed onto Weir No. 8 where it caused minor upwelling and vertical recirculation back into the orifice flow. Surface flow generally reversed direction along the left wall, while a portion flowed around the vertical baffle to enter the slot on Weir No. 8. An area of stagnation developed in the left side of the pool.

The jet was aimed upstream of the center of the right wall in Pools 2 through 10, at the downstream right corner in Pools 11 through 16 and Pool 22, and at the center of the right wall in Pools 18-21. The jet in Pool 17 oscillated between the above patterns. Minor upwelling occurred where the jet impacted the wall in all cases.

Table 4-20 Water Level Data, Configuration No. 11C

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	262.81	N/A	N/A	N/A	N/A	0.02
Exit Channel	0.02	262.79	250.50	250.50	12.29	2.00	0.10
23	0.12	262.69	250.50	256.50	12.19	1.25	0.44
22	0.56	262.25	250.50	256.25	11.75	1.25	0.51
21	1.07	261.74	250.50	256.00	11.24	1.25	0.47
20	1.54	261.28	250.50	255.75	10.78	1.25	0.66
19	2.20	260.61	250.50	255.25	10.11	1.25	0.69
18	2.89	259.93	250.25	254.50	9.55	1.25	0.99
17	3.88	258.94	249.86	253.86	8.88	1.25	0.65
16	4.53	258.29	249.46	253.21	8.63	1.25	0.65
15	5.17	257.64	249.07	252.57	8.37	1.25	0.73
14	5.91	256.91	248.68	251.93	8.03	1.25	0.62

Table 4-20 Water Level Data, Configuration No. 11C

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
13	6.53	256.29	248.27	251.27	7.81	1.25	0.72
12	7.25	255.57	247.86	250.61	7.50	1.25	0.66
11	7.91	254.90	247.45	249.95	7.24	1.25	0.69
10	8.61	254.21	247.03	249.28	6.97	1.25	0.72
9	9.32	253.49	246.61	248.36	6.67	1.25	0.62
8	9.94	252.88	246.19	247.19	6.48	1.25	0.45
7	10.39	252.42	245.76	246.76	6.45	1.25	0.52
6	10.91	251.91	245.32	246.32	6.36	1.25	0.49
5	11.40	251.42	244.88	245.88	6.31	1.25	0.51
4	11.91	250.90	244.43	245.43	6.25	1.25	0.55
3	12.46	250.35	243.97	244.97	6.15	1.50	0.48
2	12.95	249.87	243.51	244.51	6.13	1.50	0.44
1	13.39	249.42	243.04	243.04	6.15	1.50	0.34
Count Station	13.73	249.09	243.00	243.00	N/A	12.00	
248	13.73	249.09	242.00	248.00	6.59	6.00	1.06
247	14.79	248.03	241.00	247.00	6.53	6.00	1.07
246	15.86	246.96	240.00	246.00	6.46	6.00	1.02
245	16.88	245.94	239.00	245.00	6.44	6.00	N/A

4.3.2.4 Documentation Test, Configuration No. 11 Test D

The water surface elevations recorded in the ladder for Test Configuration No. 11D are in Table 4-21. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-49. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-50 and 4-51, respectively. Photos for this test are shown in Photos 4-28 through 4-31. Video for this test is provided in Appendix B.

The main jet from the slot in Weir No. 9 impacted the right wall about a third of the way between Weir No. 9 and Weir No. 8, causing minor upwelling on the wall, and continued along the face of Weir No. 1 and around the baffle block. The flow around the baffle block created a vortex on its upstream face. Recirculation in the upstream right corner was caused by the upstream portion of the jet. In the left side of Pool 1, there was a large area of stagnation along Weir No. 2 between the slot and the orifice, extending midway to Weir No. 1. Flow from the orifice in Weir No. 2 was generally directed at the following orifice, with a portion of the expanding jet impacting Weir No. 1 and creating minor upwelling. The surface flow from the upwelling split into three portions: flow upstream along the left wall; flow into the center of the left side of the pool (directed either into the stagnation area or back into the orifice flow); and flow directly into the slot in Weir No. 1.

In the count station, the jet from Weir No. 1 impacted the right wall a quarter of the way between Weir No. 1 and the angled wall from the crowder, causing minor upwelling on the angled wall and creating an area of recirculation along the face of Weir No. 1. The flow then followed the angled wall until the flow vane split the flow between the crowder and the trash rack, with a majority flowing through the crowder. Orifice flow was constant along the left wall and passed directly through the trash rack. A large stagnant area was present over the diffuser between Weir No. 1.

The flow through the fish crowder was relatively stable with some undulation in the lower half. Flow exiting the crowder impacted Weir No. 248, passed around the vertical fins, and over the weir crest.

In Pool 8, the jet from the slot in Weir No. 9 impacted the right wall about a third of the way between Weir No. 9 and Weir No. 8, causing minor upwelling along the length of the wall and creating an area of recirculation in the upstream right corner. The main jet flowed along the face of Weir No. 8 and around the baffle block into the slot. This flow caused an intermittent vortex to form on the upstream face of the baffle block. Orifice flow created minor upwelling on Weir No. 8 between the vertical baffle and the left wall, and the surface flow divided into three parts: flow upstream along the left wall; back flow down into the orifice flow; and flow tracking smoothly around the vertical baffle into the slot in Weir No. 8. The latter flow interacted with the main jet flow around the baffle block as intermittent vertical circulation.

Jets into Pools 3 through 6 adhered to the face and triangular fin of the previous weir. Pools 11, 13, 14, 18, and 19 had intermittent short circuiting creating a clockwise circulation cell in the right side of the pool. The jets into these pools oscillated between this flow pattern and impacting the right side of the downstream baffle block. The jets were aimed at the right side of the baffle block in Pools 15, 16, 20, and 21; at the center of the right baffle of the downstream weir in Pool 17; and at the downstream right corner of Pool 22.

Table 4-21 Water Level Data, Configuration No. 11D

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	262.66	N/A	N/A	N/A	N/A	0.05
Exit Channel	0.05	262.62	250.50	251.50	12.12	2.00	0.14
23	0.19	262.47	250.50	251.50	11.97	1.25	0.31
22	0.50	262.17	250.50	251.50	11.67	1.25	0.28
21	0.78	261.89	250.50	251.50	11.39	1.25	0.32
20	1.10	261.57	250.50	251.50	11.07	1.25	0.38
19	1.48	261.18	250.50	251.50	10.68	1.25	0.47
18	1.96	260.71	250.25	251.25	10.33	1.25	0.62
17	2.58	260.09	249.86	250.86	10.04	1.25	0.50
16	3.08	259.59	249.46	250.46	9.93	1.25	0.56
15	3.64	259.03	249.07	250.07	9.76	1.25	0.50
14	4.14	258.52	248.68	249.68	9.65	1.25	0.61
13	4.75	257.92	248.27	249.27	9.44	1.25	0.58
12	5.33	257.33	247.86	248.86	9.27	1.25	0.50
11	5.84	256.83	247.45	248.45	9.17	1.25	0.62
10	6.45	256.21	247.03	248.03	8.97	1.25	0.59
9	7.04	255.63	246.61	247.61	8.81	1.25	0.60
8	7.64	255.03	246.19	247.19	8.63	1.25	0.66
7	8.29	254.37	245.76	246.76	8.40	1.25	0.66
6	8.95	253.72	245.32	246.32	8.18	1.25	0.60
5	9.55	253.12	244.88	245.88	8.02	1.25	0.74
4	10.28	252.38	244.43	245.43	7.73	1.25	0.88
3	11.16	251.51	243.97	244.97	7.31	1.50	0.82
2	11.98	250.69	243.51	244.51	6.95	1.50	0.81
1	12.79	249.88	243.04	243.04	6.60	1.50	0.62

Table 4-21 Water Level Data, Configuration No. 11D

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Count Station	13.41	249.26	243.00	243.00	N/A	12.00	
248	13.41	249.26	242.00	248.00	6.76	6.00	1.09
247	14.50	248.17	241.00	247.00	6.67	6.00	1.03
246	15.52	247.14	240.00	246.00	6.64	6.00	1.11
245	16.63	246.03	239.00	245.00	6.53	6.00	N/A

4.3.2.5 Documentation Test, Configuration No. 11 Test E

The water surface elevations recorded in the ladder for Test Configuration No. 11E are in Table 4-22. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-52. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-53 and 4-54, respectively. Photos for this test are shown in Photos 4-32 through 4-35. Video for this test is provided in Appendix B.

In Pool 1, the jet from the slot in Weir No. 2 short circuited and entered the slot in Weir No. 1 directly the majority of the time, alternating with the jet impacting the downstream right corner and recirculating back towards the slot in Weir No. 2. During the primary pattern, a vortex formed on the right side of the baffle block on Weir No. 1. In the secondary pattern, an intermittent vortex formed in the downstream right corner, with eddy shedding along the right wall and to the left of the jet. There were stagnant areas in the upstream right corner and along Weir No. 2 from the slot to the left wall extending about a third of the way into the pool towards Weir No. 1. Orifice flow proceeded straight from the orifice in Weir No. 2 to the orifice in Weir No.1. Recirculation occurred to the left of the main jet where it interacted with the orifice flow near the vertical baffle on Weir No. 1.

In the count station, the jet through the Weir No. 1 slot impacted the right wall midway between Weir No. 1 and the angled wall to the crowder, causing upwelling, then tracked along the angled wall to the entrance to the fish crowder. About 2/3 of the flow passed through the crowder, with the remainder diverted past the flow vane into the trash rack. Orifice flow exited the orifice in Weir No. 1 and entered the trash rack in the left portion of the trash rack. There was a large area of stagnation in the upstream left corner between the slot in Weir No. 1 and the left wall where it intersected with the trash rack.

Flow through the crowder was generally uniform with minor vertical velocity variations. The flow exited the crowder somewhat more to the right side. The flow impacted Weir No. 248, upwelled and flowed around both sides of the weir. Flow from the trash rack proceeded straight to the left side of the weir.

In Pool 8, the jet from the slot in Weir No. 9 impacted Weir No. 8 about 2/3 of the way between the baffle block and the right wall. The jet caused upwelling along Weir No. 8 from that point to the baffle block. Some flow from the jet recirculated from the right downstream corner back along the right wall and returned to the main jet. There was an area of stagnation in the right upstream corner between Weir No. 9 and the jet. A constant vortex with a diffuse core formed off the baffle block on Weir No. 8, was occasionally swept downstream, and reformed immediately. Intermittent vortices occurred along the right wall and on the left edge of the jet. There was an arc-shaped area of stagnation from the left edge of the jet to the orifice flow. The orifice flow impacted Weir No. 8 and caused minor upwelling and reverse flow along the left wall.

The jets into Pool 2 and Pools 4 through 22 oscillated between the upstream face of the baffle block and halfway across the upstream right face of the weir. The jet in Pool 3 oscillated between the upstream face of Weir No. 3 and the right downstream corner of the pool. In all pools, there was a constant vortex located on the left face of the baffle block and intermittent vortices shed off of the left edge of the jet. Upwelling occurred on the baffle block and right wall in Pools 4 through 22; this effect is minor in Pools 19 through 22. The flow from the orifices impacted the downstream weir and created minor upwelling in all pools with reverse flow along the left wall. There were recirculation areas along the right wall and in the upstream right corner.

Table 4-22 Water Level Data, Configuration No. 11E

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	262.50	N/A	N/A	N/A	N/A	0.04
Exit Channel	0.04	262.46	250.50	250.50	11.96	2.00	0.23
23	0.27	262.23	250.50	250.50	11.73	1.25	0.31
22	0.57	261.93	250.50	250.50	11.43	1.25	0.28
21	0.85	261.65	250.50	250.50	11.15	1.25	0.32
20	1.18	261.32	250.50	250.50	10.82	1.25	0.37
19	1.54	260.96	250.50	250.50	10.46	1.25	0.44
18	1.98	260.52	250.25	250.25	10.14	1.25	0.62
17	2.60	259.90	249.86	249.86	9.85	1.25	0.47
16	3.07	259.43	249.46	249.46	9.77	1.25	0.58
15	3.66	258.84	249.07	249.07	9.58	1.25	0.50
14	4.15	258.35	248.68	248.68	9.47	1.25	0.59
13	4.74	257.76	248.27	248.27	9.29	1.25	0.57
12	5.31	257.19	247.86	247.86	9.13	1.25	0.57
11	5.88	256.62	247.45	247.45	8.96	1.25	0.59
10	6.47	256.03	247.03	247.03	8.79	1.25	0.64
9	7.12	255.38	246.61	246.61	8.57	1.25	0.66
8	7.77	254.73	246.19	246.19	8.33	1.25	0.66
7	8.43	254.07	245.76	245.76	8.10	1.25	0.70
6	9.14	253.36	245.32	245.32	7.82	1.25	0.68
5	9.82	252.68	244.88	244.88	7.58	1.25	0.69
4	10.50	252.00	244.43	244.43	7.35	1.25	0.81
3	11.31	251.19	243.97	243.97	7.00	1.50	0.75
2	12.05	250.45	243.51	243.51	6.71	1.50	0.76
1	12.81	249.69	243.04	243.04	6.41	1.50	0.62
Count Station	13.43	249.07	243.00	243.00	N/A	12.00	
248	13.43	249.07	242.00	248.00	6.57	6.00	1.11
247	14.54	247.96	241.00	247.00	6.46	6.00	0.94
246	15.48	247.02	240.00	246.00	6.52	6.00	1.11
245	16.59	245.91	239.00	245.00	6.41	6.00	N/A

4.3.2.6 Documentation Test, Configuration No. 11 Test F

The water surface elevations recorded in the ladder for Test Configuration No. 11F are in Table 4-23. Sketches of the flow patterns in the count station and Pool 8 are provided in Figure 4-55. Velocity vectors representing the flow conditions in the count station and Pool 8 are shown in Figures 4-56 and 4-57, respectively. Photos for this test are shown in Photos 4-36 through 4-39. Video for this test is provided in Appendix B.

The Weir No. 2 slot jet into Pool 1 tended to short circuit into the slot in Weir No. 1 with a slight curve into the right side of the pool. A portion of the jet continued straight towards the vertical baffle on Weir No. 1 rather than entering the slot. A clockwise circulation cell developed on the right side of the pool and a counterclockwise cell was present in the downstream left side. Orifice flow diffused midway through the pool after intersecting the circulation cell from the left side of the jet. There was a stagnant area along Weir No. 2 between the slot and the orifice extending about ¼ of the way into the pool towards Weir No. 1.

In the count station, flow from the Weir No. 1 slot entered as a broad jet and impacted the right wall about 2/3 of the way from Weir No. 1 to the angled wall to the crowder. Flow continued along the wall through the fish crowder. In the upstream right corner, a small recirculation was present. A portion of the flow from the slot in Weir No. 1 flowed directly to the crowder, with some of the flow diverted by the flow vane towards the trash rack. There was a boot-shaped stagnant area at the upstream left side of the diffuser, extending from Weir No. 1 along the left side of the slot jet to the center of the count station. Flow downstream of this area slowly entered the trash rack. Orifice flow passed straight across the diffuser and through the trash rack.

Flow through the fish crowder was generally uniform, with minor vertical velocity variations in the lower third of the stream. Flow exiting the crowder mainly passed to the right side of Weir No. 248. Some flow also passed to the left along the trash rack. Flow in the lower portion of the crowder continued out of the crowder directly to Weir No. 248, upwelling and flowing to either side of the weir.

In Pool 8, the Weir No. 9 slot jet flows towards the middle of the right baffle of Weir No. 8. This pattern was predominant, with intermittent short circuiting straight to the Weir No. 8 slot. Flow in the right side of the pool recirculated slowly, with a small stagnant area in the upstream right corner. A counter clockwise circulation cell developed in the left half of the pool. The orifice flow generally entered the Weir No. 8 orifice directly, with a portion tending to flow towards the slot.

All pools exhibited generally similar flow patterns. The slot jets were aimed at their respective downstream baffle blocks and intermittently short circuited. There was an area of recirculation in the upstream right corner of the pool and along the right wall, which was intermittently moving and stagnant. There was a constant swirling on the left side of the baffle block caused by flow from the previous slot. Orifice flow moved directly towards the next orifice, a small portion of which impacted the downstream baffle block and created minor upwelling and reverse flow along the upper portion of the left wall.

Table 4-23 Water Level Data, Configuration No. 11F

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
Forebay	0.00	257.25	N/A	N/A	N/A	N/A	0.03
Exit Channel	0.03	257.22	250.50	250.50	6.72	2.00	0.16
23	0.19	257.06	250.50	250.50	6.56	1.25	0.21
22	0.41	256.85	250.50	250.50	6.35	1.25	0.23
21	0.63	256.62	250.50	250.50	6.12	1.25	0.23

Table 4-23 Water Level Data, Configuration No. 11F

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Depth at Pool Center (ft)	Slot Width (ft)	Headloss (proto ft)
20	0.86	256.39	250.50	250.50	5.89	1.25	0.29
19	1.15	256.10	250.50	250.50	5.60	1.25	0.33
18	1.48	255.77	250.25	250.25	5.40	1.25	0.59
17	2.07	255.18	249.86	249.86	5.13	1.25	0.37
16	2.44	254.82	249.46	249.46	5.15	1.25	0.43
15	2.87	254.39	249.07	249.07	5.12	1.25	0.35
14	3.22	254.04	248.68	248.68	5.16	1.25	0.40
13	3.62	253.64	248.27	248.27	5.16	1.25	0.38
12	3.99	253.26	247.86	247.86	5.19	1.25	0.38
11	4.37	252.88	247.45	247.45	5.22	1.25	0.38
10	4.75	252.50	247.03	247.03	5.26	1.25	0.37
9	5.12	252.14	246.61	246.61	5.32	1.25	0.35
8	5.47	251.78	246.19	246.19	5.38	1.25	0.35
7	5.83	251.43	245.76	245.76	5.45	1.25	0.35
6	6.18	251.08	245.32	245.32	5.53	1.25	0.29
5	6.47	250.78	244.88	244.88	5.68	1.25	0.32
4	6.79	250.46	244.43	244.43	5.81	1.25	0.28
3	7.07	250.19	243.97	243.97	5.99	1.50	0.25
2	7.32	249.93	243.51	243.51	6.19	1.50	0.22
1	7.54	249.72	243.04	243.04	6.44	1.50	0.25
Count Station	7.79	249.47	243.00	243.00	N/A	12.00	
248	7.79	249.47	242.00	248.00	6.97	6.00	1.31
247	9.09	248.16	241.00	247.00	6.66	6.00	0.98
246	10.08	247.18	240.00	246.00	6.68	6.00	1.04
245	11.12	246.14	239.00	245.00	6.64	6.00	N/A

4.3.3 Water Level Fluctuation Testing

ENSR conducted water level fluctuation tests to assess the variability in water surface in the ladder pools over the entire operating range. These tests were referred to as the “Insurance Tests” and provided additional documentation of water levels over a range of forebay elevations, ladder flows, and sill settings. ENSR documented hydraulic conditions in the ladder for the insurance tests as summarized in Table 4-24. As in the baseline and modification testing programs, ladder flows, diffuser flows, forebay elevation, weir pool elevations, and water surface elevation in the count station were documented for each test. ENSR used the estimates provided by the USACE for the exit section, diffuser, and total ladder flows as a starting point for the test program. For each test the desired flows were set for the exit section and diffuser, the model was allowed to stabilize and the water surface elevation in the model forebay was recorded.

Table 4-24 Water Level Fluctuation Test Program

Test	Weirs	Sills	Target Forebay Elev. (ft)	Actual Forebay Elev. (ft)	Weir Head (ft)	Exit Section Flow (cfs)	Diffuser Flow (cfs)	Ladder Flow (cfs)
1	Final design	High	268.0	268.3	1.0	84.3	0.61	84.9
2	Final design	High	267.0	267.1	1.0	76.0	9.0	85.0
3	Final design	High	266.0	266.0	1.0	68.0	17.0	85.0
4	Final design	High	265.0	265.0	1.0	60.7	24.3	85.0
5	Final design	High	264.0	263.9	1.0	53.1	31.9	85.0
6	Final design	High	263.0	263.0	1.0	46.7	38.3	85.0
7	Final design	High	262.5	262.5	1.0	43.2	41.9	85.0
8	Final design	High	262.0	262.0	1.0	39.9	45.2	85.0
9	Final design	High	261.0	261.1	1.0	33.7	51.4	85.0
10	Final design	1-ft	265.0	265.3	1.0	88.3	0.0	88.3
11	Final design	1-ft	264.0	264.0	1.0	77.2	7.8	85.0
12	Final design	1-ft	263.0	263.3	1.0	72.7	12.3	85.0
13	Final design	1-ft	262.5	262.6	1.0	68.0	17.0	85.0
14	Final design	1-ft	262.0	262.0	1.0	64.6	20.4	85.0
15	Final design	1-ft	261.0	260.9	1.0	57.7	27.4	85.0
16	Final design	1-ft	260.0	259.9	1.0	50.5	34.6	85.0
17	Final design	1-ft	259.0	259.0	1.0	43.9	41.1	85.0
18	Final design	1-ft	258.0	257.9	1.0	37.8	47.2	85.0
19	Final design	1-ft	257.0	256.9	1.0	31.9	53.1	85.0
20	Final design	No Sills	264.0	263.9	1.0	84.0	1.0	85.0
21	Final design	No Sills	263.0	263.2	1.0	77.2	7.9	85.0
22	Final design	No Sills	262.5	262.6	1.0	73.7	11.3	85.0
23	Final design	No Sills	262.0	262.2	1.0	70.0	15.0	85.0
24	Final design	No Sills	261.0	261.1	1.0	63.1	21.9	85.0
25	Final design	No Sills	250.0	260.2	1.0	57.1	28.0	85.0
26	Final design	No Sills	259.0	259.2	1.0	50.5	34.6	85.0
27	Final design	No Sills	258.0	258.0	1.0	43.2	41.9	85.0
28	Final design	No Sills	257.0	257.1	1.0	37.8	47.2	85.0

In addition to the single water surface elevation measurements made in each pool, time series of water levels in two representative pools for each test were recorded. Measurements were made with pressure transducers at the centerline (CL) and near the right wall (RW) of Pools 8 and 10. Four pressure transducers were installed on taps in the floor of Pools 8 and 10 (two in each pool) at the locations shown in Figure 4-58. The measurement locations were chosen to capture the water surface variation in the center of the pool (CL) and at the approximate location where the slot jet impacts the wall. The RW location was based on discussions with USACE and a review of previous observations of the range of jet impact locations on the right ladder wall. The pressure transducers were calibrated to a static water level prior to testing and halfway through the test program. A time series of pressure measurements was recorded by each transducer at a 1Hz frequency over a period of approximately 30 minutes.

Figures 4-59 through 4-62 present water surface level fluctuation test results for Insurance Test 1 at the centerline of Pool 8, the right wall of Pool 8, the centerline of Pool 16, and the right wall of Pool 16, respectively. The fluctuation was defined as the difference between the instantaneous water surface elevation and the average water surface elevation for the test at that location. Similar figures showing fluctuation in water surface elevation for the remaining insurance tests are located in the raw data appendix (Appendix B).

Table 4-25 summarizes the excursion in the water surface level at each measurement location for Insurance Tests 1 through 28, calculated as the difference between the maximum and minimum water surface level measured during the test. In addition, the water surface elevation in each pool from the manometer reading is provided.

Table 4-25 Water Level Excursion Data, Insurance Tests 1 through 28

Insurance Test #	Pool	Location	Manometer WSE (ft)	WSE Excursion (ft)
1	8	Centerline	256.4	0.30
1	8	Right Wall	256.4	0.40
1	16	CL	262.8	0.28
1	16	RW	262.8	0.35
2	8	CL	255.7	0.26
2	8	RW	255.7	0.45
2	16	CL	261.8	0.24
2	16	RW	261.8	0.32
3	8	CL	255.0	0.24
3	8	RW	255.0	0.45
3	16	CL	260.8	0.22
3	16	RW	260.8	0.24
4	8	CL	254.3	0.27
4	8	RW	254.3	0.35
4	16	CL	260.1	0.25
4	16	RW	260.1	0.23
5	8	CL	253.6	0.24
5	8	RW	253.6	0.28
5	16	CL	259.2	0.22
5	16	RW	259.2	0.34
6	8	CL	253.0	0.18
6	8	RW	253.0	0.22
6	16	CL	258.4	0.17
6	16	RW	258.4	0.27
7	8	CL	252.7	0.18
7	8	RW	252.7	0.22
7	16	CL	258.0	0.17
7	16	RW	258.0	0.27
8	8	CL	252.3	0.16
8	8	RW	252.3	0.20
8	16	CL	257.6	0.17
8	16	RW	257.6	0.29
9	8	CL	251.7	0.16
9	8	RW	251.7	0.24
9	16	CL	256.8	0.19
9	16	RW	256.8	0.25
10	8	CL	256.9	0.47
10	8	RW	257.1	0.48

Table 4-25 Water Level Excursion Data, Insurance Tests 1 through 28

Insurance Test #	Pool	Location	Manometer WSE (ft)	WSE Excursion (ft)
10	16	CL	262.1	0.34
10	16	RW	262.4	0.37
11	8	CL	255.9	0.49
11	8	RW	255.9	0.51
11	16	CL	260.8	0.29
11	16	RW	260.8	0.24
12	8	CL	255.4	0.18
12	8	RW	255.4	0.28
12	16	CL	260.2	0.26
12	16	RW	260.2	0.23
13	8	CL	255.0	0.29
13	8	RW	255.0	0.29
13	16	CL	259.6	0.27
13	16	RW	259.6	0.18
14	8	CL	254.6	0.18
14	8	RW	254.6	0.28
14	16	CL	259.1	0.26
14	16	RW	259.1	0.23
15	8	CL	253.9	0.28
15	8	RW	253.9	0.36
15	16	CL	258.1	0.26
15	16	RW	258.1	0.20
16	8	CL	253.4	0.15
16	8	RW	253.4	0.26
16	16	CL	257.2	0.22
16	16	RW	257.2	0.20
17	8	CL	252.8	0.14
17	8	RW	252.8	0.28
17	16	CL	256.5	0.18
17	16	RW	256.5	0.19
18	8	CL	252.2	0.13
18	8	RW	252.2	0.22
18	16	CL	255.6	0.17
18	16	RW	255.6	0.22
19	8	CL	251.5	0.11
19	8	RW	251.5	0.19
19	16	CL	254.6	0.21
19	16	RW	254.6	0.20
20	8	CL	255.6	0.37
20	8	RW	255.6	0.25
20	16	CL	260.7	0.45
20	16	RW	260.7	0.18
21	8	CL	255.3	0.36

Table 4-25 Water Level Excursion Data, Insurance Tests 1 through 28

Insurance Test #	Pool	Location	Manometer WSE (ft)	WSE Excursion (ft)
21	8	RW	255.3	0.20
21	16	CL	260.1	0.50
21	16	RW	260.1	0.16
22	8	CL	254.9	0.36
22	8	RW	254.9	0.20
22	16	CL	259.6	0.41
22	16	RW	259.6	0.15
23	8	CL	254.6	0.32
23	8	RW	254.6	0.20
23	16	CL	259.2	0.47
23	16	RW	259.2	0.18
24	8	CL	254.0	0.34
24	8	RW	254.0	0.20
24	16	CL	258.3	0.38
24	16	RW	258.3	0.18
25	8	CL	253.4	0.29
25	8	RW	253.4	0.20
25	16	CL	257.5	0.37
25	16	RW	257.5	0.18
26	8	CL	252.8	0.23
26	8	RW	252.8	0.18
26	16	CL	256.6	0.34
26	16	RW	256.6	0.19
27	8	CL	252.1	0.24
27	8	RW	252.1	0.14
27	16	CL	255.5	0.32
27	16	RW	255.5	0.16
28	8	CL	251.6	0.17
28	8	RW	251.6	0.16
28	16	CL	254.7	0.33
28	16	RW	254.7	0.17

In general the RW water level excursion was greater than the CL excursion during tests with high or medium sills, likely a result of the jet impact on the right wall or corner. With no sills, the CL tended to have a higher water level excursion than the RW location, by an average of 0.17 feet for Pools 8 and 16 combined.

With the high sill configuration over the range of Insurance Tests conducted, no short-circuiting was observed. For the 1-ft sill configuration minor and intermittent short-circuiting was observed in the upper pools. Minor short-circuiting was observed during the no sill configuration, but the low energy/low flow condition appeared hydraulically stable and relatively consistent over the exit section.

5.0 Conclusions and Recommendations

5.1 Conclusions

The overall objective of ENSR's study was to develop a physical hydraulic scale model of the JDAN ladder exit section and count station, and use the model as a tool to assess, document, and improve the hydraulics in the exit section and count station for a series of weir configurations and potential ladder modifications. This objective was met and improvements were made to the JDAN ladder exit channel to the forebay, exit section, and count station through a combination of testing in the 1:5 scale physical model and USACE and Agency witness tests. The final JDAN ladder exit section design alleviated the potential hydraulic issues with the baseline configuration as described for each portion of the ladder below.

Exit Channel to the Forebay:

- The sills in the existing slotted weirs in the exit channel to the forebay and the upstream slotted weir were removed to increase the flow capacity of the exit channel during low forebay conditions. The existing sills and weir restricted flows at low forebay and resulting in relatively low flow depths over the sills.

- The downstream stub wall in the exit channel to the forebay was moved upstream to stabilize the hydraulics in the pool upstream of Weir No. 23.

Exit Section/Weirs:

- Rounded edges and corners were incorporated into the weir design to potentially improve passage conditions for lamprey. However, the rounded weirs and orifice openings increased the hydraulic efficiency of the weirs and required refinement of the weir sill elevations through iterative testing. In addition, the rounded slot diffused the weir jet, and resulted in short-circuiting during some flow conditions in the lower pools.

- Three sill settings were developed for the full forebay operating range from 257 ft (MOP) to 268 ft: no sills, 1-ft sills (in all weirs except Weir No. 1), and high sills. Addition of 1-ft sills to the high sill configuration helped train the slot jet flow in a direction along the slot and minimized short-circuiting in the pools. With the high sill configuration over the range of Insurance Tests conducted, no short-circuiting was observed. For the 1-ft sill configuration minor and intermittent short-circuiting was observed in the upper pools. Minor short-circuiting was observed during the no sill configuration, but the low energy/low flow condition appeared hydraulically stable and relatively consistent over the exit section.

- The final location of the weir triangles on the downstream face of the right weir baffle appeared to provide the most desirable jet trajectory of all of the positions tested, resulting in the weir slot jet generally traveling across the length of the pool to the downstream right corner and efficiently dissipating energy.

- The orifice opening was moved away from the left wall to allow for energy dissipation and prevent orifice to orifice flow with high velocities.

Count Station:

- The count station floor was raised by 1 ft to eliminate the count station ramp and the step at the downstream face of Weir No. 1, potentially streamlining the passage route through the count station.

- A lamprey “sidewalk” was added along the left side of the diffuser floor grating to provide a potential attachment point for lamprey passing to the orifice in Weir No. 1. The orifice in Weir No. 1 was maintained flush with the left side wall to enhance this passage route.

- Fairings were added to the upstream and downstream side of the count station crowder to minimize flow separation around the crowder. In addition, a series of horizontal flow guide vanes were developed by ENSR to minimize swirling through the crowder.

In general, the JDAN ladder final design exhibited no major sloshing, problems with energy dissipation, or seiching. The Insurance Tests confirmed that the water levels in the pools are relatively stable over the entire operating forebay range and that there is considerable flexibility in ladder operation over the three sill settings developed in the model study.

5.2 Recommendations

Based on the testing performed in the physical model ENSR recommends implementing the final design in the JDAN ladder as shown at prototype scale in Figure 5-1. The details of the final design changes include:

- Pools:
  - o The JDAN exit section design incorporated the pool spacing shown on the final prototype layout (Figure 5-1) and in Table 5-1. The final model layout is shown in Figure 4-37;
  - o A tapered filler piece was added to Pool 18 to fill the existing tapered section on the right sidewall per testing performed during the second site visit on August 13-15, 2007.
- Weirs: Alternative 5 – Final configuration weirs with lamprey rounding were employed. Other details included:
  - o 18-in by 18-in orifices with centers 4.0 ft from the left ladder wall were installed in Weirs No. 2 through 23 (Weir No. 1 orifice is flush against the left wall);
  - o Triangular fins were installed on downstream side of right baffles placed near the slot with accommodation for the slot flap actuator; and
  - o Weirs No. 18-23 were wider than the remaining weirs with L-shaped sill flaps to accommodate flows at lower forebay elevations (Figure 4-34 and 4-35).
- Sills:
  - o Sills were set to the final sill settings developed during the modification testing for Configuration No. 10. (Table 4-16).
  - o The three sill settings for the low, medium, and high forebay operating ranges are referred to as no-sills, 1-ft sills, and high sills, respectively.

- Exit channel to forebay (Figure 4-33):
  - o Removed the existing upstream baffle and stub wall;
  - o Modified the remaining downstream baffle wall to remove the sill and added an 18-in by 18-in orifice along the left wall flush with the bottom;
  - o Moved the remaining downstream stub wall upstream by 4.5 ft and rounded the end of the stub wall;
  - o Added a triangular flow splitter with a rounded edge to the downstream edge of the transition wall on the left side of the exit channel to the forebay; and
  - o Removed the 8-in baffle on the upstream side of the left baffle of Weir No. 23.
- Count Station (Figure 4-30 and 4-36):
  - o Raised the entire count station floor by 1.0 ft to match the elevation at the base of Weir No. 1 and sloped the floor downstream of the crowder to the base of Weir No. 248;
  - o Added an 18-in to 12-in wide solid lamprey "sidewalk" along the left side of the diffuser floor from the Weir No. 1 orifice to the count station;
  - o Added fairings to the upstream and downstream side of the count station crowder; and
  - o Added a horizontal flow guide vane to the upstream fairing on the crowder. The vane details are in Figure 4-36.

Table 5-1 Model and Prototype Exit Section Weir Stations

	Weir Station (Model in)				Weir Station (Prototype ft)			
Weir	Downstream (D/S) Baffle		Upstream (U/S) Baffle		Downstream Baffle		Upstream Baffle	
	D/S Face	U/S Face	D/S Face	U/S Face	D/S Face	U/S Face	D/S Face	U/S Face
1	0.00	2.00	4.26	6.26	0.00	0.83	1.78	2.61
2	36.00	38.00	40.26	42.26	15.00	15.83	16.78	17.61
3	71.21	73.21	75.47	77.47	29.67	30.50	31.45	32.28
4	106.01	108.01	109.84	111.84	44.17	45.00	45.77	46.60
5	140.81	142.81	144.64	146.64	58.67	59.50	60.27	61.10
6	174.41	176.41	178.24	180.24	72.67	73.50	74.27	75.10
7	208.01	210.01	211.84	213.84	86.67	87.50	88.27	89.10
8	240.41	242.41	244.24	246.24	100.17	101.00	101.77	102.60
9	272.81	274.81	276.64	278.64	113.67	114.50	115.27	116.10
10	304.80	306.80	308.63	310.63	127.00	127.83	128.60	129.43
11	337.20	339.20	341.03	343.03	140.50	141.33	142.10	142.93
12	368.40	370.40	372.23	374.23	153.50	154.33	155.10	155.93
13	399.60	401.60	403.43	405.43	166.50	167.33	168.10	168.93
14	430.80	432.80	434.63	436.63	179.50	180.33	181.10	181.93
15	460.80	462.80	464.63	466.63	192.00	192.83	193.60	194.43
16	490.80	492.80	494.63	496.63	204.50	205.33	206.10	206.93

Table 5-1 Model and Prototype Exit Section Weir Stations

Weir	Weir Station (Model in)				Weir Station (Prototype ft)			
	Downstream (D/S) Baffle		Upstream (U/S) Baffle		Downstream Baffle		Upstream Baffle	
	D/S Face	U/S Face	D/S Face	U/S Face	D/S Face	U/S Face	D/S Face	U/S Face
17	520.80	522.80	524.63	526.63	217.00	217.83	218.60	219.43
18	550.80	552.80	555.06	557.06	229.50	230.33	231.28	232.11
19	579.60	581.60	583.86	585.86	241.50	242.33	243.28	244.11
20	608.40	610.40	612.66	614.66	253.50	254.33	255.28	256.11
21	637.20	639.20	641.46	643.46	265.50	266.33	267.28	268.11
22	666.00	668.00	670.26	672.26	277.50	278.33	279.28	280.11
23	694.80	696.80	699.06	701.06	289.50	290.33	291.28	292.11

In addition, ENSR recommends the following operational measures for the final design in the JDAN ladder:

- Field adjust the bulkhead knife gate based on observations of crowder performance and count station performance.
- The sills settings developed allow for operational flexibility. USACE should determine the optimum forebay operating range for each sill setting based on the information from the physical modeling and from field performance. The final sill settings are summarized in Table 4-16.

Comment Report: All Comments
Project: John Day North Fish Ladder
Review: Physical Hydraulic Model Study Draft Report
Displaying 45 comments for the criteria specified in this report.

1547 ms to run this page

Id	Discipline	Section/Figure	Page Number	Line Number
1824633	Program Management	n/a'	4-4	paragraph 2
At first "right wall", clarify direction looking ......for example downstream from forebay entrance or north wall in prototype..... Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08				
1-0	Evaluation **Concurred** Clarified in text by adding "looking downstream". Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08			
	Current Comment Status: **Comment Closed**			
1824648	Program Management	n/a'	4-13	paragraph 2
1) explain short circuiting at first mention of it (page 4-11?) 2) In general, (add comma) Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08				
1-0	Evaluation **Concurred** Added discussion of short-circuiting in Section 1.1 Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08			
	Current Comment Status: **Comment Closed**			
1824654	Program Management	n/a'	4-15	paragraph 2
Add Comma after (268 ft), Add Comma-Paragraph 3- During the witness test, Orifice -to-orifice (add high velocity) and through flow Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08 Revised 10-Mar-08.				
1-0	Evaluation **Concurred** Made changes to text per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** okay Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08			
	Current Comment Status: **Comment Closed**			
1824660	Program Management	n/a'	4-16	paragraph 6
1) Add Comma After the ..... test, Aside 2) was the spacing of the pools documented in report? Probably just in the drawings. Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08				

1-0	Evaluation **Concurred** Made changes to text per comment. Spacing was documented in final model layout. In final, we added prototype layout drawing in Figure 5-1 with spacing. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824673	Program Management	n/a'	4-18	paragraph 1 and 2

1) Add comma For Tests 5B- 5G, 2)Use of but "we moved" the triangular to the triangular fin was moved. Applicable throughout report

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred** Made changes to text per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824686	Program Management	n/a'	4-20	paragraph 1 and 2

Add Commas During the witness testing, With this configuration in place, Fairing or Faring? throughout document-Not sure about spelling

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

1-0	Evaluation **Concurred** Made changes to text per comment. Fairing is correct spelling. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824694	Program Management	n/a'	4-21	paragraph 1

Add space- 1 ft Add USACE spreadsheet printouts to Appendix.

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred** Made changes to text per comment. Agreed with reviewer during comment review meeting that USACE will provide their spreadsheets for the DDR as the versions they provided us were not in final format. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done- discussed USACE adding spreadsheet to 30% DDR Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08

	Current Comment Status: **Comment Closed**

1824699	Program Management	n/a'	4-22	bullet 7

I- shaped sill flaps or "L"-shaped?

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred** Changed to uppercase "L" for clarity. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824702	Program Management	n/a'	4-24	paragraph 5

Add comma- In Pool 8,

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred** Made change to text per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824709	Program Management	n/a'	4-26	paragraph 1

vortex in right corner- quantify how significant (need to review videos)

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

1-0	Evaluation **Concurred** Added clarification to text. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824718	Program Management	n/a'	4-31	paragraph 2 & 5, 6

Add comma During the primary pattern, Quantify this vortex paragraph 5- Constant vortex- how big?

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred**

	Added clarification to text. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824728	Program Management	n/a'	4-35	paragraph 1

Start right wall (RW) abbreviation sooner if you like (start page 4-4)?

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Non-concurred** Chose to keep as is and use it only to refer to the transducer location. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 03-Apr-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824739	Program Management	n/a'	Figure Number 4-12 in large appendix report	n/a

Make velocity magnitude easier to discern. I used a pen tip to guess. Provide in a numerical format also?

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

Revised 10-Mar-08.

1-0	Evaluation **Concurred** Included a summary table of velocities on plots. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** The table is great Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1824744	Program Management	n/a'	Figure Number 4-42 in large appendix report	n/a

Clarify stagnation areas are tree like shaped on drawings in write up. Don't expect to quantify on each drawing

Submitted By: Natalie Richards (503-808-4879). Submitted On: 10-Mar-08

1-0	Evaluation **Concurred** Change made to drawing as requested. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** done Submitted By: Natalie Richards (503-808-4879) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1837403	Hydraulics	n/a'	General	n/a

In the end of report, the sill settings were categorized as High, med, low. The latter suggest there were sills at no Sill setting. Recommend changing to: High, Low (or 1' sill) No sills

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0 Evaluation **Concurred**
Changed text in Document Test and Insurance Test Program tables and added clarification in Section 4.3 and made text changes in Insurance Test section as appropriate.

Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08

1-1 Backcheck Recommendation **Close Comment**

Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08

Current Comment Status: **Comment Closed**

1837406	Hydraulics	n/a'	1-1, Para 2, 3rd to last sentence	n/a

85.0 & 113.0 suggest more precision than actually exits for ladder control, round to nearest whole number

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

Revised 18-Mar-08.

1-0 Evaluation **Concurred**
Made changes to text per comment.

Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08

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

Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08

Current Comment Status: **Comment Closed**

1837409	Hydraulics	n/a'	2-4, last paragrpah	n/a

Reasons for 1:5 instead of 1:10: Should probably include that viscosity will likely have more effect with the rounded shapes, and doubling the model size adds a buffer against viscous scale effects on results

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

Revised 18-Mar-08.

1-0 Evaluation **Concurred**
Added "and viscous effects" after surface tension.

Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08

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

Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08

Current Comment Status: **Comment Closed**

1837412	Hydraulics	n/a'	4-1, 2, Table 4-1	n/a

No. 2--With the removal of the Holey wall, would that not make it a modificfation rather than baseline (testing phase) No 9--ENSR did preliminary horizontal vanes on Day 2 (Count Station)

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0
Evaluation **Concurred**
In our initial test program, configuration No. 2 was the "baseline" condition and the configuration No. 1

	case with holey wall was requested as a "pre-baseline" condition. That is why we left it as baseline. Also, the initial weir configuration had not changed. We will leave it as is. Agree with second comment and made changes in text. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837416	Hydraulics	n/a'	4-4, Para 1 and Figure 4-3	n/a

Explain what the clouds, dashed lines and solid lines mean in Fig 4-3, both in text on page 4-4 and on Fig 4-3.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Made changes to text and figures per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Open Comment** Need the word 'cloud' in the 2nd sentence of 1rst Para sentence under 4.1.2.1 before 'indicates stagnation areas ...' Figures are good. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
2-0	Evaluation **Concurred** Changed text to read: "...stagnation areas and upwelling with "clouds", and the extent of the weir slot jets with dashed lines." to be consistent with the first part of the sentence. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 14-Apr-08
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 15-Apr-08
	Current Comment Status: **Comment Closed**

1837418	Hydraulics	n/a'	4-4, Para 2	n/a

Describe convention when first mention one side of channel or other (Facing downstream).

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Made changes to text per comment. See comment 1824608. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837425	Hydraulics	n/a'	4-5, Table 4-5, and all other water elev. data tables	n/a

Col 6 'Depth' Add 'Pool' to heading The values in column are currently depth over sill, need pool depths (CL) instead. Replace values in col. with pool depths.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

Revised 18-Mar-08.

1-0	Evaluation **Concurred** Made changes to tables per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837427	Hydraulics	n/a'	4-5, last sentence (runs to next page)	n/a

Could add that reason for more flow to picket lead was due to increased diffuser flow.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

Revised 18-Mar-08.

1-0	Evaluation **Concurred** Made changes to text per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837433	Hydraulics	n/a'	4-20, 1rst Para, 3rd sent.	n/a

added 1' sills...to alleviate short-circuiting. Add 'and to assure more consistent flow patterns in all pools.'

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Made changes to text per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837435	Hydraulics	n/a'	4-21	n/a

Need to mention somewhere on this page that we removed the 1' sill from Weir 1 to prevent significant violation of 1' weir head criteria there.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

Revised 18-Mar-08.

1-0	Evaluation **Concurred** Added sentence in Section 4.2.8.2. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837436	Hydraulics	n/a'	4-22, bullet 2, 1st sub-bullet	n/a
Orifice CL's are 4.0 feet from side wall (not 4.5') Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08 Revised 18-Mar-08.				
1-0	Evaluation **Concurred** Corrected dimensions in text. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08			
	Current Comment Status: **Comment Closed**			
1837437	Hydraulics	n/a'	4-23, Table 4-17	n/a
Col. 4 (see comment 1 about sill nomenclature) 6th row (11 F) Exit and difuser flows are interchanged. Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08				
1-0	Evaluation **Concurred** Changed sill nomenclature per comment 1837403; corrected configuration 11F flaws. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08			
	Current Comment Status: **Comment Closed**			
1837449	Hydraulics	n/a'	4-27, 2nd & 3rd sentences	n/a
Conclusion incorrectly based on 'depth over sill' rather than 'pool depth', which will be much deeper than minimum 5'. Delete both sentences Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08 Revised 18-Mar-08.				
1-0	Evaluation **Concurred** Deleted after correcting tables to reflect center of pool depth. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08			
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08			
	Current Comment Status: **Comment Closed**			
1837461	Hydraulics	n/a'	4-29, 2nd & 3rd sentences	n/a
Conclusion incorrectly based on 'depth over sill' rather than 'pool depth', which will be much deeper than minimum 5'. Delete both sentences Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08				
1-0	Evaluation **Concurred**			

	Deleted after correcting tables to reflect center of pool depth. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837462	Hydraulics	n/a'	4-30, last sent of Para 1	n/a

define what you mean by 'non-coherent'.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** The "non-coherent" term does not lend any additional information beyond the intermittent and as the circulation is not described as a vortex, there is no need to define it as non-coherent. Removed the term for clarity. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 01-Apr-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837464	Hydraulics	n/a'	4-34, Table 4-24	n/a

Test 10: Weir and diffuser flow rates are interchanged.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Corrected per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837468	Hydraulics	n/a'	Fig. 4-3	n/a

See comment 1837416

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Made changes to text and figures per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837470	Hydraulics	n/a'	Fig. 4-6, and all other figures with velocity vectors	n/a

Need tables of numerical magnitudes of vectors. Would like in text when referring to figures (or could be at end of text). If possible add tables to figures (paste picture?) as well for easy referenceas well.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08	
1-0	Evaluation **Concurred** Added numerical magnitudes to figures. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1837475	Hydraulics	n/a'	Fig. 4-39	n/a

Table of spacing is good in figure 4-39. Include table in text (perhaps after summarizing final config. on page 4-23) with both model and prototype dimensions.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Added Figure 5-1, Final Prototype Layout with table in the figure in prototype dimensions. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Open Comment** Liked Figure 5-1 Didn't see table added to text as requested (not big deal, but if possible, please add) Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
2-0	Evaluation **Concurred** Inserted table on page 5-3 Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 15-Apr-08
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 15-Apr-08
	Current Comment Status: **Comment Closed**

1837492	Hydraulics	n/a'	4-2 Baseline Model	n/a

Rename heading fro 4-1 to JDAS Modified Baseline Testing. We need some explanation on how we arrived at this approach. (Since I was the primary driverof this approach, I have attached some text to help you with this:) "A true baseline for of the complete existing JDAN Exit Section was not constructed. The hydraulic conditions within the existing serpentine section were well understood and documented in Modification of Fish Ladders at John Day Dam Columbia River, Oregon and Washington Technical Report No. 103-2 Hydraulic Model Investigation, Corps of Engineers, Northwest Division, Bonneville Hydraulic Laboratory 1984. The hydraulic conditions were already known to cause biological issues at both John Day North and John Day South Fishladders. The 1984 CENWD 1:10 model study also addressed the Count Station, but later alterations were made beyond the scope of the study. The hydraulic and biological conditions that contributed to salmon delay at the existing Holey Wall and Count Station were not well understood and required viewing to help understand the nature of the problems in this area. Rather than install the existing JDAN serpentine weirs, the new JDAS weirs were instead installed in their place and attached to the existing Holey Wall and Count Station to expedite schedule and provide the technical team insight into hydraulic/biologic success of the JDAS Exit Section weirs at the same time."

(Attachment: JDAS-Modfied-Baseline-Expla.doc)

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Included in text. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Open Comment** Can't find text inseration. Didn't rename heading to 'JDAS Mofified Baseline' Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
2-0	Evaluation **Concurred**

	Had added Steve's inserted into the intro section, p 1-1 previously as it seemed appropriate to discuss it up front. Also just added (JDAS Modified Baseline) to the title for Section 4.1 Baseline Model Testing. In first paragraph in section 4.1.1 changed "initial" to "baseline" for clarification per conversation with Steve. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 14-Apr-08
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 15-Apr-08
	Current Comment Status: **Comment Closed**

1837499	Hydraulics	n/a'	general -- references	n/a

add the following references to report: Asbuilt drawings: JDD- 1-4-2/1 through 2/3, JDF - 1-4--2/37 through 2/46, Walla Walla District, Corps of Engineers 1959 Asbuilt drawings: JDF-1-5-2/17 through 2/31, Walla Walla District, Corps of Engineers 1971 Asbuilt drawings: John Day South Shore Fishladder Modifications: JDF 2-18/6 through 18/9 Modification of Fish Ladders at John Day Dam Columbia River, Oregon and Washington Technical Report No. 103-2 Hydraulic Model Investigation, Corps of Engineers, Northwest Division, Bonneville Hydraulic Laboratory 1984. John Day Dam South Fish Ladder Control Section, Hydraulic Model Study, Northwest Hydraulic Consultants, August 2002.

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Added to References section - new section, moved from footnotes to section. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Open Comment** Can't find reference section. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
2-0	Evaluation **Concurred** References were included in the report as footnotes, not as a separate references section. The text of the previous comment evaluation was in error. Sorry for the confusion. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 14-Apr-08
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 15-Apr-08
	Current Comment Status: **Comment Closed**

1837500	Hydraulics	n/a'	general	n/a

Great Job!

Submitted By: Steve Schlenker (503-808-4881). Submitted On: 18-Mar-08

1-0	Evaluation **Concurred** Thanks! Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Steve Schlenker (503-808-4881) Submitted On: 11-Apr-08
	Current Comment Status: **Comment Closed**

1842973	Hydraulics	n/a'	General Comment	n/a

The authors and the engineering team responsible for this investigation have done a great job on this study and the report.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred**

	Thanks, to USACE staff as well! Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1842975	Hydraulics	n/a'	General Comment	n/a

I understand the authors will include an executive summary in the final report.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Included in final report. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1842983	Hydraulics	1.0- Introduction	1-1	n/a

Would be good to mention the scale of the physical model some where in the introduction chapter

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Added scale to intro. This was in a paragraph that got moved out of the intro section. Thanks! Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1842994	Hydraulics	1.2 - Study objectives and 2.1 Physical Modeling Objectives	1-2 and 2-1	n/a

Suggest changing the 'Physical Modeling Objectives' to 'Physical Modeling Considerations' so that we do not have 'objectives' in two consecutive sections.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

Revised 21-Mar-08.

1-0	Evaluation **Concurred** Changed per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1843025	Hydraulics	Section 2.2	2-3	n/a

The scaling of the model should be tied to a threshold Reynolds number when flow resistance become independent of Reynolds number. I suggest re-wording the paragraph right below Figure 2-1 to use threshold Reynolds number instead of the fully rough flow concept.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Removed paragraph per comment. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1843047	Hydraulics	Section 1.2 - Study Objectives	1-2	n/a

One of the objectives of this investigation is to achieve improved flow conditions in the fish ladder to enhance adult fish and lamprey passage. It will be good to define what constitutes improved flow conditions and how an improved flow condition will be quantified. I suggest elaborating on the objective of the study or somewhere in the beginning of this document the clear goals in terms of flow circulation, short circuiting, characteristics of flow jet out of orifices, stagnant flow area, and overall level of turbulence and stability of flow, i.e., what level of circulation or stagnant flow area is acceptable or not acceptable- so that we can measure success of various modifications.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

Revised 21-Mar-08.

1-0	Evaluation **Concurred** Inserted a paragraph at the end of Section 1.1 describing desired flow conditions and defining terms such as short-circuiting. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1843079	Hydraulics	n/a'	General	n/a

One of the objectives of this investigation is to include lamprey friendly features. I understand round edges and corners were incorporated into the weir design and a lamprey 'sidewalk' has been provided. It will be helpful to shed more light into how these features are lamprey friendly- although I understand there are not a lot of information in the literature on lamprey passage. Not having adequate information could be worth stating in the report.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Provided additional text. Going to be covered in USACE DDR. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1843107	Hydraulics	Sections 5-1 and 5-2	5-1 and 5-2	n/a

I suggest having a recommendation section that clearly lists the overall recommendations out of this study. someone should be able to read that section and be able to execute the recommended changes/modifications into design. Some of the items we have in the 'Conclusions' section can belong to the recommendation section. I also suggest that we refer to a set of drawings showing the recommended modifications preferably in prototype units. So that the District personnel using the drawings do not need to think about scaling or need to convert units.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Modified the conclusion and recommendations section. Also added Figure 5-1 with Final Prototype Layout. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

1843112	Hydraulics	Throughout the document	General	n/a

I spoke to ENSR project manager and communicated editorial comments.

Submitted By: Mizan Rashid (425-881-7700). Submitted On: 21-Mar-08

1-0	Evaluation **Concurred** Made changes per minor editorial comments. Submitted By: Elizabeth Roy (425-881-7700) Submitted On: 31-Mar-08
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mizan Rashid (425-881-7700) Submitted On: 07-Apr-08
	Current Comment Status: **Comment Closed**

Comment Report: Backcheck Issue Report
Project: **John Day North Fish Ladder**
Review:**For the Physical Hydraulic Model Study Draft Report**
(sorted by Discipline , ID)
Displaying 0 comments for the criteria specified in this report.

No comments found.

Report Complete

Prepared for:
USACE Portland District
Portland, OR

John Day North Ladder Physical Hydraulic Model Study Final Report

Contract No. W9127N-06-D-0004, Task Order No. 0006

Volume II of II – Photos, Figures, Appendices

ENSR Corporation
March 26, 2008
Document No.: 09000-419-702

Prepared for:
USACE Portland District
Portland, OR

John Day North Ladder Physical Hydraulic Model Study Final Report

Contract No. W9127N-06-D-0004, Task Order No. 0006

Volume II of II – Photos, Figures, Appendices

Prepared By
Elizabeth W. Roy, P.E., Project Manager

Reviewed By
Chick Sweeney, P.E., Technical Advisor

ENSR Corporation

March 26, 2008
Document No.: 09000-419-702

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Photo 3-2 View of fish crowder and count station

Photo 4-1 Configuration 1 Test A, Pool 8 Dye Released from Weir No. 9 Slot

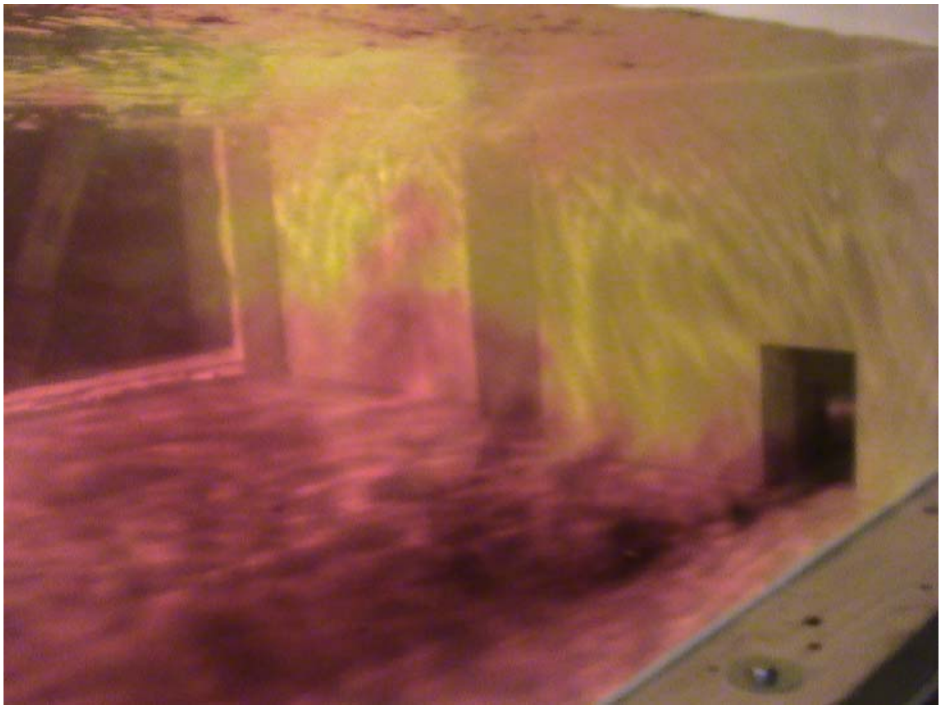

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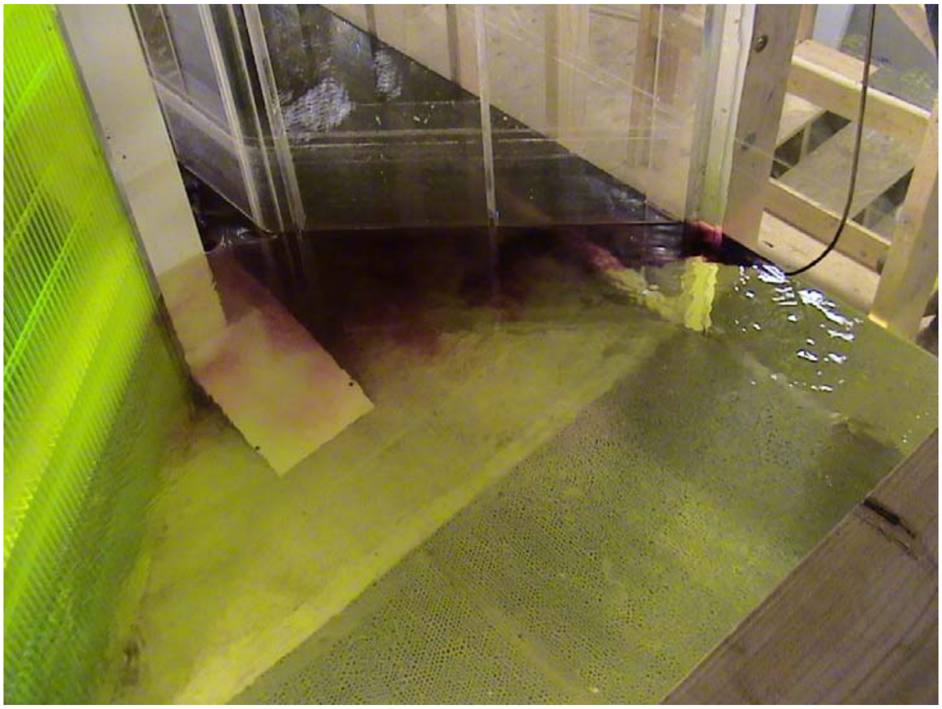
Photo 4-9 Configuration No. 2 Test B, Dye Released into Pool 8 from Weir No. 9, Looking from Left



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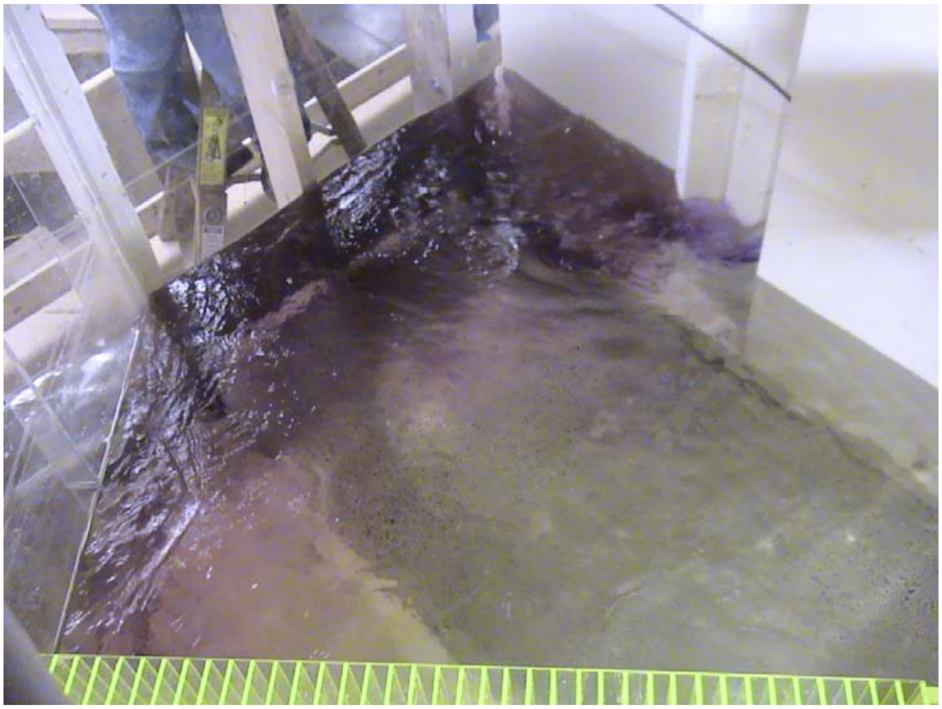


Photo 4-14 Configuration No. 2 Test E, Dye Released into Count Station from Weir No. 1, Looking from Left

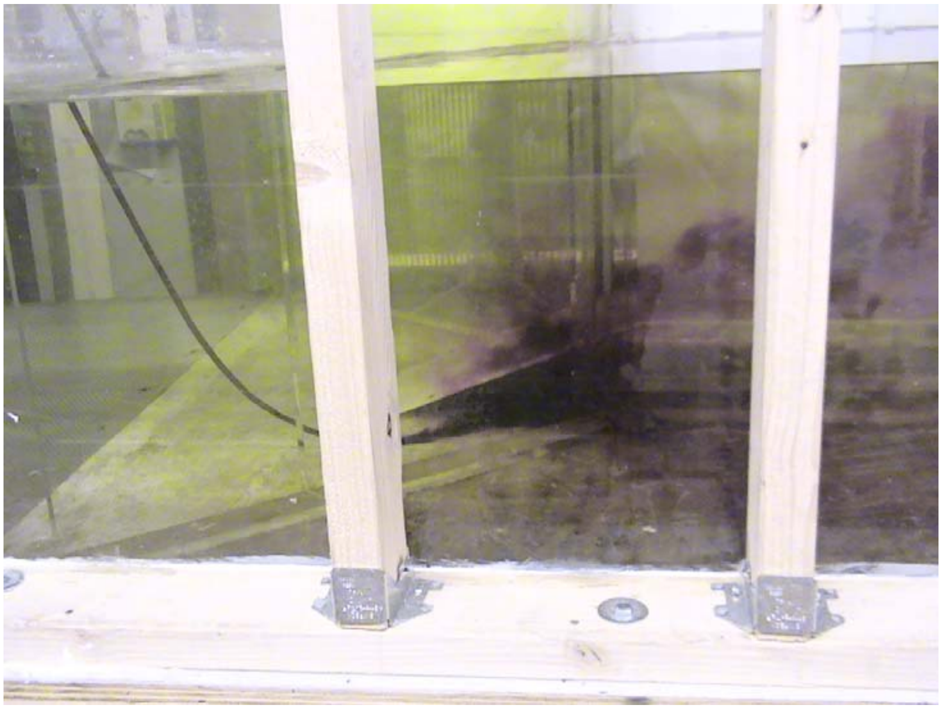
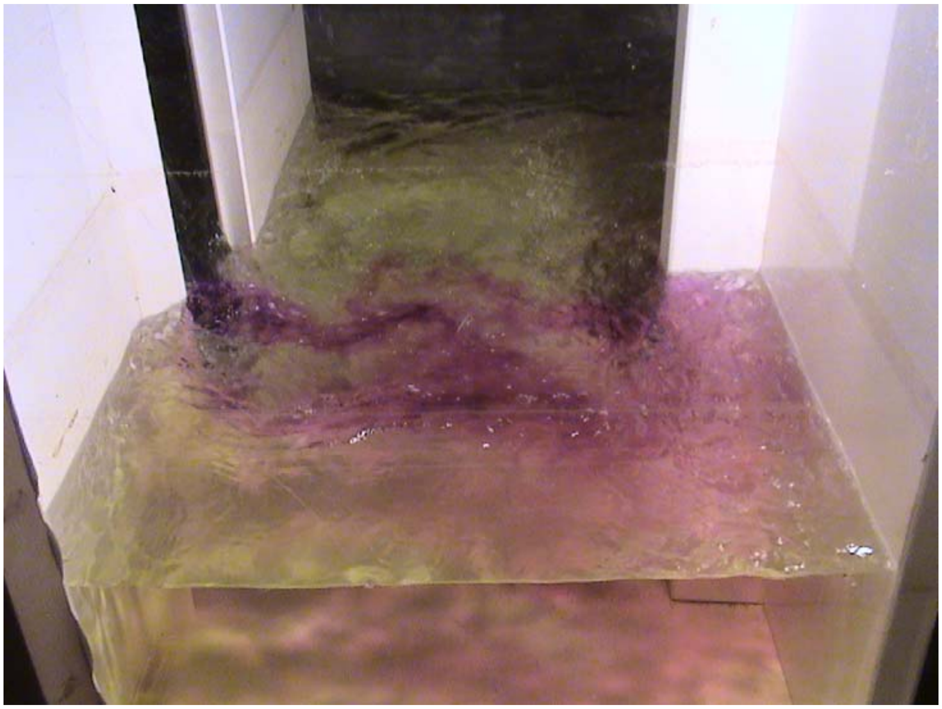


Photo 4-15 Configuration No. 2 Test E, Dye Released at the Base of the Crowder Ramp, Looking from Right



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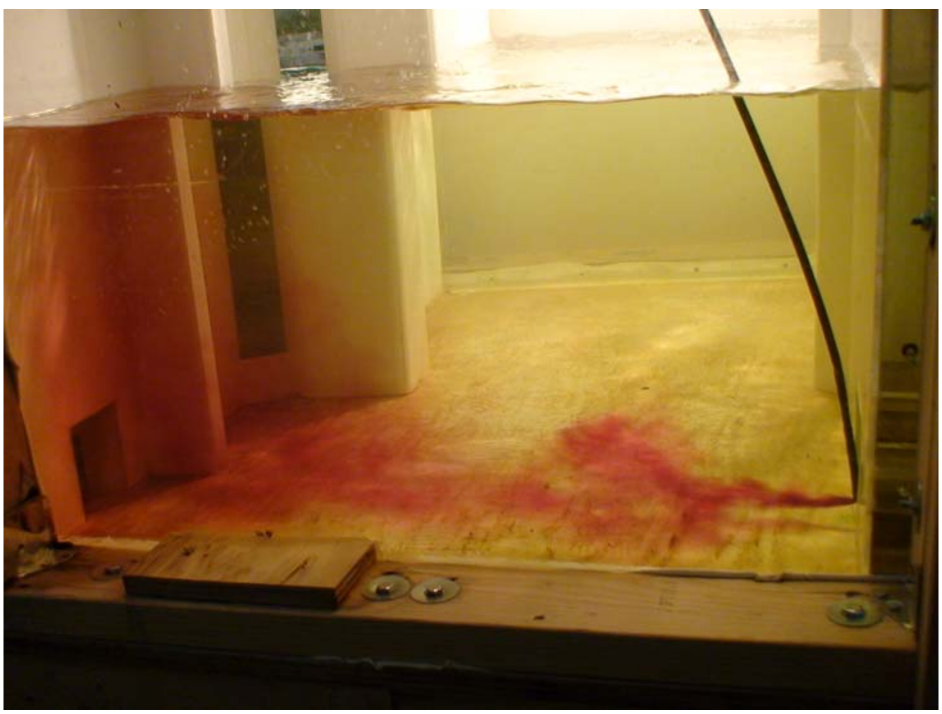

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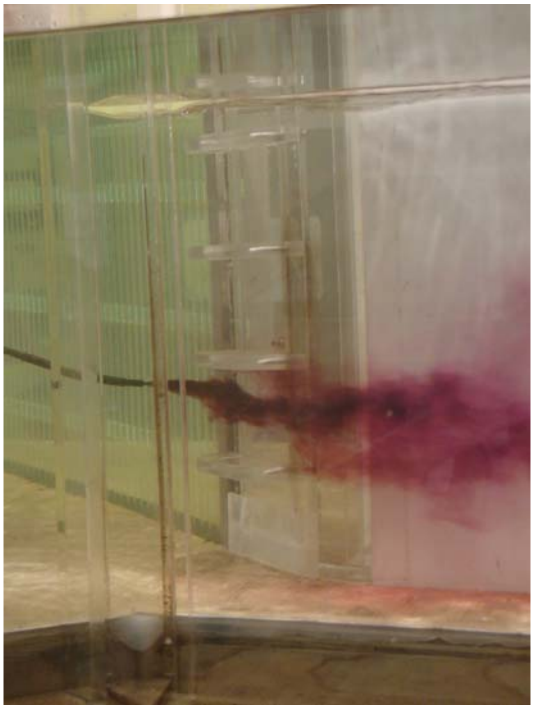

Photo 4-24 Configuration No. 11 Test C, Dye Released into Count Station from Flow Vane, Looking from Right

Photo 4-25 Configuration No. 11 Test C, Dye Released into Count Station, Looking from Left

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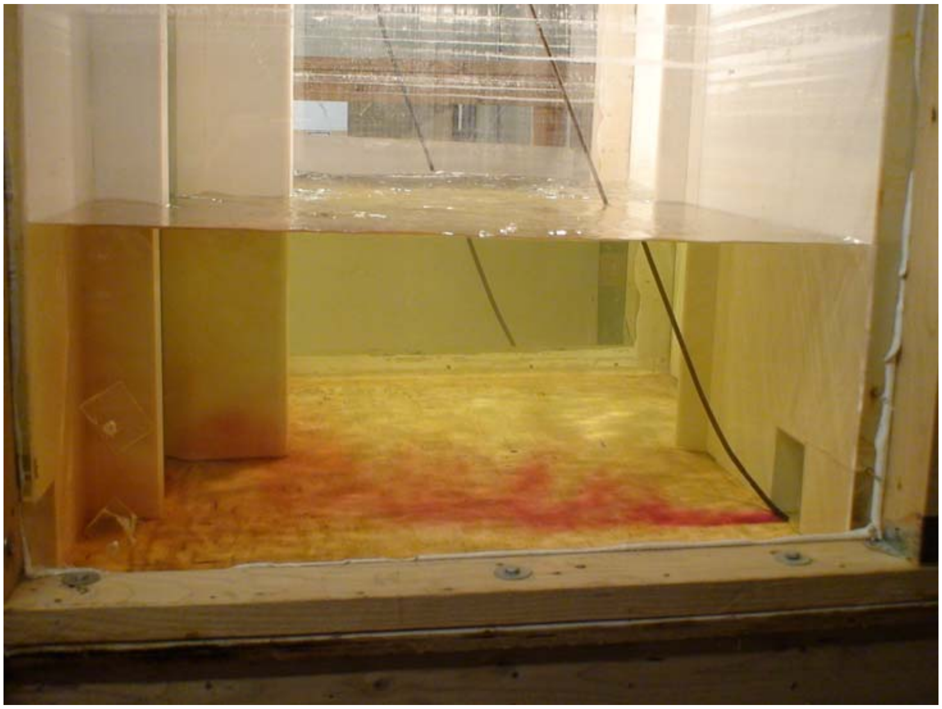


Photo 4-27 Configuration No. 11 Test C, Dye Released into Pool 8 from Weir No. 9 Orifice, Looking from Left

Photo 4-28 Configuration No. 11 Test D, Dye Released into Count Station from Flow Vane, Looking from Right

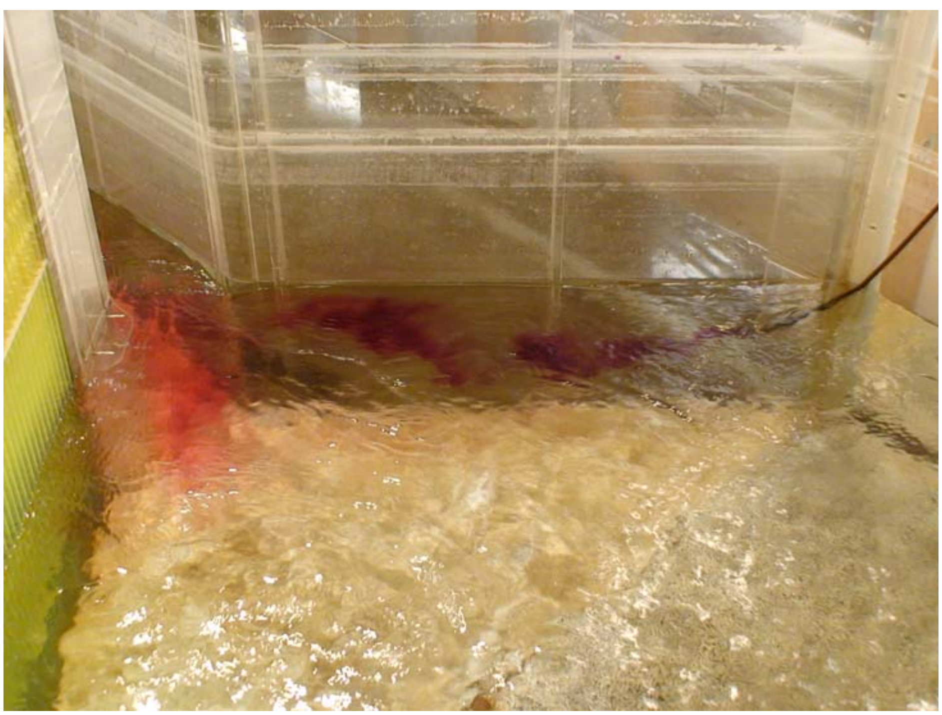


Photo 4-29 Configuration No. 11 Test D, Dye Released into Count Station, Looking from Left

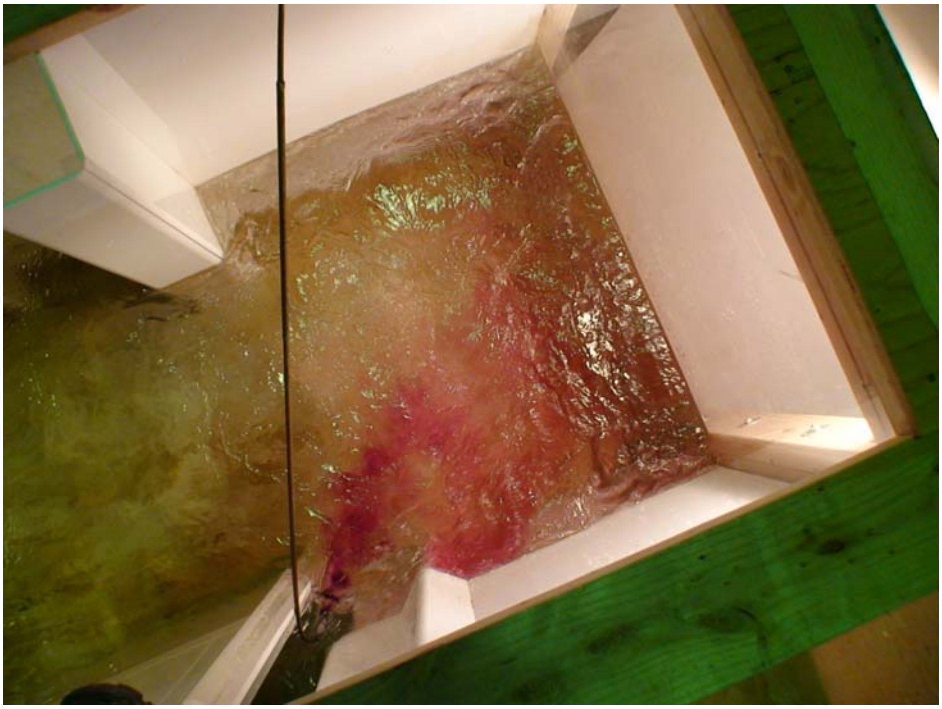


Photo 4-30 Configuration No. 11 Test D, Dye Released into Pool 8 from Weir No. 9 Slot, Looking from Above

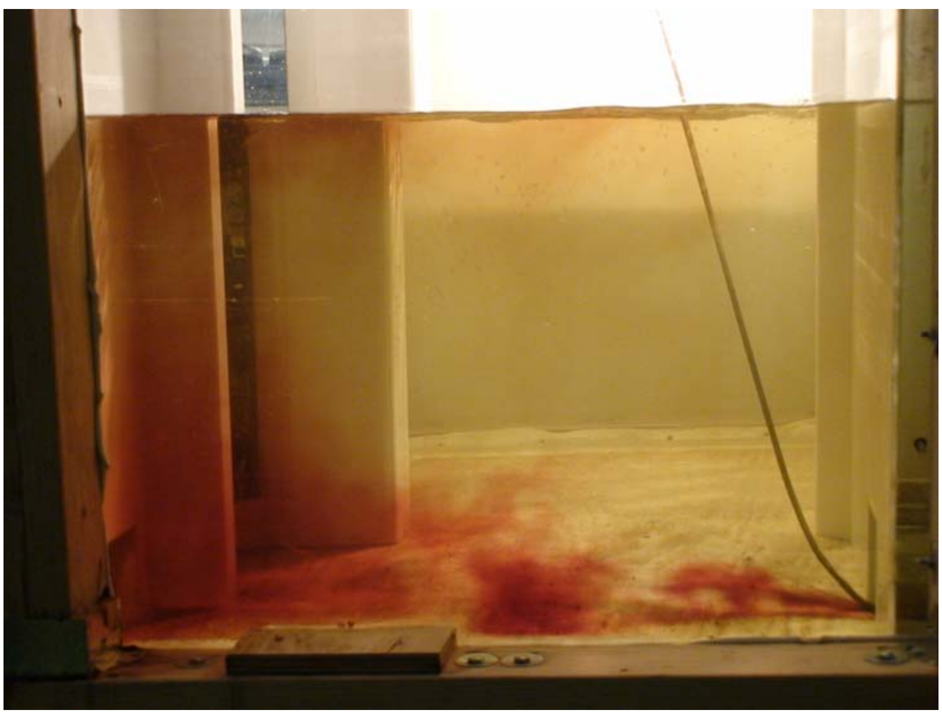


Photo 4-31 Configuration No. 11 Test D, Dye Released into Pool 8 from Weir No. 9 Orifice, Looking from Left

Photo 4-32 Configuration No. 11 Test E, Dye Released into Count Station from Flow Vane, Looking from Right

Photo 4-33 Configuration No. 11 Test E, Dye Released into Count Station, Looking from Left

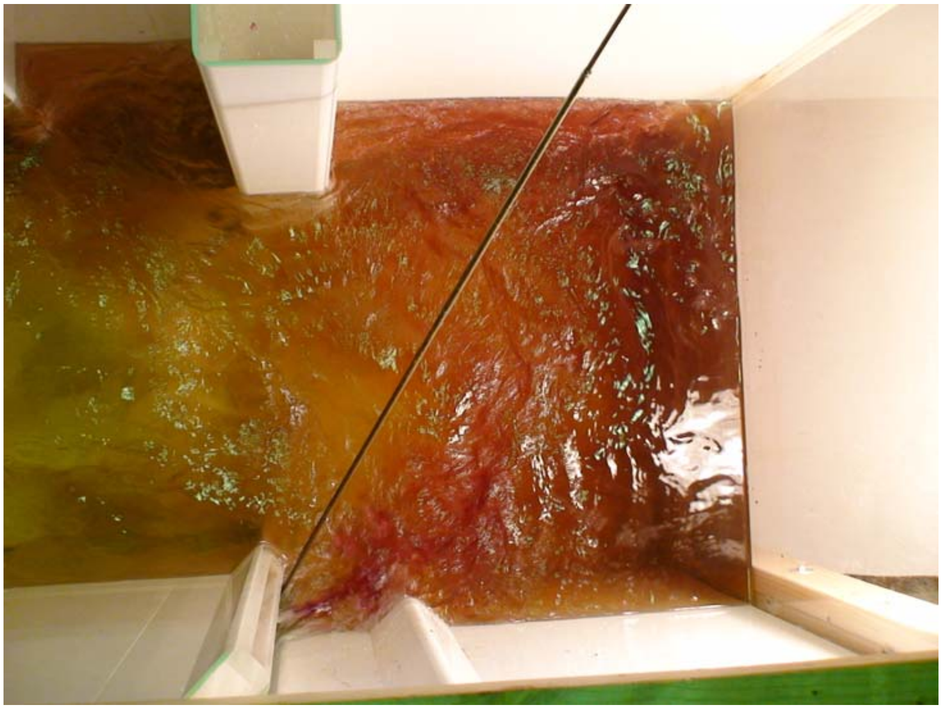


Photo 4-34 Configuration No. 11 Test E, Dye Released into Pool 8 from Weir No. 9 Slot, Looking from Above

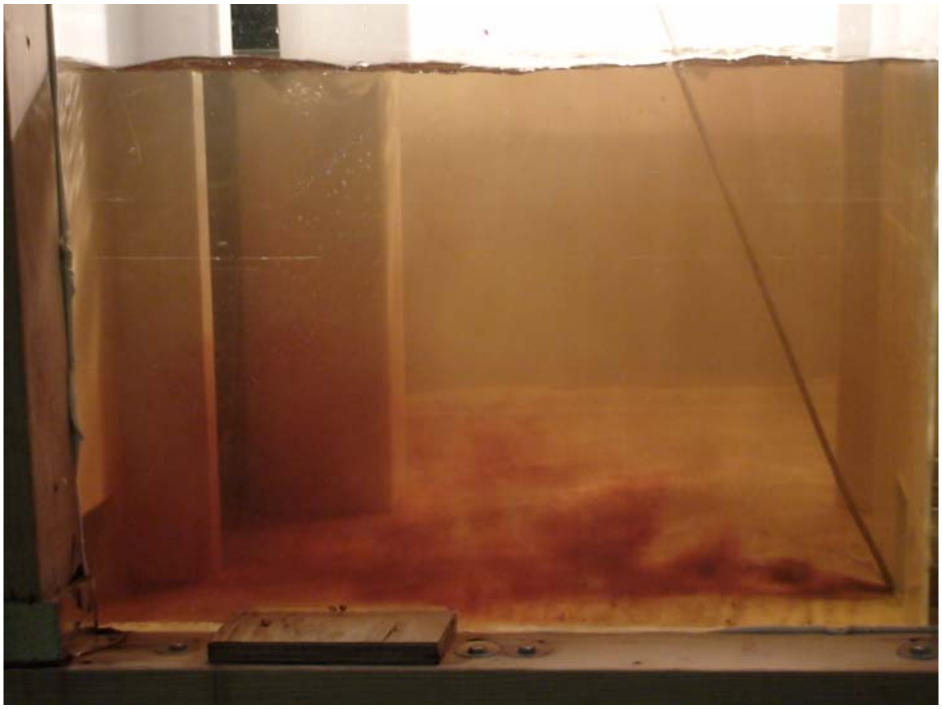


Photo 4-35 Configuration No. 11 Test E, Dye Released into Pool 8 from Weir No. 9 Orifice, Looking from Left

Photo 4-36 Configuration No. 11 Test F, Dye Released into Count Station from Flow Vane, Looking from Right

Photo 4-37 Configuration No. 11 Test F, Dye Released into Count Station, Looking from Left

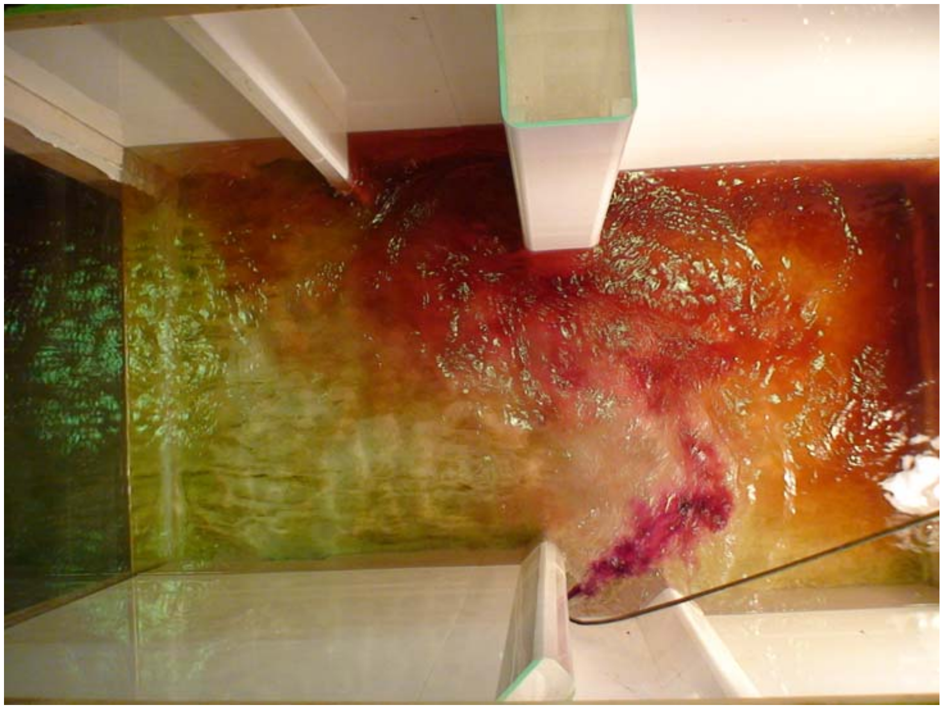
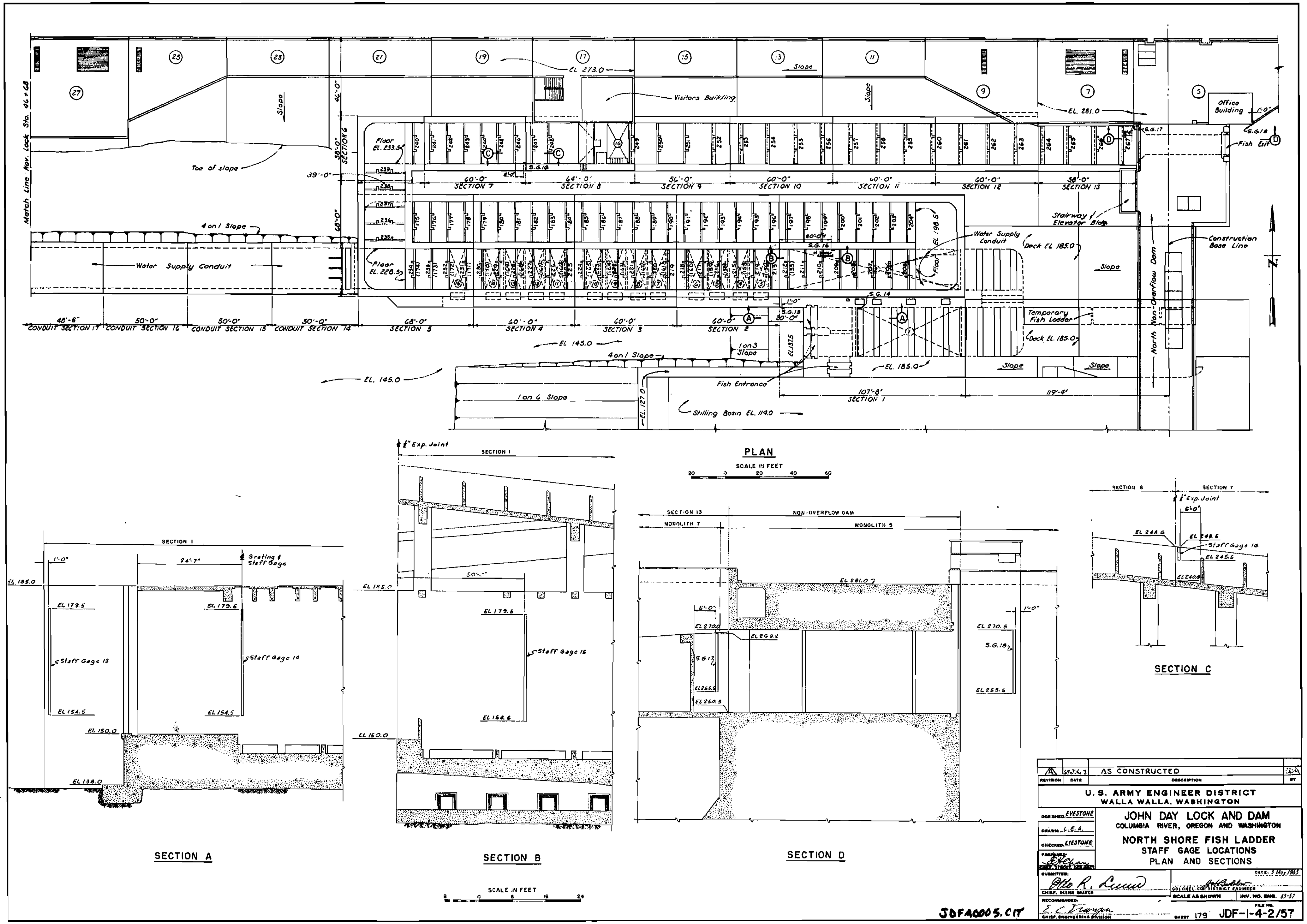


Photo 4-38 Configuration No. 11 Test F, Dye Released into Pool 8 from Weir No. 9 Slot, Looking from Above

Photo 4-39 Configuration No. 11 Test F, Dye Released into Pool 8 from Weir No. 9 Orifice, Looking from Above

CORPS OF ENGINEERS U. S. ARMY



CONT NO. 64-20 VOL. NO. I

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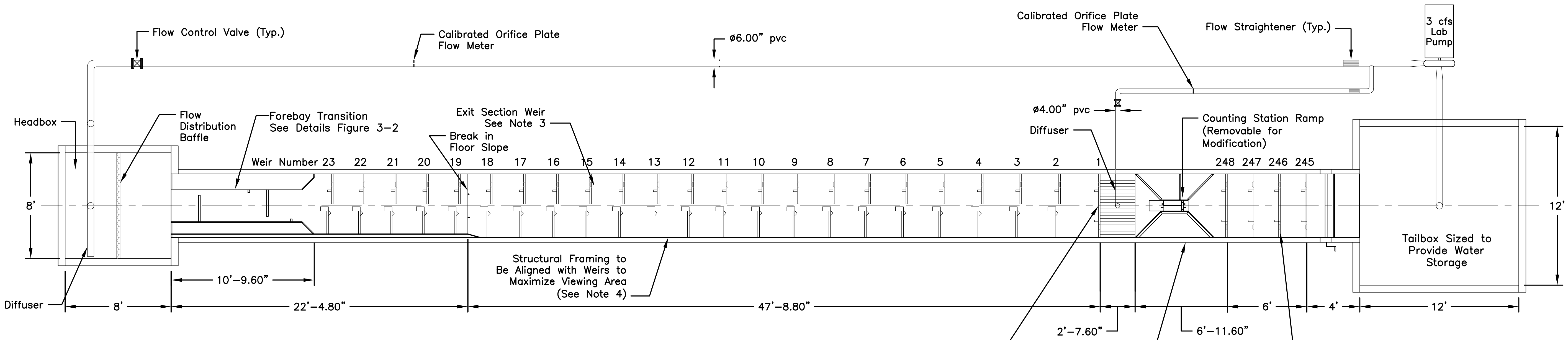
JDAN LADDER OVERVIEW PLAN AND SECTIONS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

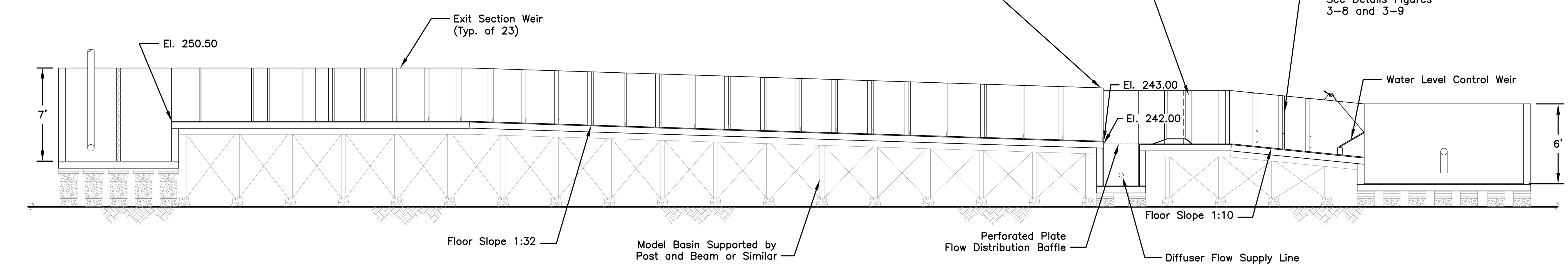
SCALE:	DATE:	PROJECT NUMBER:
NTS	02/22/08	09000-419

FIGURE NUMBER: 1-1

FILENAME: JDAN Overview



Plan View



Section at Centerline

JDAS configuration - Baseline Weir Stations (model inches)														
Weir	Downstream Baffle		Centerline	Upstream baffle		Gate Height	Weir	Downstream Baffle		Centerline	Upstream baffle		Gate Height
	D/S Face	U/S Face		D/S Face	U/S Face	(relative to floor)		D/S Face	U/S Face		D/S Face	U/S Face	(relative to floor)
1	0.00	2.00	3.13	4.26	6.26	N/A	13	399.60	401.60	402.51	403.44	405.44	4.80
2	36.00	38.00	39.13	40.26	42.26	N/A	14	430.80	432.80	433.71	434.64	436.64	5.40
3	71.21	73.21	74.12	75.05	77.05	N/A	15	460.80	462.80	463.71	464.64	466.64	5.40
4	106.01	108.01	108.92	109.85	111.85	N/A	16	490.80	492.80	493.71	494.64	496.64	6.00
5	140.81	142.81	143.72	144.65	146.65	N/A	17	520.80	522.80	523.71	524.64	526.64	6.60
6	174.41	176.41	177.32	178.25	180.25	N/A	18	550.80	552.80	553.71	554.64	556.64	6.60
7	208.01	210.01	210.92	211.85	213.85	0.60	19	579.60	581.60	582.51	583.44	585.44	7.20
8	240.41	242.41	243.32	244.25	246.25	1.20	20	608.40	610.40	611.31	612.24	614.24	7.80
9	272.81	274.81	275.72	276.65	278.65	1.80	21	637.20	639.20	640.33	641.46	643.46	9.00
10	304.80	306.80	307.71	308.64	310.64	1.80	22	666.00	668.00	669.13	670.26	672.26	10.80
11	337.20	339.20	340.11	341.04	343.04	1.80	23	694.80	696.80	697.93	699.06	701.06	12.00
12	368.40	370.40	371.31	372.24	374.24	2.40							

Notes:
1) Dimensions given in model feet and inches
2) Model to prototype scale = 1:5
3) Exit Section weirs to be replaced with lamprey friendly weirs following baseline testing
4) Both sidewalls to be fabricated using clear acrylic
5) Viewing platforms will be provided for Exit Section and Counting Station, not shown for clarity

REVISIONS

NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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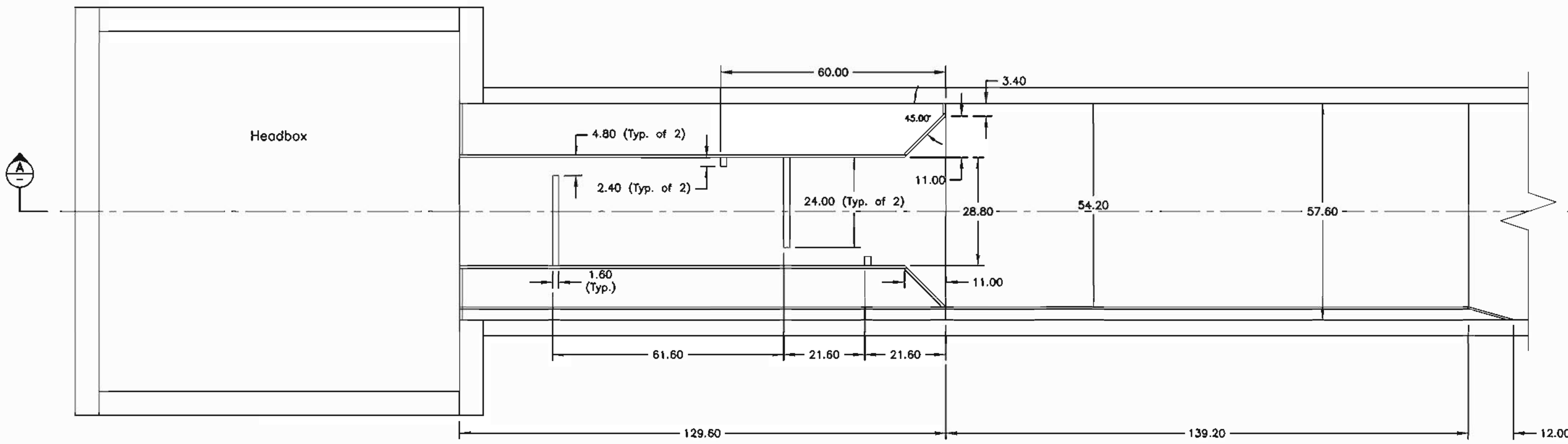
BASELINE MODEL LAYOUT
PLAN AND SECTION
John Day North Fish Ladder
U.S. Army Corps of Engineers, Portland District
Portland, Oregon

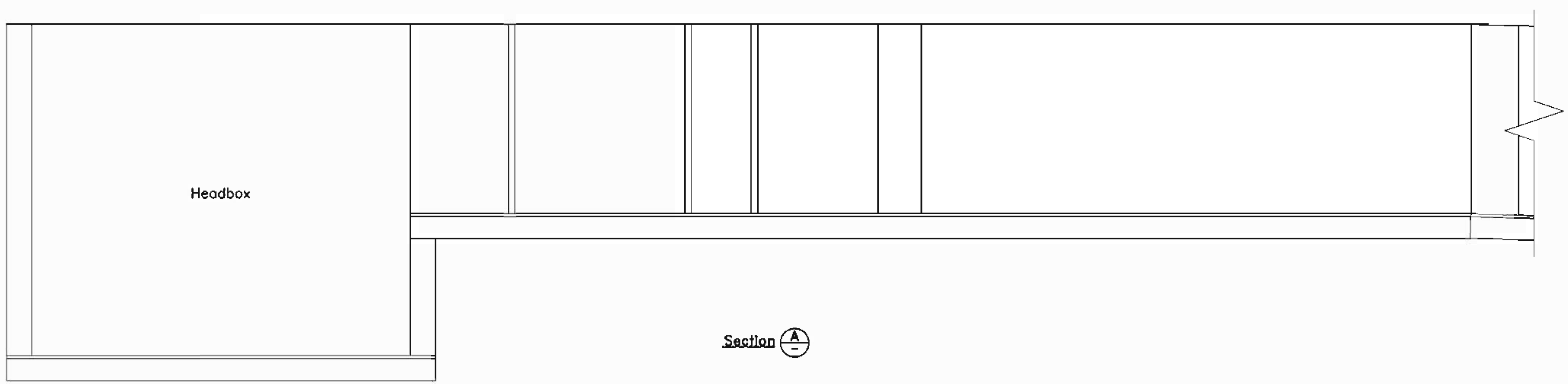
PROJECT NUMBER: 09000-419
DATE: 02/20/08
SCALE: 1" = 8'

FIGURE NUMBER: 3-1

FILENAME: 09000419-GML



Plan View



Section A

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
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DESIGNED BY: JA
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CHECKED BY: LR
APPROVED BY: CS

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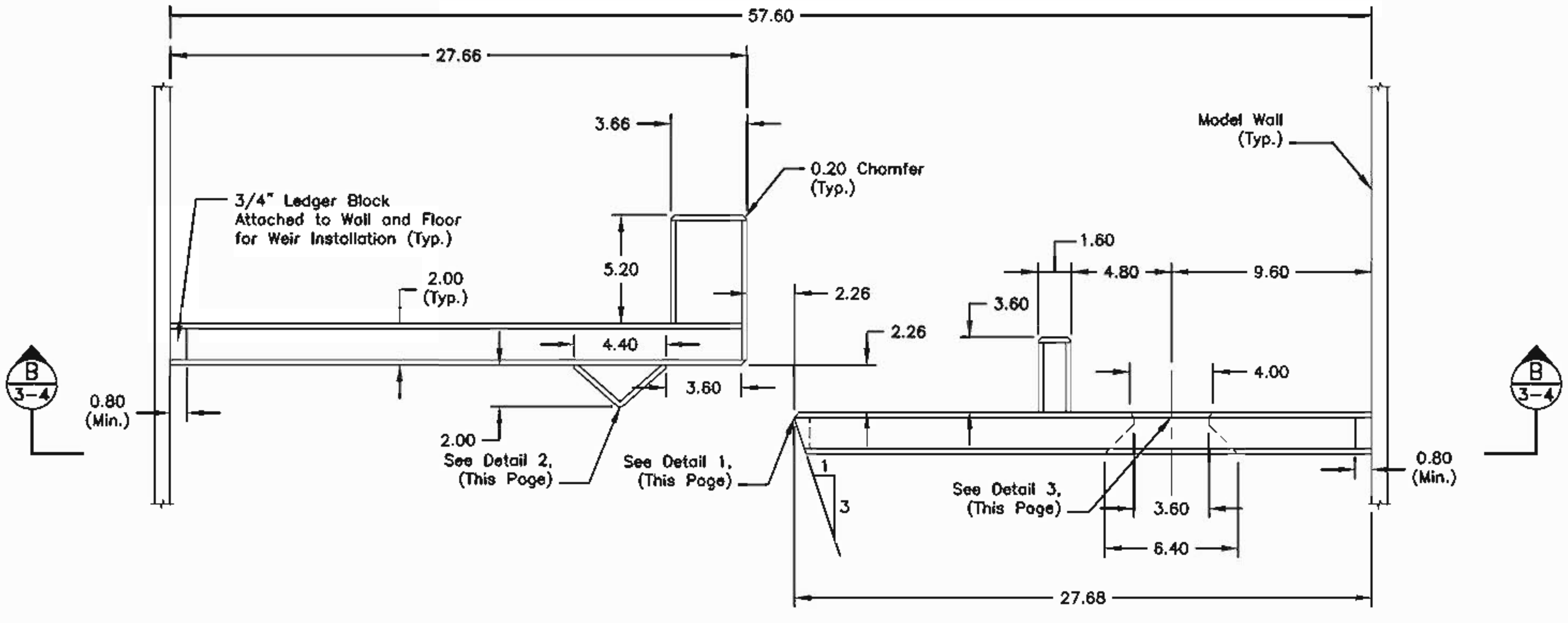
FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

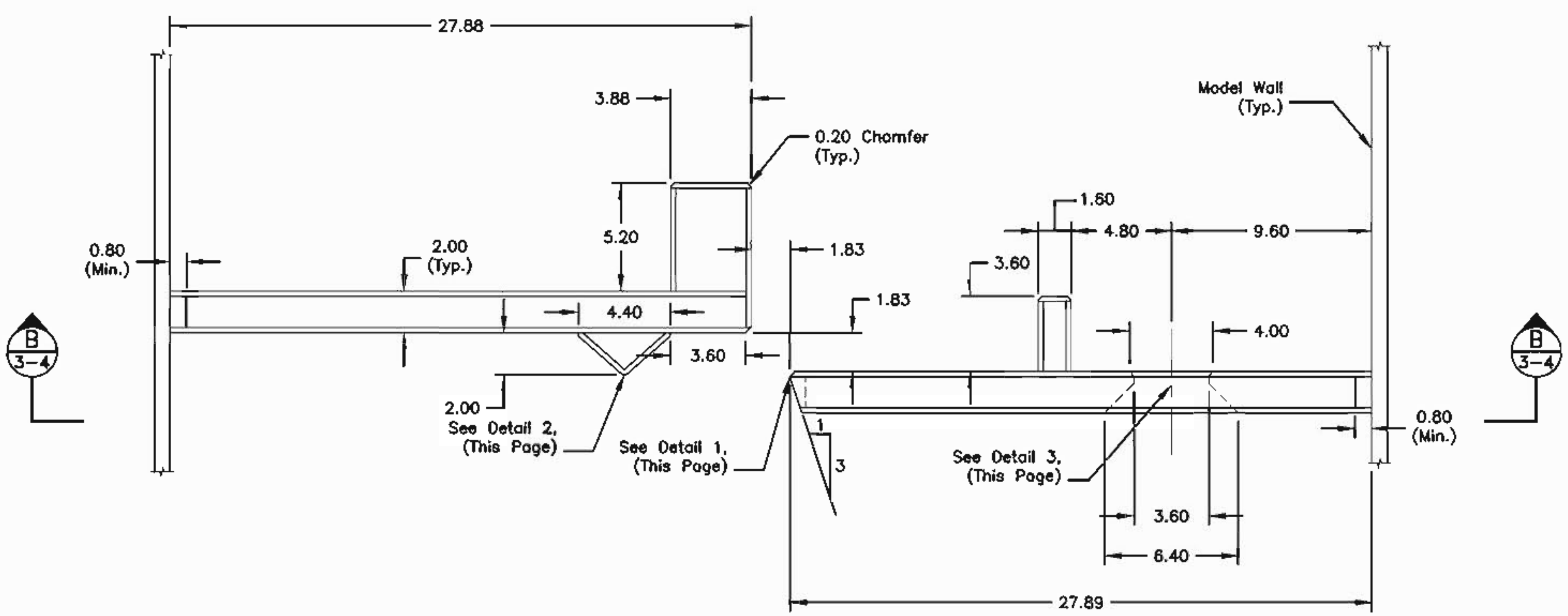
SCALE: 1:30
DATE: 06/07/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
3–2

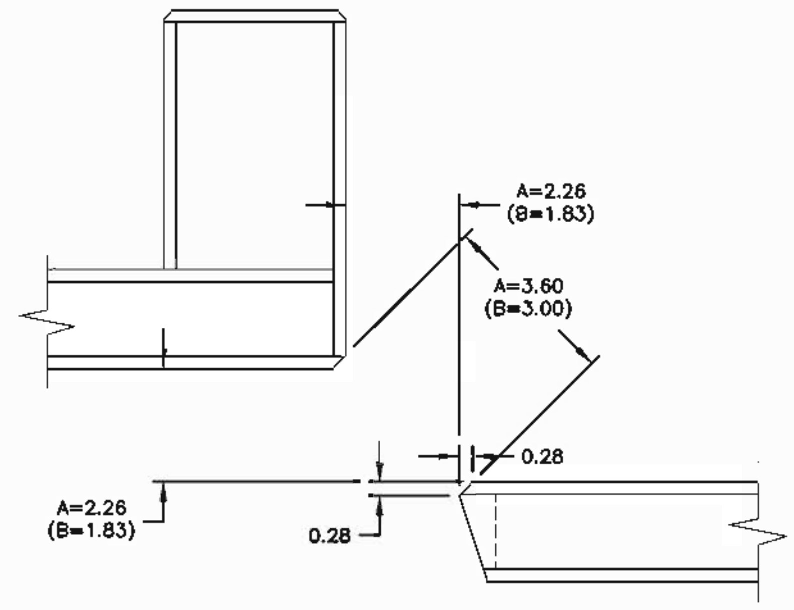
FILENAME:
For–Trans–Det



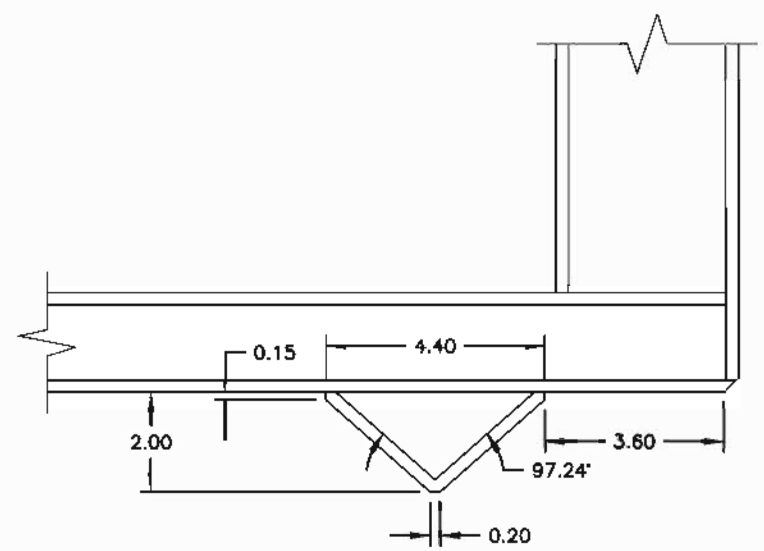
Typical Weir Plan A – Weirs 1, 2, 3, 21, 22, and 23
(Scale = 1:8)



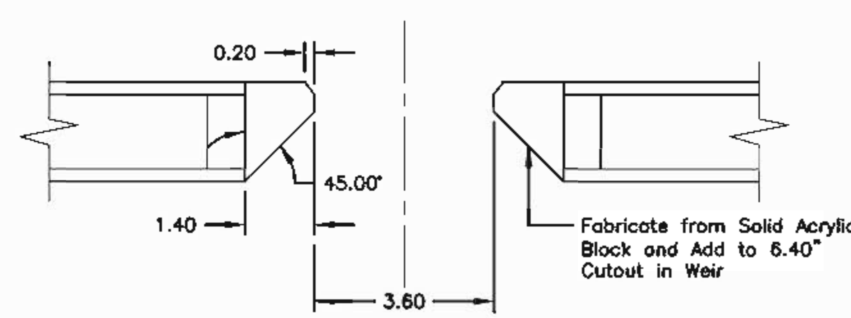
Typical Weir Plan B – Weirs 4-20
(Scale = 1:8)



Detail 1, A and B
(Scale = 1:4)



Detail 2
(Scale = 1:4)



Detail 3
(Scale = 1:4)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
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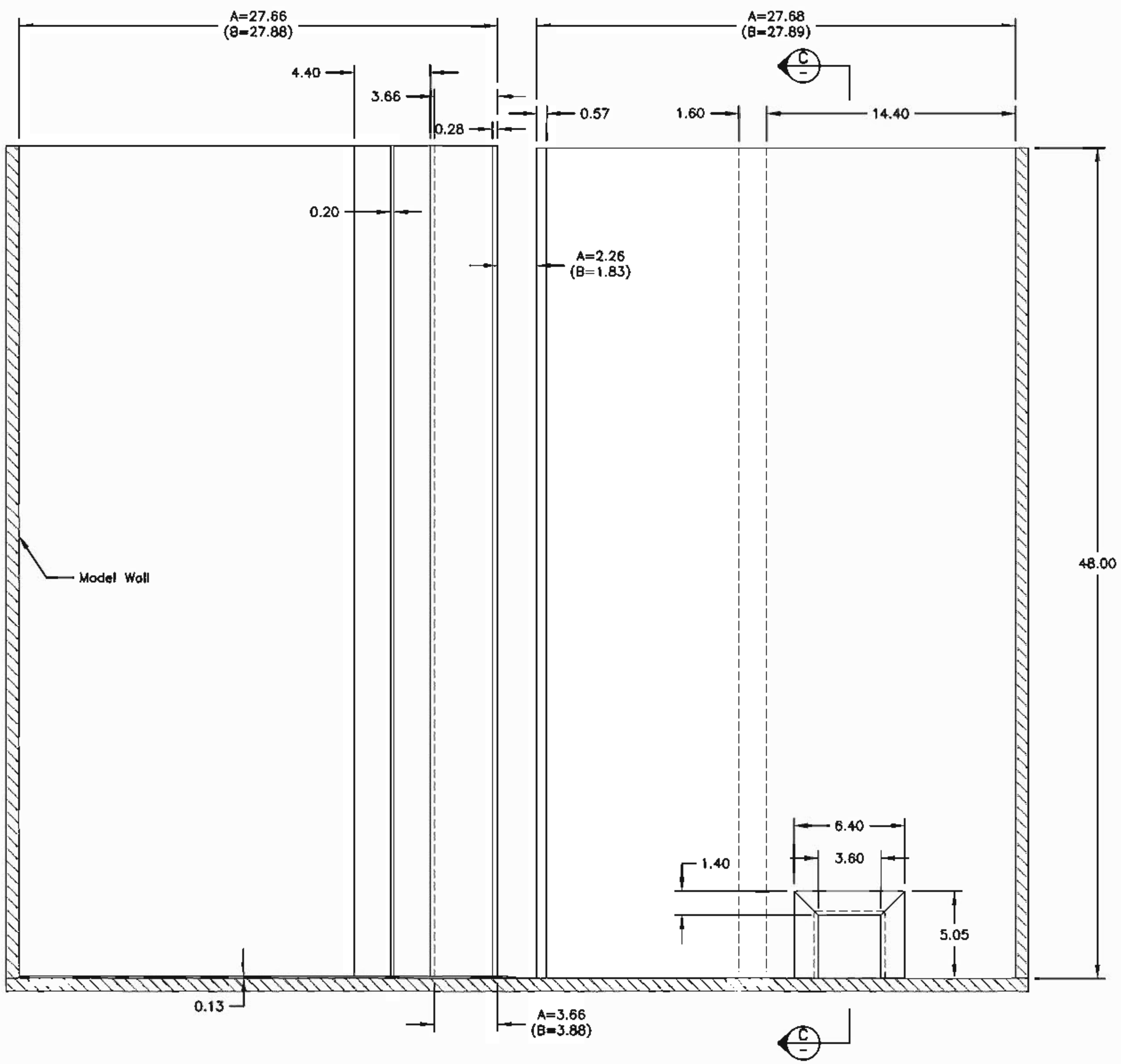
EXIT SECTION WEIRS
PLAN VIEWS
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

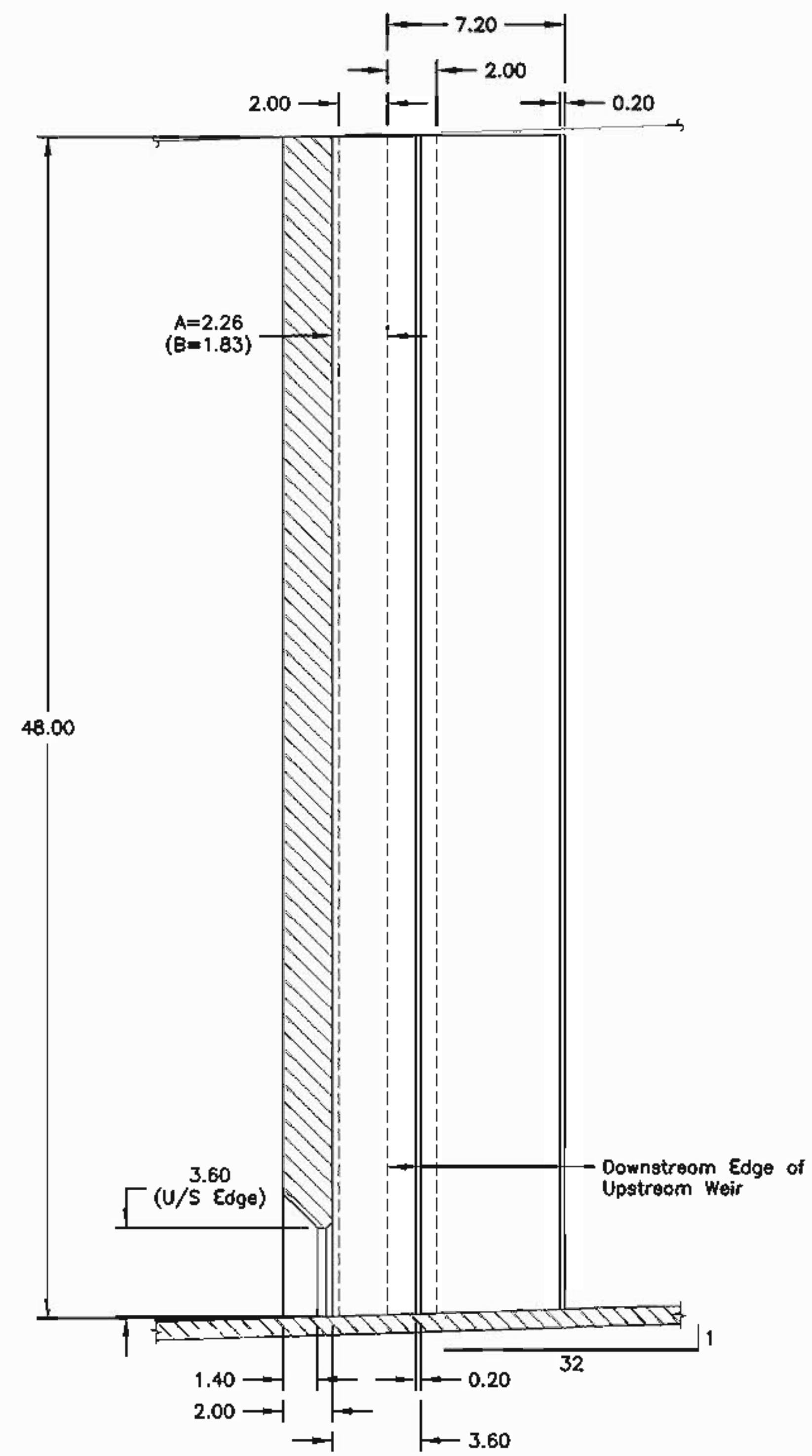
SCALE: as noted
DATE: 06/08/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-3

FILENAME: Typ-Weir-A-B



Section B/3-3



Section C/-

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
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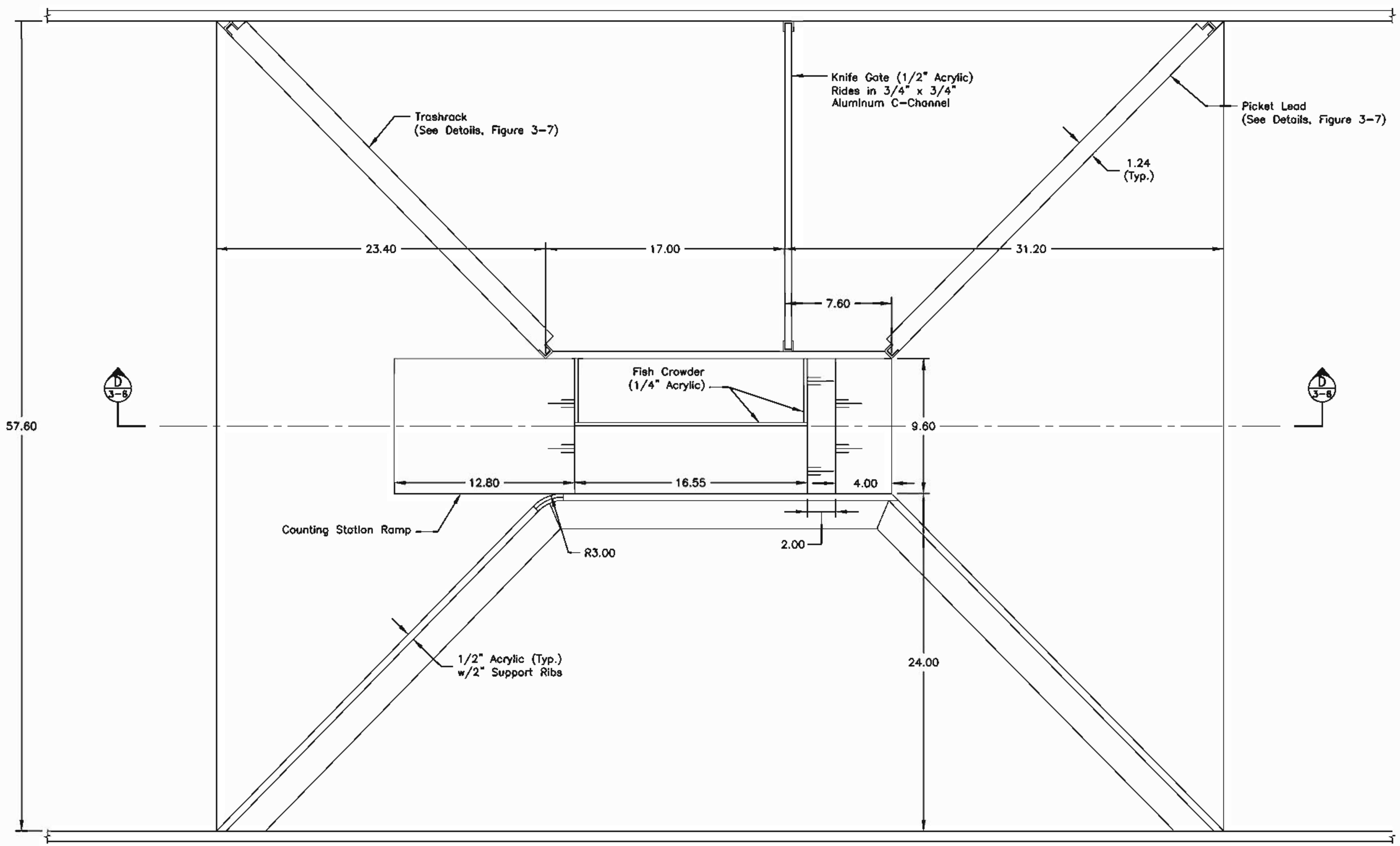
EXIT SECTION WEIRS
ELEVATION AND SECTION
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:8
DATE: 06/08/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-4

FILENAME: XSec-Weir-ES



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
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DESIGNED BY: JA
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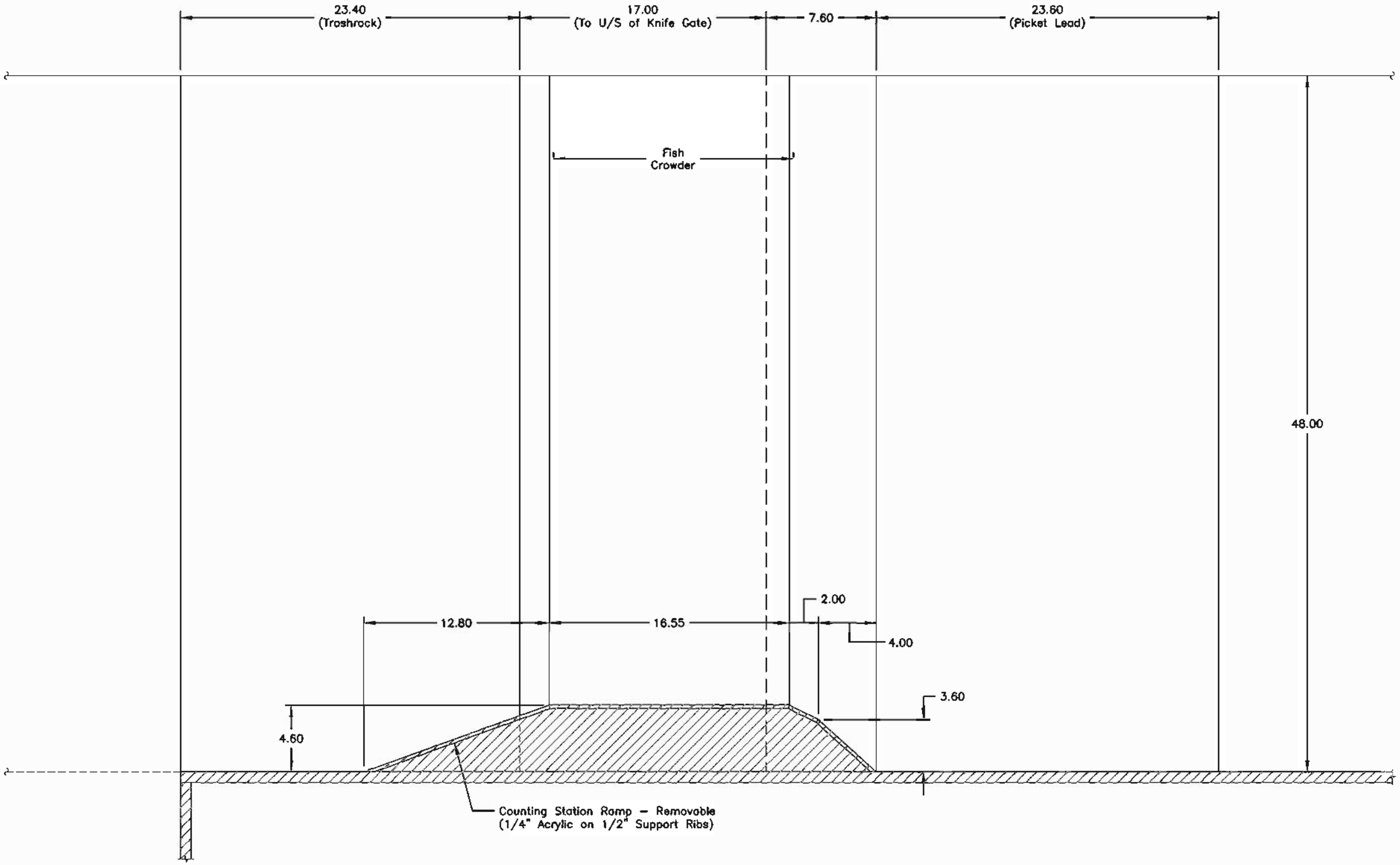
COUNTING STATION DETAILS
PLAN VIEW

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:8
DATE: 06/07/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
3–5

FILENAME:
CSta-Det-Pln



Section D / 3-5

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
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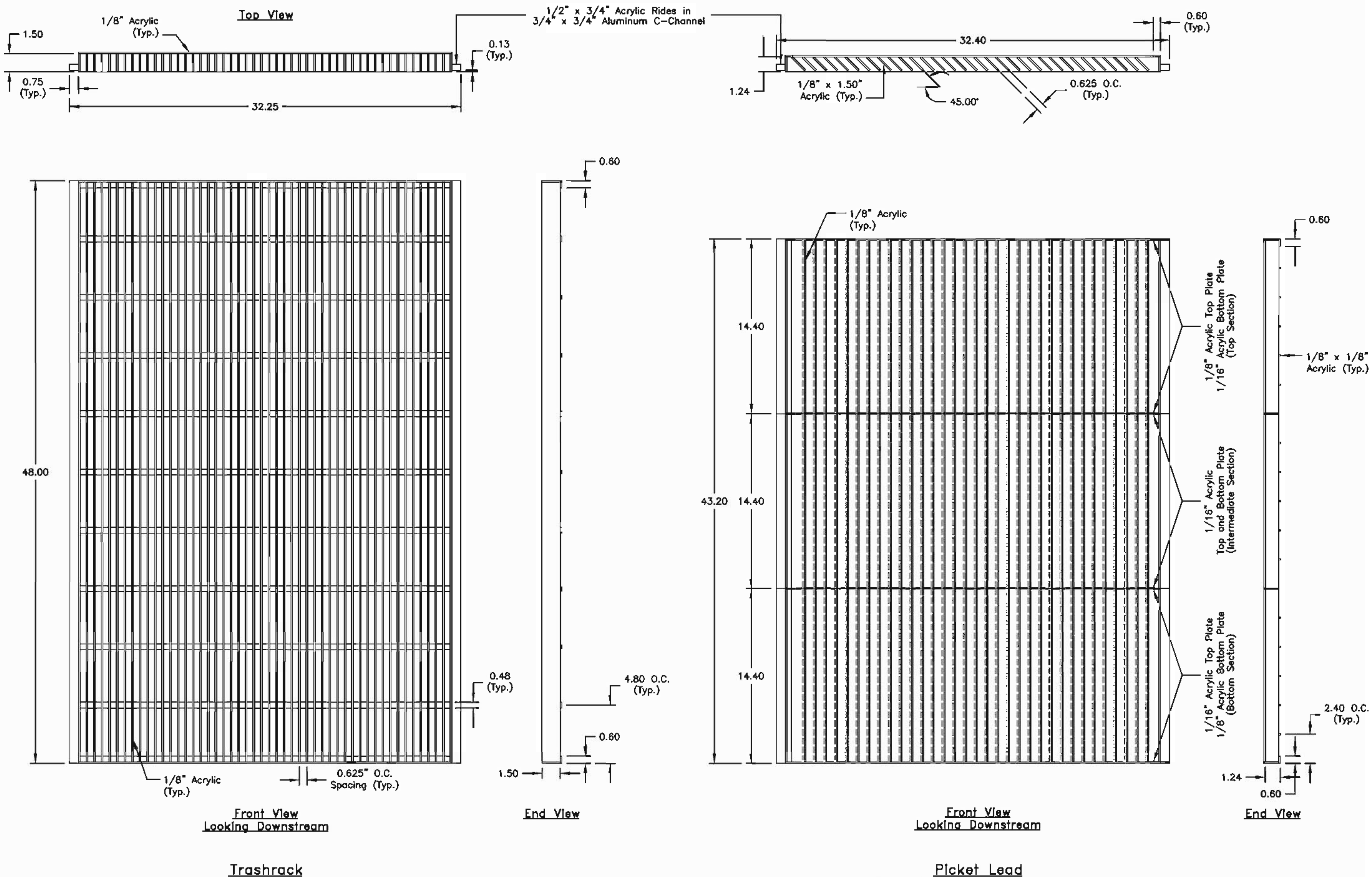
COUNTING STATION DETAILS SECTION VIEW

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:8
DATE: 06/07/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-6

FILENAME: CSta-Det-Sec



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
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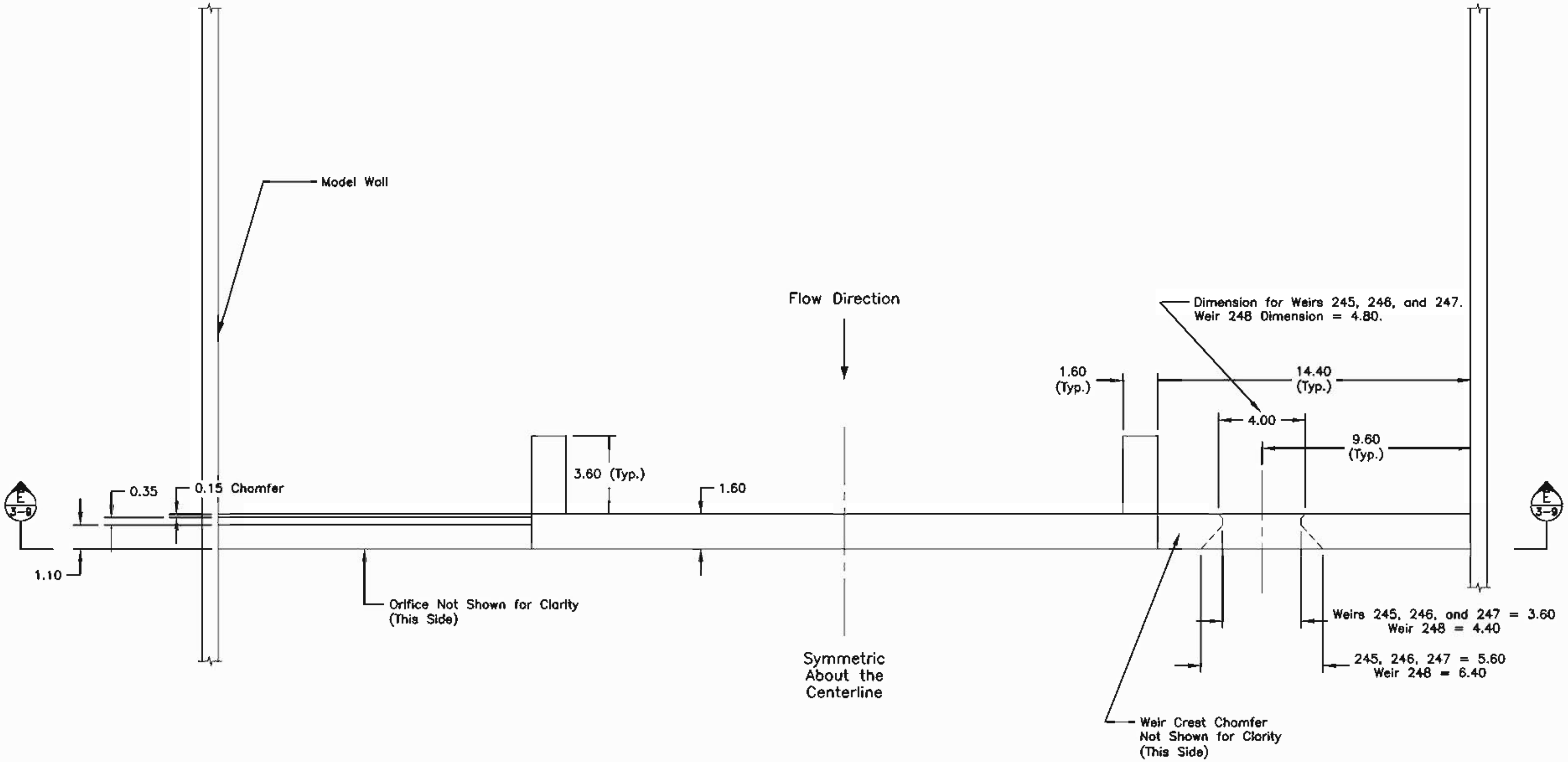
TRASHRACK AND PICKET LEAD DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:8
DATE: 05/24/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-7

FILENAME: TR-PL Det



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
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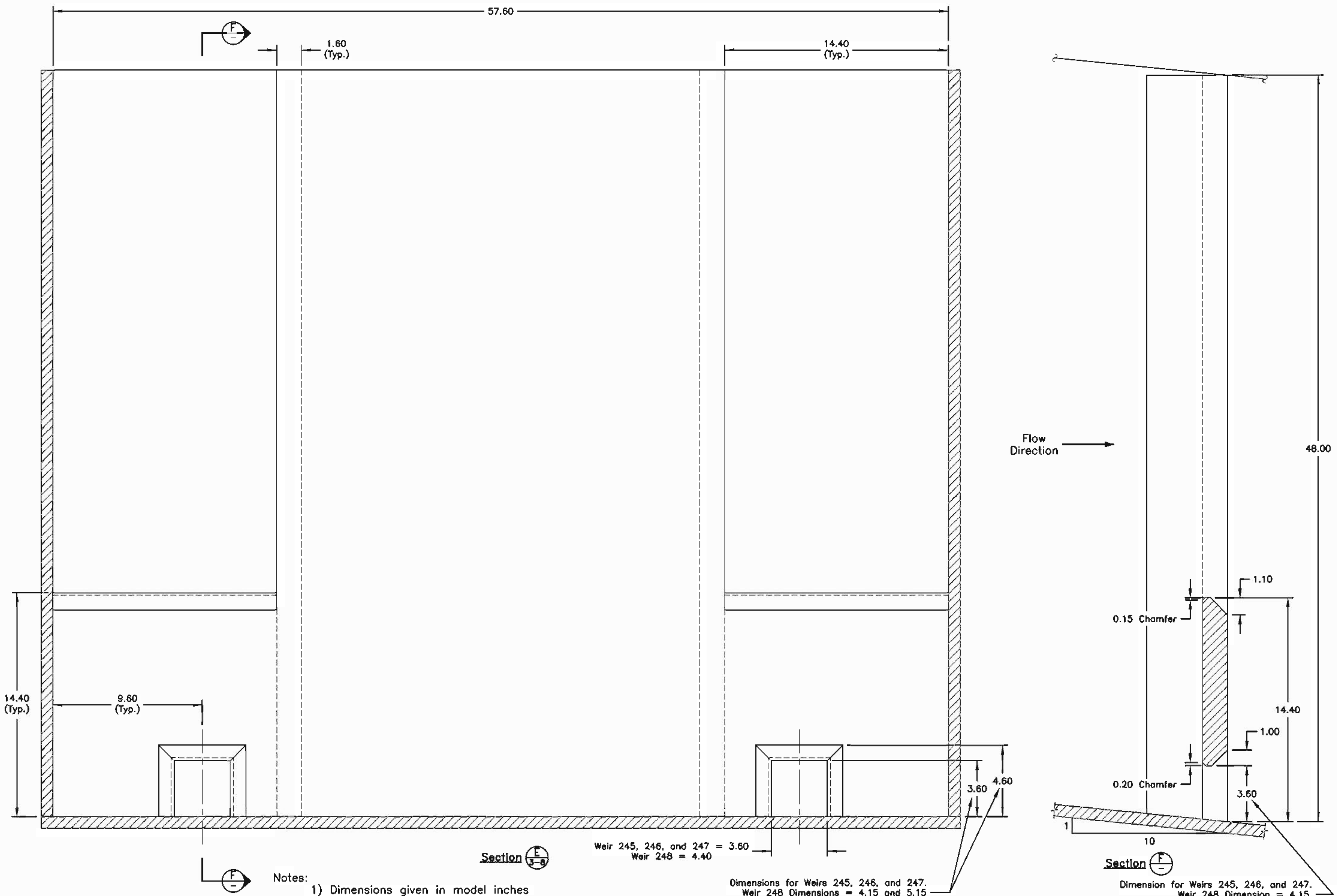
OVERFLOW/ORIFICE WEIR PLAN VIEW

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:6
DATE: 06/07/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-8

FILENAME: Over-Ori Weir



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS

NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
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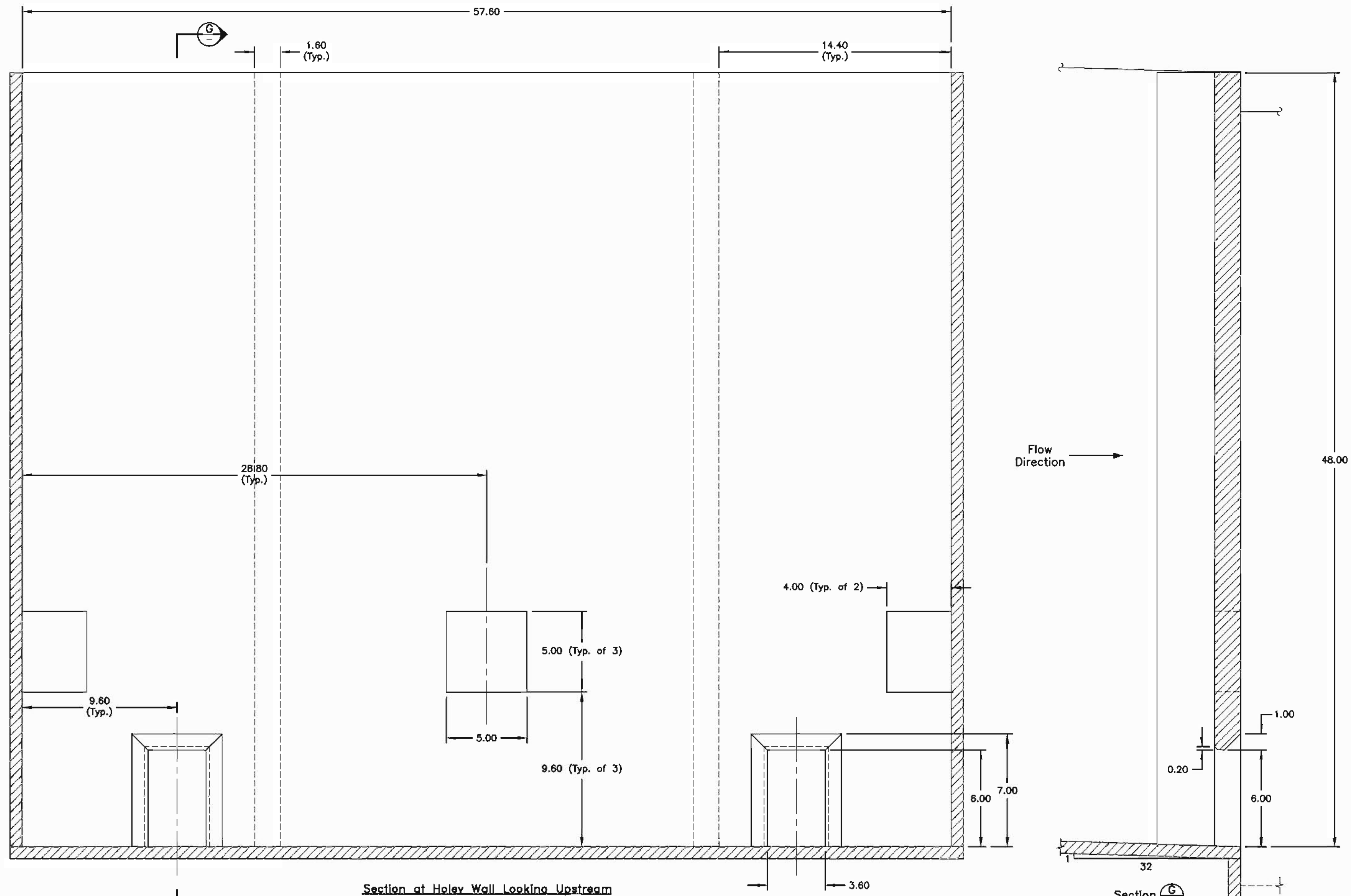
OVERFLOW/ORIFICE WEIR ELEVATION AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:6
DATE: 06/07/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
3–9

FILENAME:
Ovr-Ori-W-Sec



Section at Holey Wall Looking Upstream

Section G

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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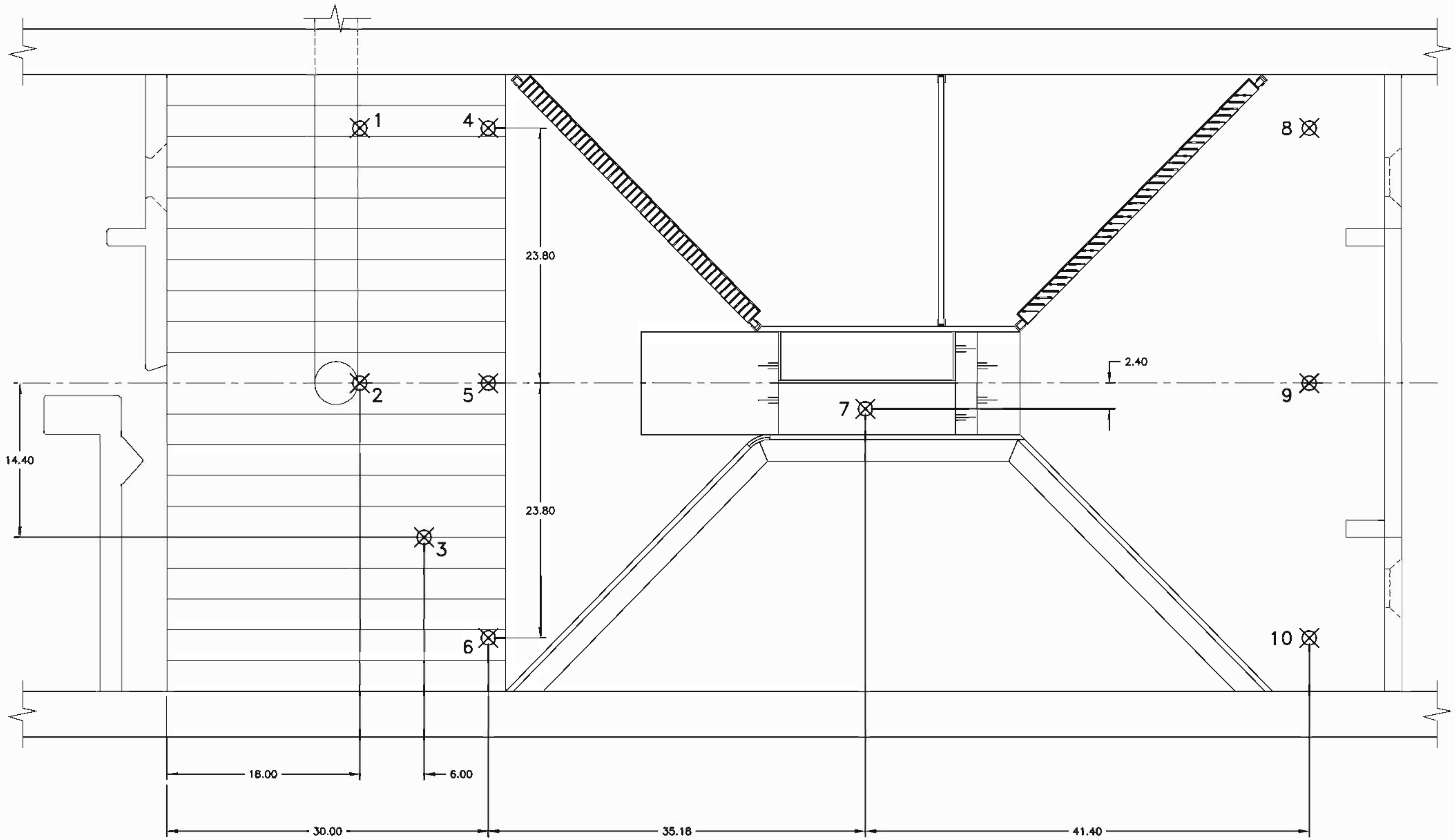
HOLEY WALL
ELEVATION AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

PROJECT NUMBER: 09000-419
DATE: 06/07/07
SCALE: 1:6

FIGURE NUMBER: 3-10

FILENAME: Holey Wall



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: JA|KM
CHECKED BY: LR
APPROVED BY: CS

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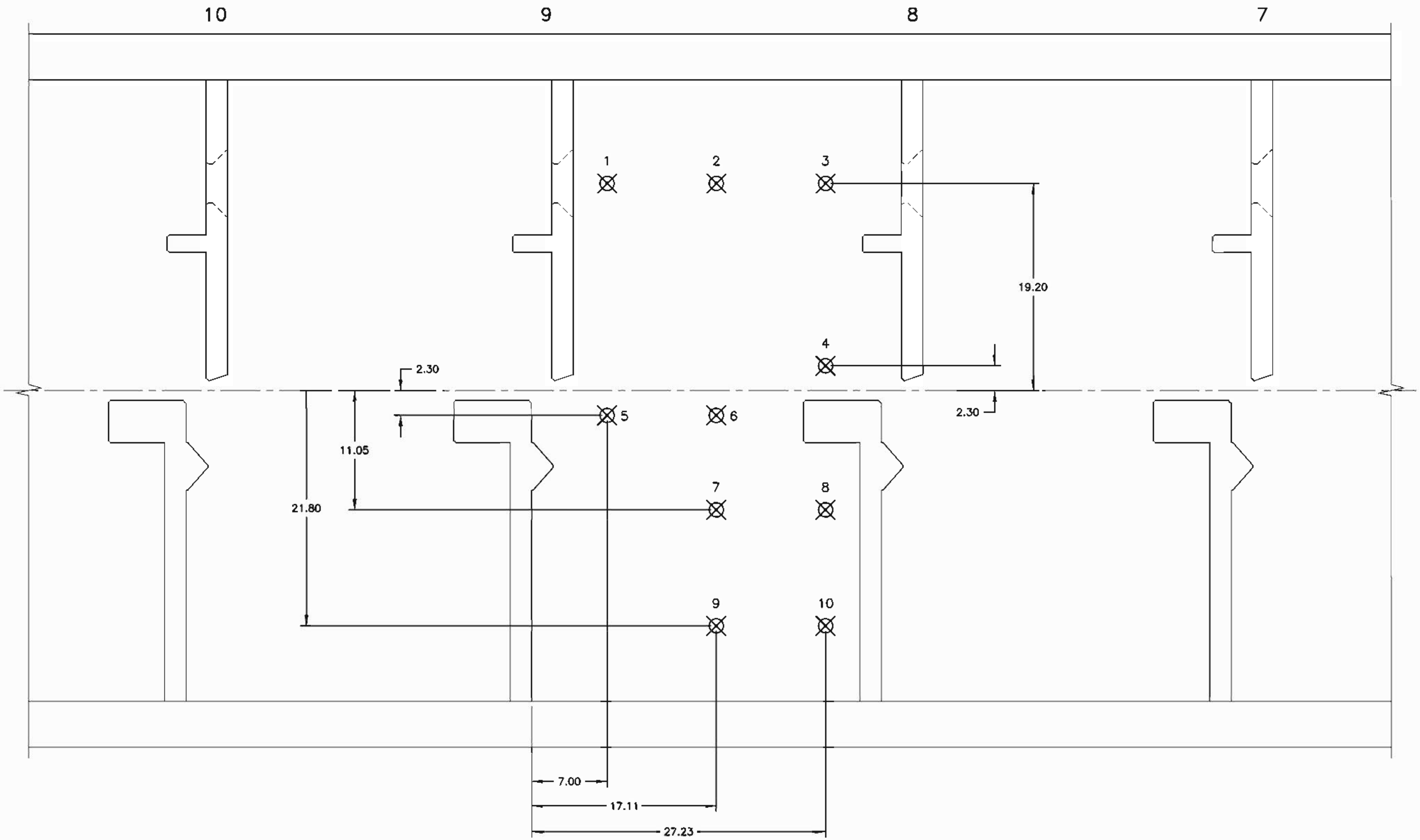
COUNT STATION VELOCITY MEAS. LOCATIONS – BASELINE TESTS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:10
DATE: 03/26/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4–1

FILENAME: BL–CtSta Meas



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: JA\KM
CHECKED BY: LR
APPROVED BY: CS

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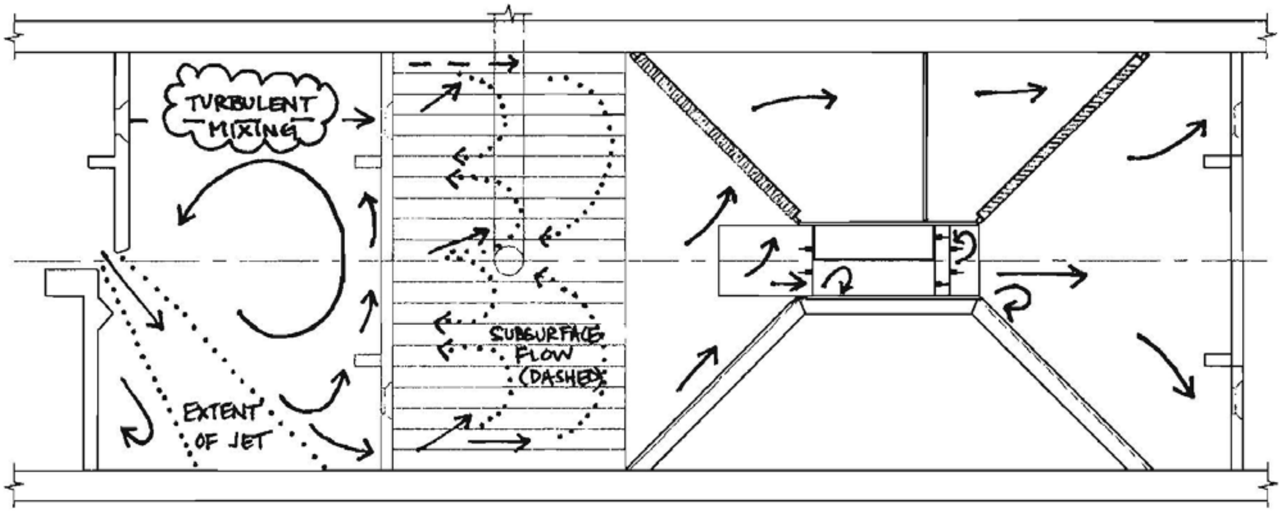
POOL 8 VELOCITY MEASUREMENT LOCATIONS – BASELINE TESTS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

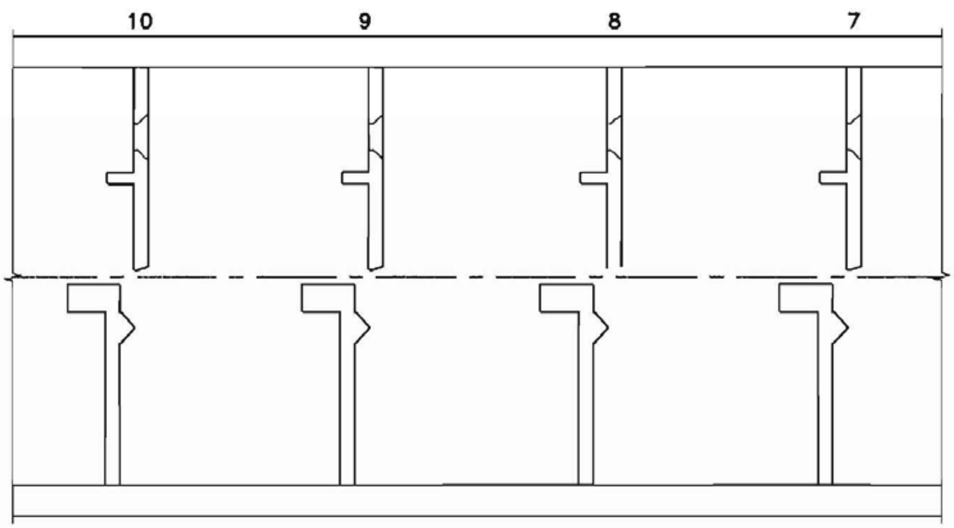
SCALE: 1:10
DATE: 03/26/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-2

FILENAME: BL-P8 Meas Loc



Count Station



Pool 8

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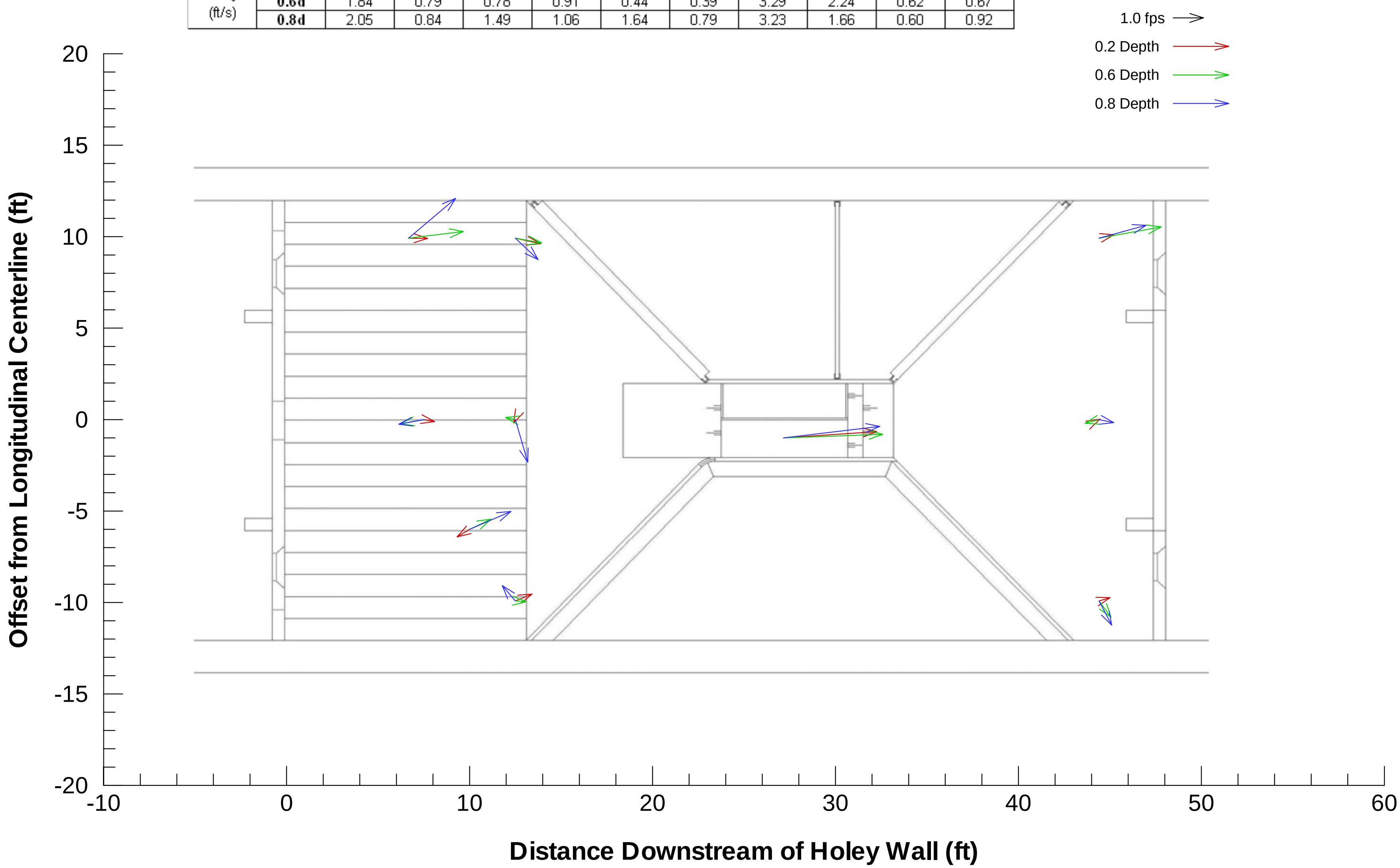
OBSERVED FLOW PATTERNS
CONFIG NO. 1 TEST A
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-3

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.63	0.36	0.50	0.88	0.13	0.61	3.10	0.60	0.18	0.38
	0.6d	1.84	0.79	0.78	0.91	0.44	0.39	3.29	2.24	0.62	0.67
	0.8d	2.05	0.84	1.49	1.06	1.64	0.79	3.23	1.66	0.60	0.92



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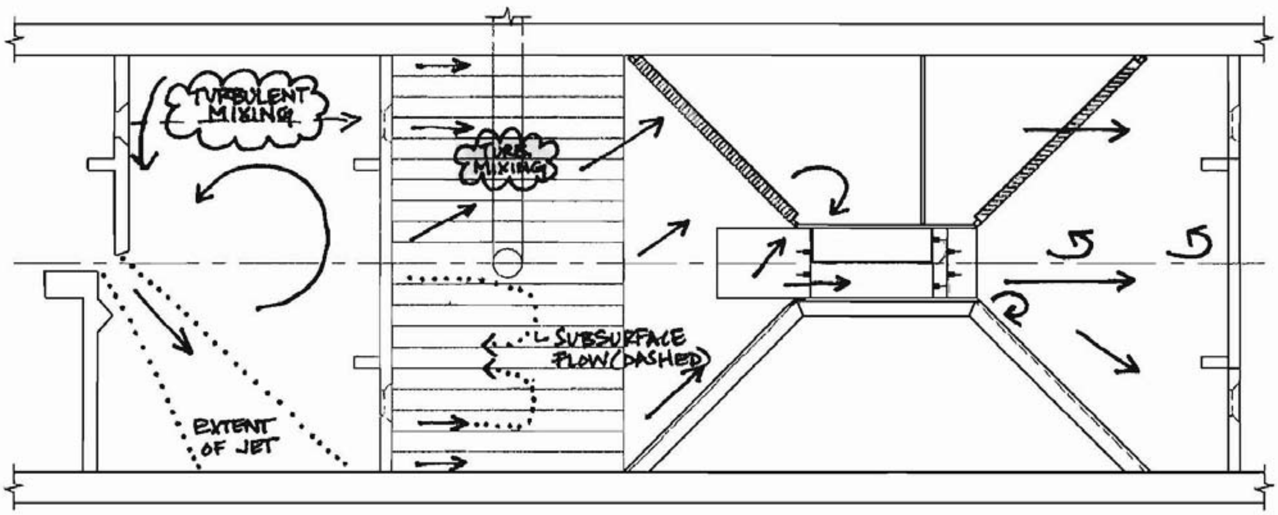
COUNT STATION VELOCITIES
CONFIGURATION No. 1 - TEST A

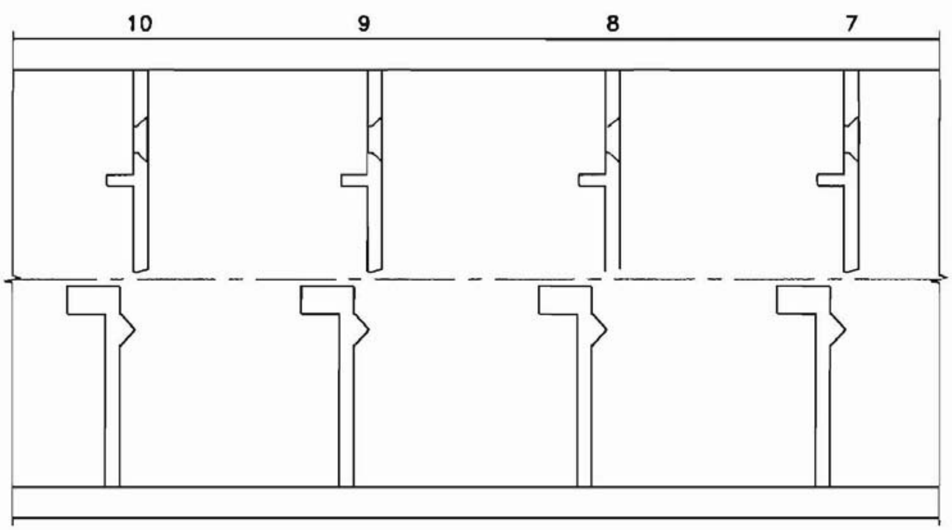
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

FIGURE NUMBER: 4-4



Count Station



Pool 8

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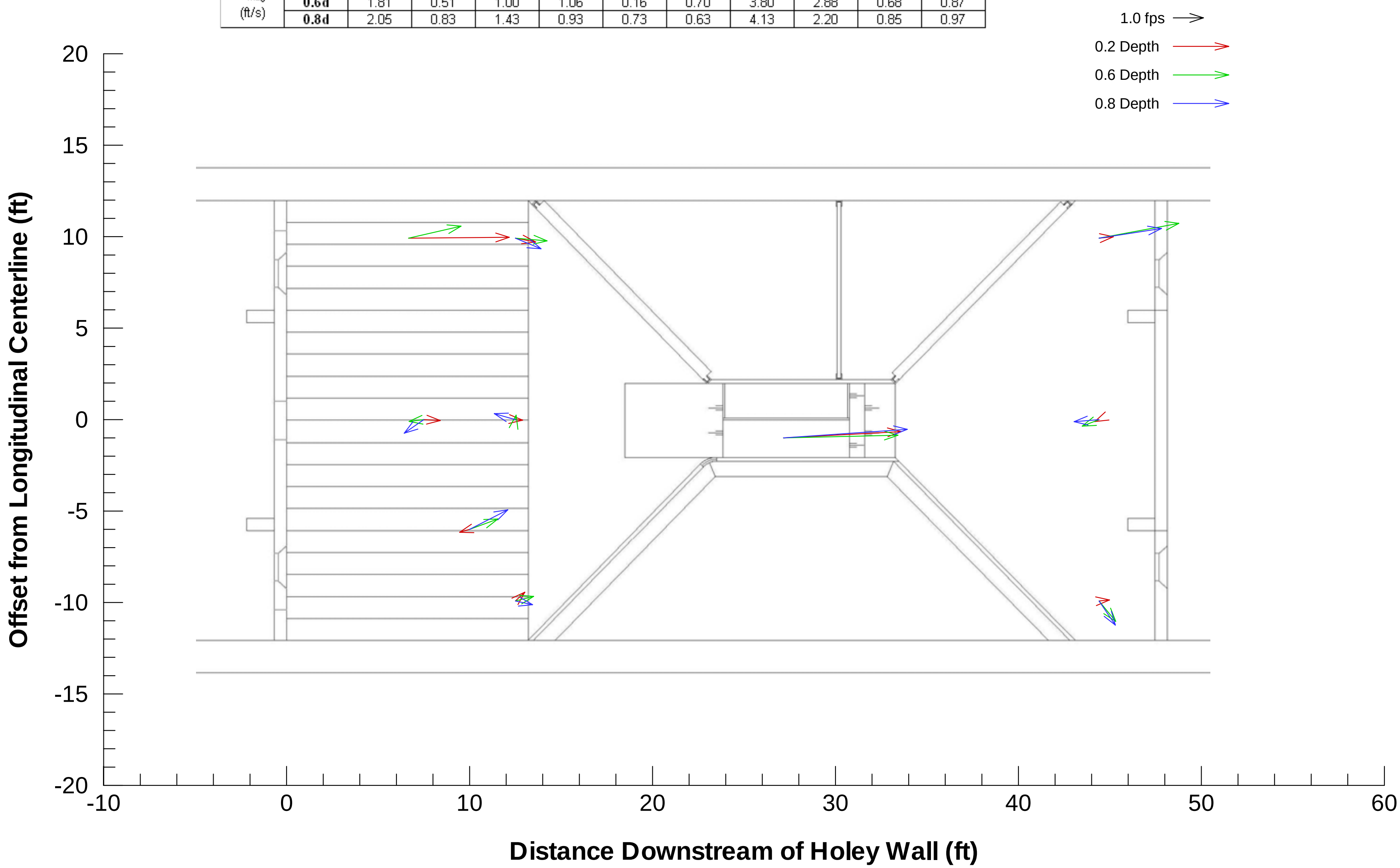
OBSERVED FLOW PATTERNS
CONFIG NO. 1 TEST B
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER: 4-5

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	3.42	0.55	0.35	0.69	0.26	0.44	3.91	0.63	0.44	0.35
	0.6d	1.81	0.51	1.00	1.06	0.16	0.70	3.80	2.88	0.68	0.87
	0.8d	2.05	0.83	1.43	0.93	0.73	0.63	4.13	2.20	0.85	0.97



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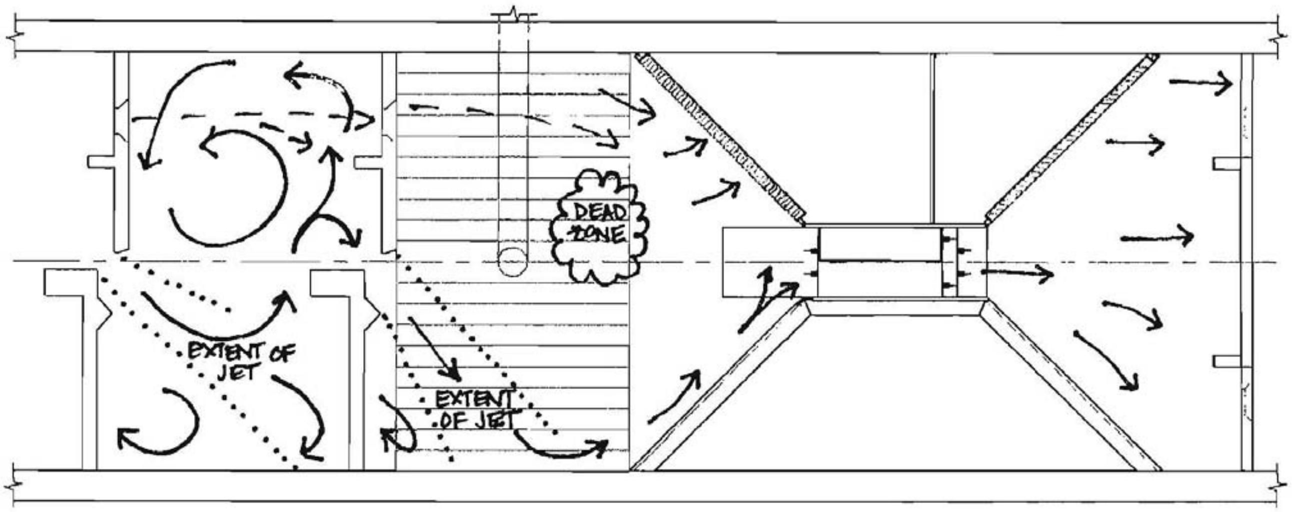
COUNT STATION VELOCITIES
CONFIGURATION No. 1 - TEST B

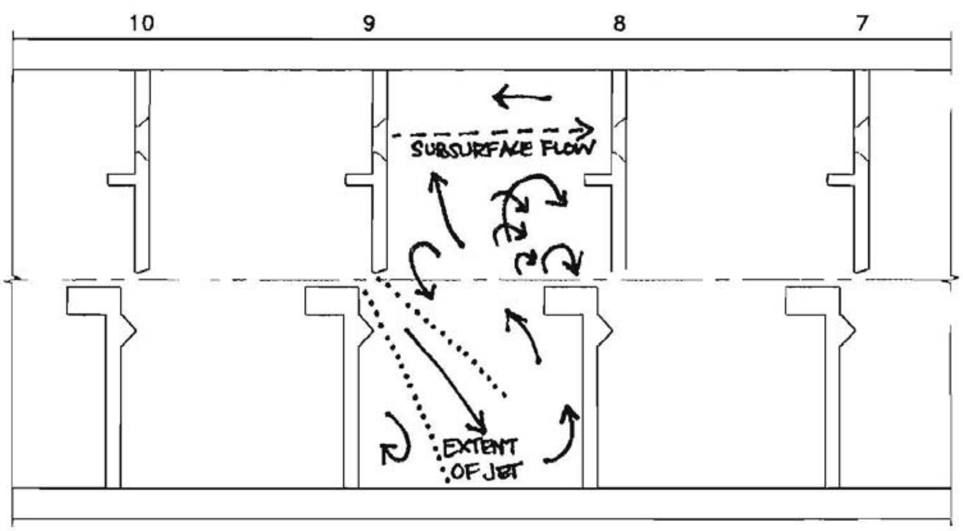
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-6**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Count Station



Pool 8

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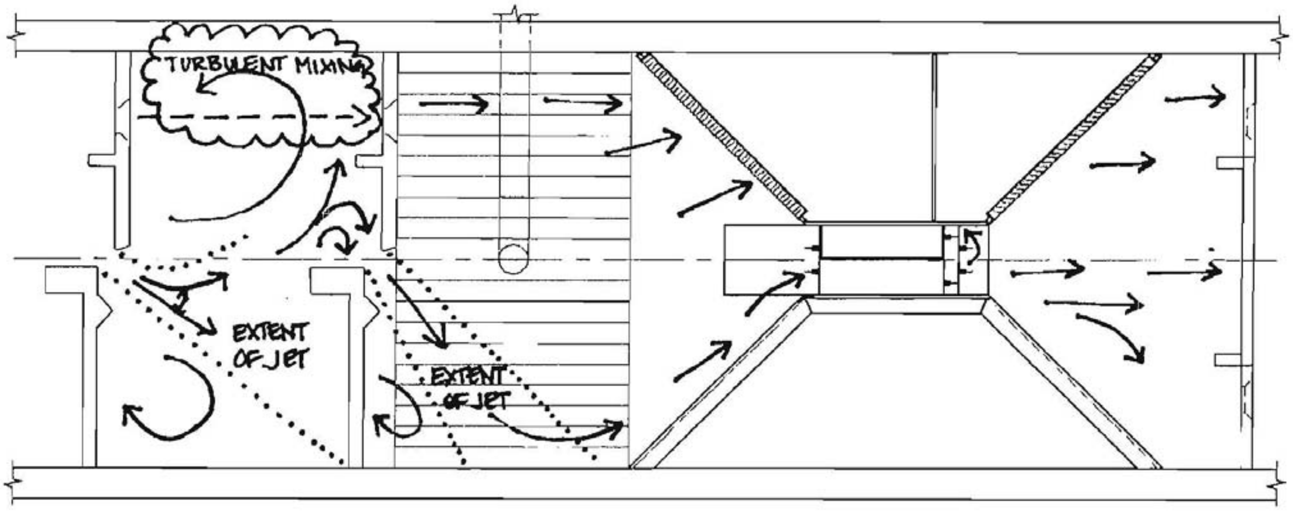
OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST A

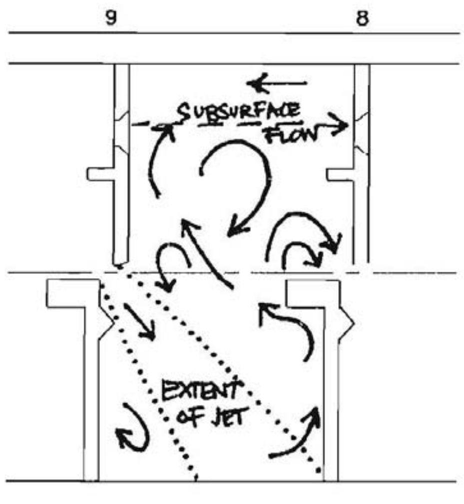
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-7

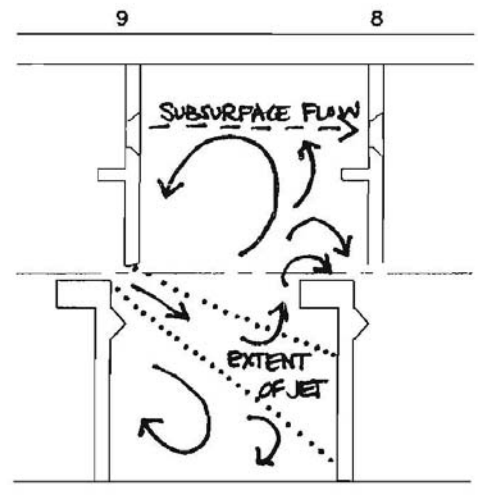
DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR



Count Station



Pool 8



Pool 8

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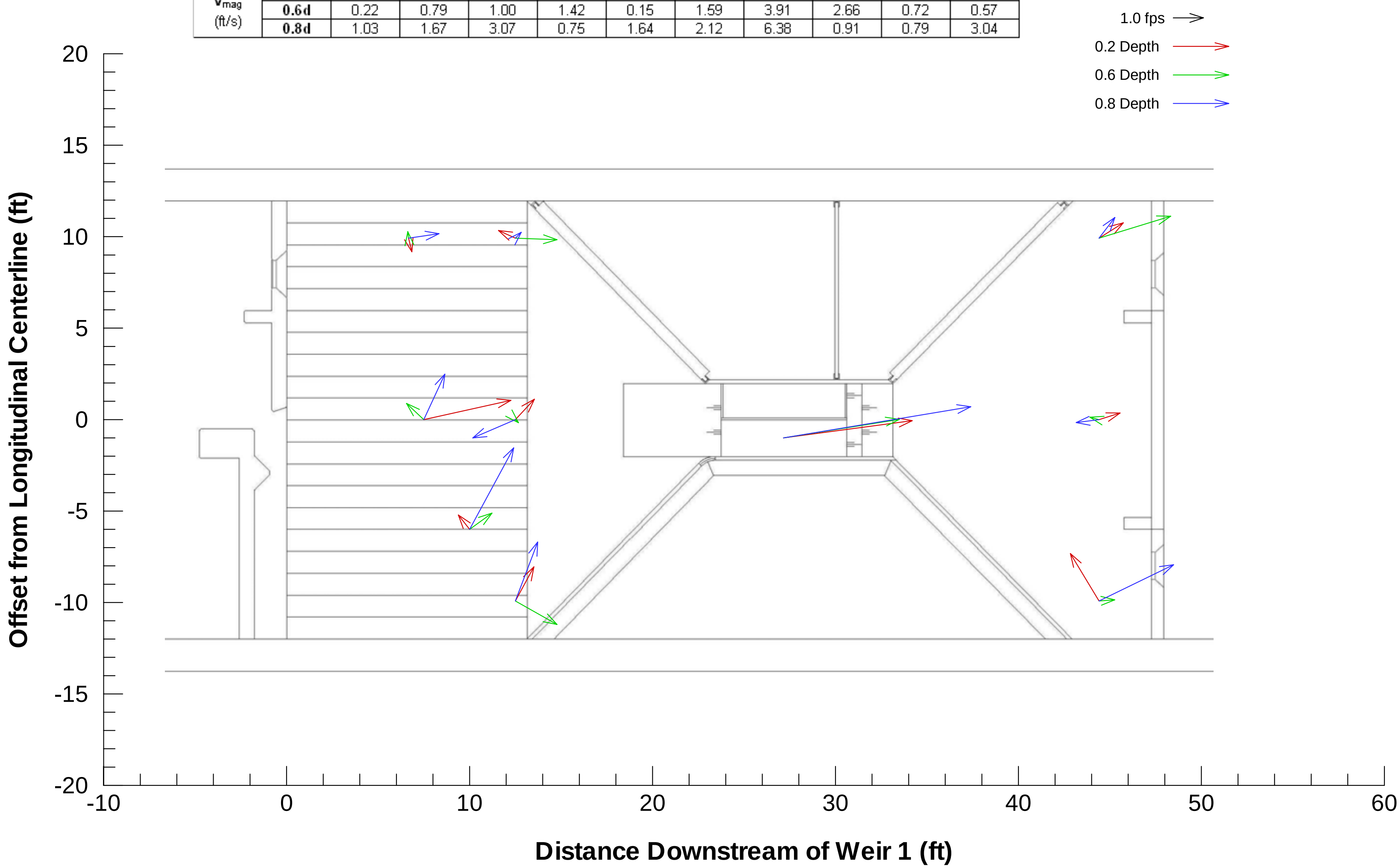
OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST B
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-8

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.47	2.98	0.64	0.66	0.95	1.29	4.31	1.02	0.74	2.00
	0.6d	0.22	0.79	1.00	1.42	0.15	1.59	3.91	2.66	0.72	0.57
	0.8d	1.03	1.67	3.07	0.75	1.64	2.12	6.38	0.91	0.79	3.04



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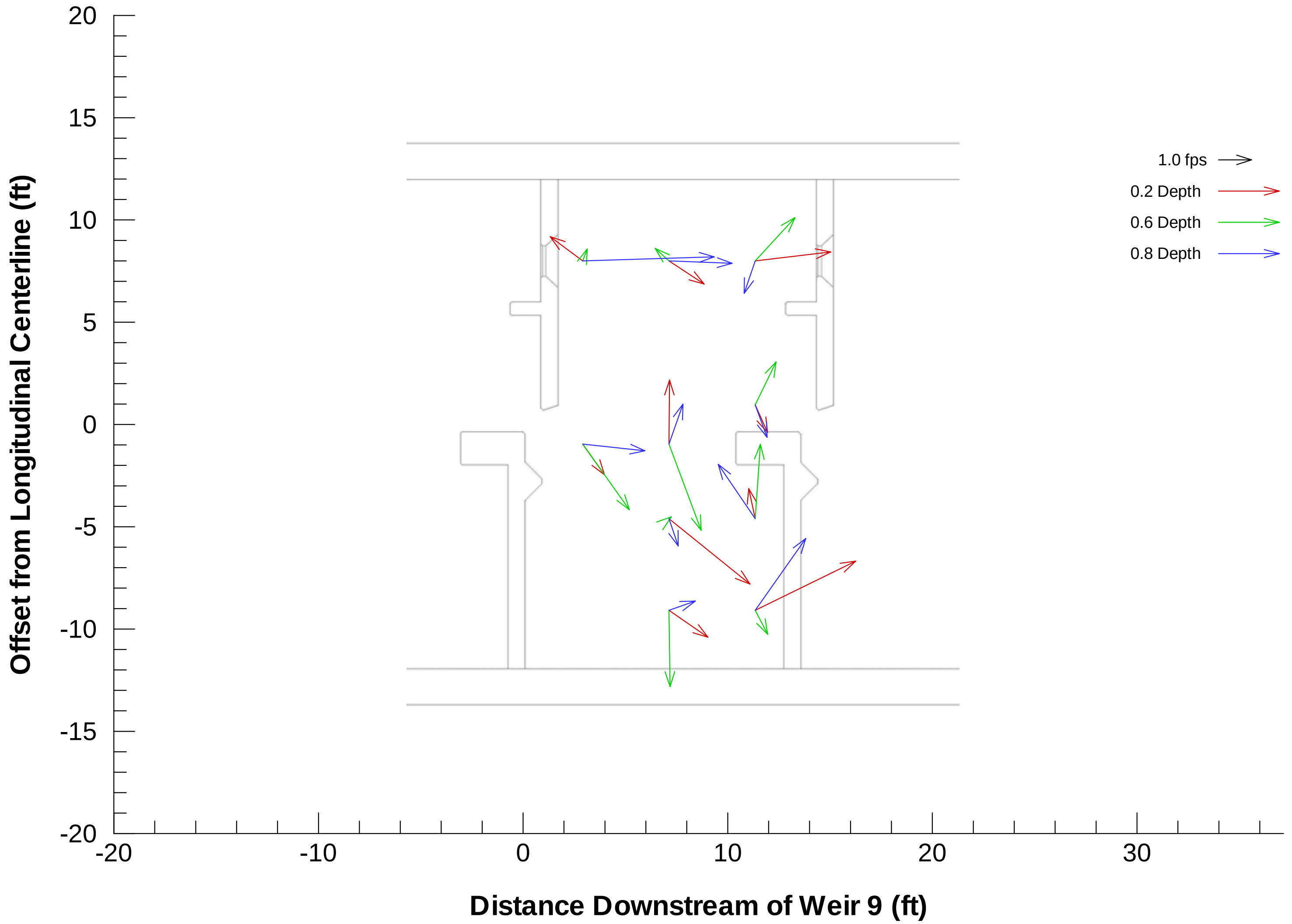
COUNT STATION VELOCITIES
CONFIGURATION No. 2 - TEST B
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-9**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	1.24	1.29	2.32	1.20	1.16	1.95	3.15	0.93	1.47	3.39
	0.6d	0.67	0.62	1.94	1.51	2.47	2.93	0.37	2.25	2.31	1.15
	0.8d	3.98	1.92	1.05	1.05	1.89	1.30	0.87	2.01	0.85	2.78



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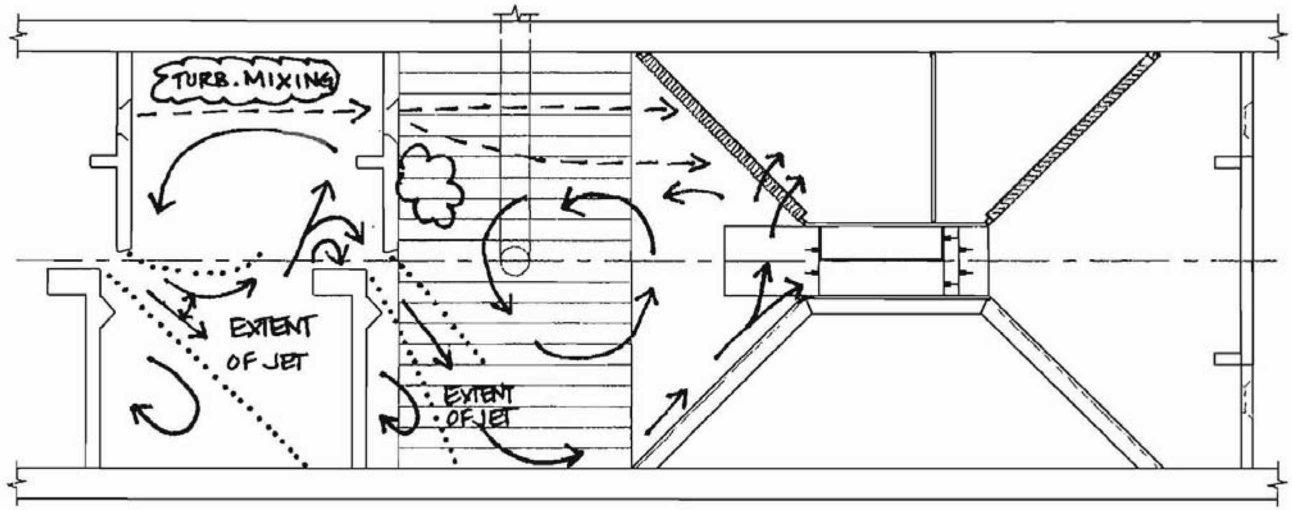
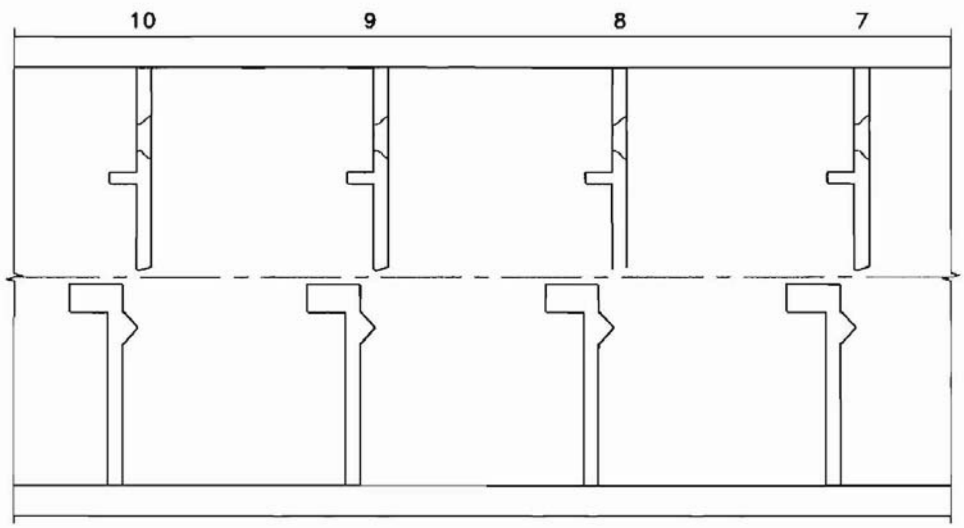
WEIR POOL 8 VELOCITIES
CONFIGURATION No. 2 - TEST B
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-10**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Count Station



Pool 8

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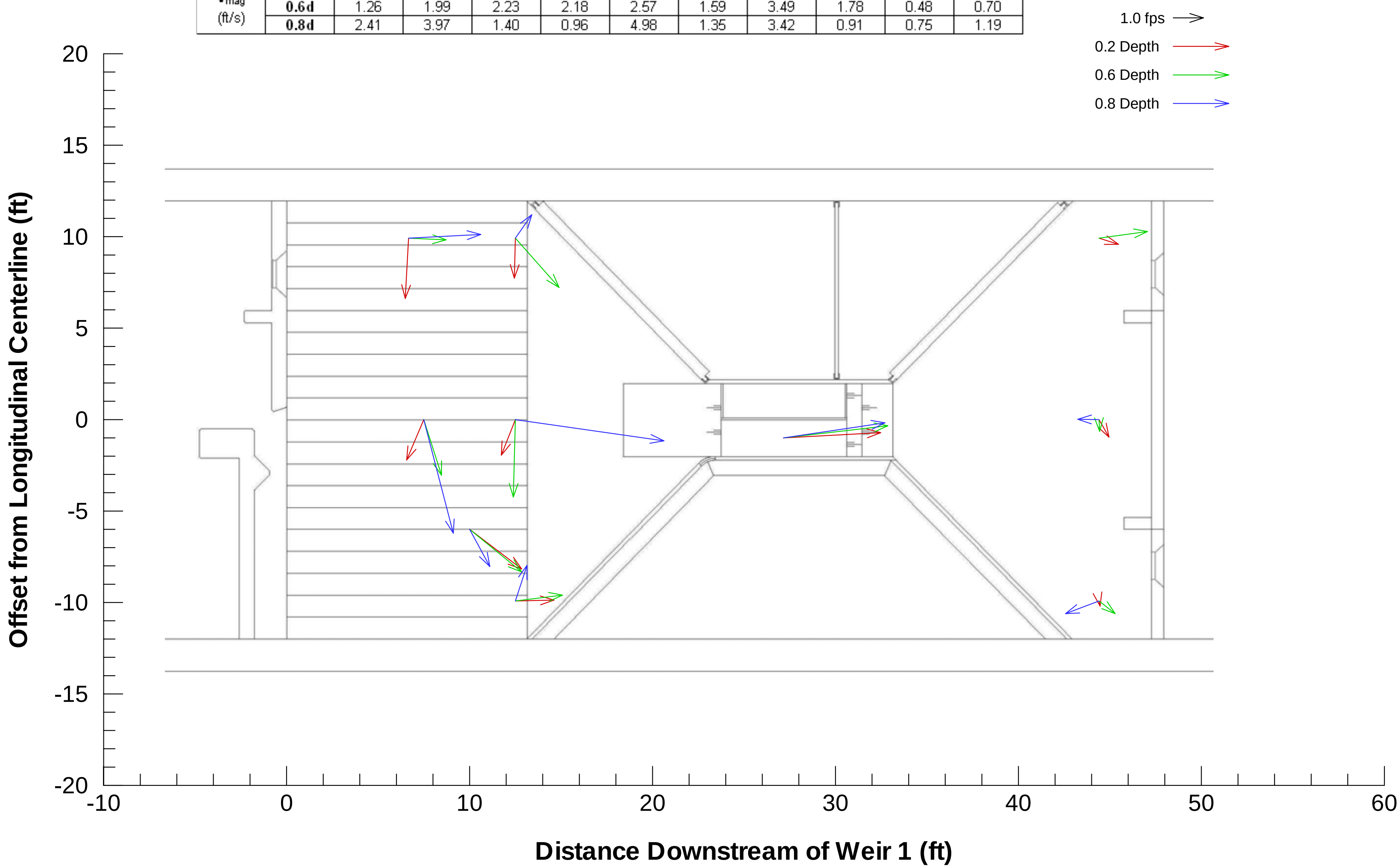
OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST C
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

DRAWN BY:	DATE:	PROJECT NUMBER:	FIGURE NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	4-11	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	2.37	1.55	2.17	1.36	1.36	1.29	3.23	0.70	0.69	0.17
	0.6d	1.26	1.99	2.23	2.18	2.57	1.59	3.49	1.78	0.48	0.70
	0.8d	2.41	3.97	1.40	0.96	4.98	1.35	3.42	0.91	0.75	1.19



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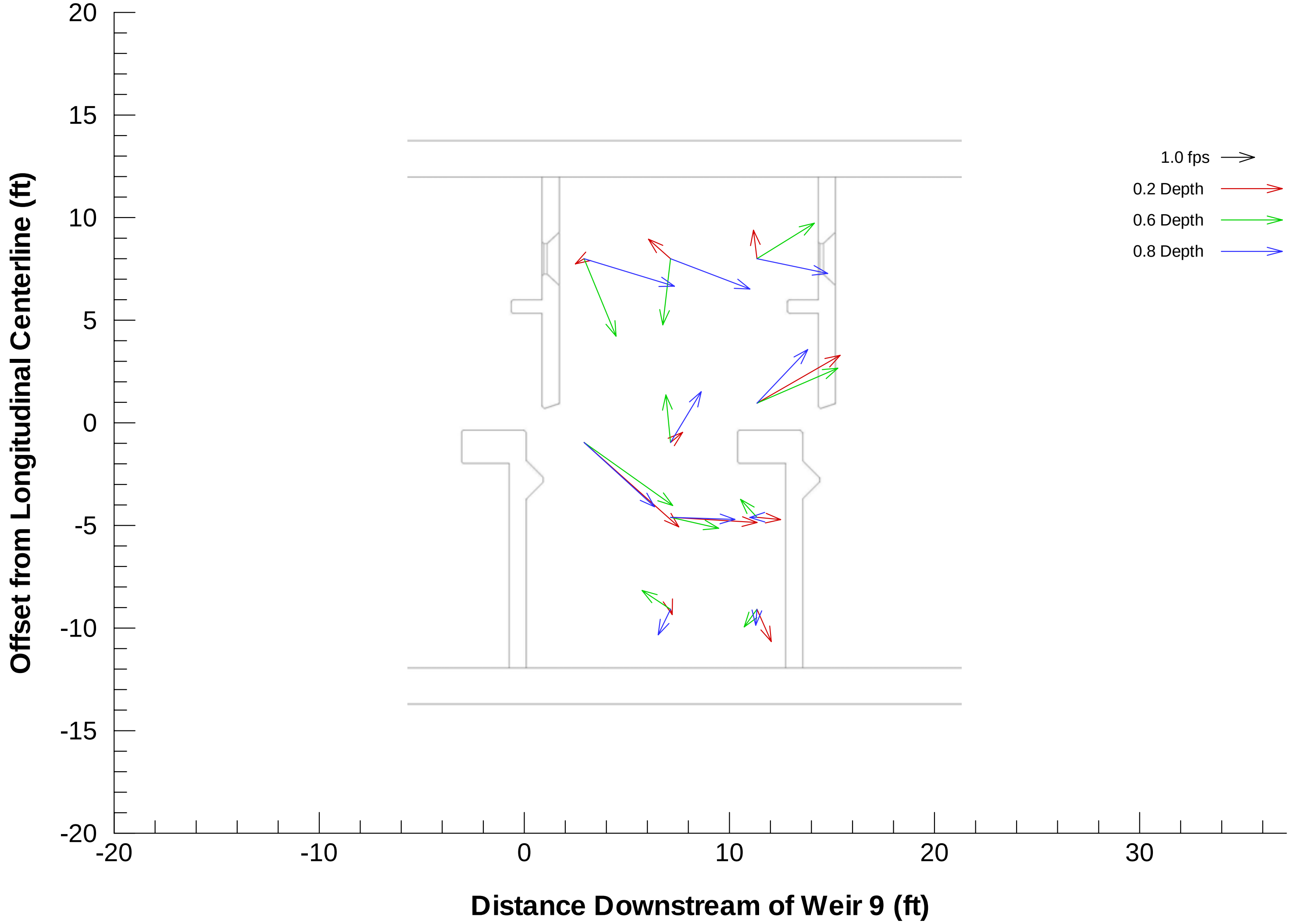
COUNT STATION VELOCITIES
CONFIGURATION No. 2 - TEST C
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-12**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	0.37	0.89	0.87	2.93	3.83	0.48	2.62	0.77	0.17	1.11
	0.6d	2.55	2.02	2.05	2.66	3.30	1.50	1.50	0.74	1.06	0.68
	0.8d	2.86	2.59	2.26	2.23	2.97	1.90	1.97	0.22	0.88	0.49



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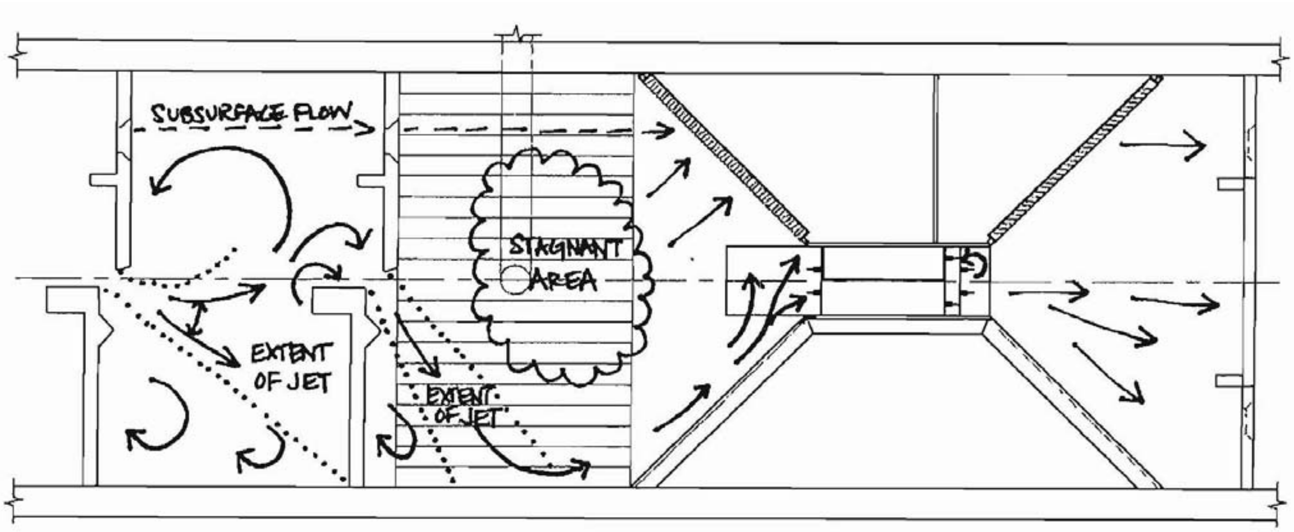
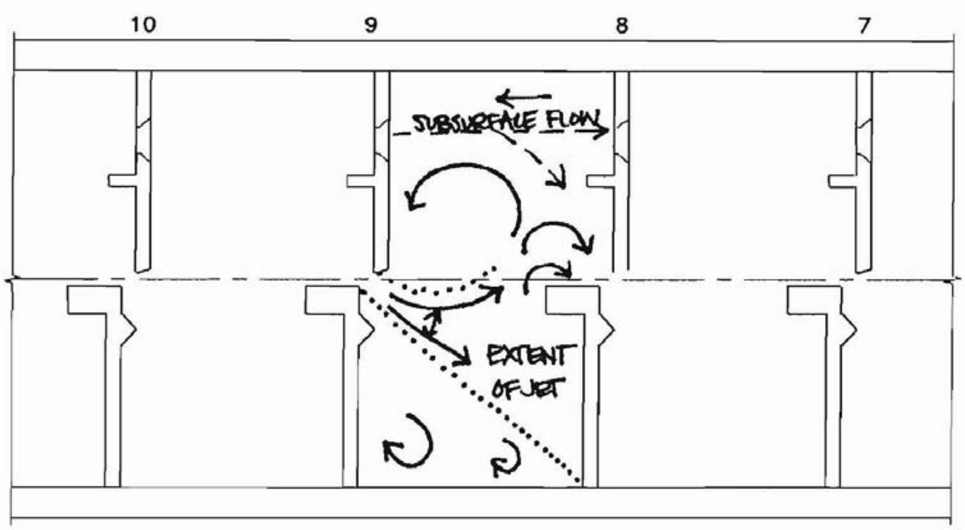
WEIR POOL 8 VELOCITIES
CONFIGURATION No. 2 - TEST C

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:			
4-13			
DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Count Station



Pool 8

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OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST D

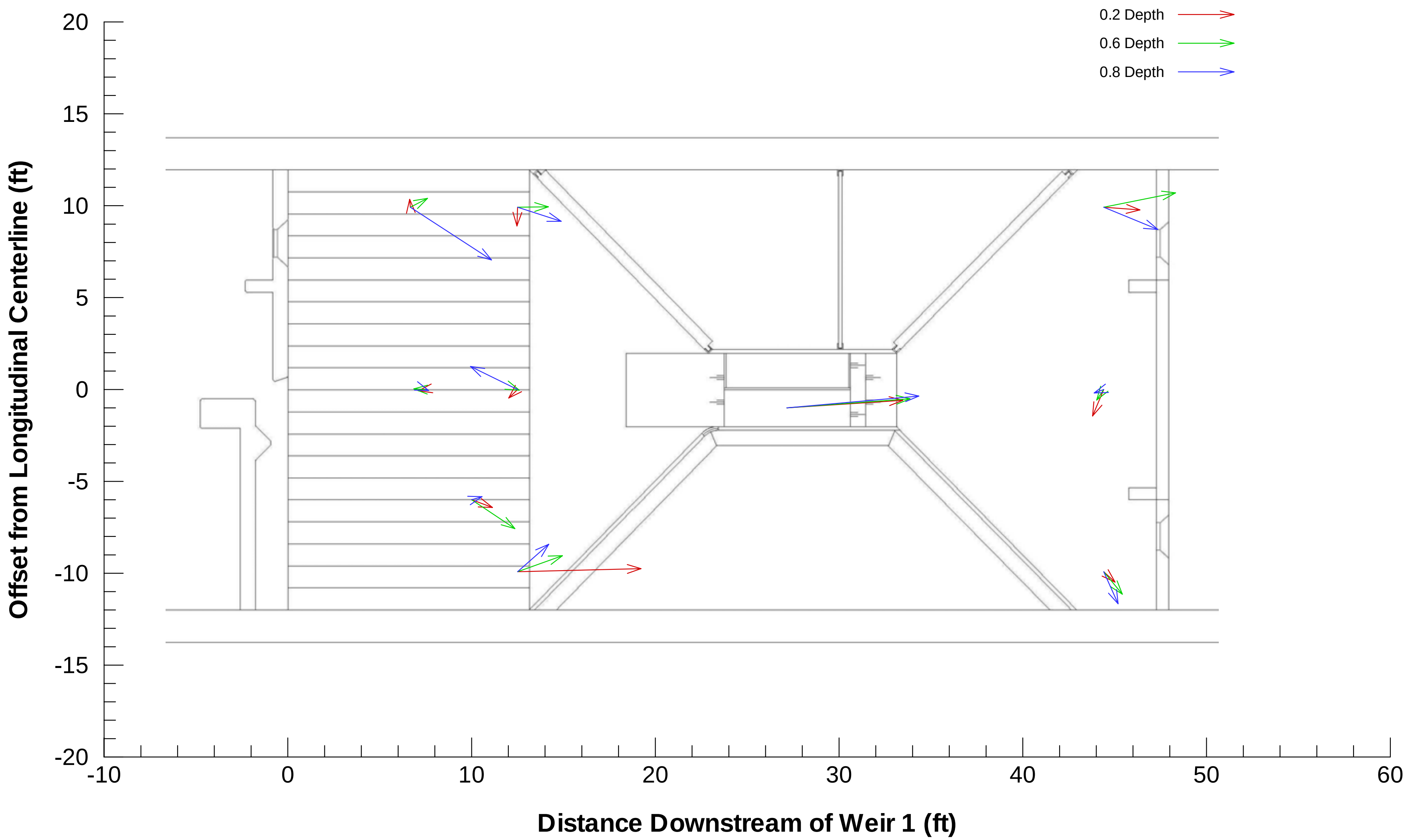
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4–14

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.27	0.24	0.74	0.62	0.42	4.16	3.84	1.29	1.02	0.51
	0.6d	0.64	0.53	1.72	1.02	0.11	1.57	4.07	2.58	0.55	0.97
	0.8d	3.19	0.35	0.36	1.54	1.75	1.38	4.39	2.00	0.38	1.16

1.0 fps



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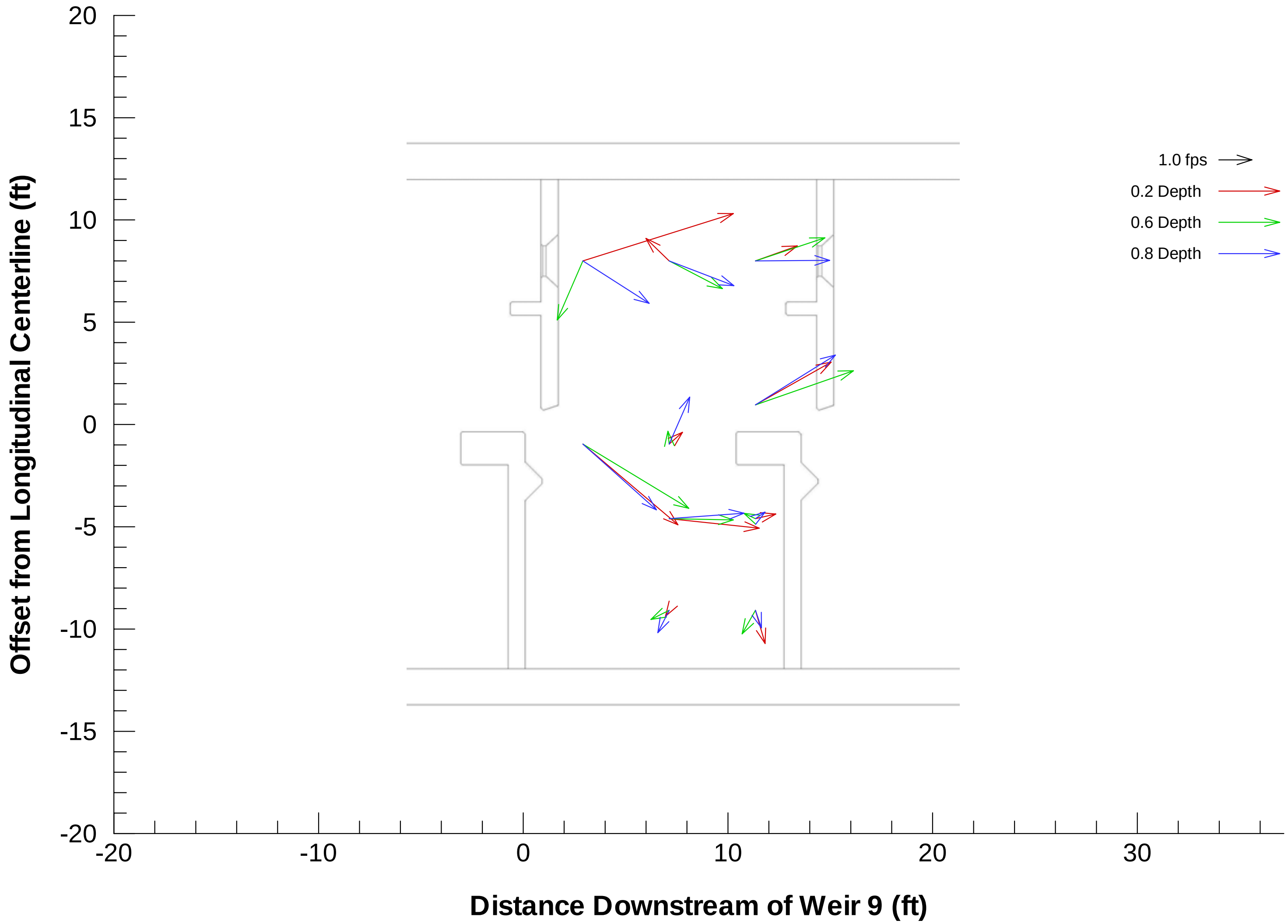
COUNT STATION VELOCITIES
CONFIGURATION No. 2 - TEST D

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-15

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	5.40	0.98	1.39	2.66	3.77	0.59	2.74	0.68	0.27	1.11
	0.6d	2.01	1.82	2.22	3.15	3.76	0.83	1.97	0.40	0.65	0.82
	0.8d	2.39	2.11	2.34	2.85	3.03	1.64	2.31	0.36	0.76	0.56



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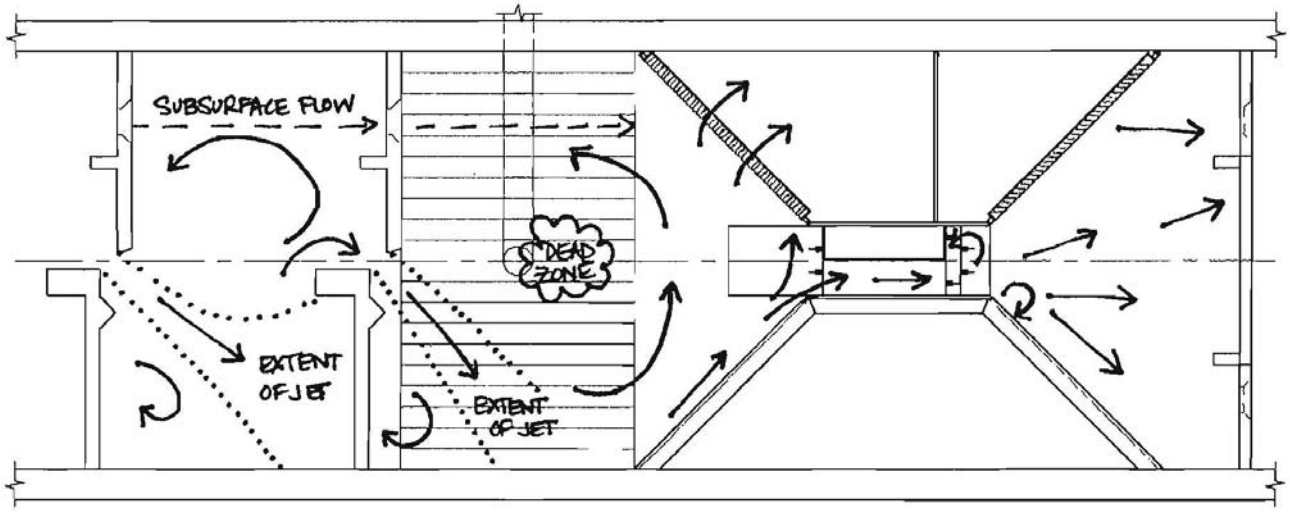
WEIR POOL 8 VELOCITIES
CONFIGURATION No. 2 - TEST D

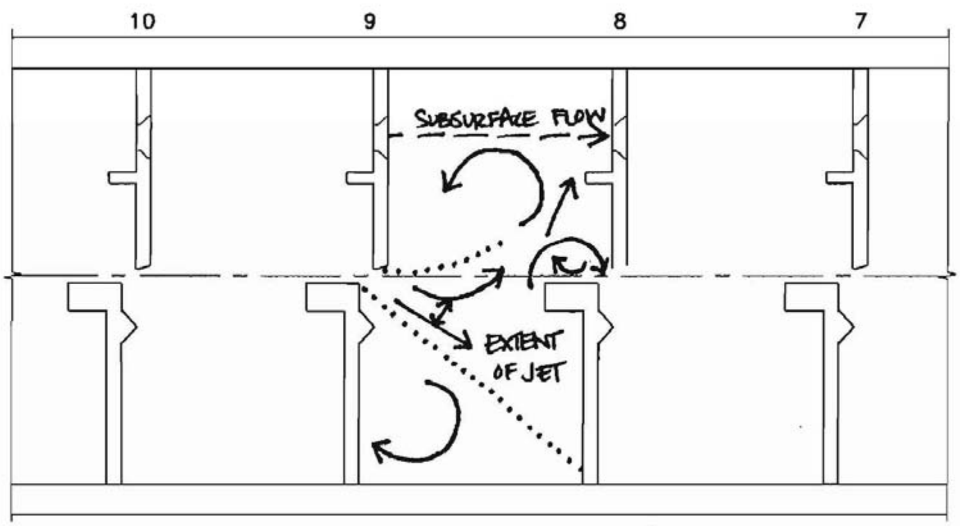
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-16

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Count Station



Pool 8

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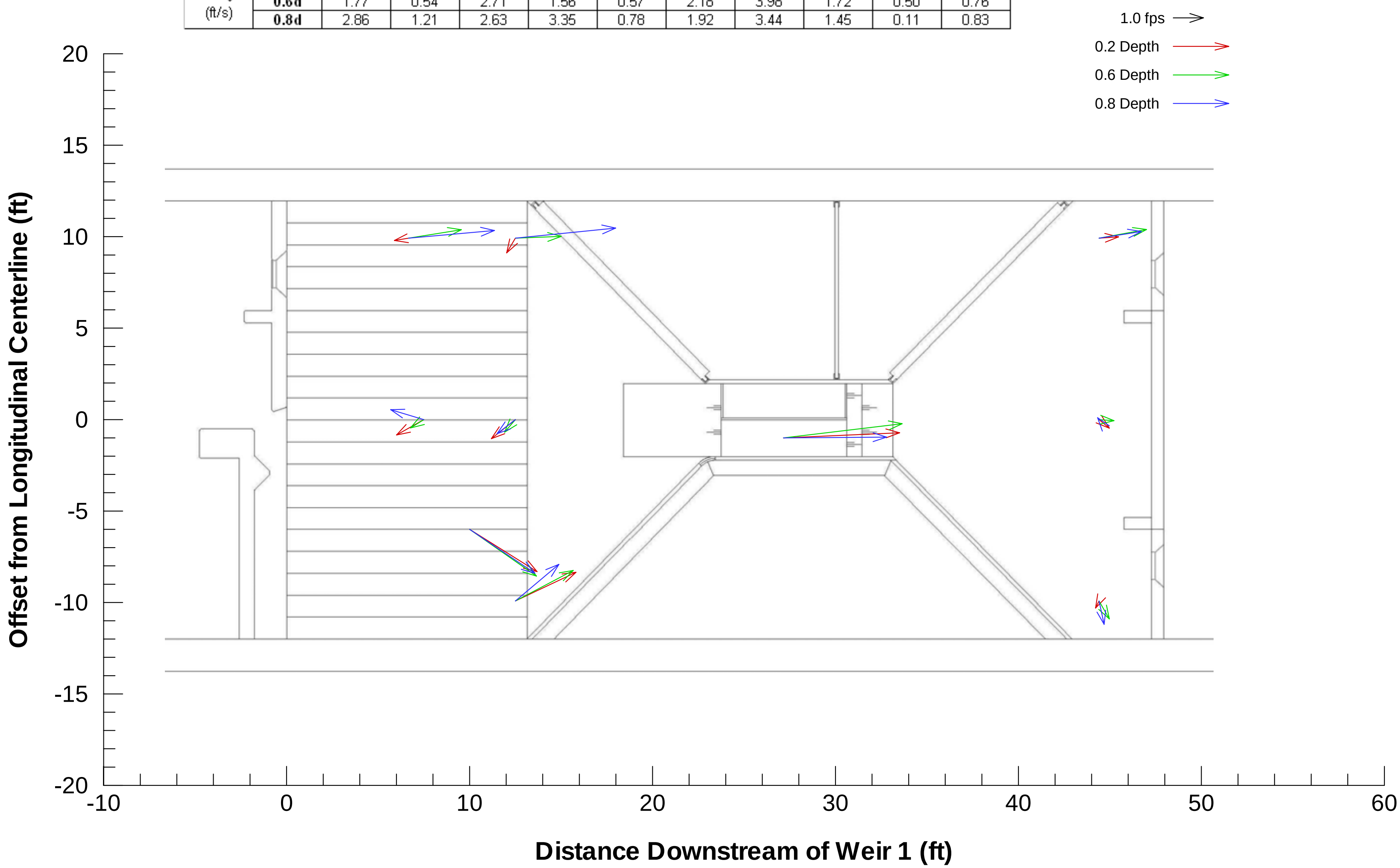
OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST E
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-17

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.48	1.04	2.64	0.61	1.02	2.23	3.85	0.74	0.45	0.27
	0.6d	1.77	0.54	2.71	1.56	0.57	2.18	3.98	1.72	0.50	0.76
	0.8d	2.86	1.21	2.63	3.35	0.78	1.92	3.44	1.45	0.11	0.83



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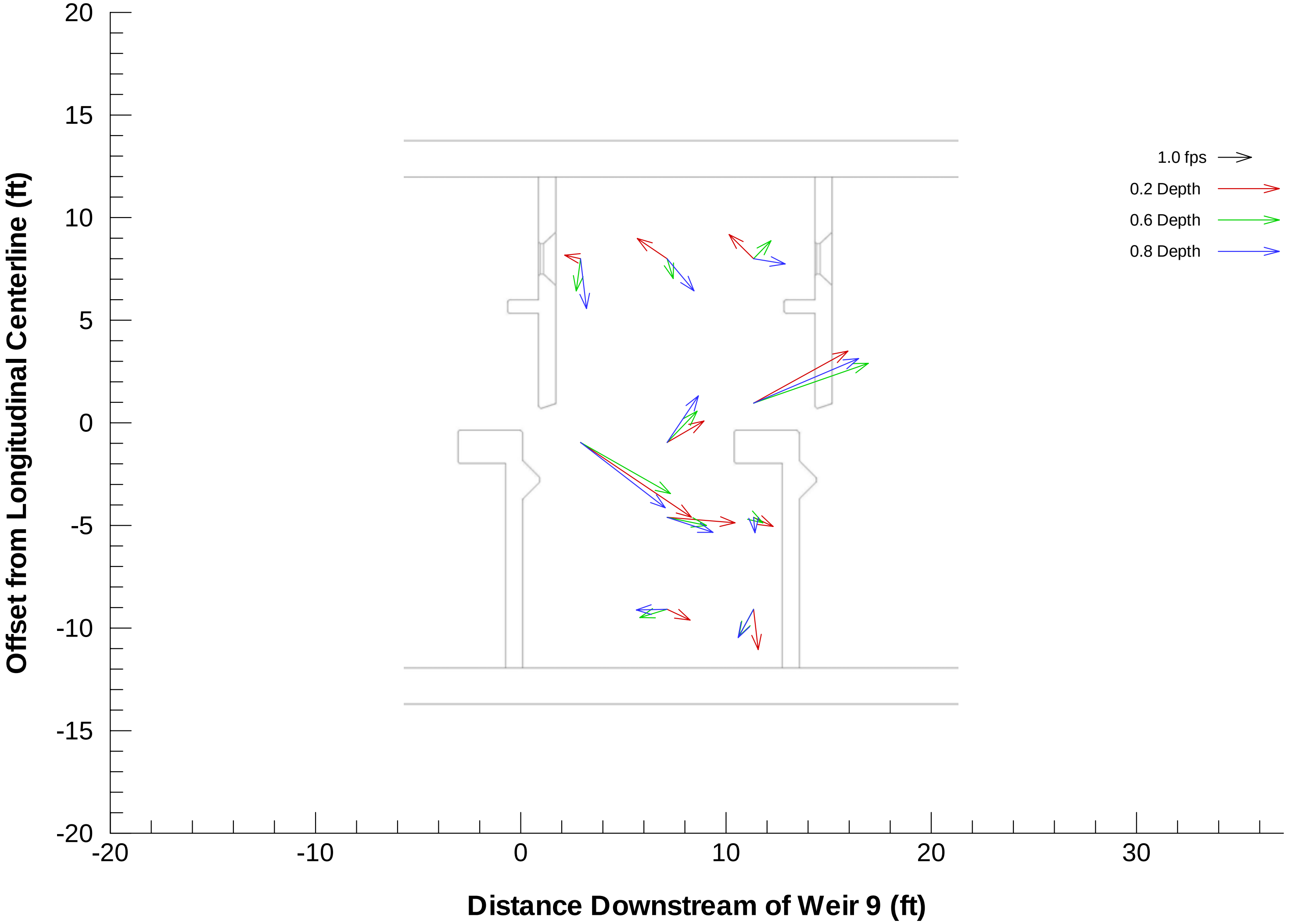
COUNT STATION VELOCITIES
CONFIGURATION No. 2 - TEST E

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-18

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.79	1.09	1.04	3.27	4.03	1.33	2.06	0.72	0.79	1.35
	0.6d	1.16	0.67	0.89	3.69	3.12	1.36	1.23	0.99	0.90	1.16
	0.8d	1.52	1.27	1.00	3.47	3.27	1.70	1.50	1.06	0.95	1.09



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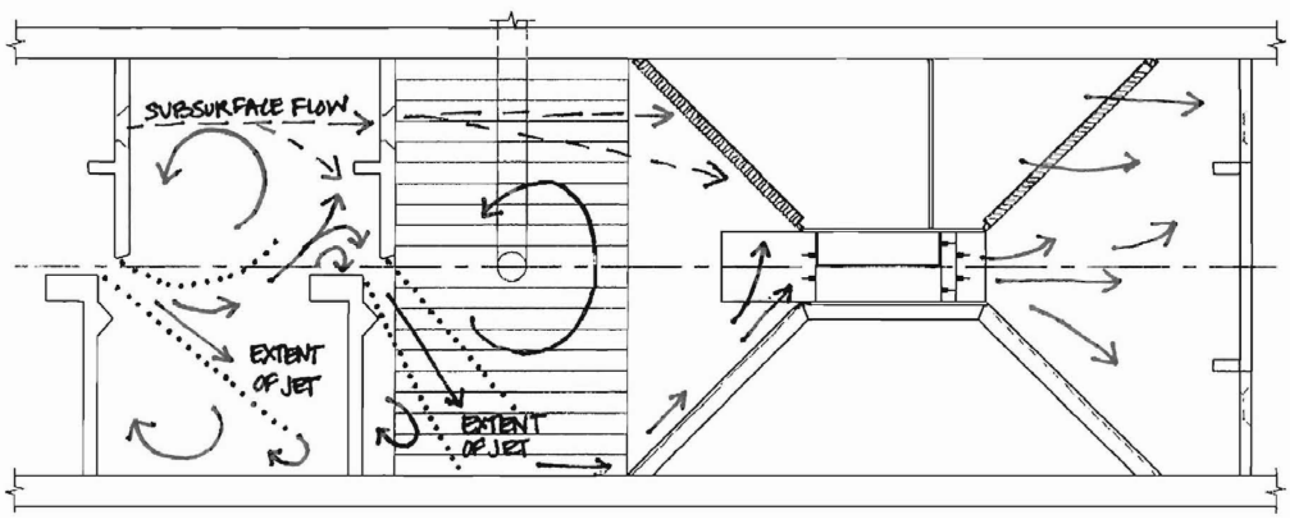
WEIR POOL 8 VELOCITIES
CONFIGURATION No. 2 - TEST E

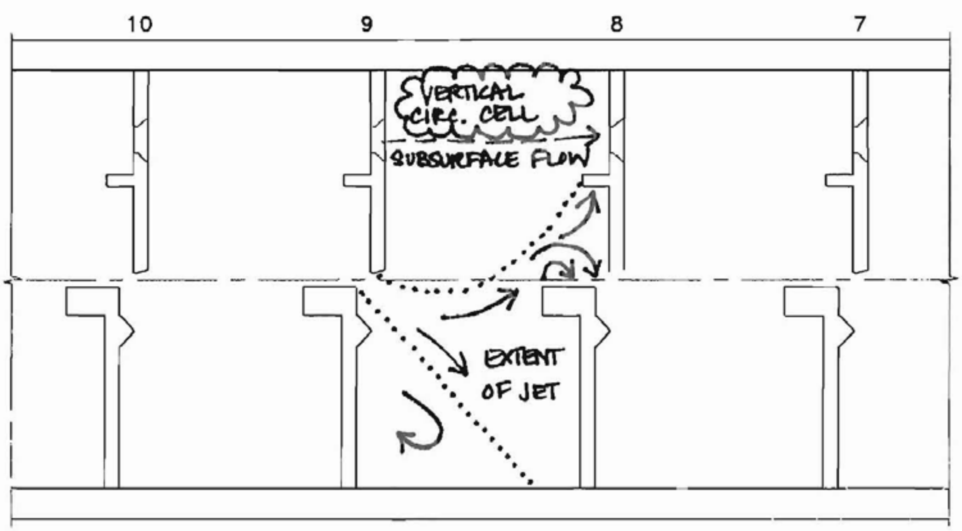
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-19

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Count Station



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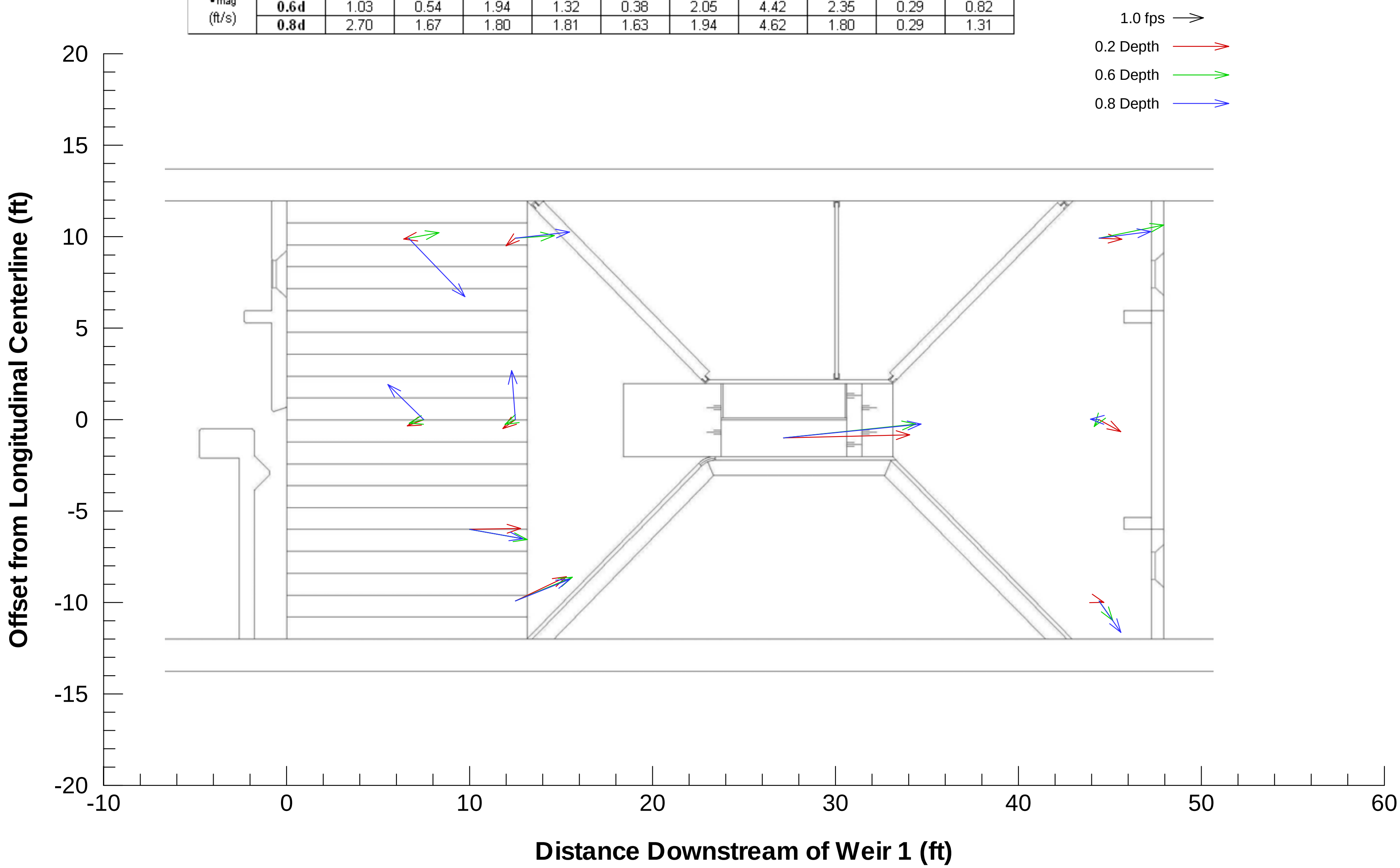
OBSERVED FLOW PATTERNS
CONFIG NO. 2 TEST F
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4–20

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900–419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.17	0.59	1.70	0.43	0.51	1.87	4.19	0.90	0.85	0.17
	0.6d	1.03	0.54	1.94	1.32	0.38	2.05	4.42	2.35	0.29	0.82
	0.8d	2.70	1.67	1.80	1.81	1.63	1.94	4.62	1.80	0.29	1.31



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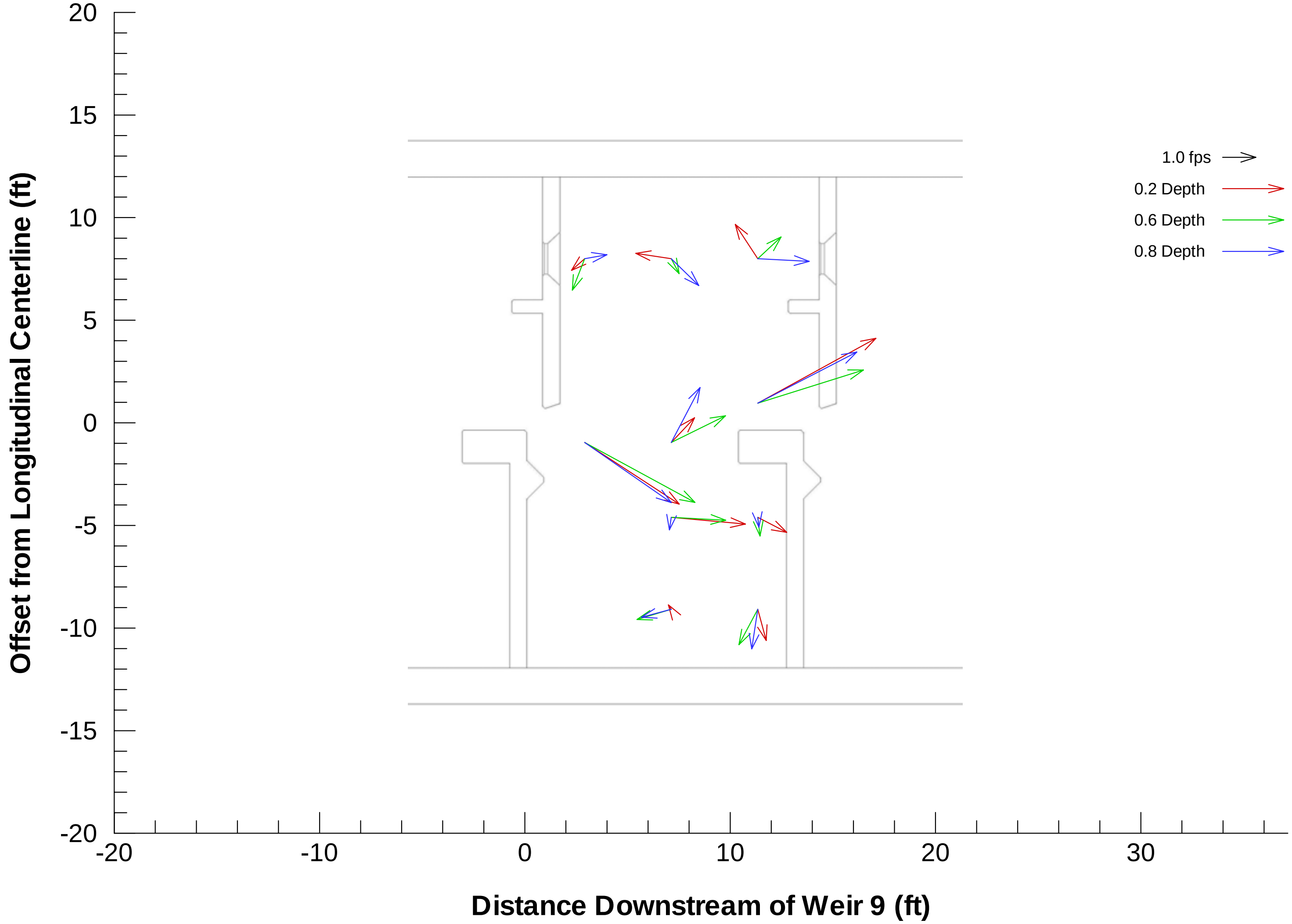
COUNT STATION VELOCITIES
CONFIGURATION No. 2 - TEST F

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-21

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	0.65	1.09	1.29	4.06	3.41	1.09	2.25	1.13	0.28	1.17
	0.6d	1.22	0.54	1.04	3.34	3.79	1.82	1.67	0.81	1.10	1.29
	0.8d	0.69	1.16	1.55	3.38	3.20	1.87	0.39	0.63	0.95	1.23



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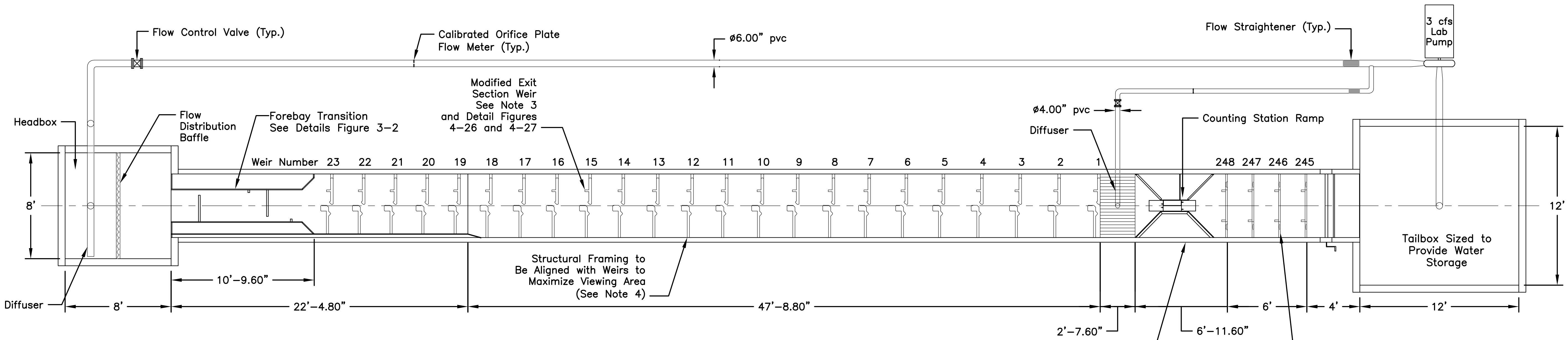
WEIR POOL 8 VELOCITIES
CONFIGURATION No. 2 - TEST F

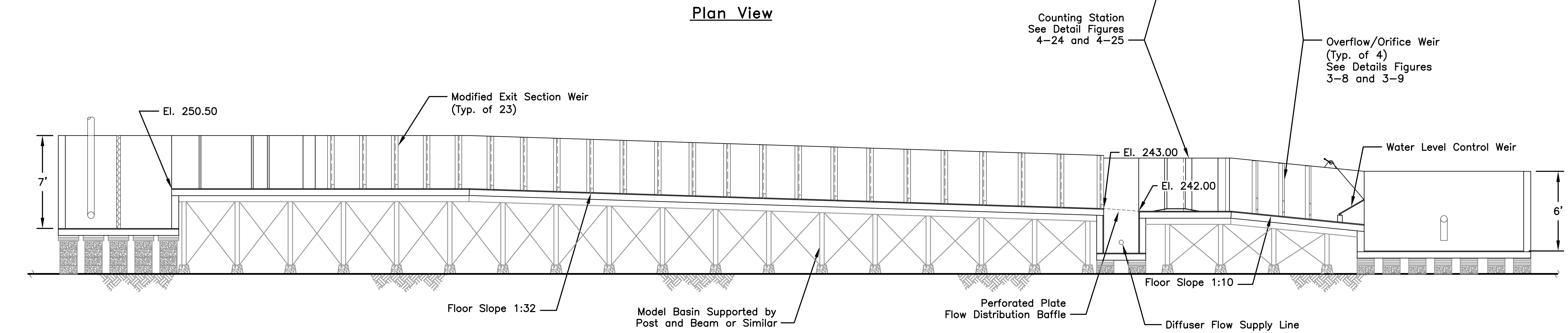
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-22

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/20/08	09000-419	LR



Plan View



Section at Centerline

JDAS configuration - Modified Weir Stations (model inches)

Weir	Downstream Baffle		Centerline	Upstream baffle		Weir	Downstream Baffle		Centerline	Upstream baffle	
	D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face
1	0.00	2.40	3.27	4.14	6.14	13	399.60	402.00	402.66	403.32	405.32
2	36.00	38.40	39.27	40.14	42.14	14	430.80	433.20	433.86	434.52	436.52
3	71.21	73.61	74.27	74.93	76.93	15	460.80	463.20	463.86	464.52	466.52
4	106.01	108.41	109.07	109.73	111.73	16	490.80	493.20	493.86	494.52	496.52
5	140.81	143.21	143.87	144.53	146.53	17	520.80	523.20	523.86	524.52	526.52
6	174.41	176.81	177.47	178.13	180.13	18	550.80	553.20	553.86	554.52	556.52
7	208.01	210.41	211.07	211.73	213.73	19	579.60	582.00	582.66	583.32	585.32
8	240.41	242.81	243.47	244.13	246.13	20	608.40	610.80	611.67	612.54	614.54
9	272.81	275.21	275.87	276.53	278.53	21	637.20	639.60	640.47	641.34	643.34
10	304.80	307.20	307.86	308.52	310.52	22	666.00	668.40	669.27	670.14	672.14
11	337.20	339.60	340.26	340.92	342.92	23	694.80	697.20	698.07	698.94	700.94
12	368.40	370.80	371.46	372.12	374.12						

Notes:
1) Dimensions given in model feet and inches
2) Model to prototype scale = 1:5
3) Exit Section weirs to be replaced with lamprey friendly weirs following baseline testing
4) Both sidewalls to be fabricated using clear acrylic
5) Viewing platforms will be provided for Exit Section and Counting Station, not shown for clarity

REVISIONS

NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA\KM
CHECKED BY: LR
APPROVED BY: CS

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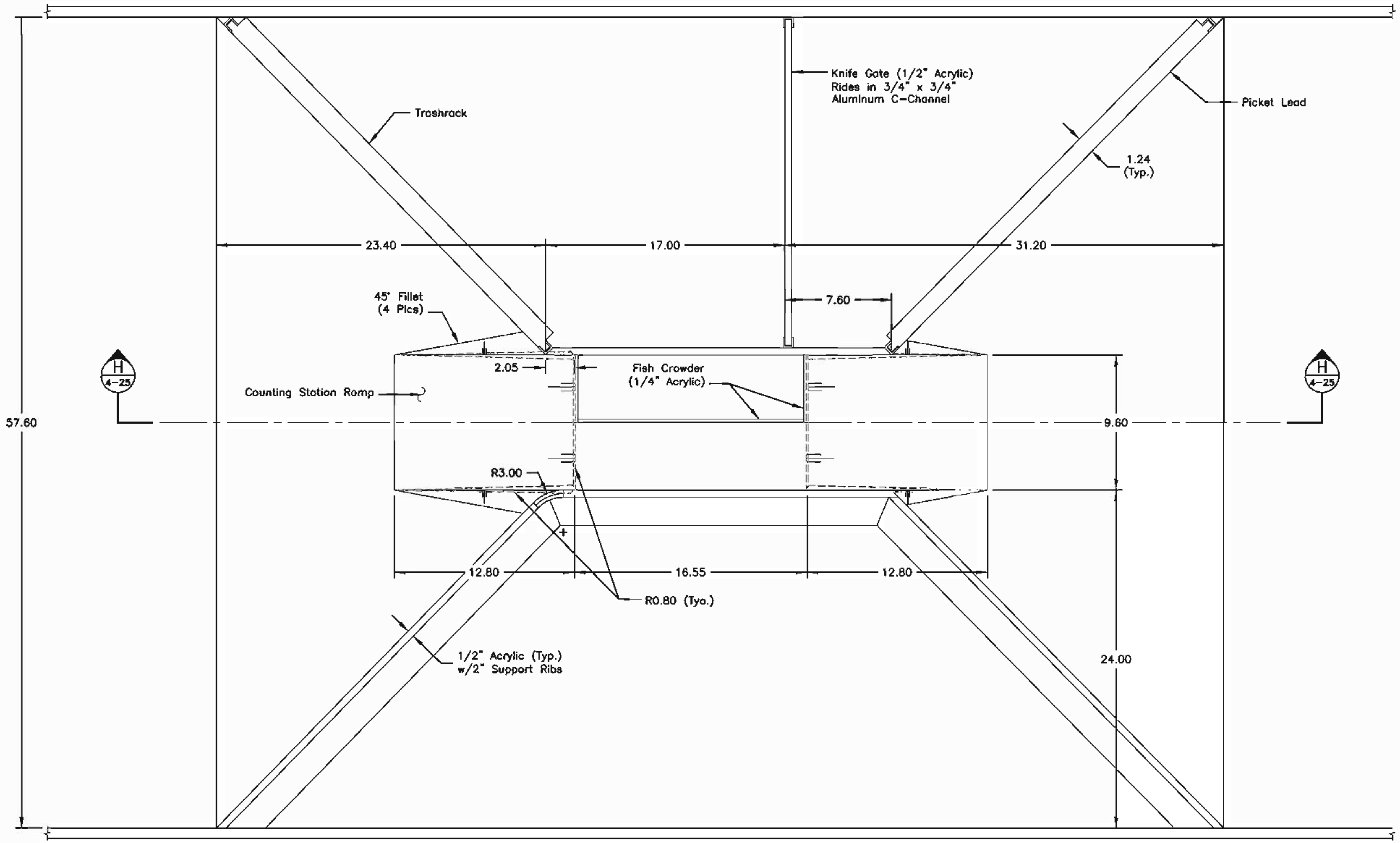
MODIFIED MODEL LAYOUT PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers, Portland District
Portland, Oregon

SCALE: 1" = 8'
DATE: 03/24/08
PROJECT NUMBER: 09000–419

FIGURE NUMBER: 4–23

FILENAME: 09000419–GML–Mod



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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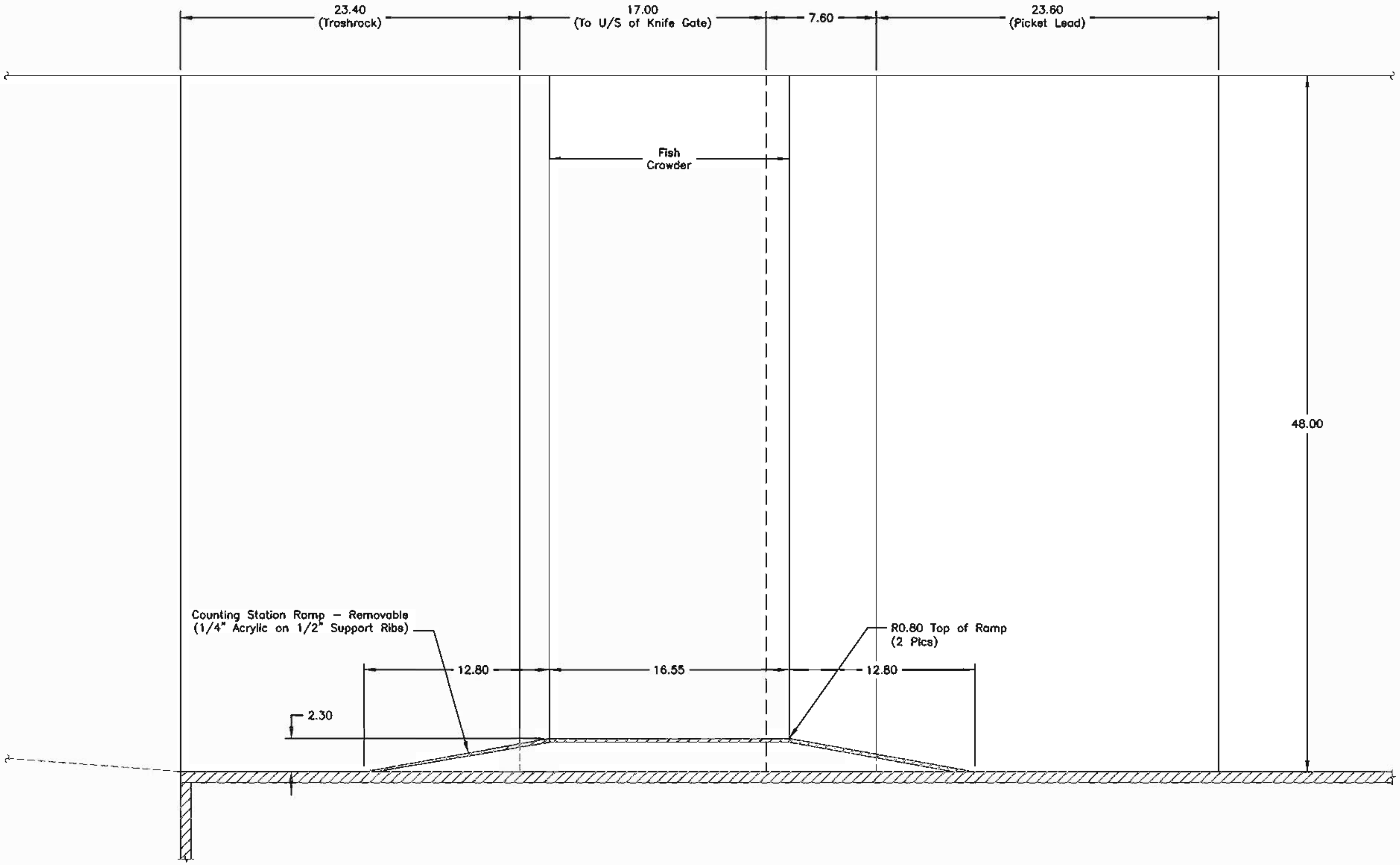
MODIFIED COUNTING STATION
DETAILS - PLAN VIEW
John Day North Fish Ladder
U.S. Army Corps of Engineers - Portland District
Portland, Oregon

SCALE: 1:8
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-24

FILENAME: CSto-Det-Pln-Mod



Section H (4-24)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA\KM
CHECKED BY: LR
APPROVED BY: CS

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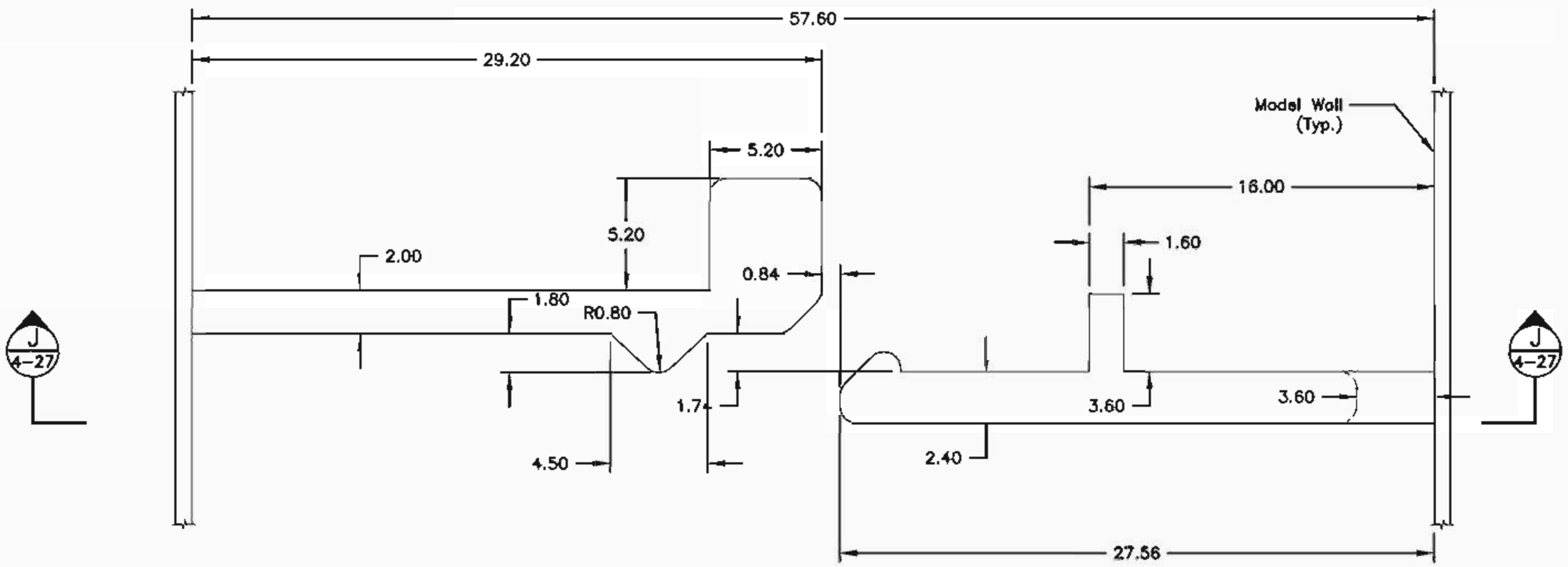
MODIFIED COUNTING STATION DETAILS – SECTION VIEW

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

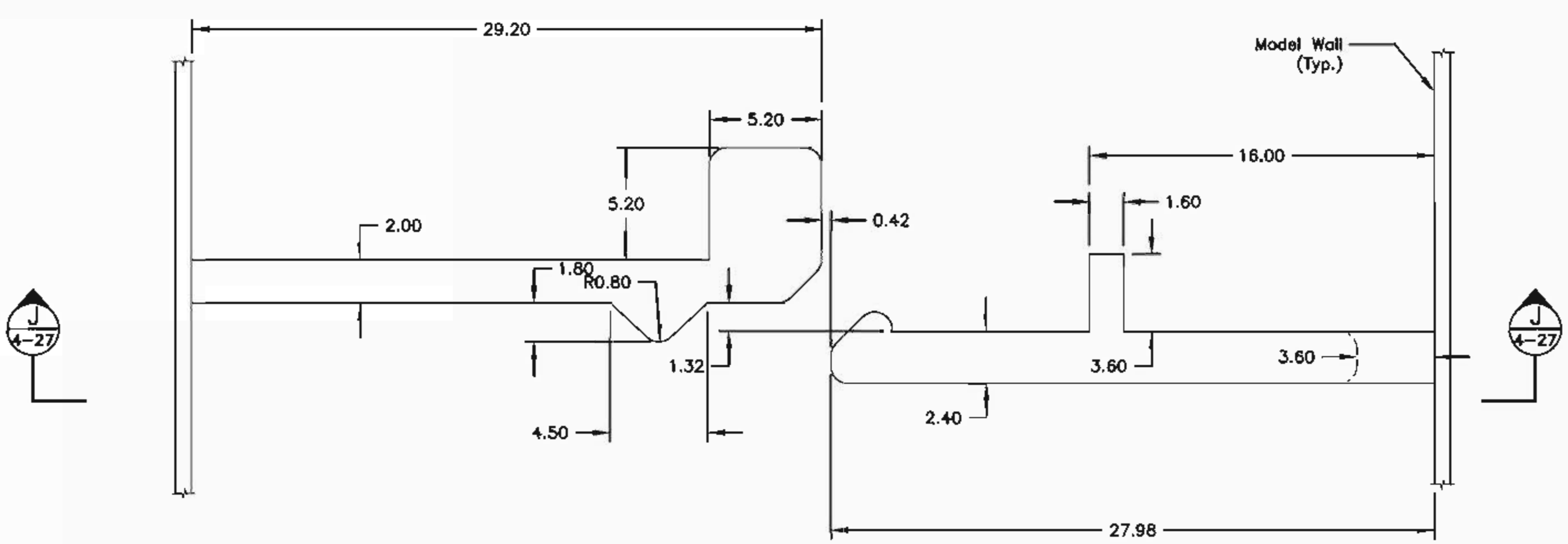
SCALE: 1:8
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4–25

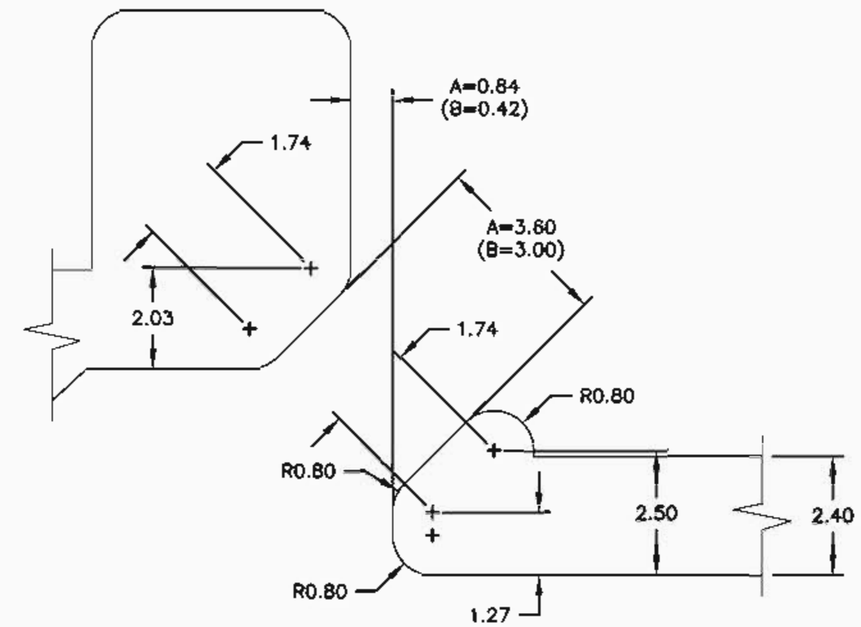
FILENAME: CSta-Det-Sec-Mod



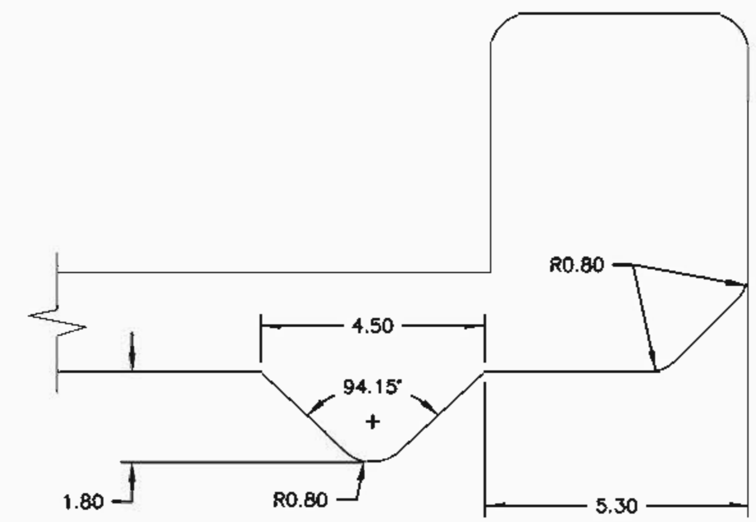
Typical Weir Plan A – Modified Weirs 1, 2, 3, 21, 22, and 23
(Scale = 1:8)



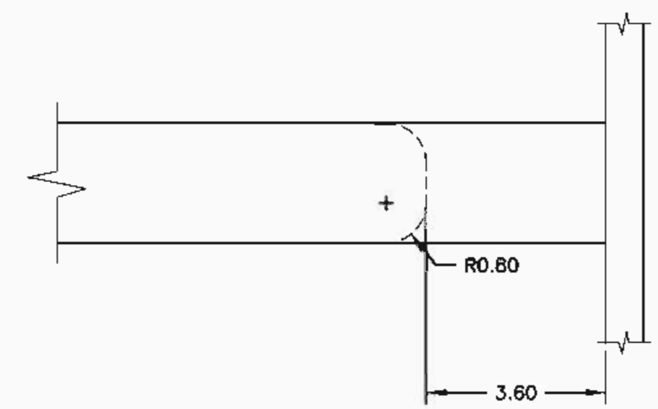
Typical Weir Plan B – Modified Weirs 4-20
(Scale = 1:8)



Detail 1, A and B
(Scale = 1:4)



Detail 2
(Scale = 1:4)



Detail 3
(Scale = 1:4)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
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CHECKED BY: LR
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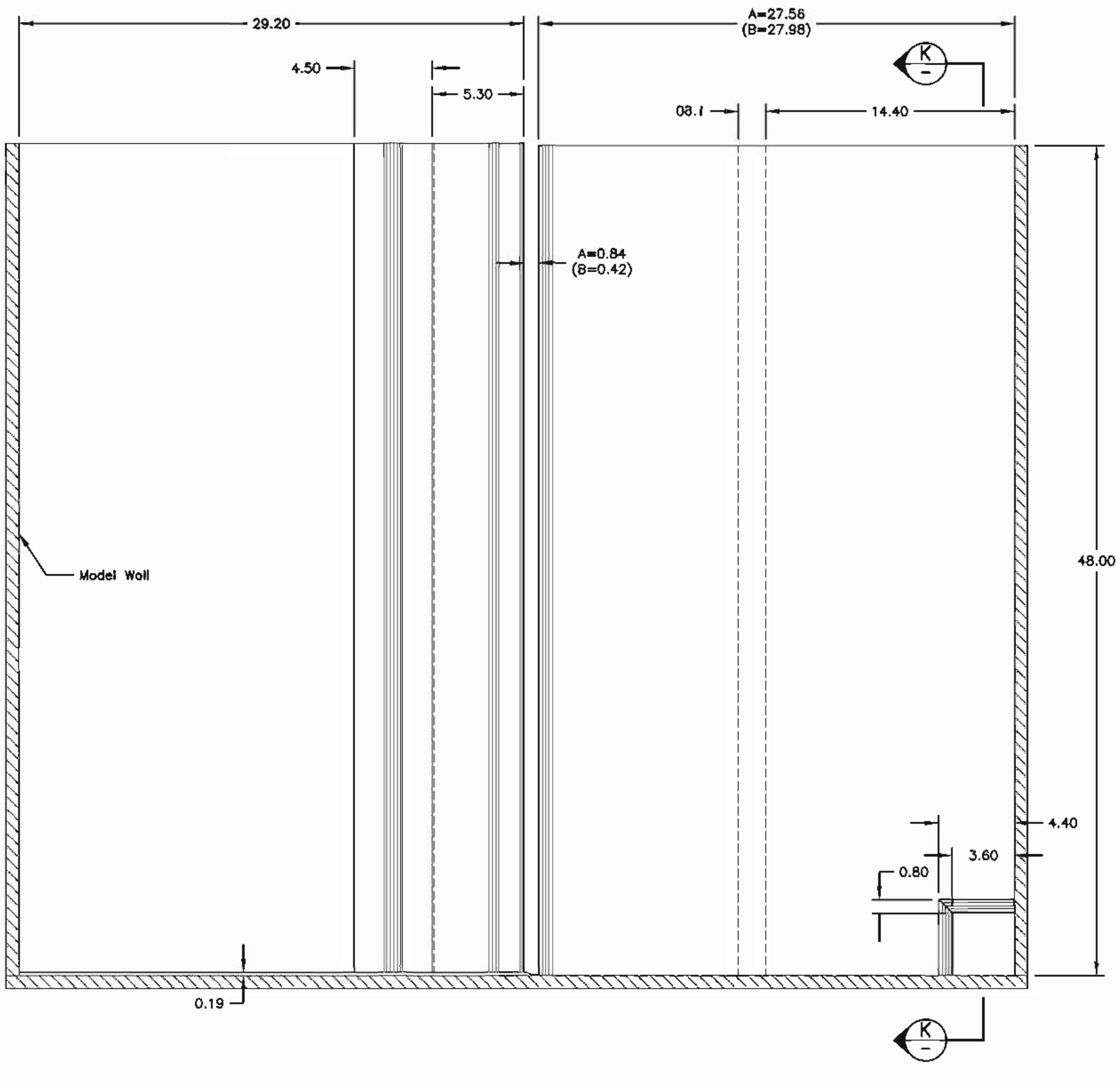
MODIFIED EXIT SECTION WEIRS PLAN VIEWS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

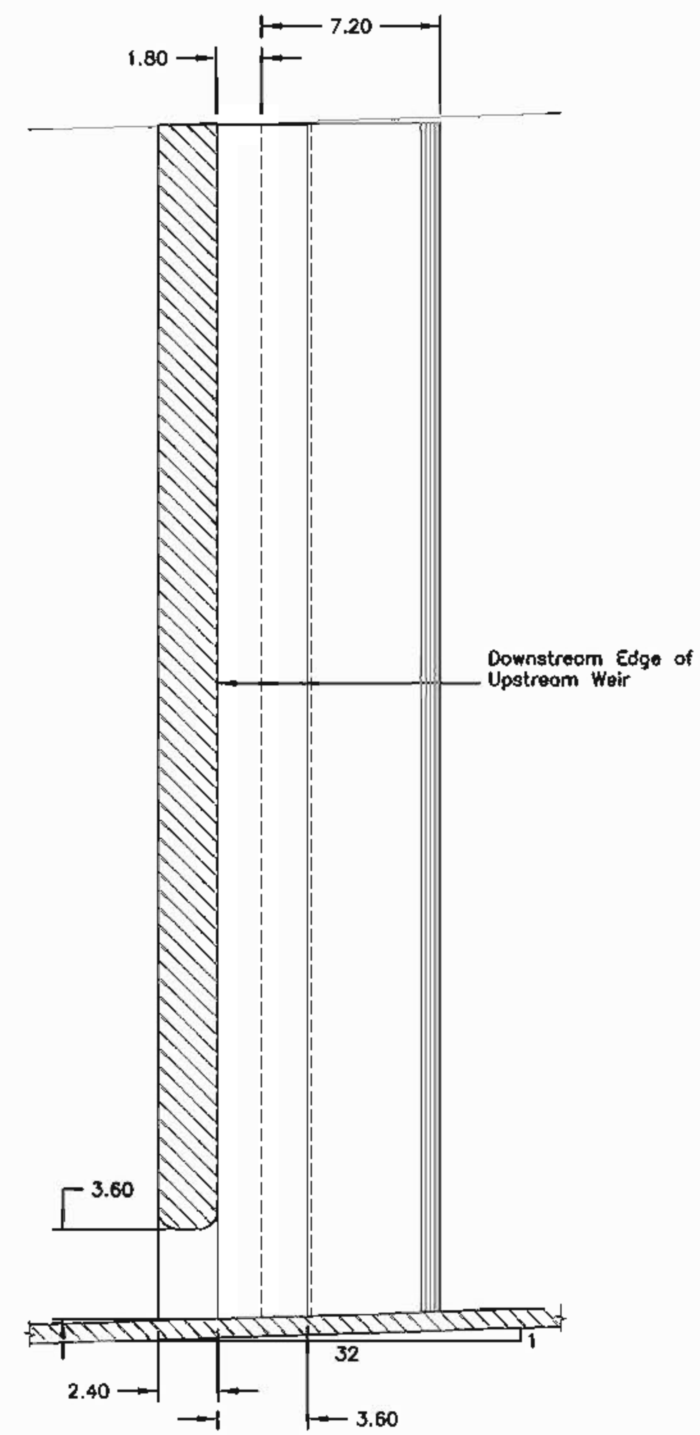
SCALE: as noted
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-26

FILENAME: Mod-Weirs



Section J 4-26



Section K

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
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APPROVED BY: CS

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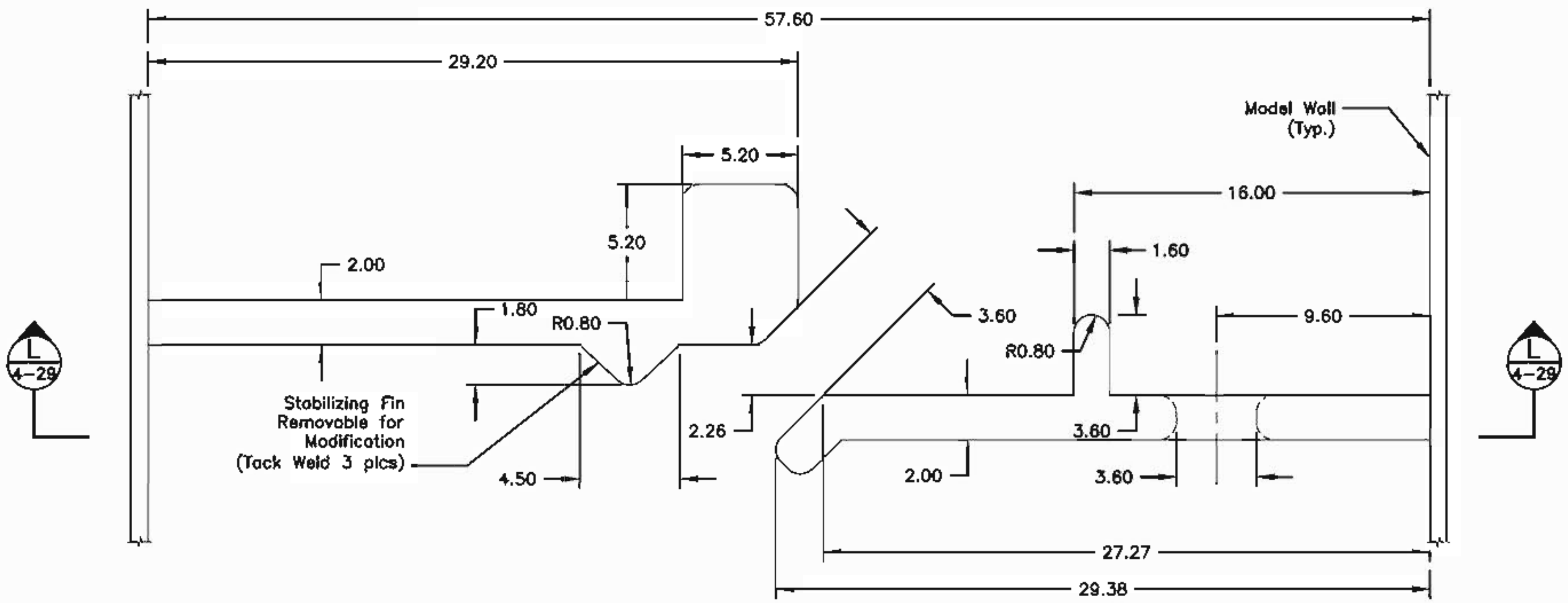
EXIT SECTION WEIRS
ELEVATION AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers - Portland District
Portland, Oregon

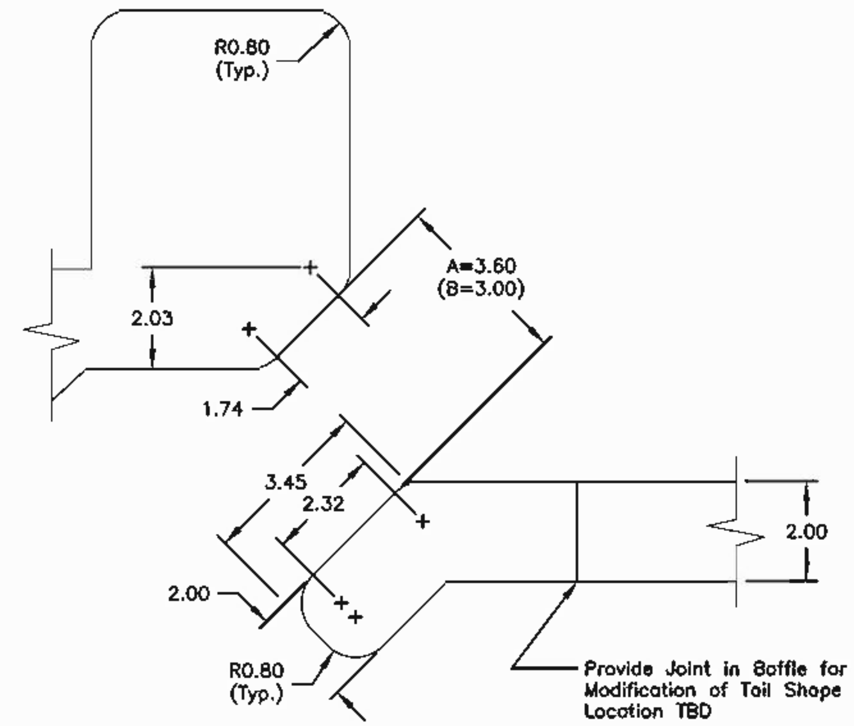
PROJECT NUMBER: 09000-419
DATE: 03/24/08
SCALE: 1:8

FIGURE NUMBER:
4-27

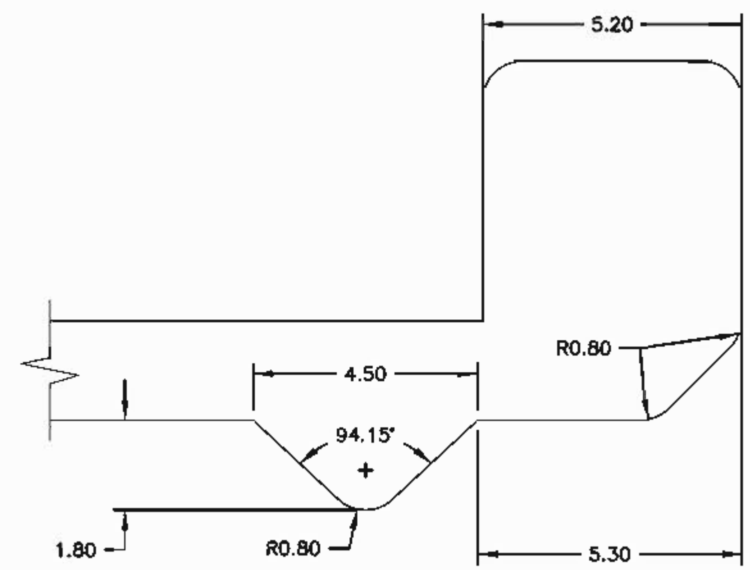
FILENAME:
XSec-Mod-Weir



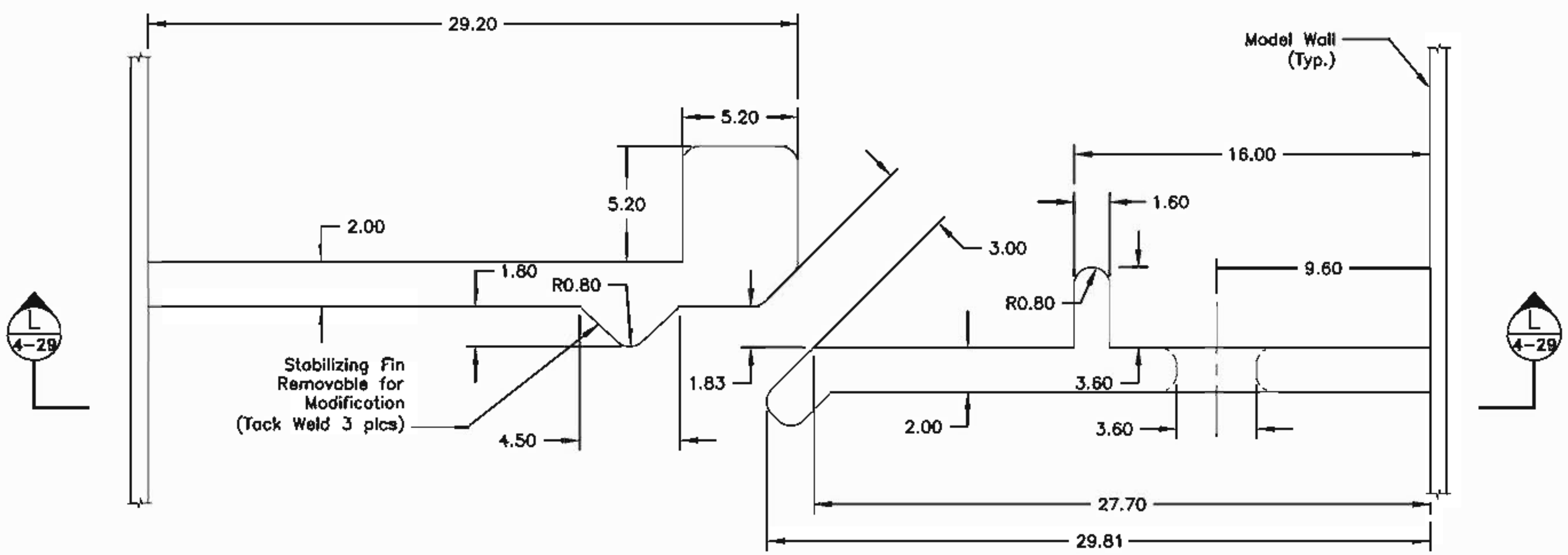
Typical Weir Plan A – Modified Weirs 2, 3, 21, 22, and 23
(Scale = 1:8)
(EXISTING MODIFIED WIER 1 DOES NOT CHANGE – ORIFICE REMAINS AT LADDER WALL)



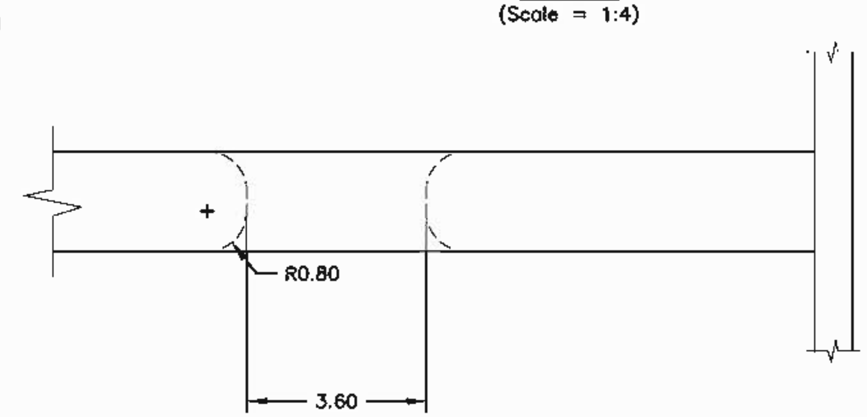
Detail 1, A and B
(Scale = 1:4)



Detail 2
(Scale = 1:4)



Typical Weir Plan B – Modified Weirs 4-20
(Scale = 1:8)



Detail 3
(Scale = 1:4)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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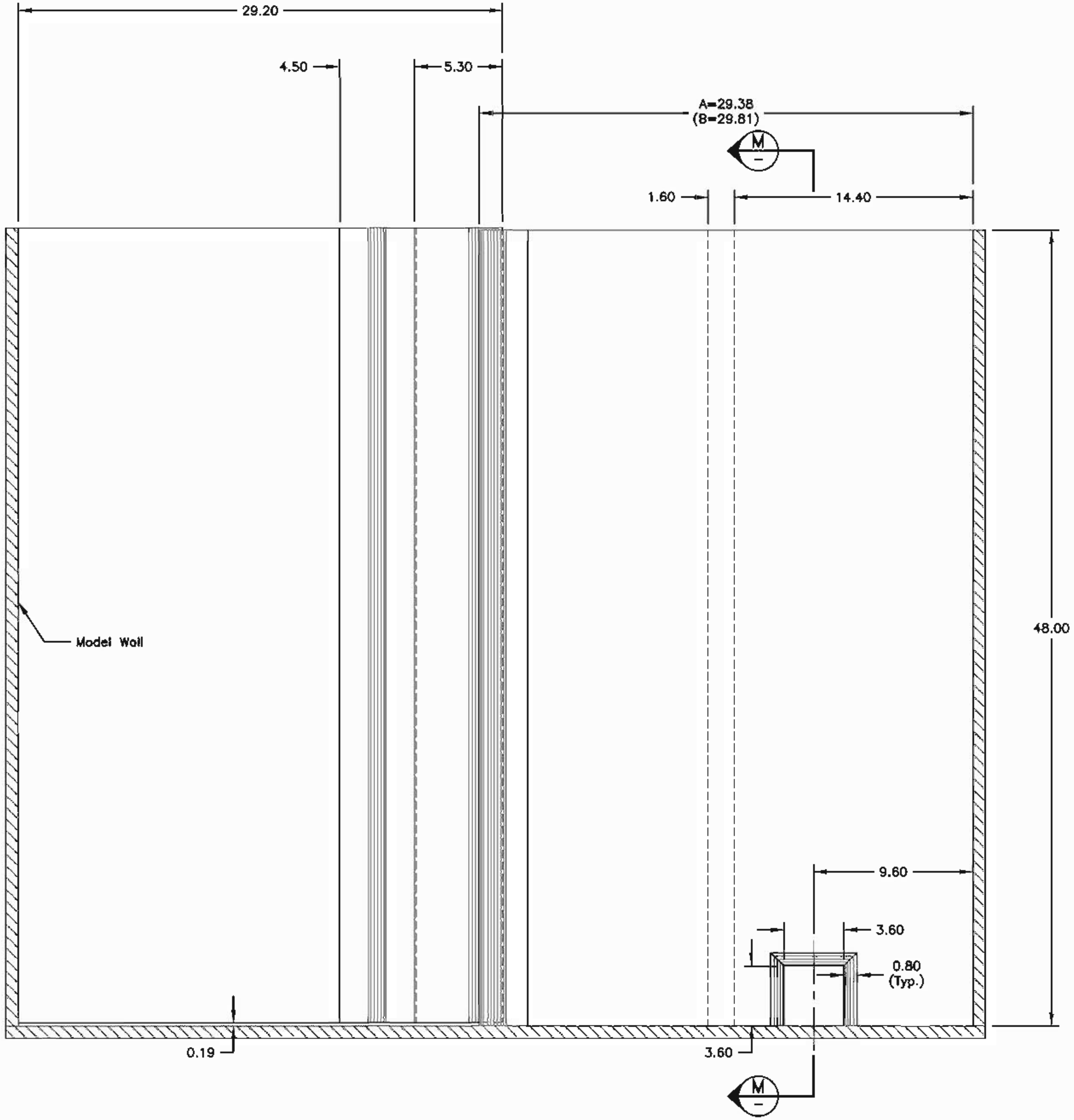
MODIFIED EXIT SECTION WEIRS PLAN VIEWS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

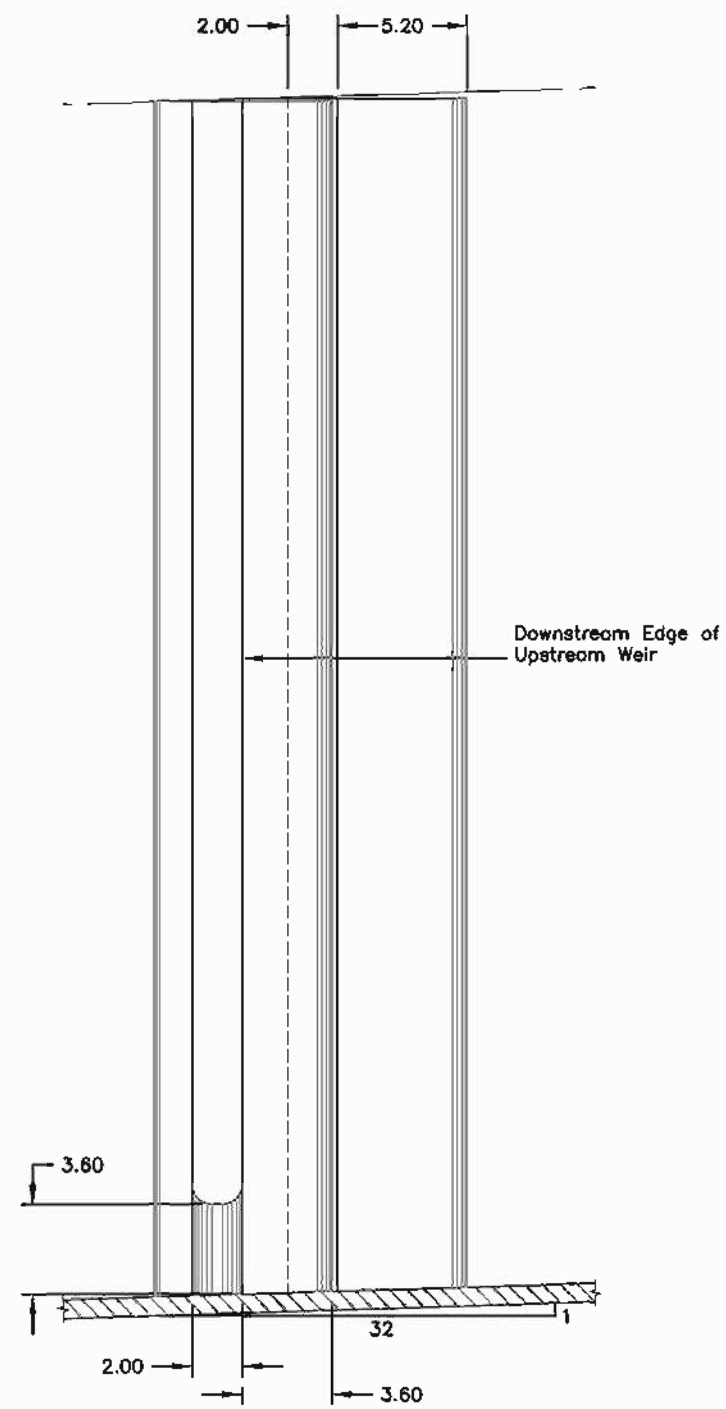
PROJECT NUMBER: 09000-419
DATE: 03/24/08
SCALE: as noted

FIGURE NUMBER: 4-28

FILENAME: Mod-Weirs-Rev3



Section L (4-28)



Section M

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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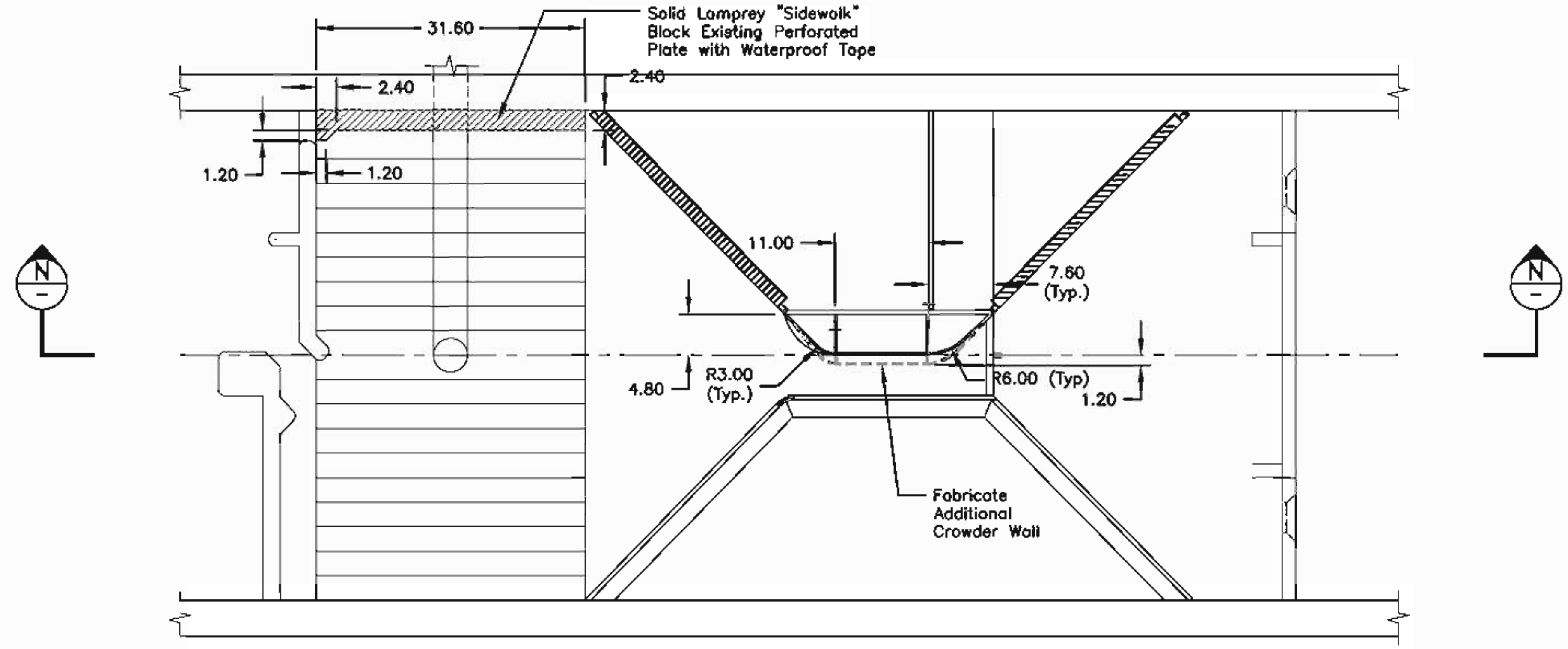
MODIFIED EXIT SECTION WEIRS ELEVATION AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers - Portland District
Portland, Oregon

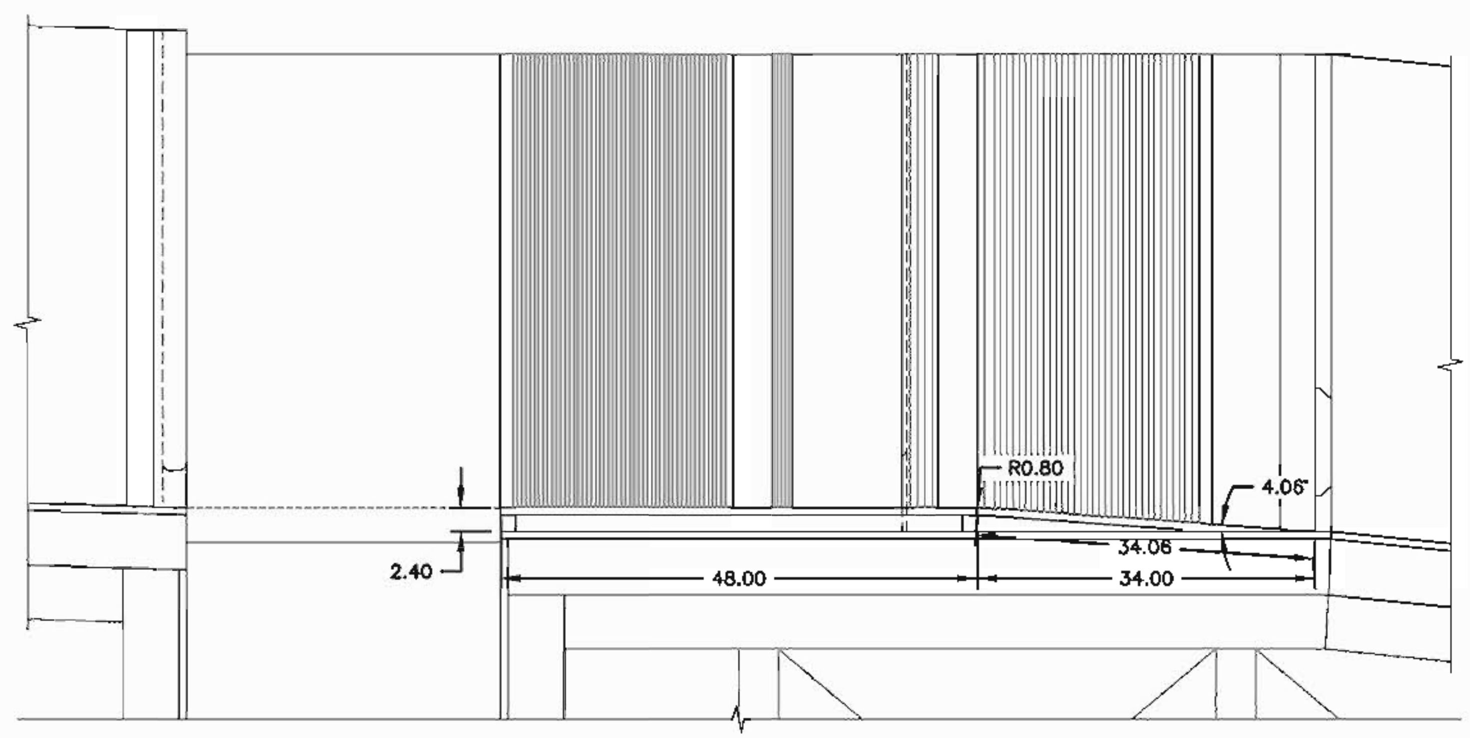
SCALE: 1:8
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-29

FILENAME: Mod-Weir-Sec-Rev3



Plan View



Section N

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
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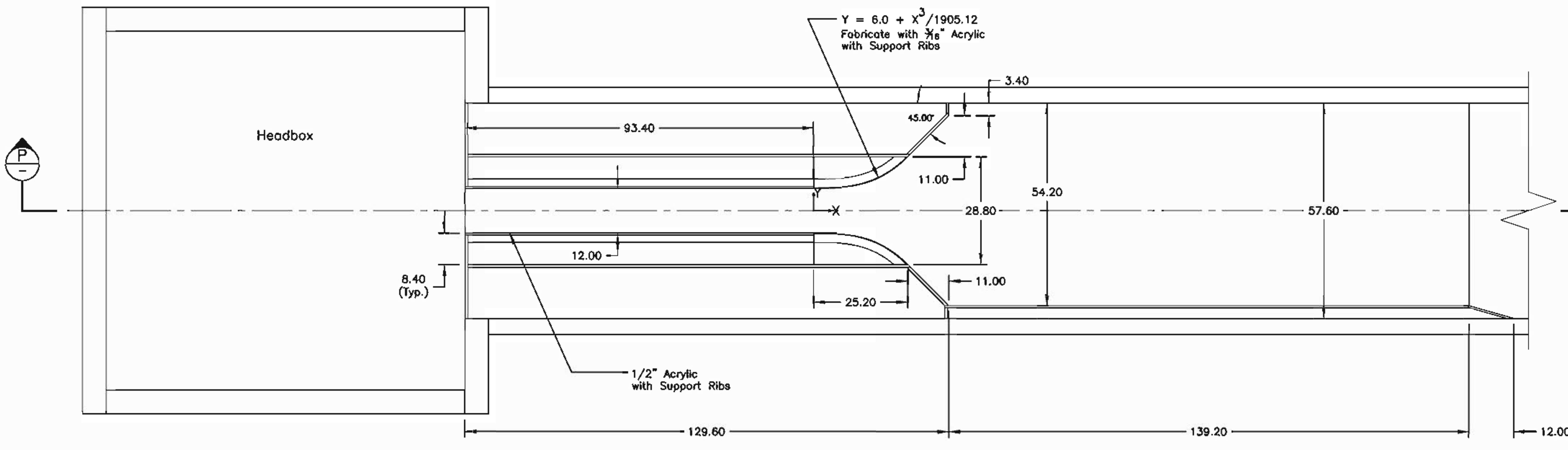
MODIFIED COUNTING STATION
DETAILS – PLAN VIEW

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

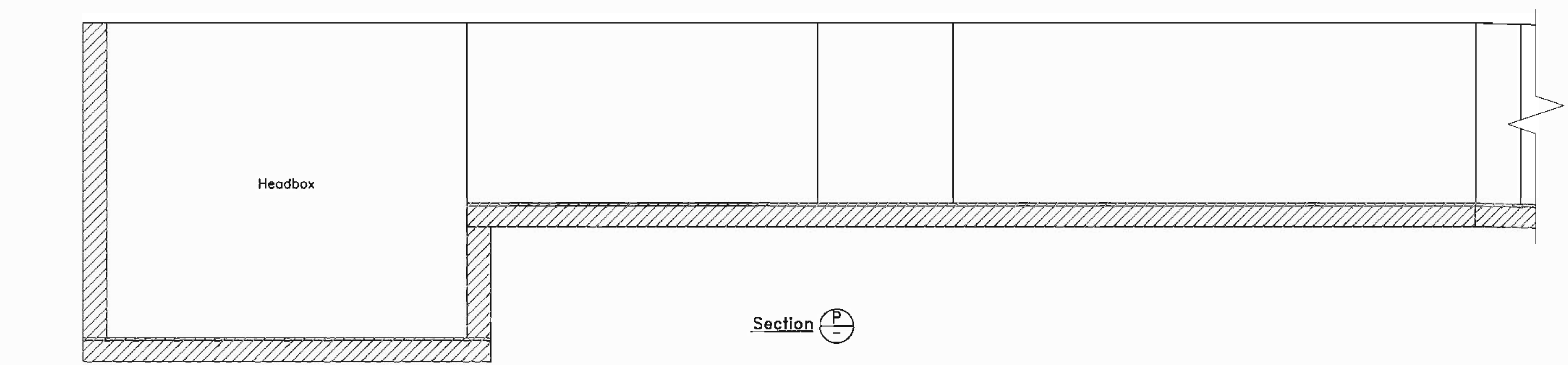
SCALE: 1:20
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
4–30

FILENAME:
CSta–Mod2



Plan View



Section P

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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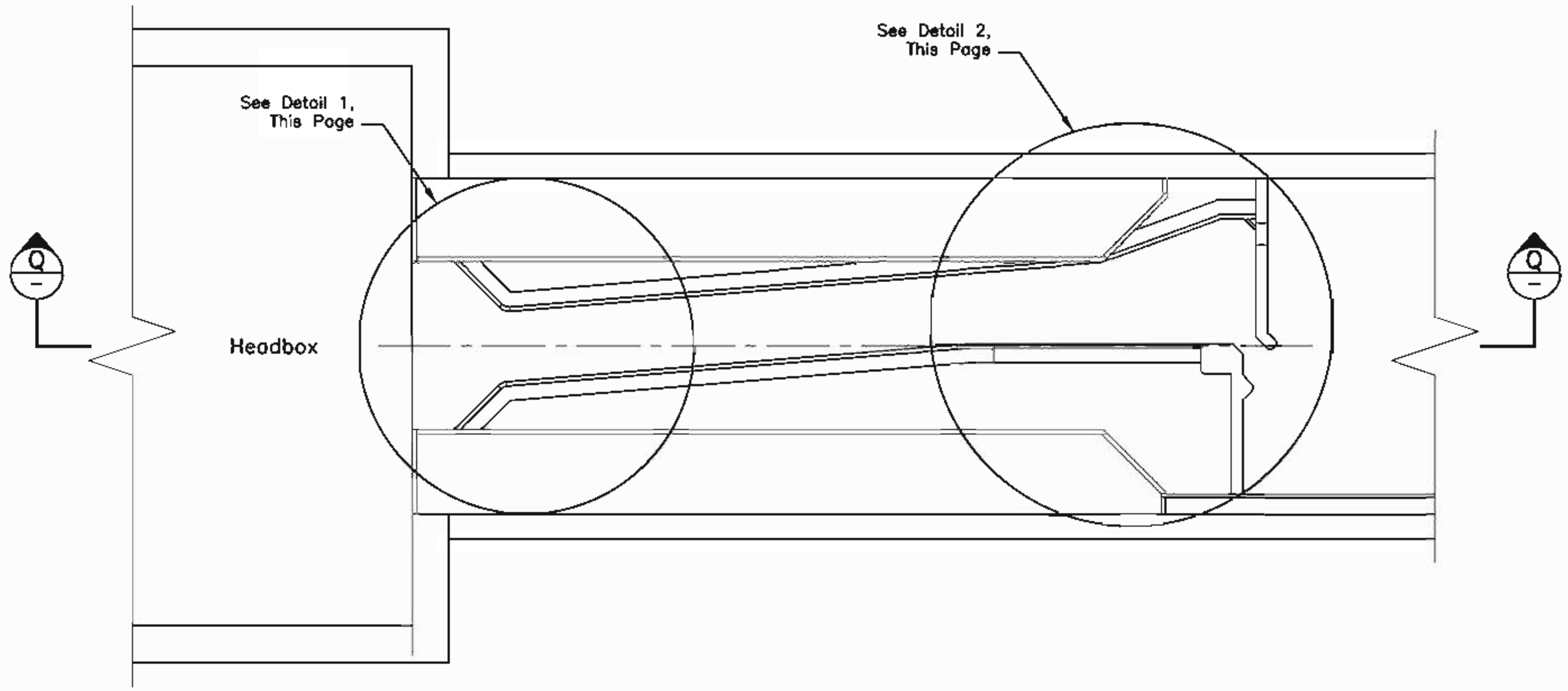
FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

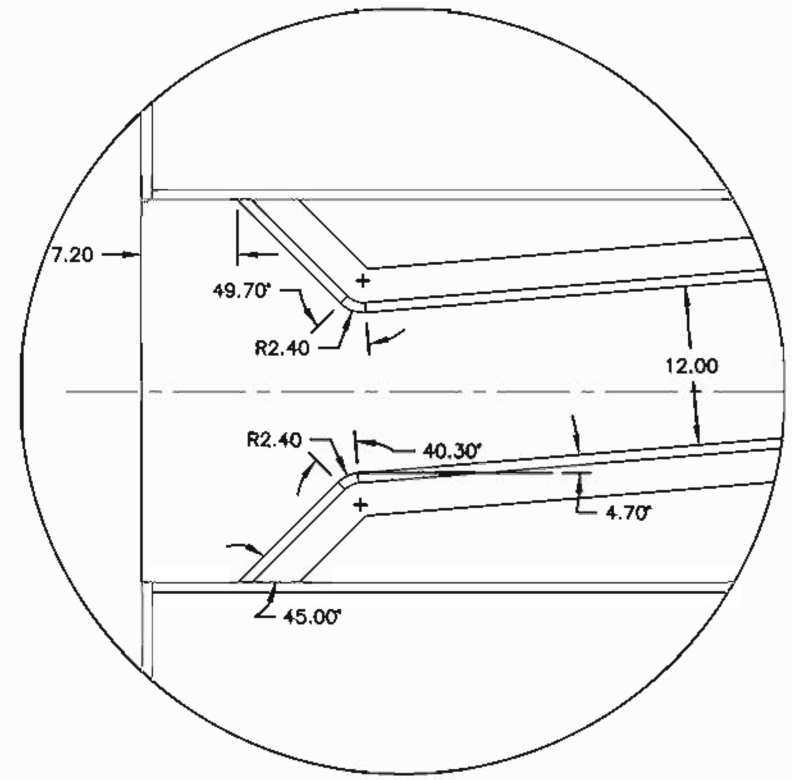
SCALE: 1:30
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-31

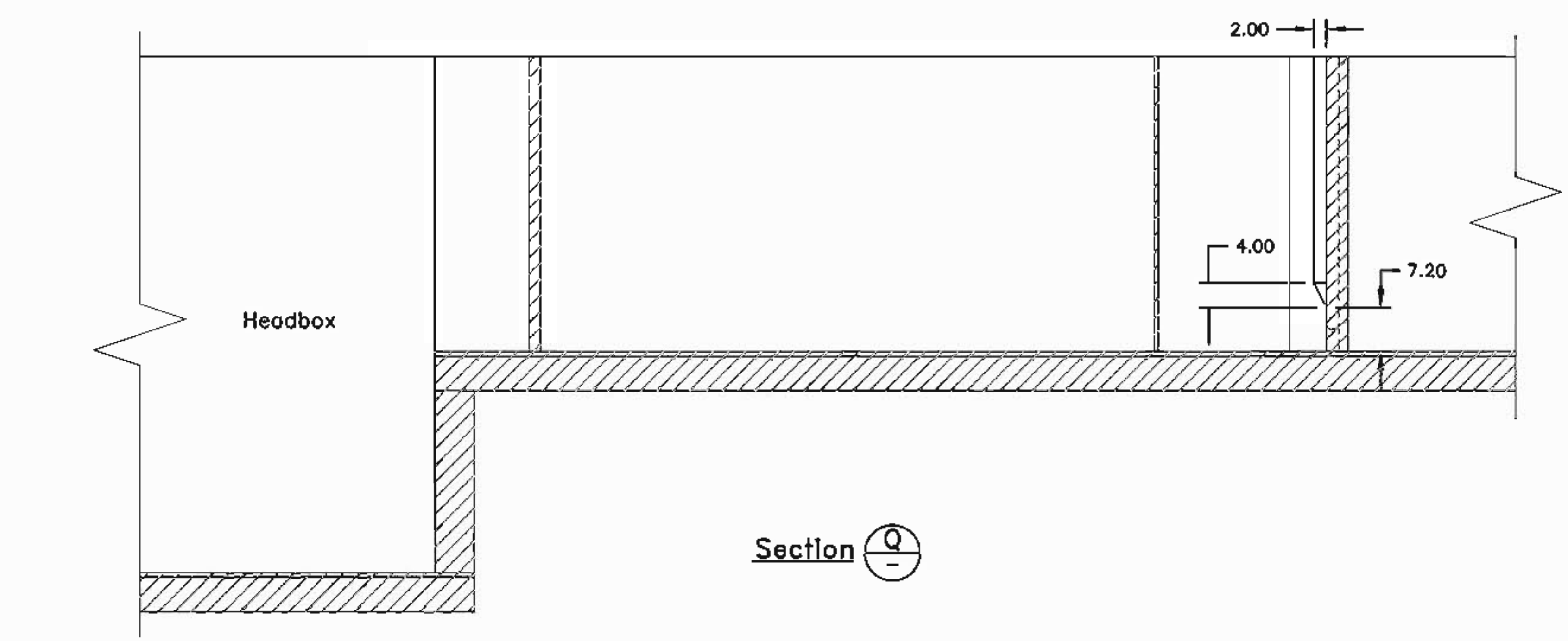
FILENAME: For-Trans-Det-Rev



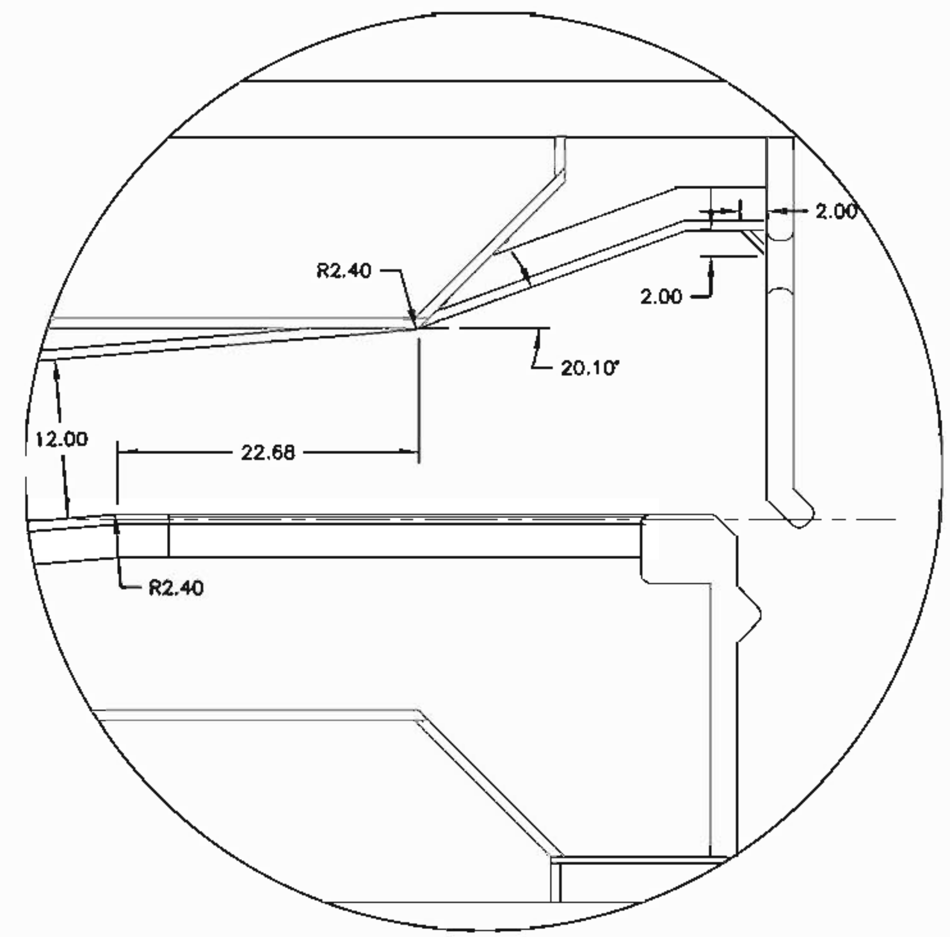
Plan View



Detail 1 – Plan View at Transition Inlet
(Scale = 1:15)



Section Q



Detail 2 – Plan View at Weir 23
(Scale = 1:15)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
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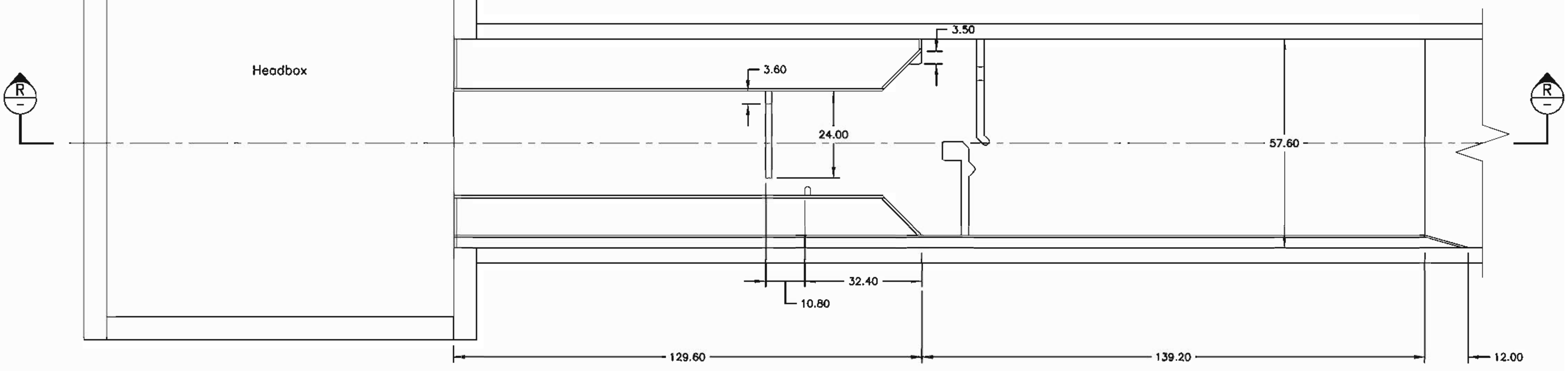
MODIFIED FOREBAY TRANSITION
PLAN AND SECTION
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

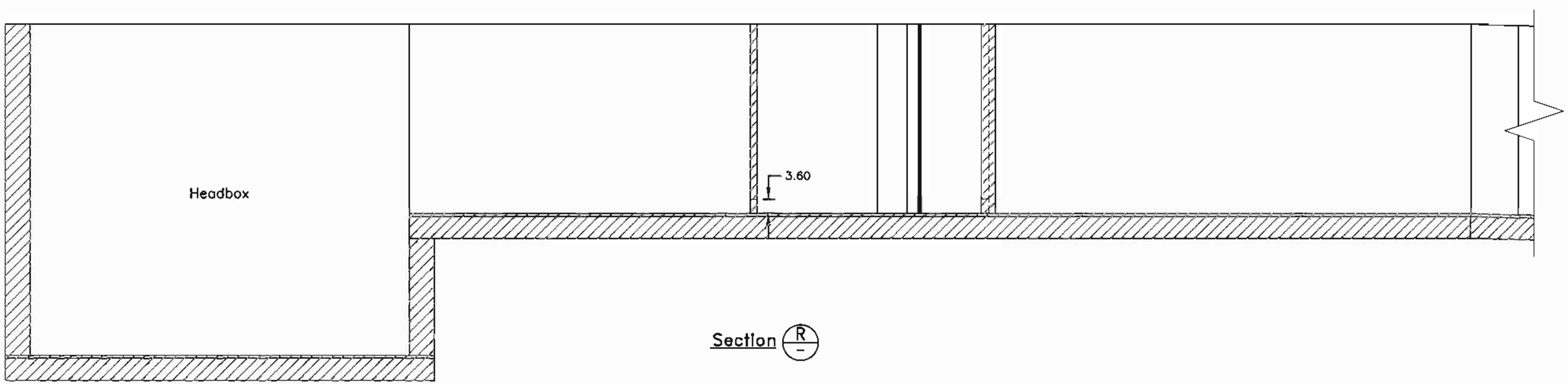
SCALE: 1:30
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4–32

FILENAME: For-Trans-Rev4



Plan View



Section R

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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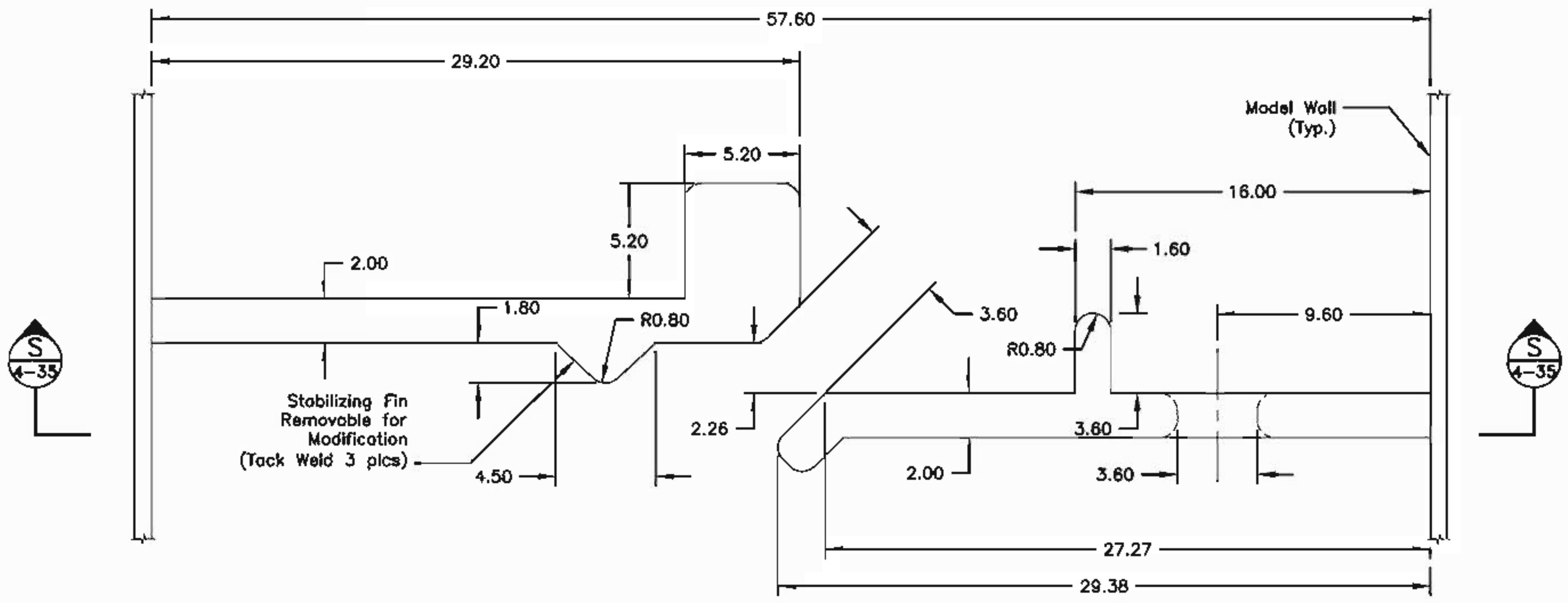
FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

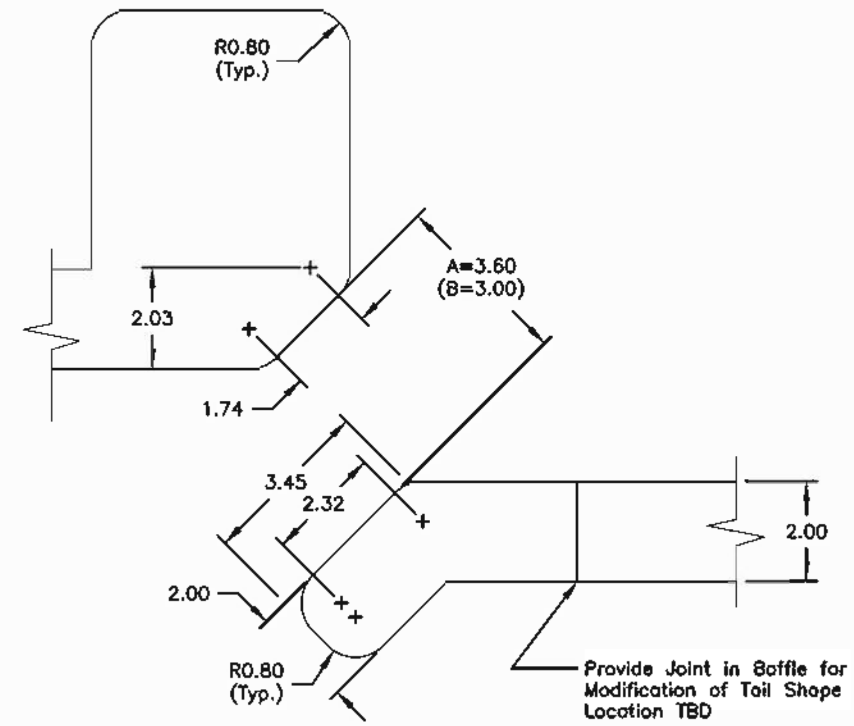
SCALE: 1:30
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
4–33

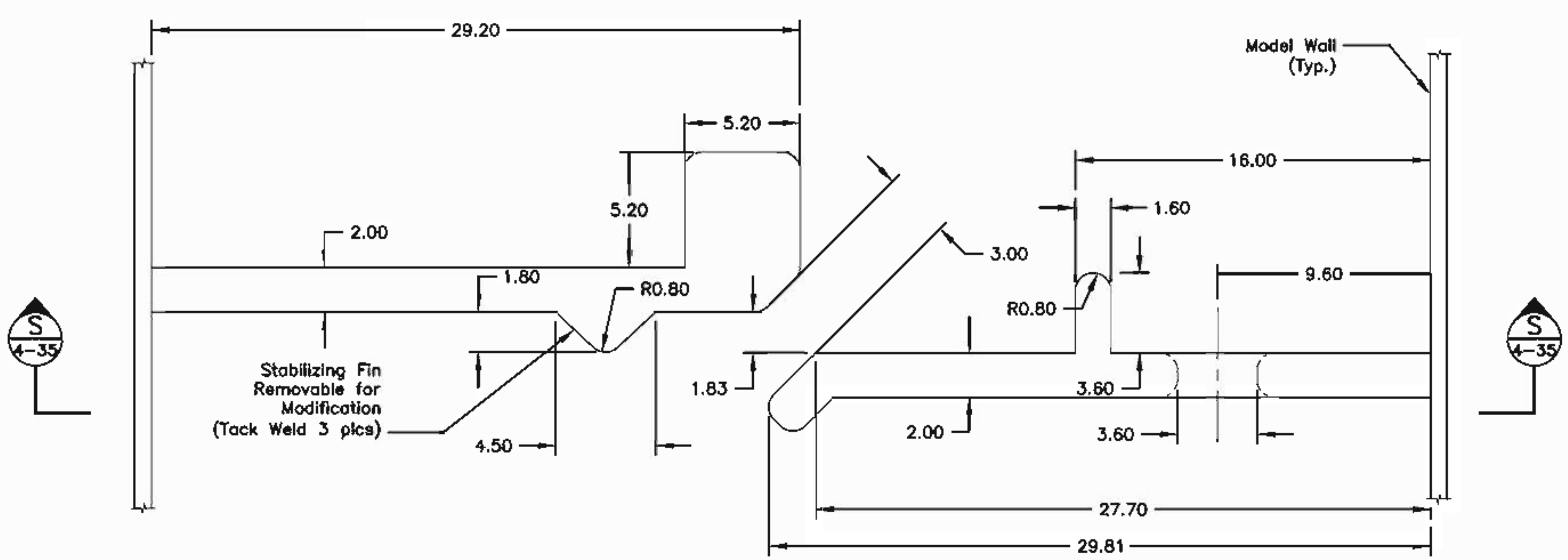
FILENAME:
For-Trans-Rev6



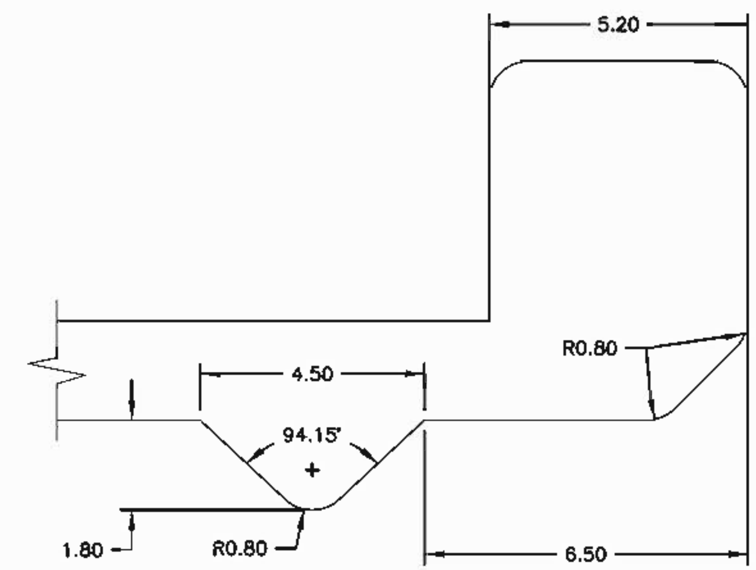
Typical Weir Plan A – Modified Weirs 2, 3, 18, 19, 20, 21, 22, and 23
(Scale = 1:8)
(EXISTING MODIFIED WIER 1 DOES NOT CHANGE – ORIFICE REMAINS AT LADDER WALL)



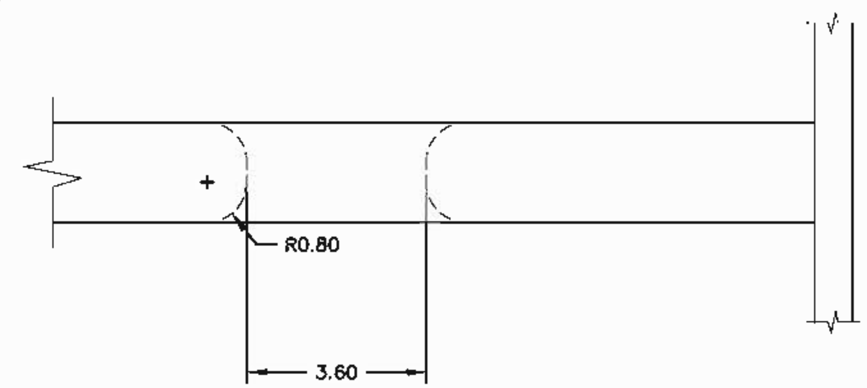
Detail 1, A and B
(Scale = 1:4)



Typical Weir Plan B – Modified Weirs 4-17
(Scale = 1:8)



Detail 2
(Scale = 1:4)



Detail 3
(Scale = 1:4)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

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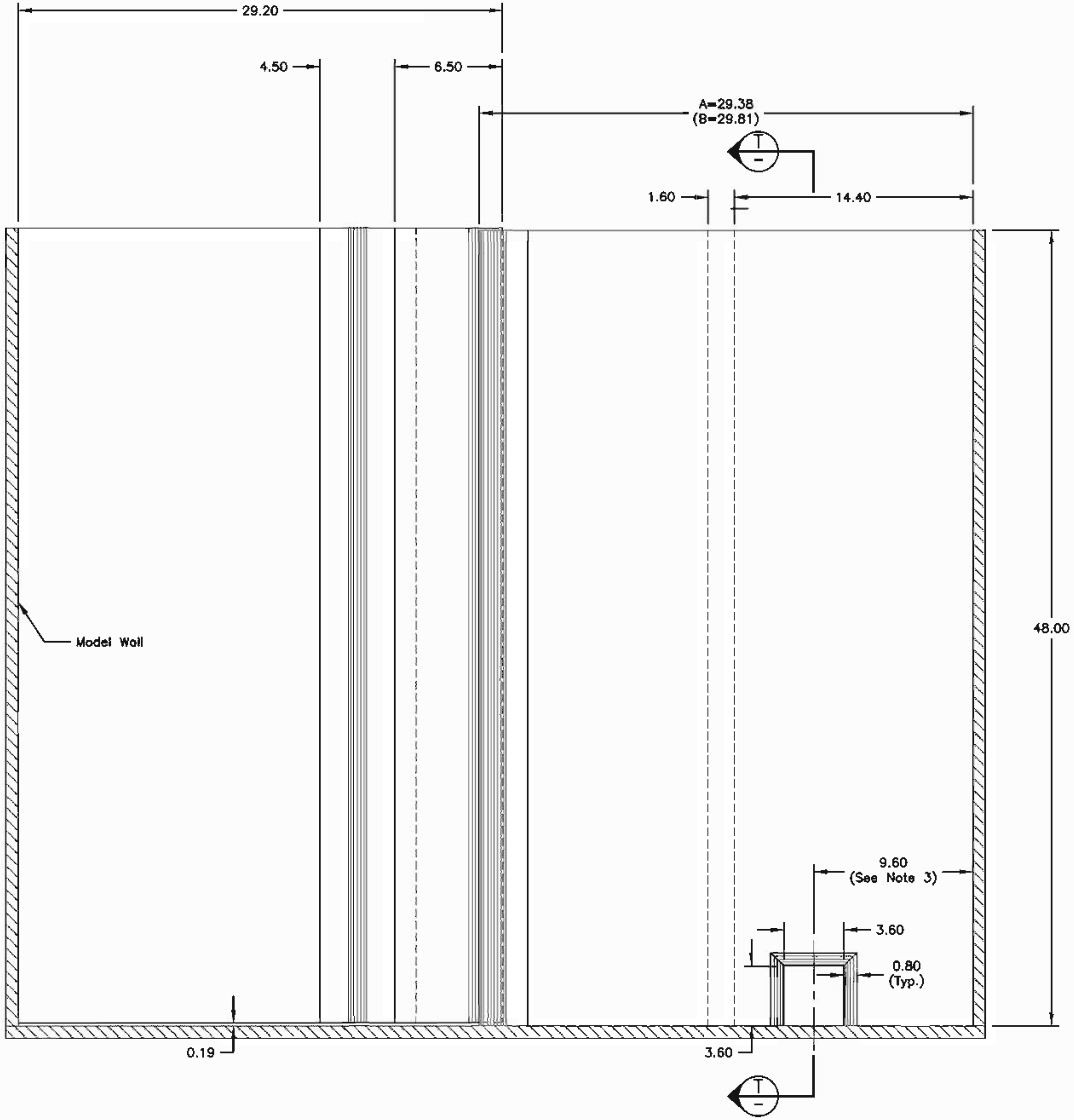
MODIFIED EXIT SECTION WEIRS PLAN VIEWS
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

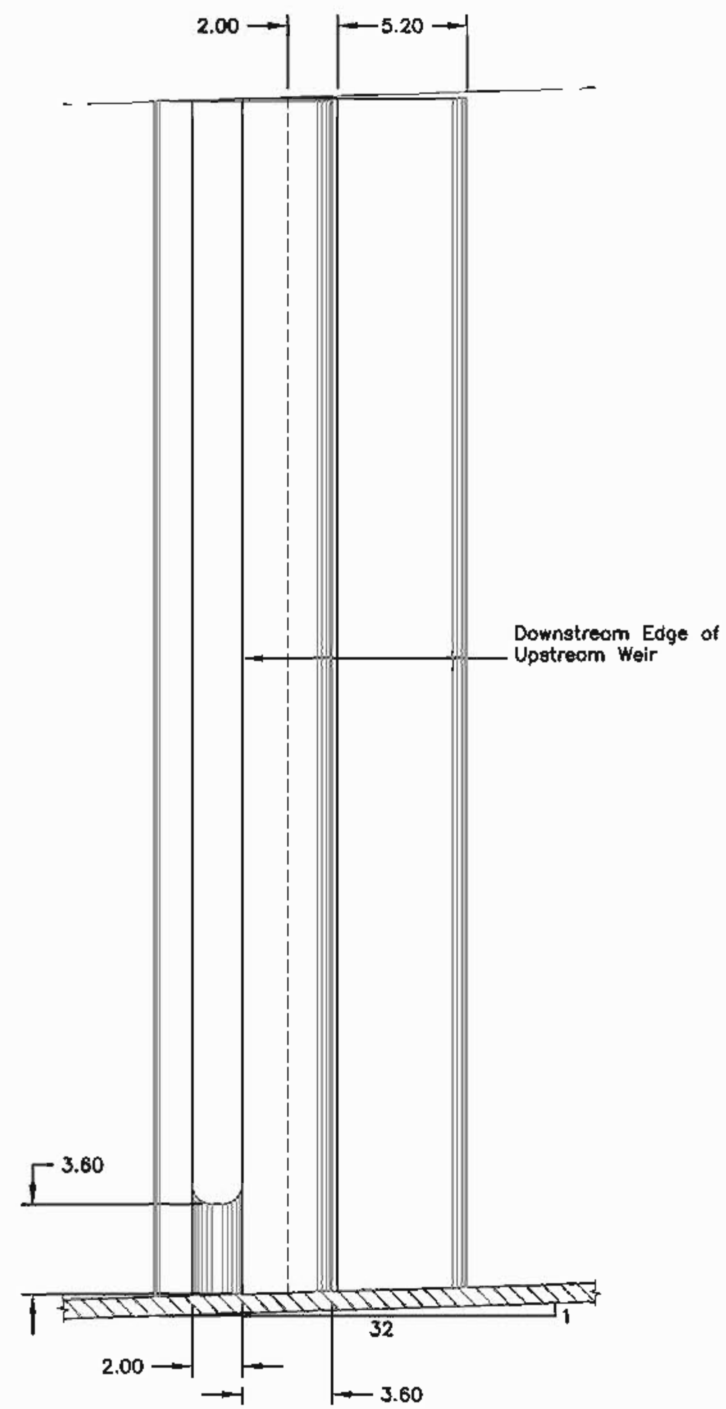
PROJECT NUMBER: 09000-419
DATE: 03/24/08
SCALE: as noted

FIGURE NUMBER: 4-34

FILENAME: Mod-Weirs-Rev4



Section $\frac{S}{4-34}$



Section $\frac{T}{-}$

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weir 1 Orifice located at left wall, all others as shown

REVISIONS		
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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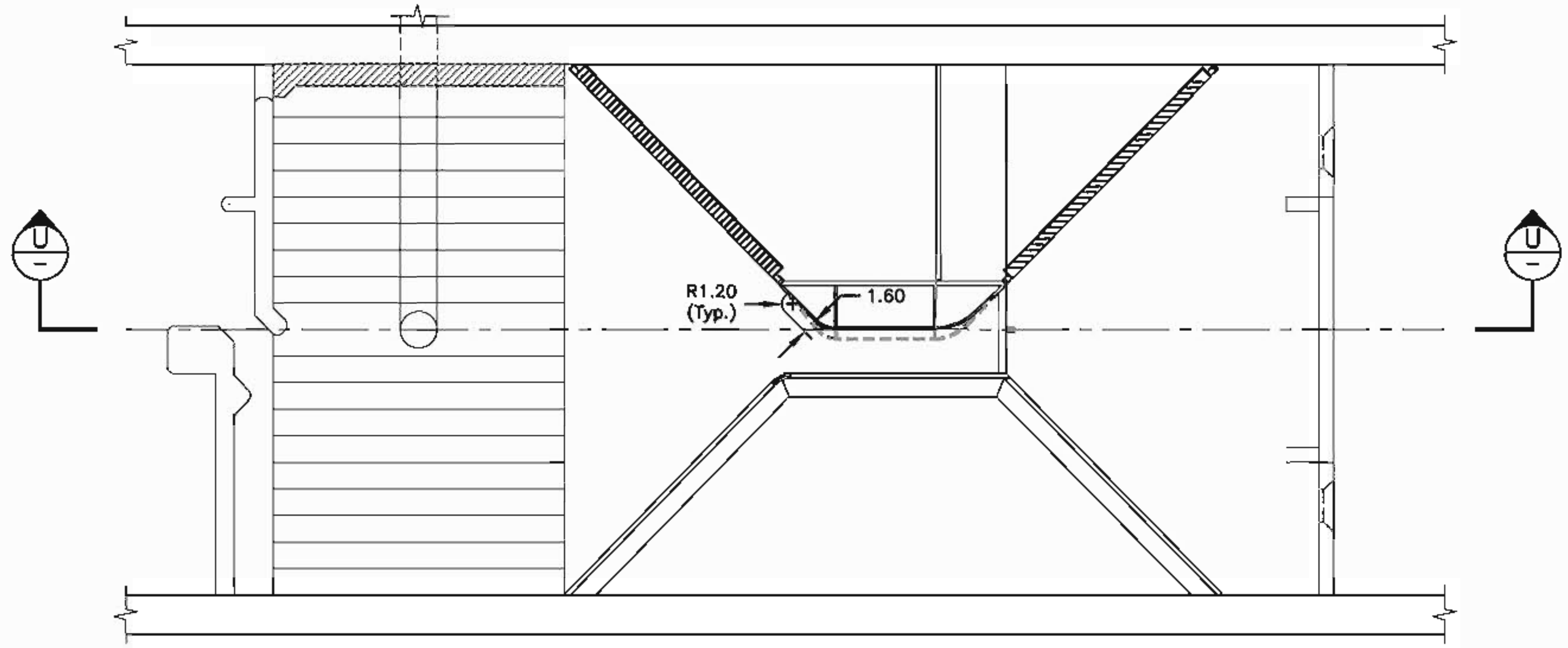
MODIFIED EXIT SECTION WEIRS
ELEVATION AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

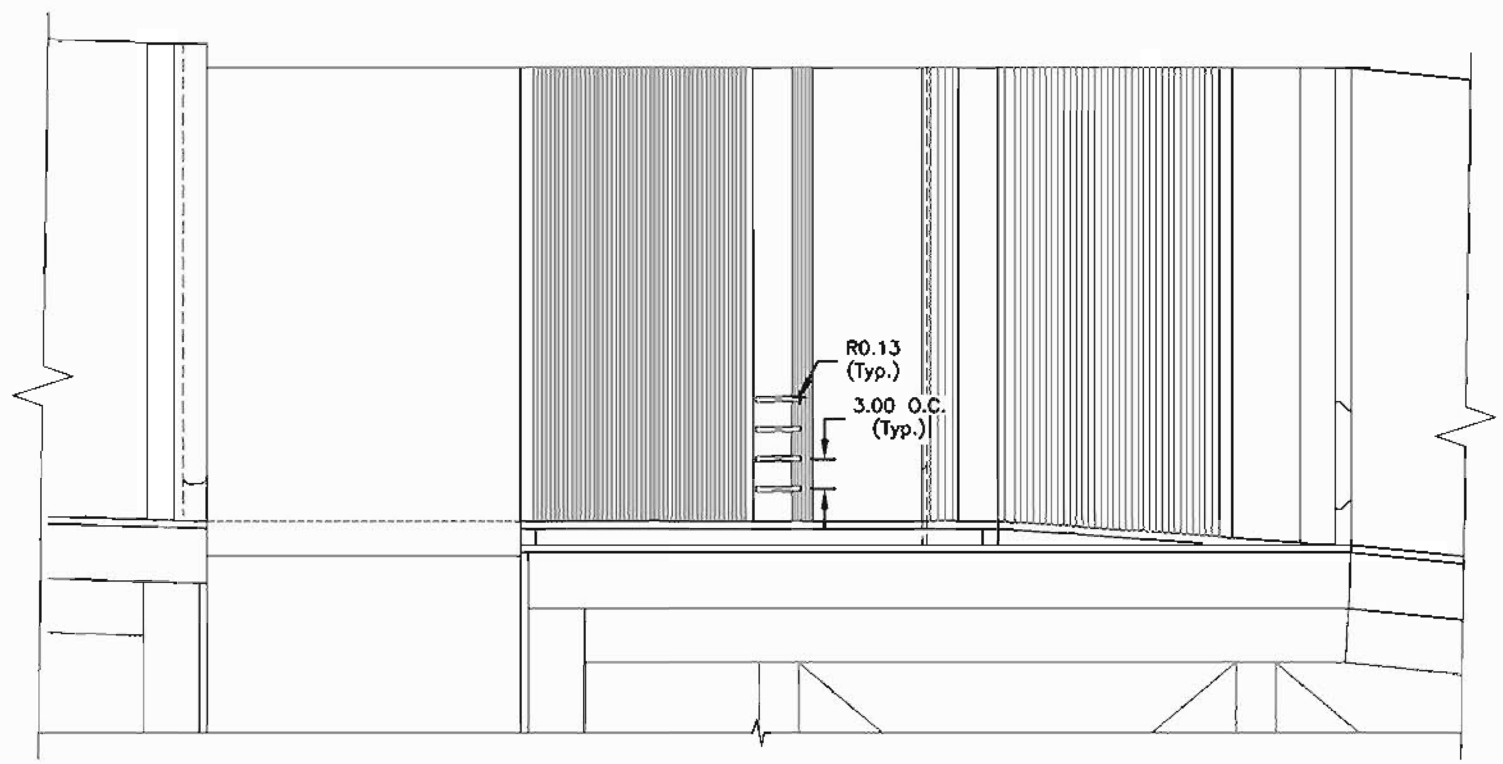
SCALE: 1:8
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER:
4-35

FILENAME:
Mod-Weir-Sec-Rev4



Plan View



Section U

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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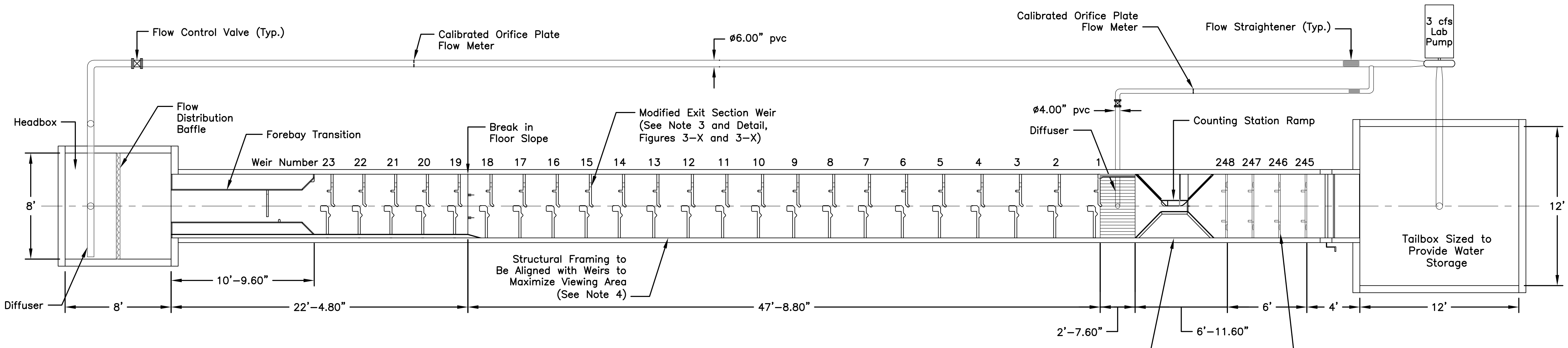
CROWDER FAIRING GUIDE VANES PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

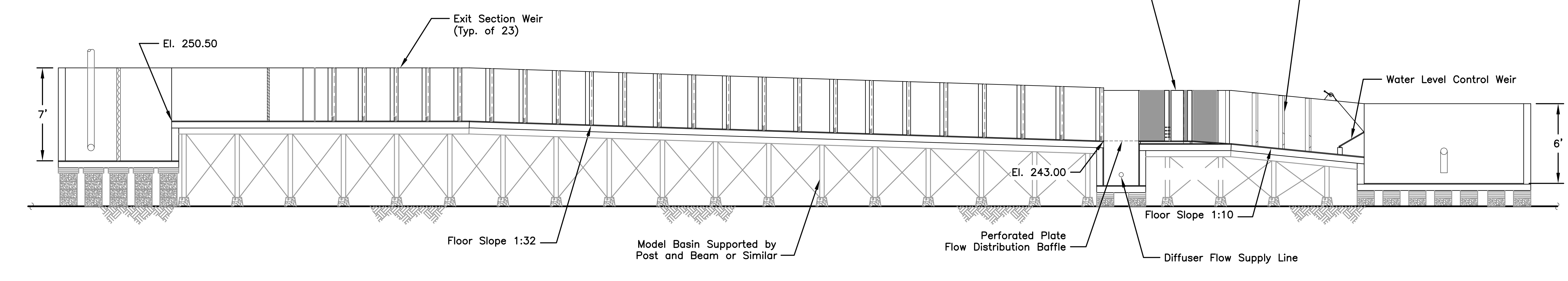
SCALE: 1:20
DATE: 03/24/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4–36

FILENAME: CSto-Mod2 w-Vane



Plan View



Section at Centerline

Final Modified Weir Stations (model inches) - Used for Documentation Tests

Weir	Downstream Baffle		Centerline	Upstream baffle		Weir	Downstream Baffle		Centerline	Upstream baffle	
	D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face
1	0.00	2.00	3.27	4.26	6.26	13	399.60	401.60	402.66	403.43	405.43
2	36.00	38.00	39.27	40.26	42.26	14	430.80	432.80	433.86	434.63	436.63
3	71.21	73.21	74.27	75.47	77.47	15	460.80	462.80	463.86	464.63	466.63
4	106.01	108.01	109.07	109.84	111.84	16	490.80	492.80	493.86	494.63	496.63
5	140.81	142.81	143.87	144.64	146.64	17	520.80	522.80	523.86	524.63	526.63
6	174.41	176.41	177.47	178.24	180.24	18	550.80	552.80	553.86	555.06	557.06
7	208.01	210.01	211.07	211.84	213.84	19	579.60	581.60	582.66	583.86	585.86
8	240.41	242.41	243.47	244.24	246.24	20	608.40	610.40	611.67	612.66	614.66
9	272.81	274.81	275.87	276.64	278.64	21	637.20	639.20	640.47	641.46	643.46
10	304.80	306.80	307.86	308.63	310.63	22	666.00	668.00	669.27	670.26	672.26
11	337.20	339.20	340.26	341.03	343.03	23	694.80	696.80	698.07	699.06	701.06
12	368.40	370.40	371.46	372.23	374.23						

Notes:
1) Dimensions given in model feet and inches
2) Model to prototype scale = 1:5
3) Exit Section weirs to be replaced with lamprey friendly weirs following baseline testing
4) Both sidewalls to be fabricated using clear acrylic
5) Viewing platforms will be provided for Exit Section and Counting Station, not shown for clarity

REVISIONS
NO: DESCRIPTION: DATE: BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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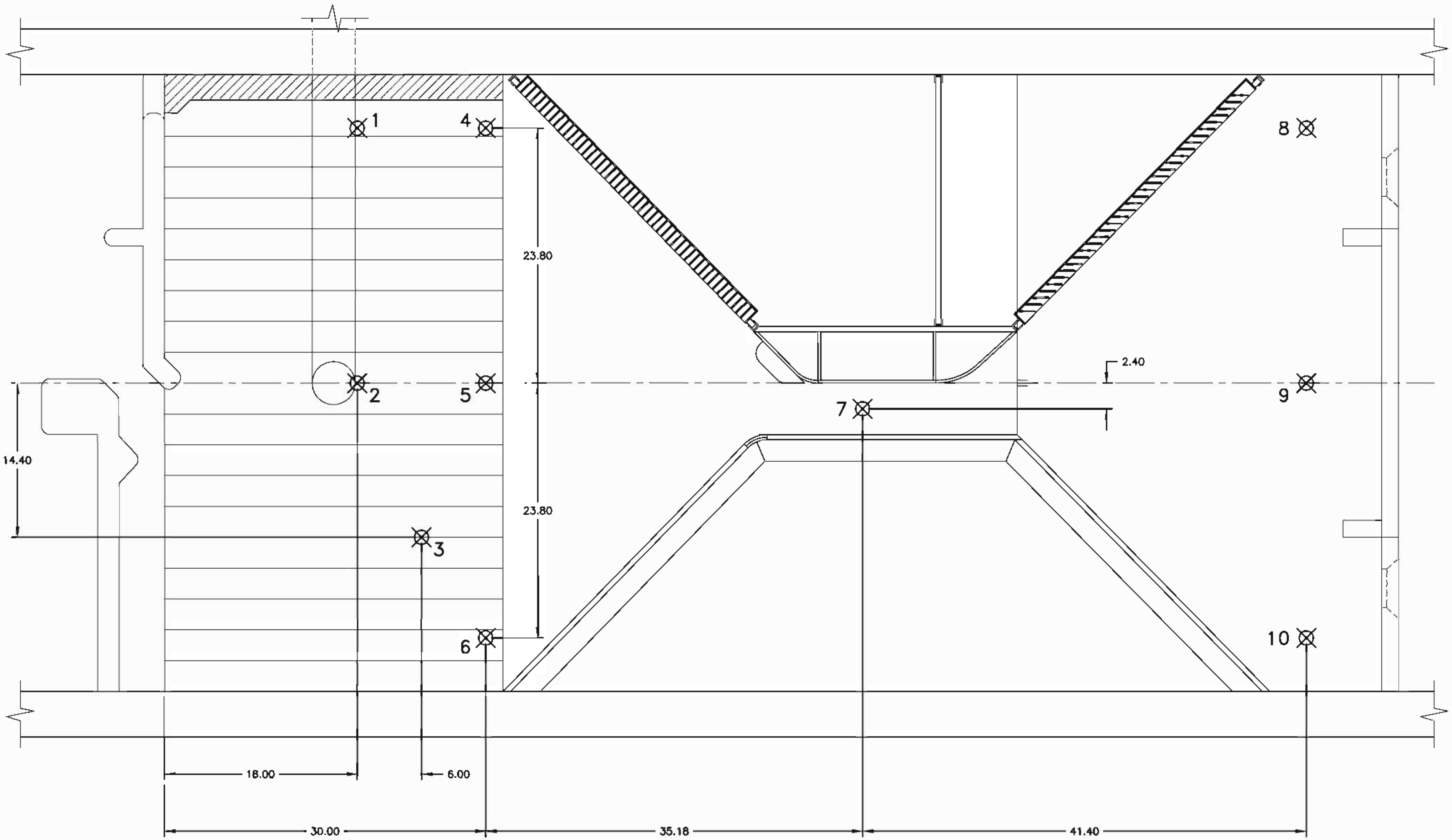
FINAL MODEL LAYOUT PLAN AND SECTION
John Day North Fish Ladder
U.S. Army Corps of Engineers, Portland District
Portland, Oregon

PROJECT NUMBER: 09000–419
DATE: 03/24/08
SCALE: 1" = 8'

FIGURE NUMBER: 4–37

FILENAME: Doc Model Layout



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: JA/KM
CHECKED BY: LR
APPROVED BY: CS

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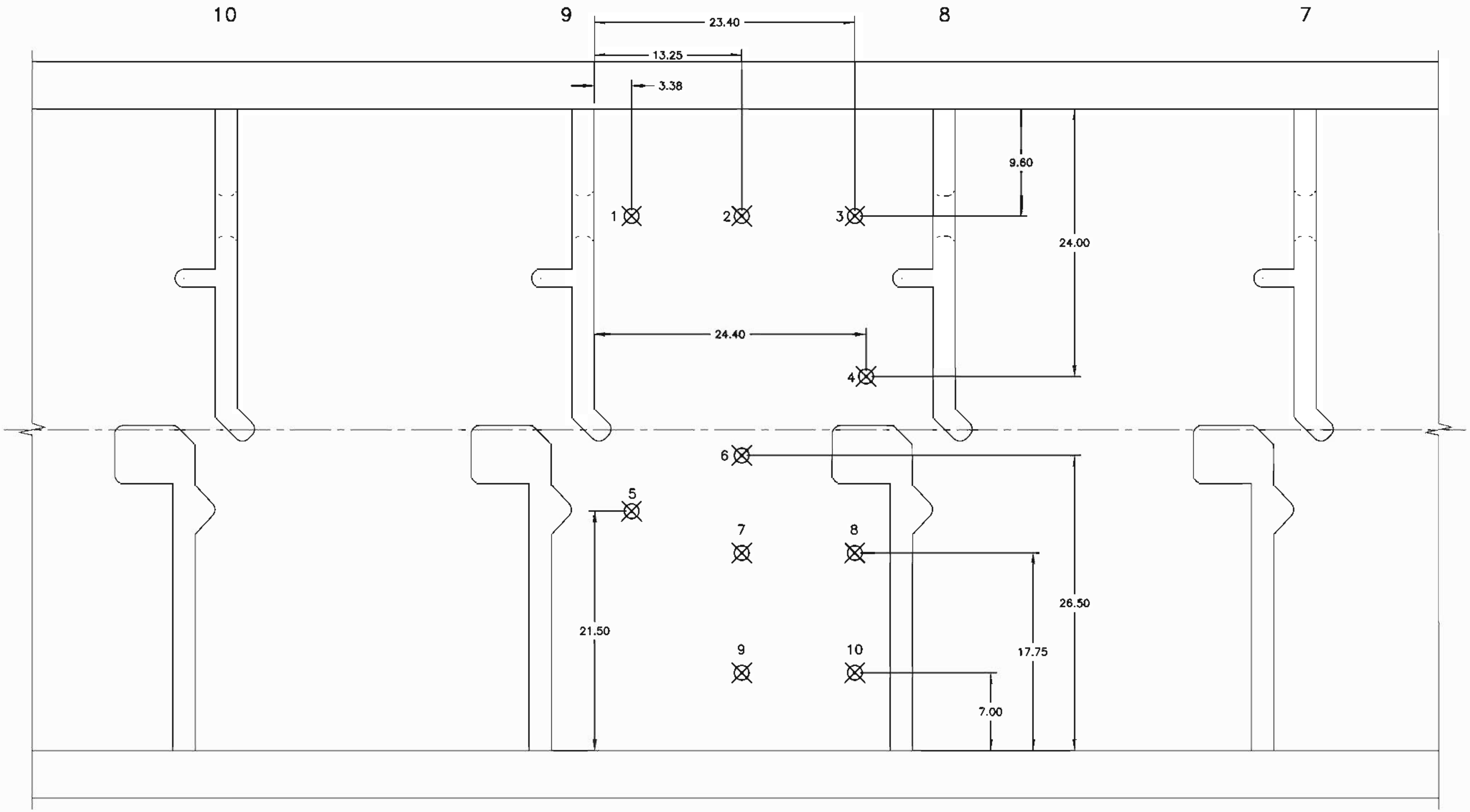
COUNT STATION VELOCITY MEAS. LOCATIONS – DOCUMENTATION TESTS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:10
DATE: 03/26/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 4-38

FILENAME: Doc-CtSta Meas



Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: JA?KM
CHECKED BY: LR
APPROVED BY: CS

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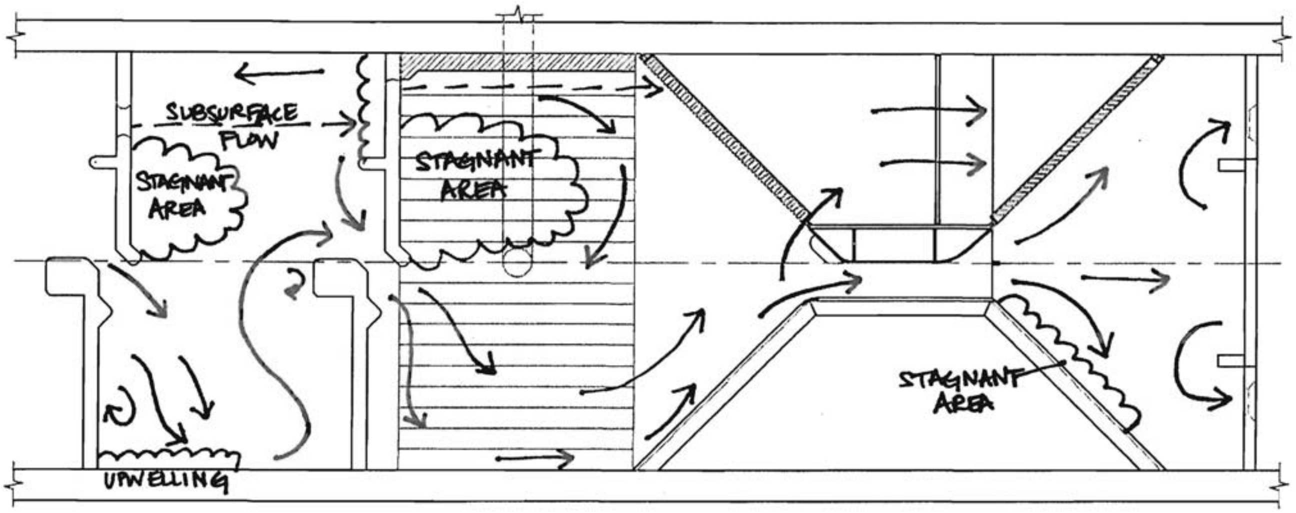
POOL 8 VELOCITY MEASUREMENT LOCATIONS – DOCUMENTATION TESTS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

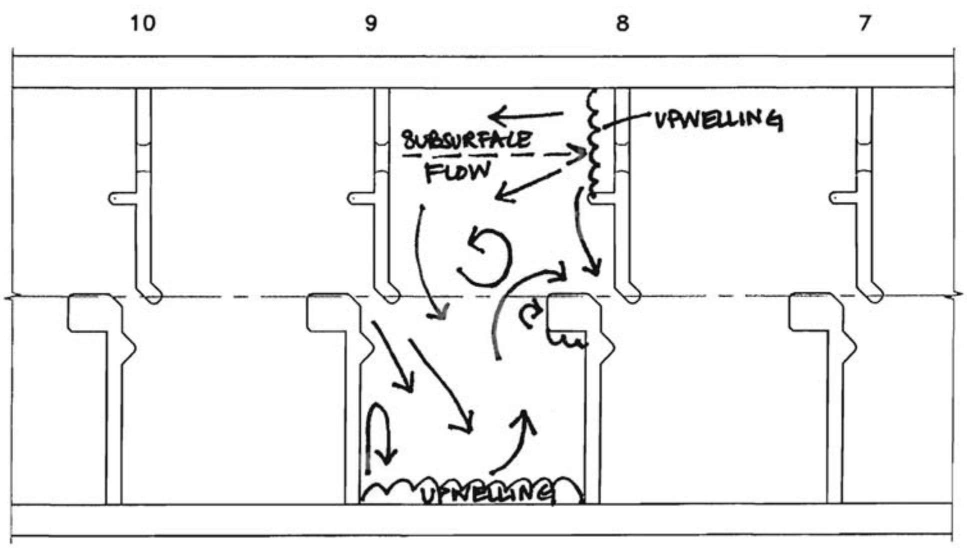
SCALE:	DATE:	PROJECT NUMBER:
1:10	03/26/08	09000-419

FIGURE NUMBER:
4–39

FILENAME:
Doc–P8 Meos Loc



Count Station



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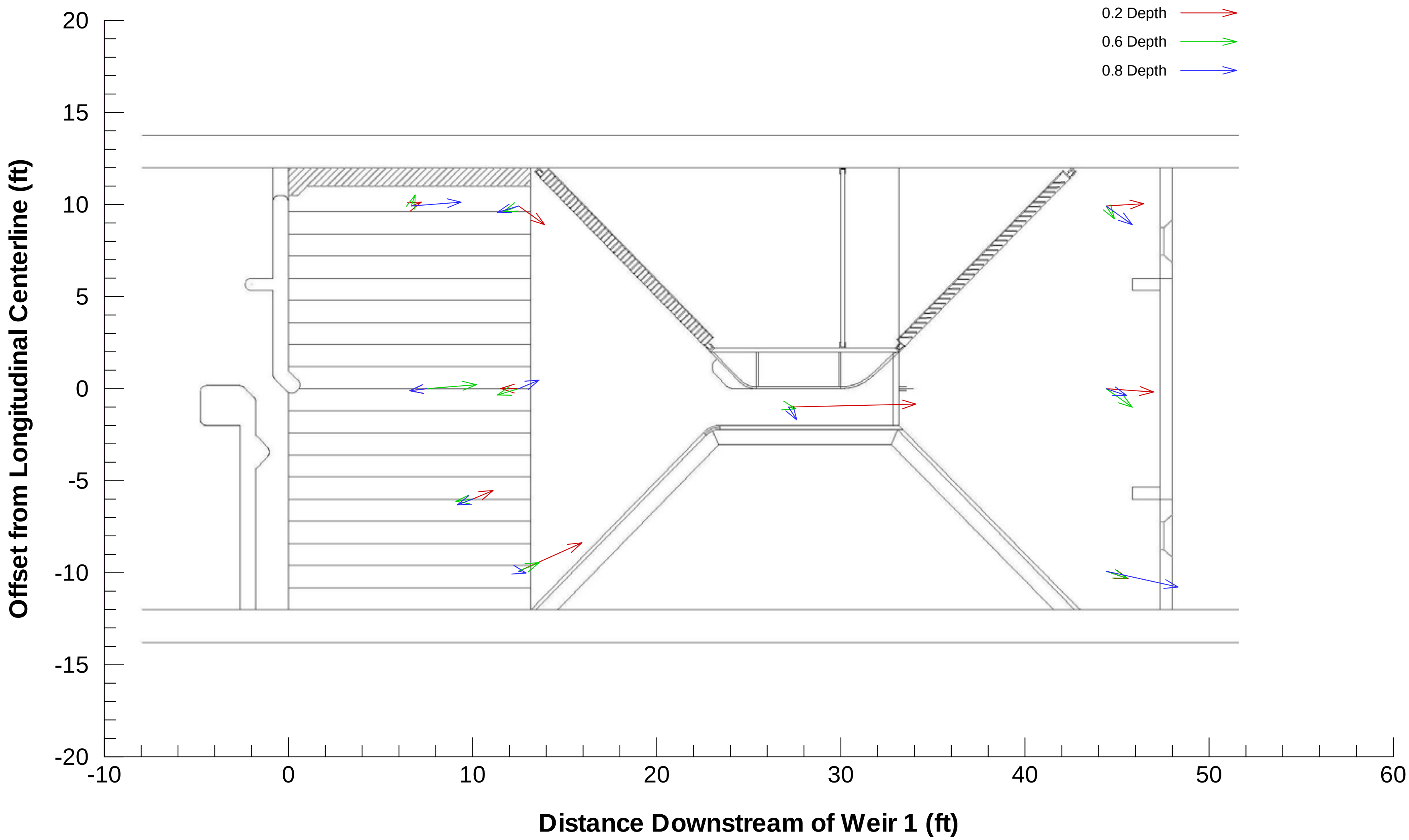
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST A
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-40

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.38	0.56	0.73	1.06	0.59	2.28	4.20	1.25	1.59	0.77
	0.6d	0.40	1.65	0.56	0.54	0.73	0.73	0.27	0.53	1.06	0.72
	0.8d	1.65	0.56	0.54	0.73	0.73	0.27	0.53	1.06	0.72	2.43



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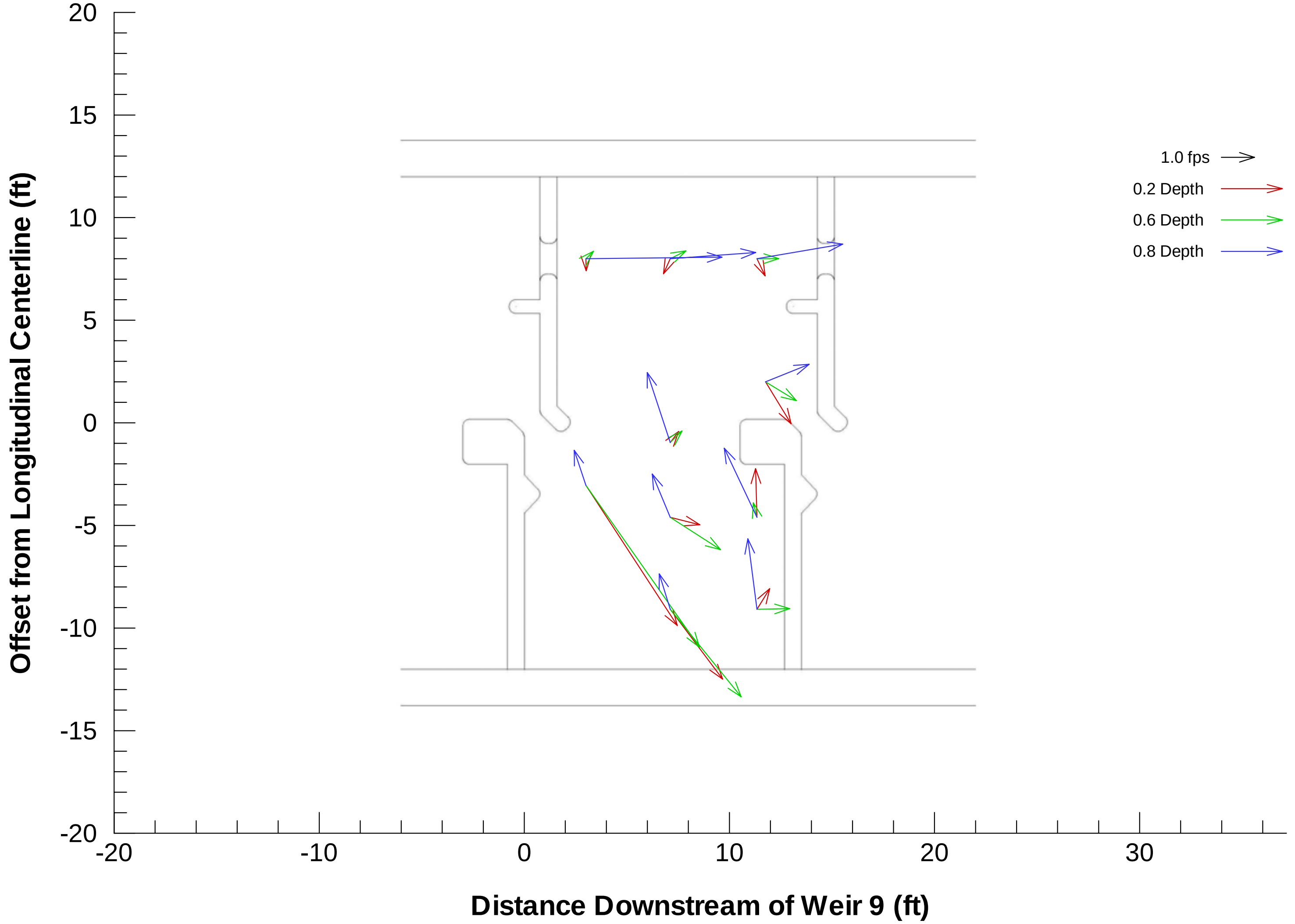
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST A

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-41

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.41	0.50	0.60	1.48	5.12	0.42	0.92	1.60	2.63	0.74
	0.6d	0.35	0.74	0.98	1.22	6.00	0.51	1.82	0.86	3.39	1.23
	0.8d	4.18	2.59	2.65	1.47	1.19	2.25	1.45	2.31	1.12	2.20



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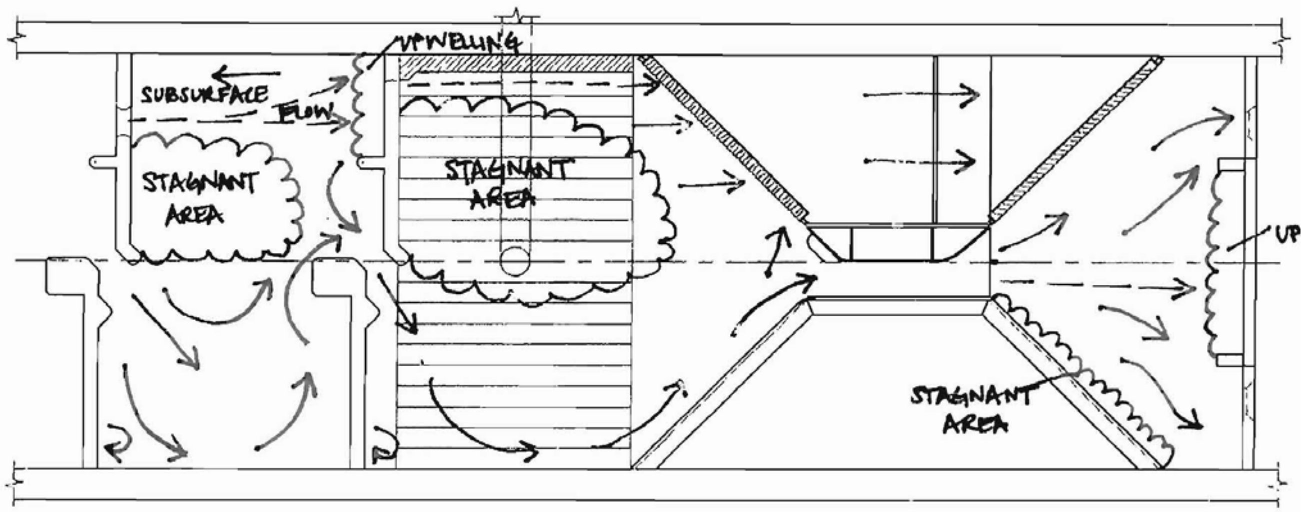
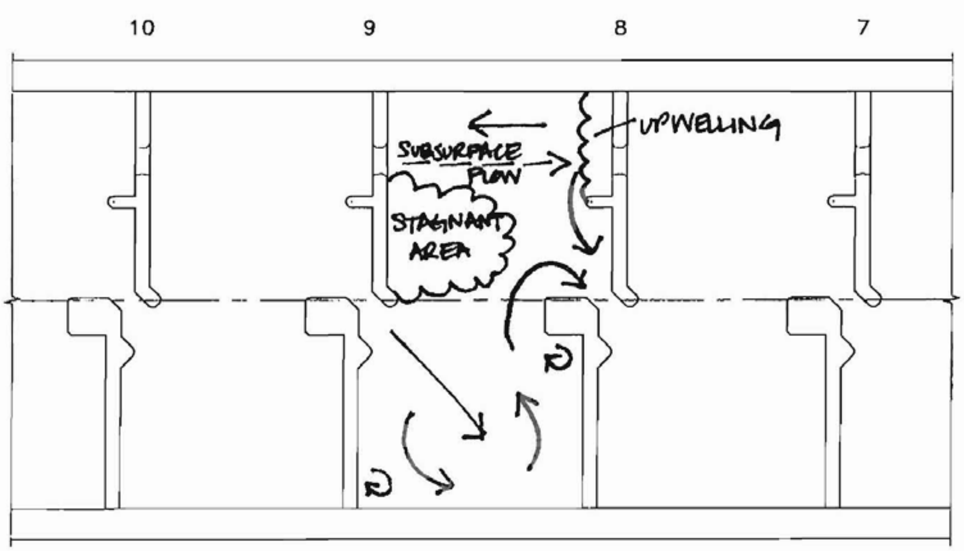
WEIR POOL 8 VELOCITIES
CONFIGURATION NO. 11 - TEST A
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: 4-42

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR



Count Station



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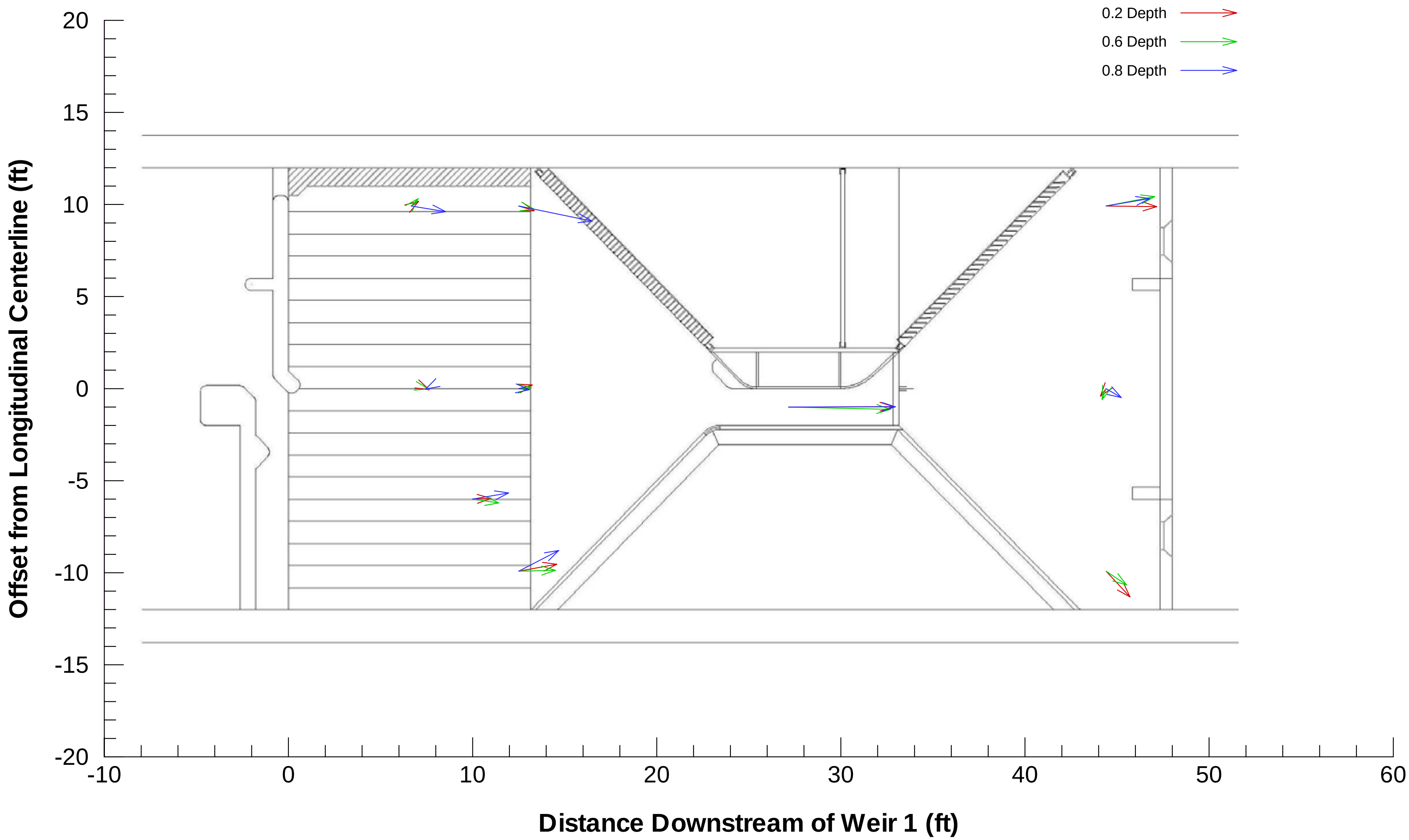
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST B
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER: 4-43

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	0.29	0.11	0.62	0.54	0.47	1.27	3.47	1.74	0.33	1.16
	0.6d	0.33	0.10	0.89	0.53	0.42	1.21	3.36	1.73	0.42	0.83
	0.8d	1.20	0.07	1.25	2.49	0.37	1.51	3.52	1.46	0.58	--



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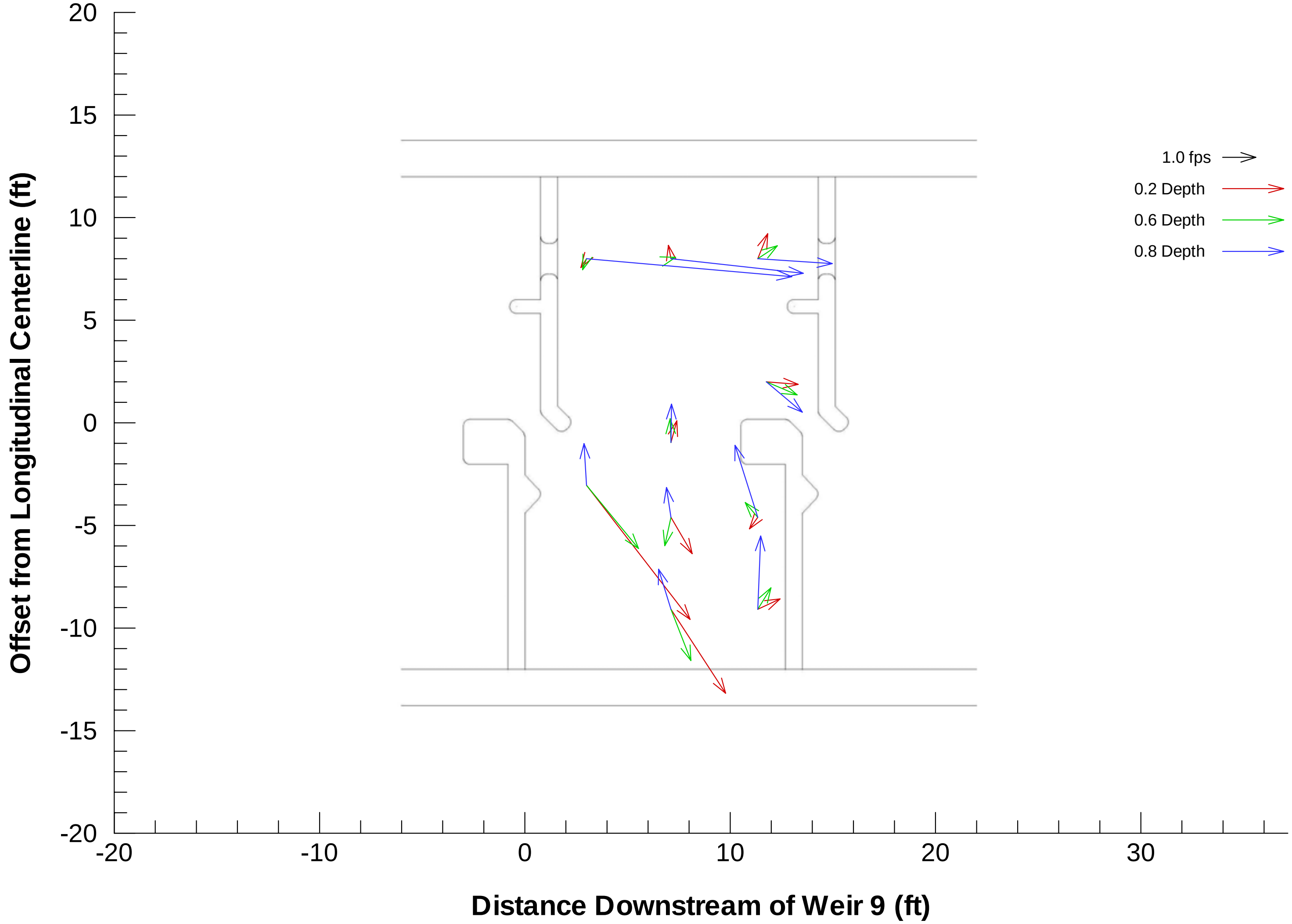
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST B

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-44**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.36	0.45	0.82	0.96	5.12	0.93	1.31	0.62	3.02	0.90
	0.6d	0.45	0.23	0.70	1.01	2.53	0.97	0.89	0.59	1.71	1.03
	0.8d	6.21	4.01	2.24	1.42	1.31	1.22	0.94	2.28	1.29	2.23



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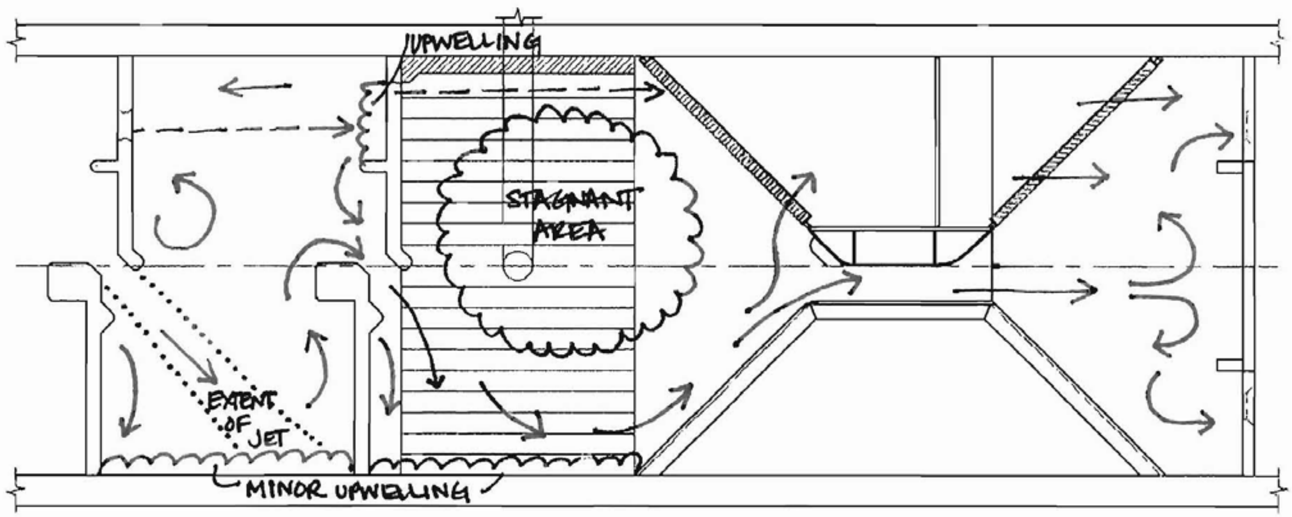
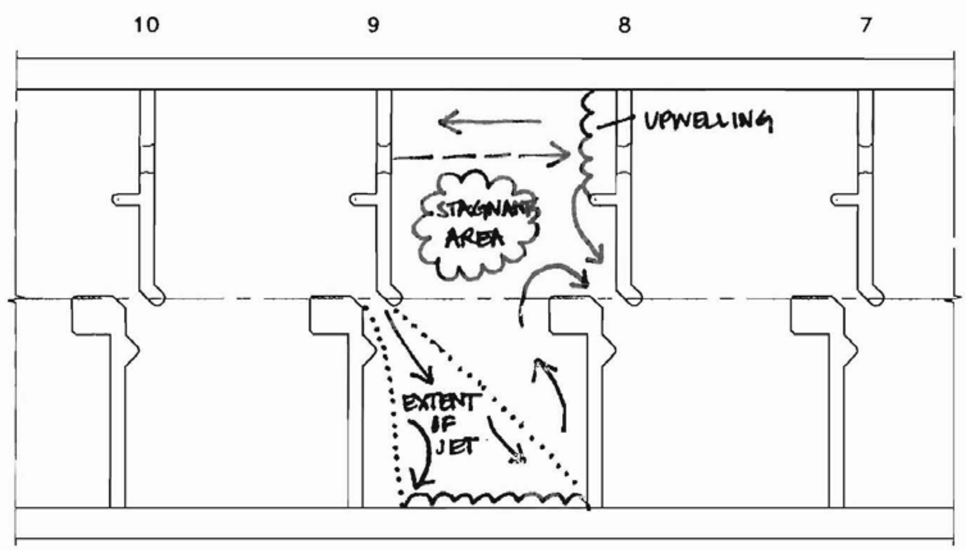
WEIR POOL 8 VELOCITIES
CONFIGURATION 11 - TEST B
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-45**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR



Count Station



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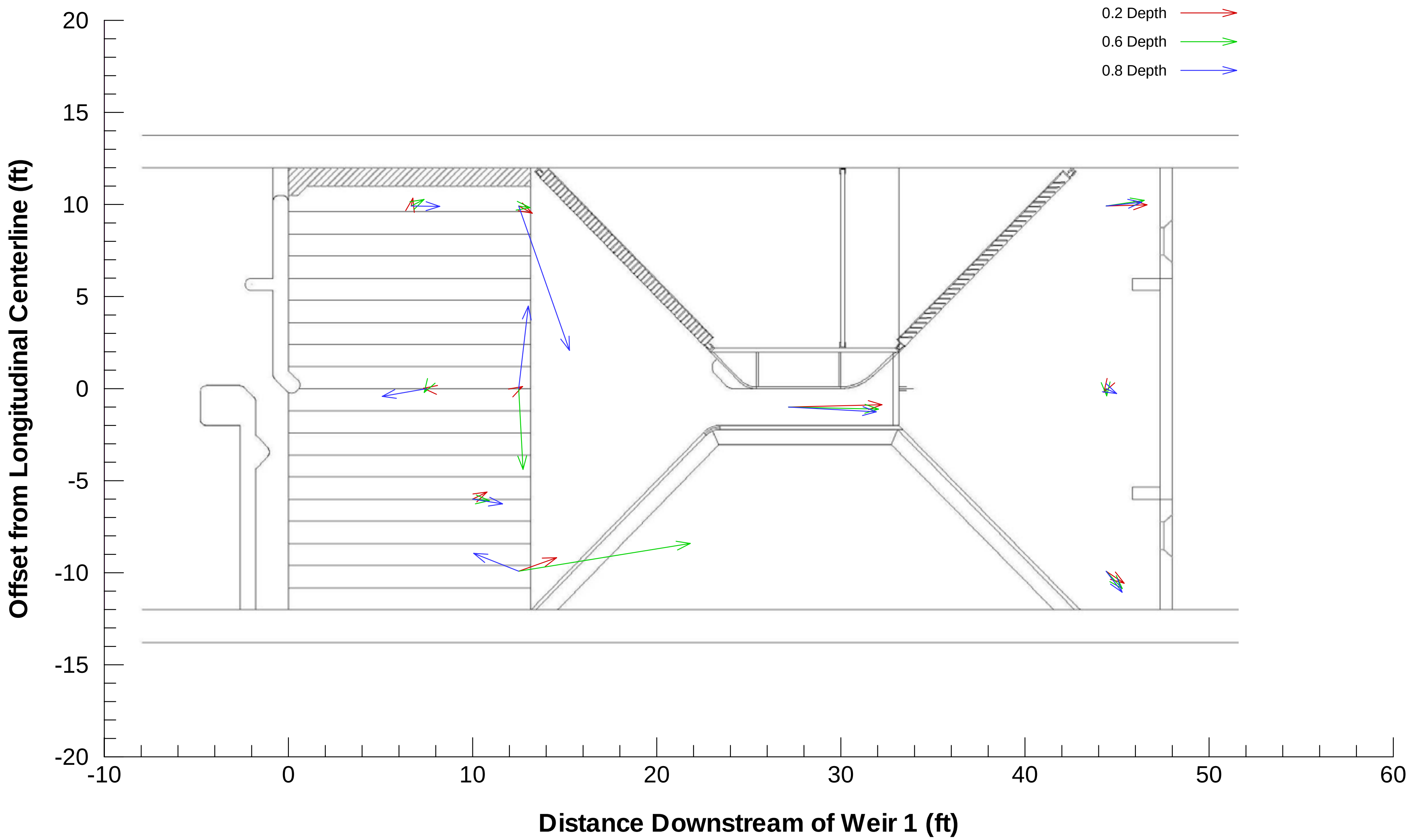
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST C
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER: 4-46

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.28	0.16	0.54	0.51	0.16	1.33	3.08	1.38	0.15	0.72
	0.6d	0.48	0.25	0.56	0.39	2.67	5.83	2.97	1.31	0.28	0.79
	0.8d	0.94	1.48	1.04	5.49	2.74	1.65	2.90	1.18	0.39	0.87



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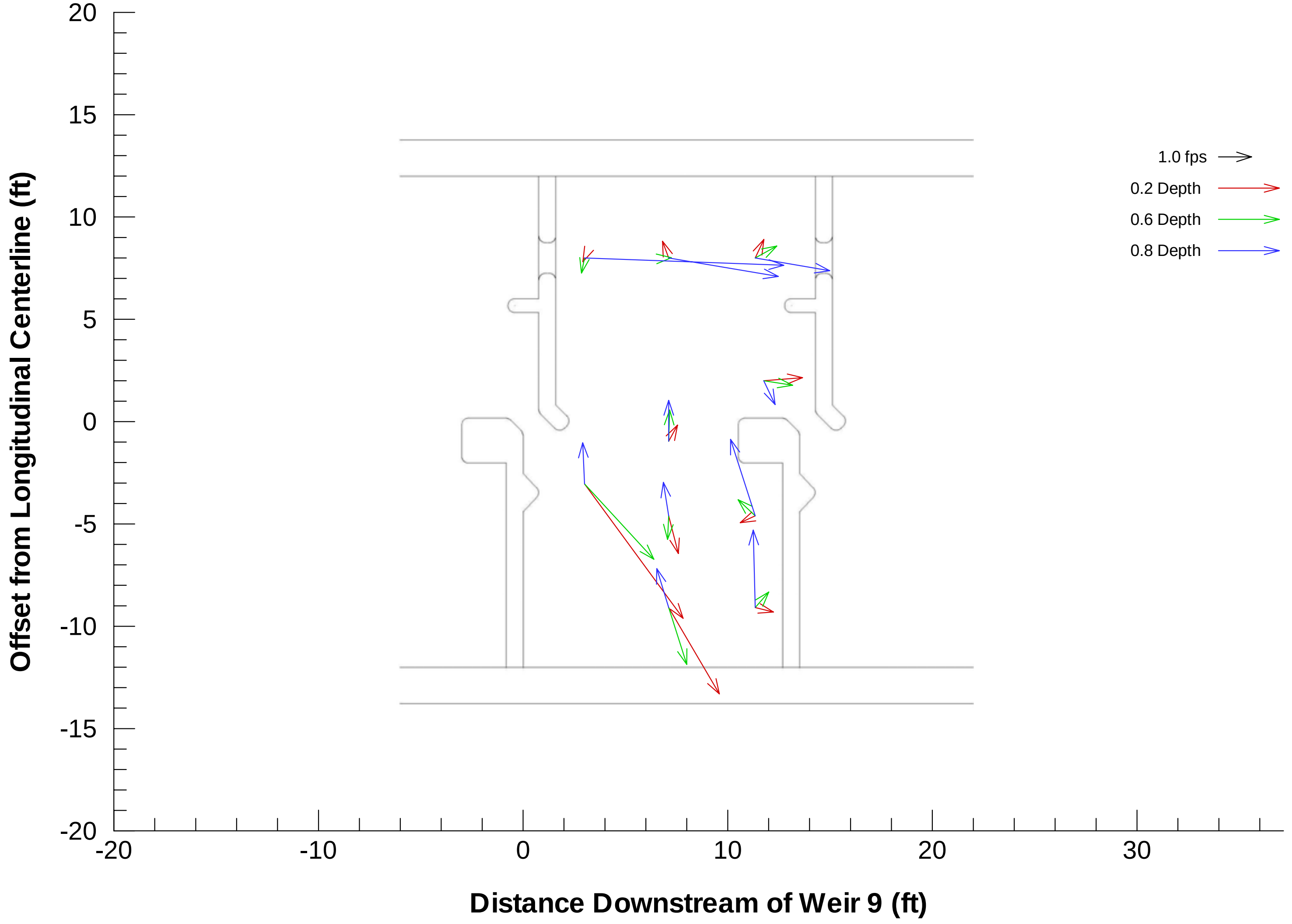
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST C

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-47

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.23	0.57	0.62	1.25	5.05	0.77	1.19	0.59	3.03	0.78
	0.6d	0.54	0.25	0.74	0.95	3.16	1.21	0.72	0.73	1.83	0.87
	0.8d	6.03	3.37	2.29	0.80	1.30	1.32	1.04	2.43	1.24	2.36



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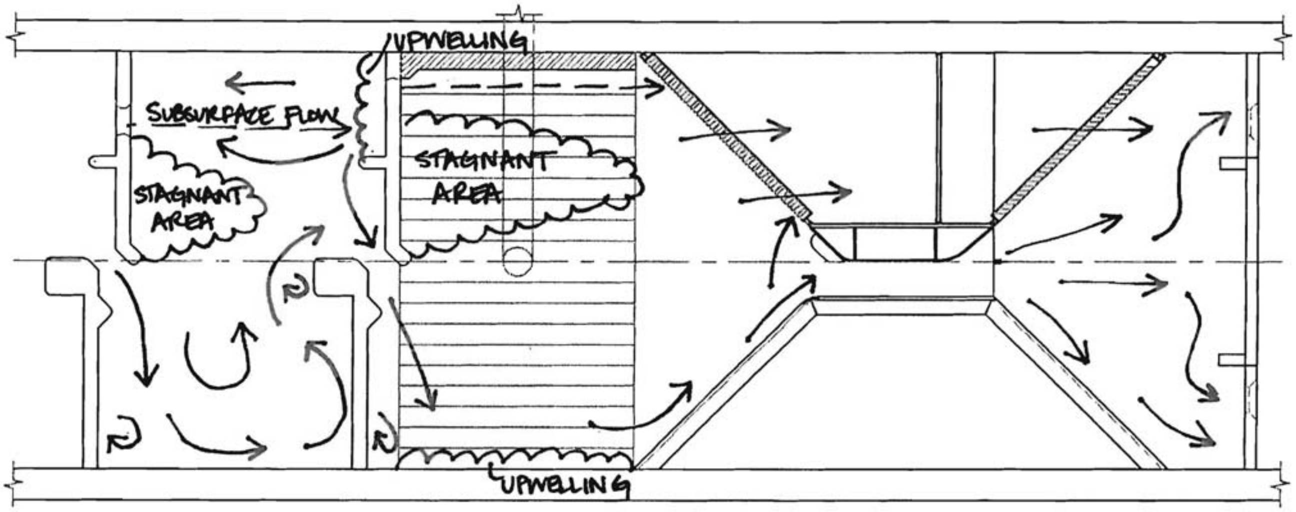
WEIR POOL 8 VELOCITIES
CONFIGURATION NO. 11 - TEST C

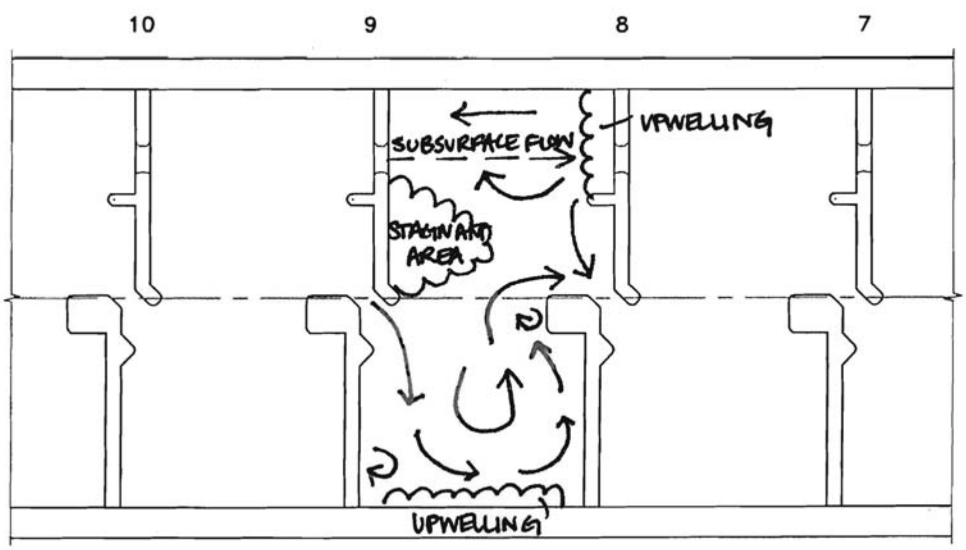
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-48

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR



Count Station



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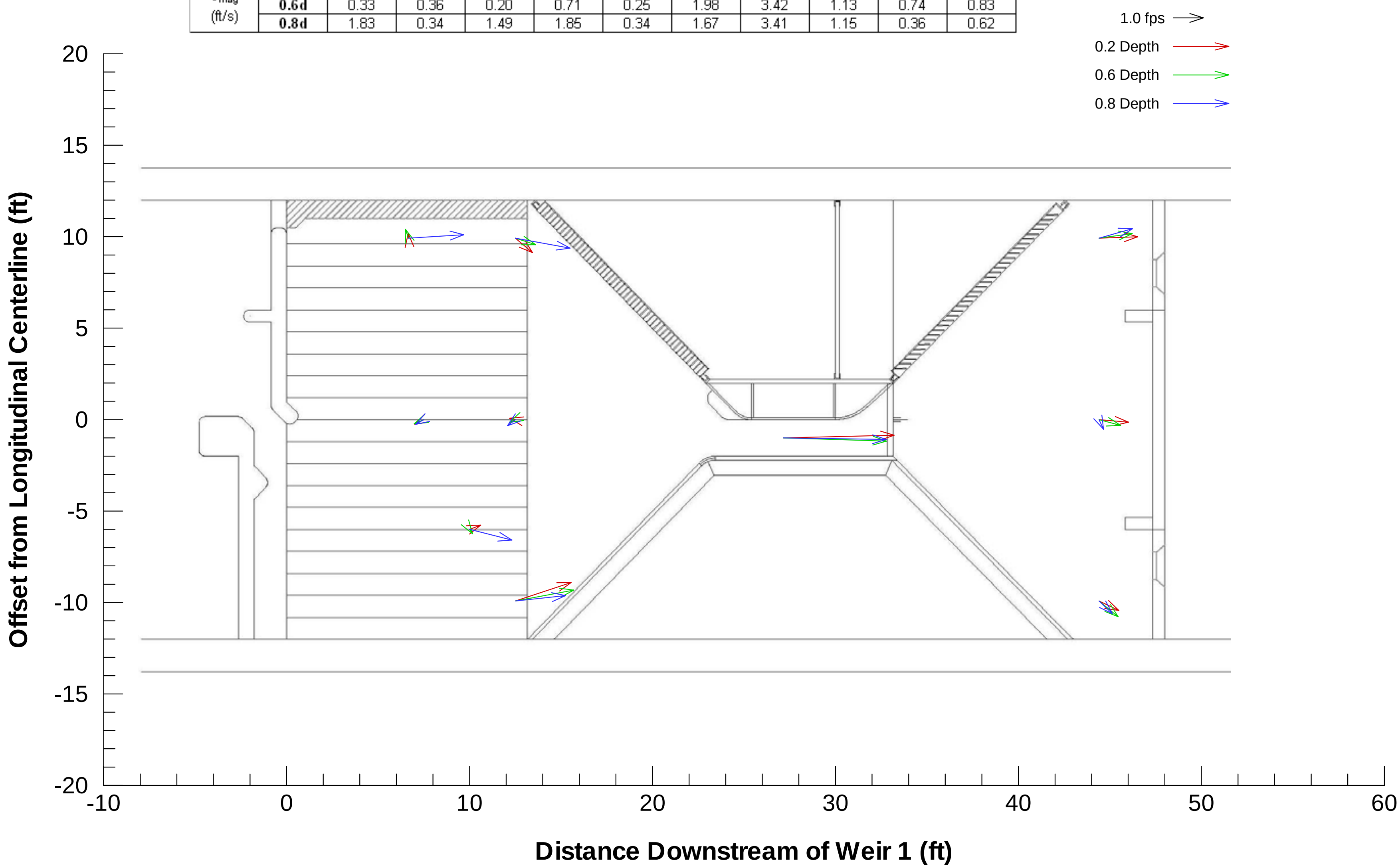
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST D
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4–49

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900–419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.16	0.34	0.40	0.75	0.25	1.95	3.67	1.30	0.98	0.73
	0.6d	0.33	0.36	0.20	0.71	0.25	1.98	3.42	1.13	0.74	0.83
	0.8d	1.83	0.34	1.49	1.85	0.34	1.67	3.41	1.15	0.36	0.62



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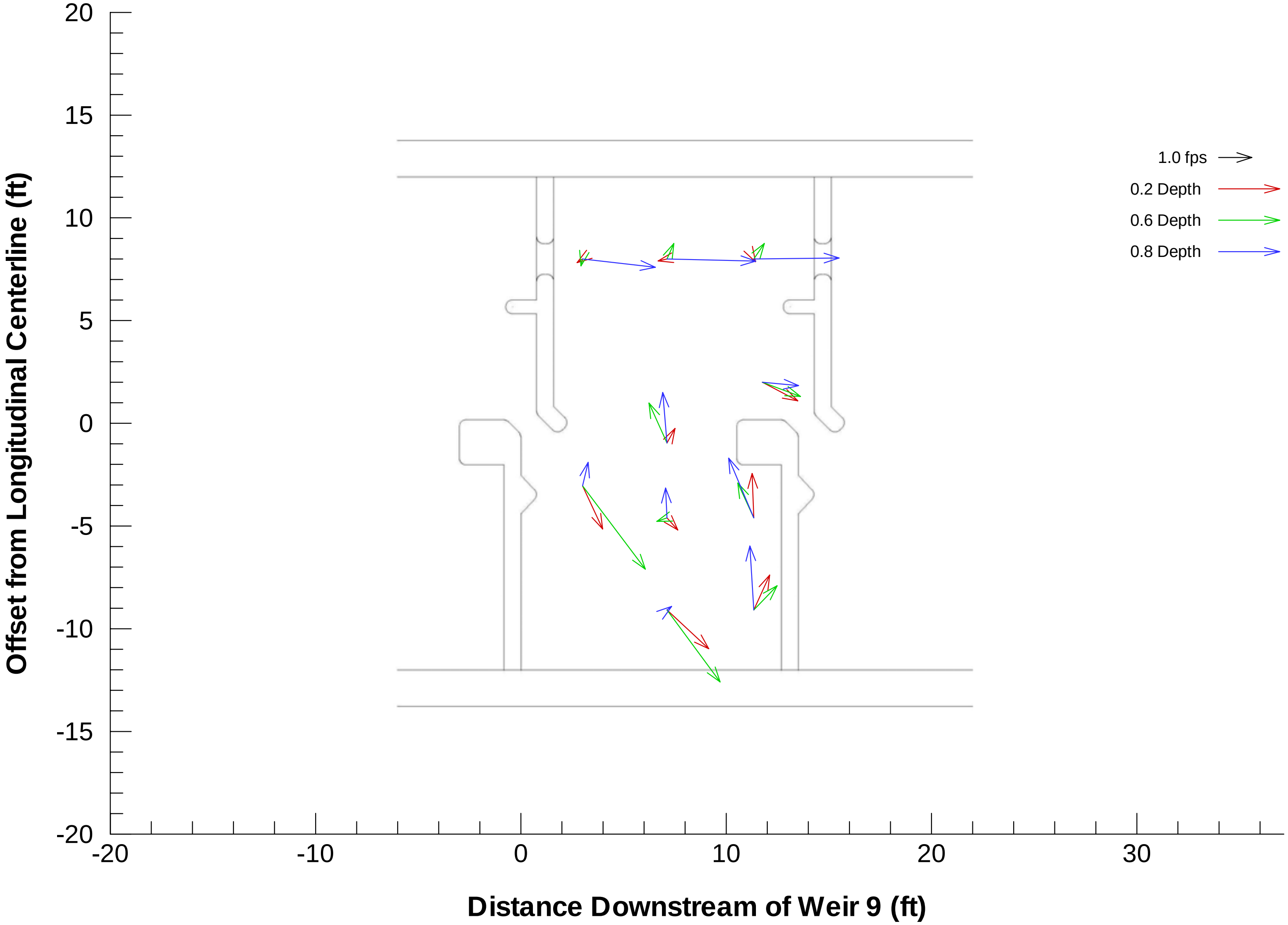
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST D
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:
4-50

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.26	0.29	0.14	1.21	1.45	0.51	0.65	1.42	1.72	1.24
	0.6d	0.40	0.55	0.56	1.22	3.17	1.32	0.55	1.26	2.69	1.31
	0.8d	2.21	2.68	2.57	1.10	0.75	1.57	0.97	1.96	0.25	1.94



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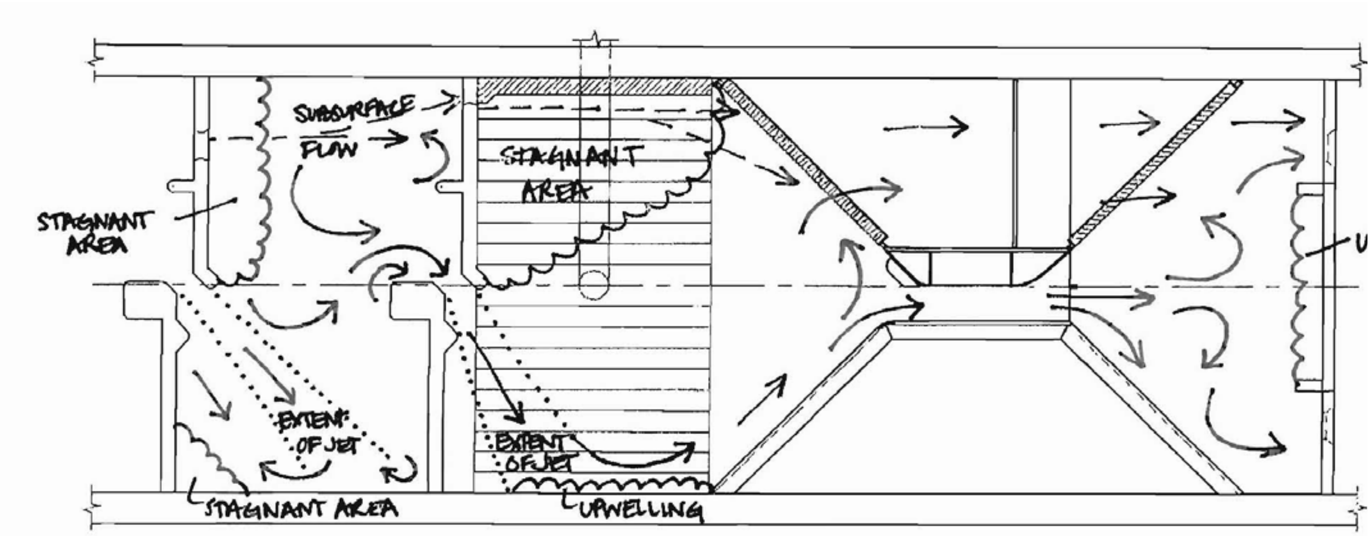
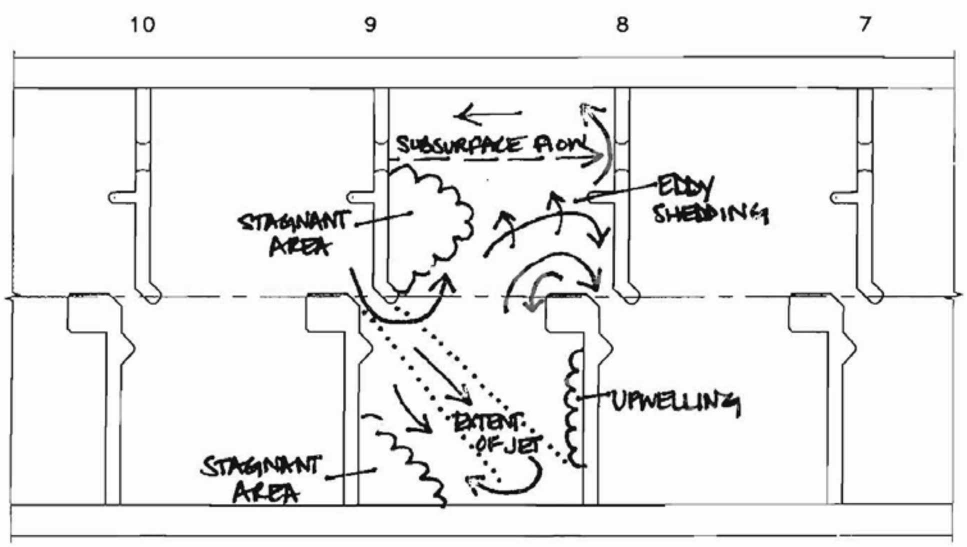
WEIR POOL 8 VELOCITIES
CONFIGURATION NO. 11 - TEST D

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:	DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
4-51	SB	2/20/08	09000-419	LR



Count Station



Pool 8

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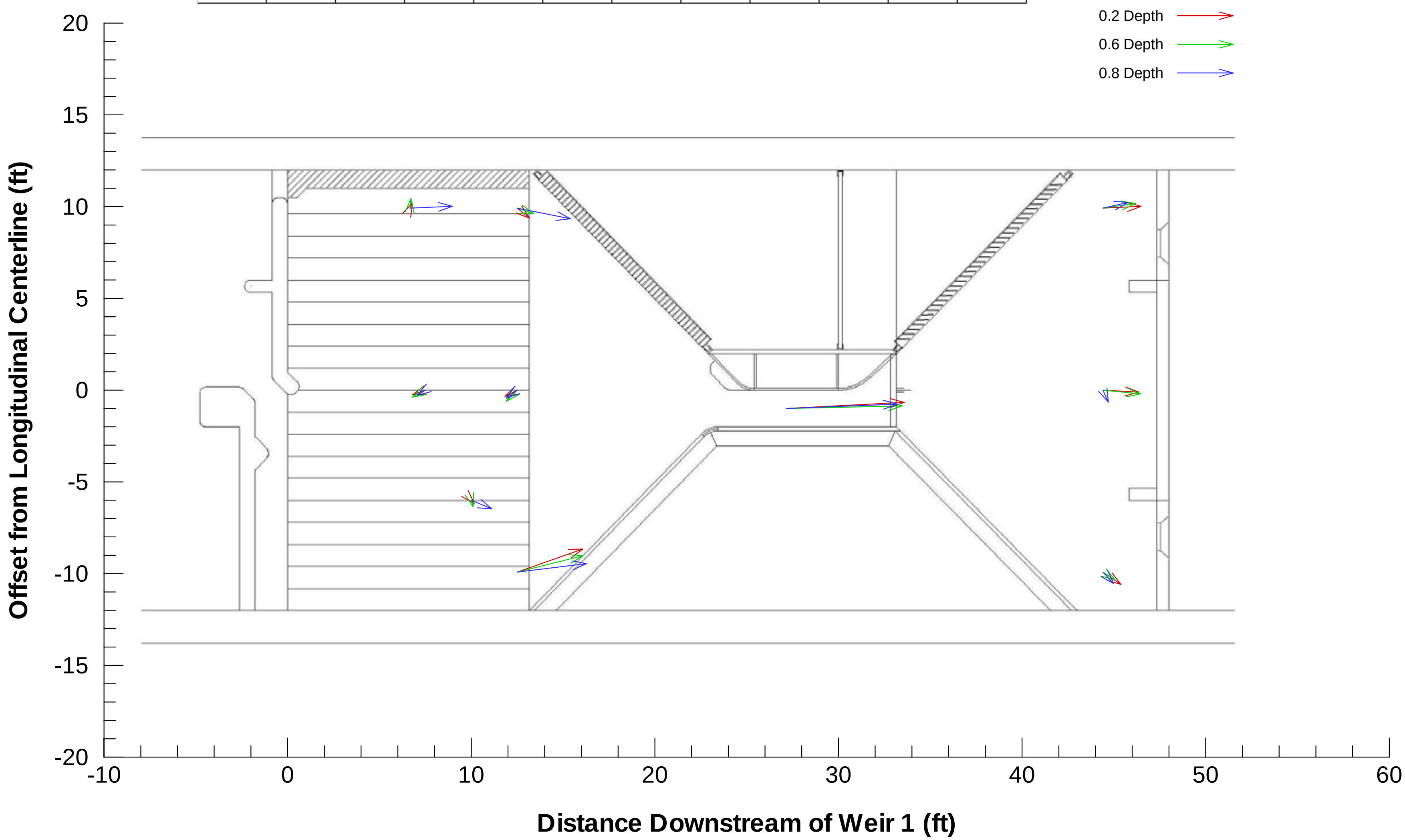
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST E
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:	DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
4-52	JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.19	0.45	0.15	0.52	0.45	2.29	3.90	1.27	1.20	0.73
	0.6d	0.33	0.49	0.24	0.59	0.52	2.24	3.83	1.11	1.28	0.49
	0.8d	1.40	0.32	0.75	1.79	0.45	2.30	3.67	0.85	0.48	0.52



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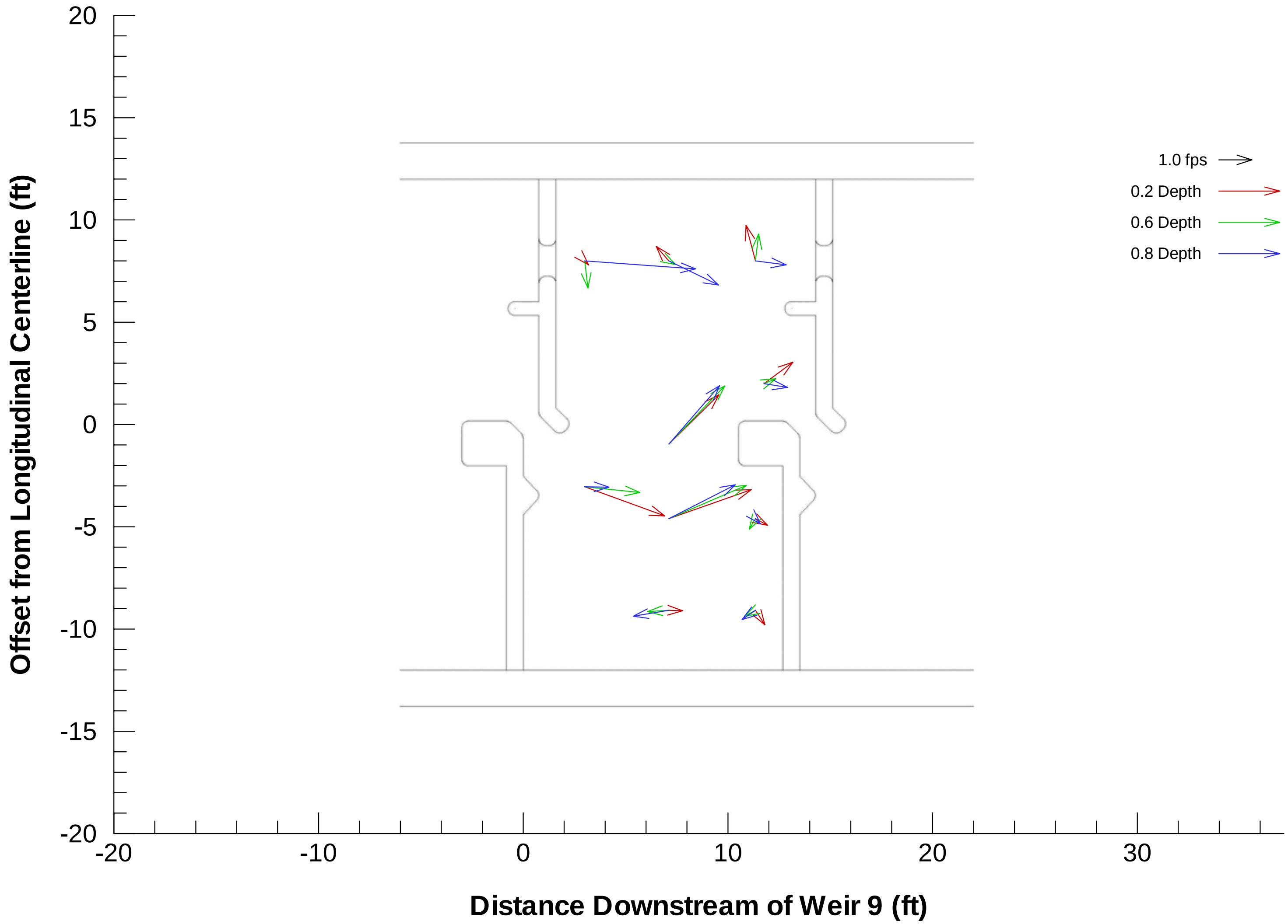
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST E
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-53**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	**0.2d**	0.39	0.58	1.16	1.18	2.64	2.15	2.73	0.49	0.42	0.68
	0.6d	0.88	0.23	0.89	0.56	1.70	2.45	2.56	0.72	0.65	0.79
	0.8d	3.43	1.74	1.13	0.73	0.74	2.35	2.29	0.29	1.11	0.50



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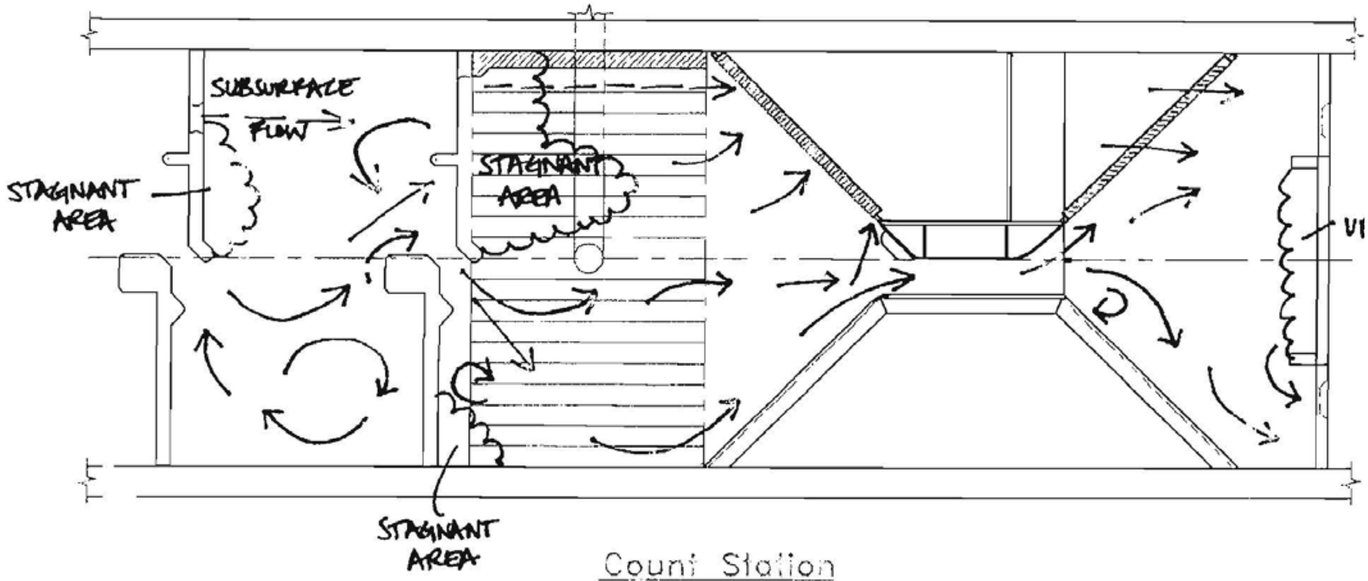
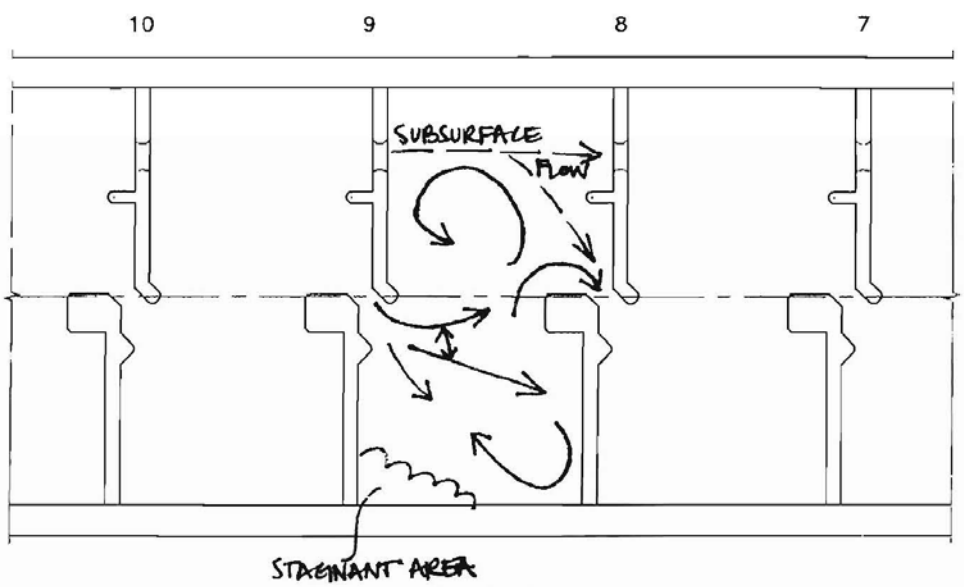
WEIR POOL 8 VELOCITIES
CONFIGURATION NO. 11 - TEST E
John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-54**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR



Count Station



Pool 8

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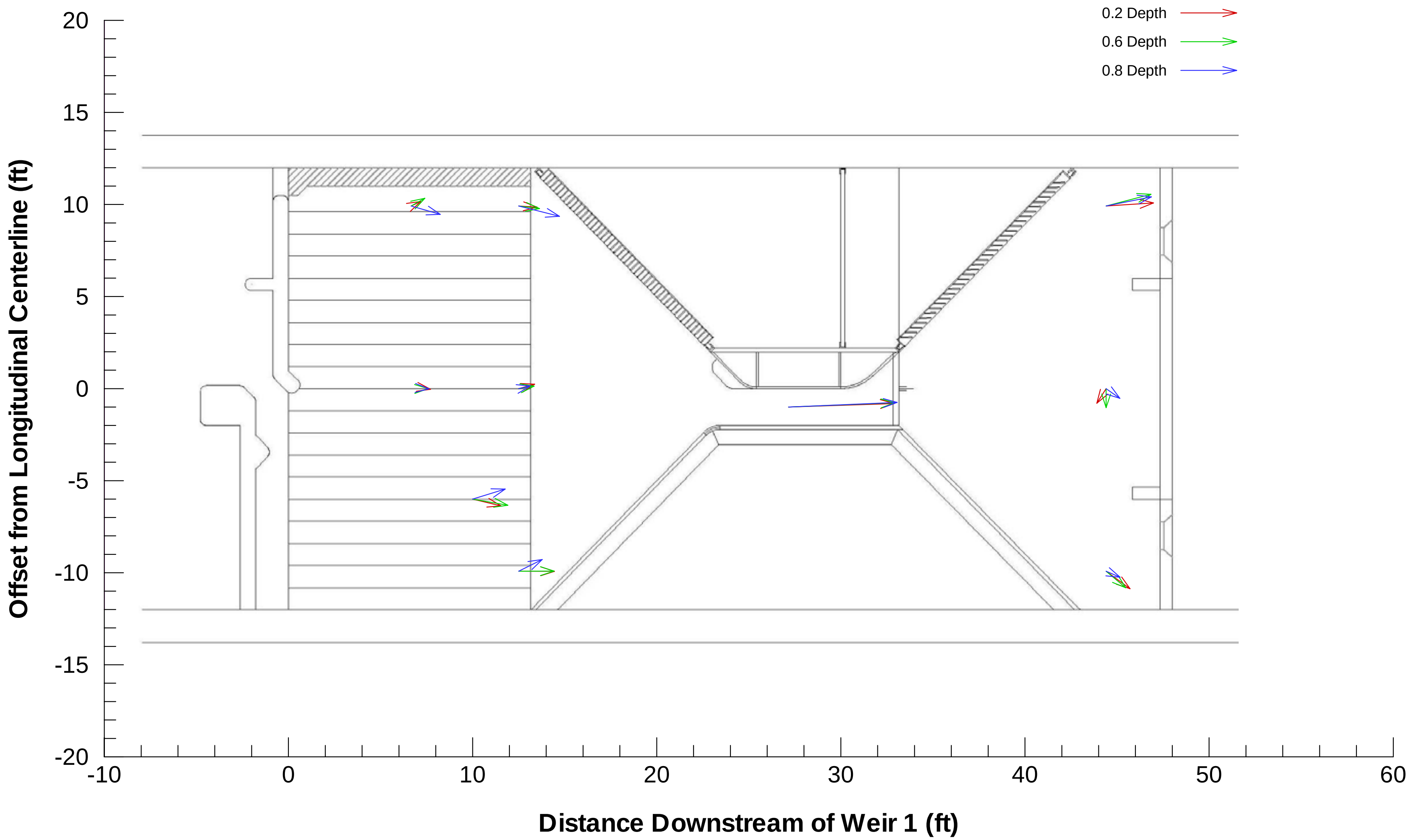
OBSERVED FLOW PATTERNS
CONFIG NO. 11 TEST F
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-55

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
JA	02/19/08	0900-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.35	0.14	0.97	0.61	0.55	1.18	3.48	1.66	0.58	0.97
	0.6d	0.54	0.12	1.19	0.70	0.52	1.17	3.50	1.65	0.63	0.86
	0.8d	1.06	0.11	1.19	1.40	0.42	0.87	3.59	1.53	0.55	0.51



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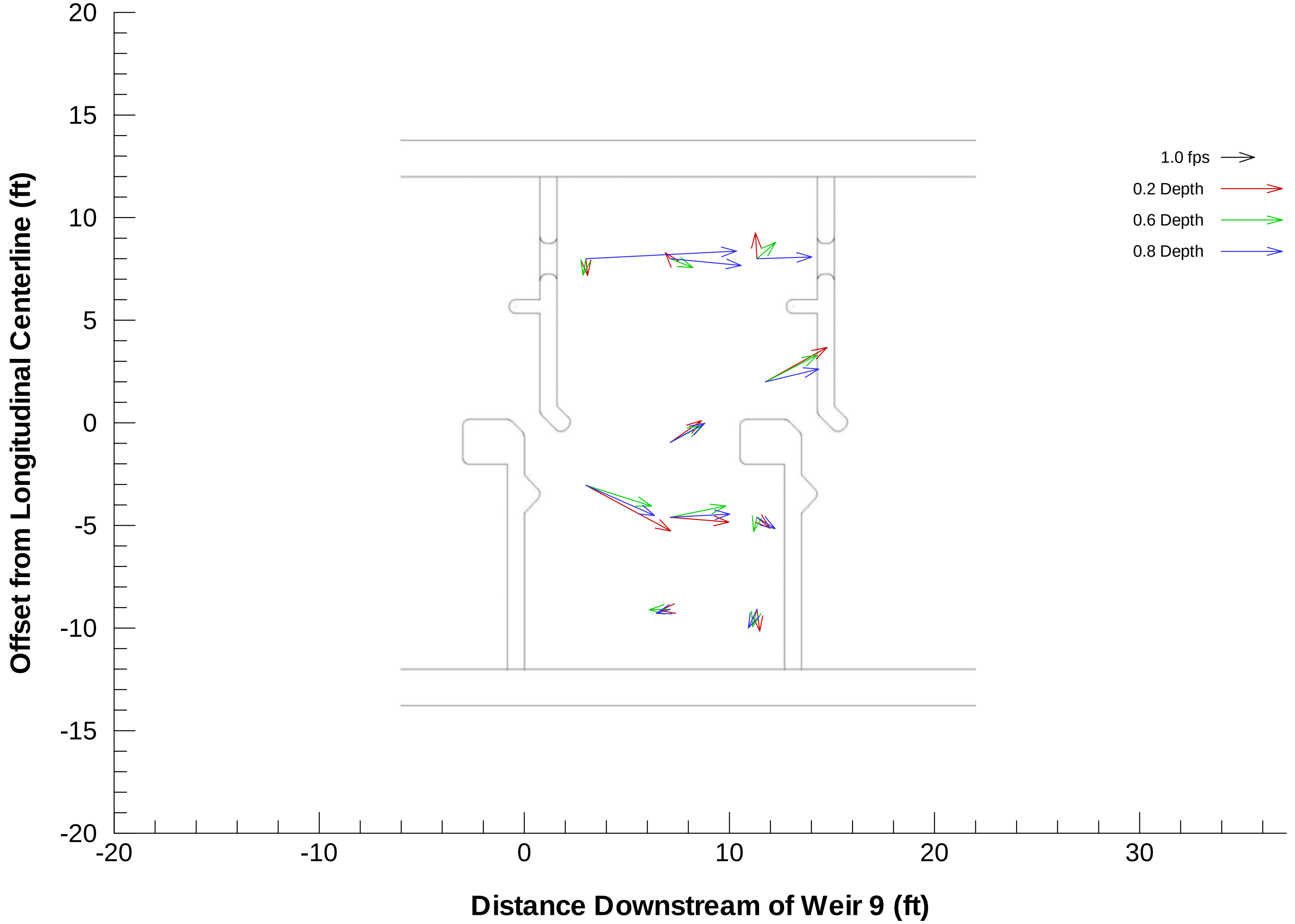
COUNT STATION VELOCITIES
CONFIGURATION NO. 11 - TEST F

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER: **4-56**

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	2/20/08	09000-419	LR

Location		1	2	3	4	5	6	7	8	9	10
V_{mag} (ft/s)	0.2d	0.51	0.23	0.77	2.13	2.92	1.16	1.78	0.51	0.30	0.67
	0.6d	0.52	0.79	0.76	1.76	2.08	1.10	1.71	0.44	0.63	0.55
	0.8d	4.55	2.15	1.67	1.65	2.29	1.19	1.80	0.68	0.45	0.62



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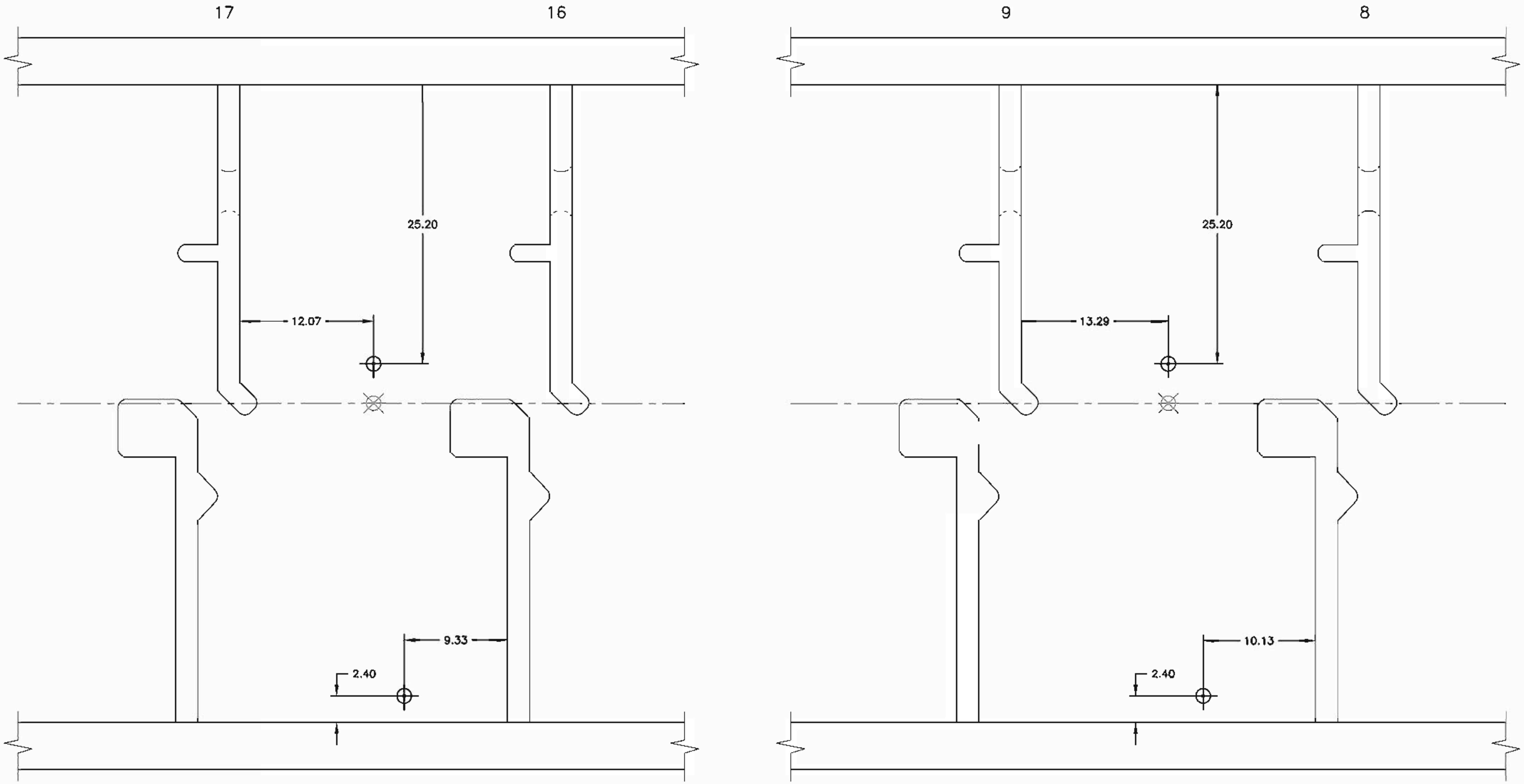
WEIR POOL 8 VELOCITIES
CONFIGURATION NO. 11 - TEST F

John Day North Fish Ladder
USACE - Portland District
Portland, Oregon

FIGURE NUMBER:	DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
4-57	SB	2/20/08	09000-419	LR



Pool 16

Pool 8

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Drill 3/8" dia. hole at each pressure tap location
4) Install pressure transducers below new tap locations using tapped acrylic blank, or similar.

Existing Pressure Tap

New Pressure Tap

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: JA/KM
CHECKED BY: LR
APPROVED BY: LR

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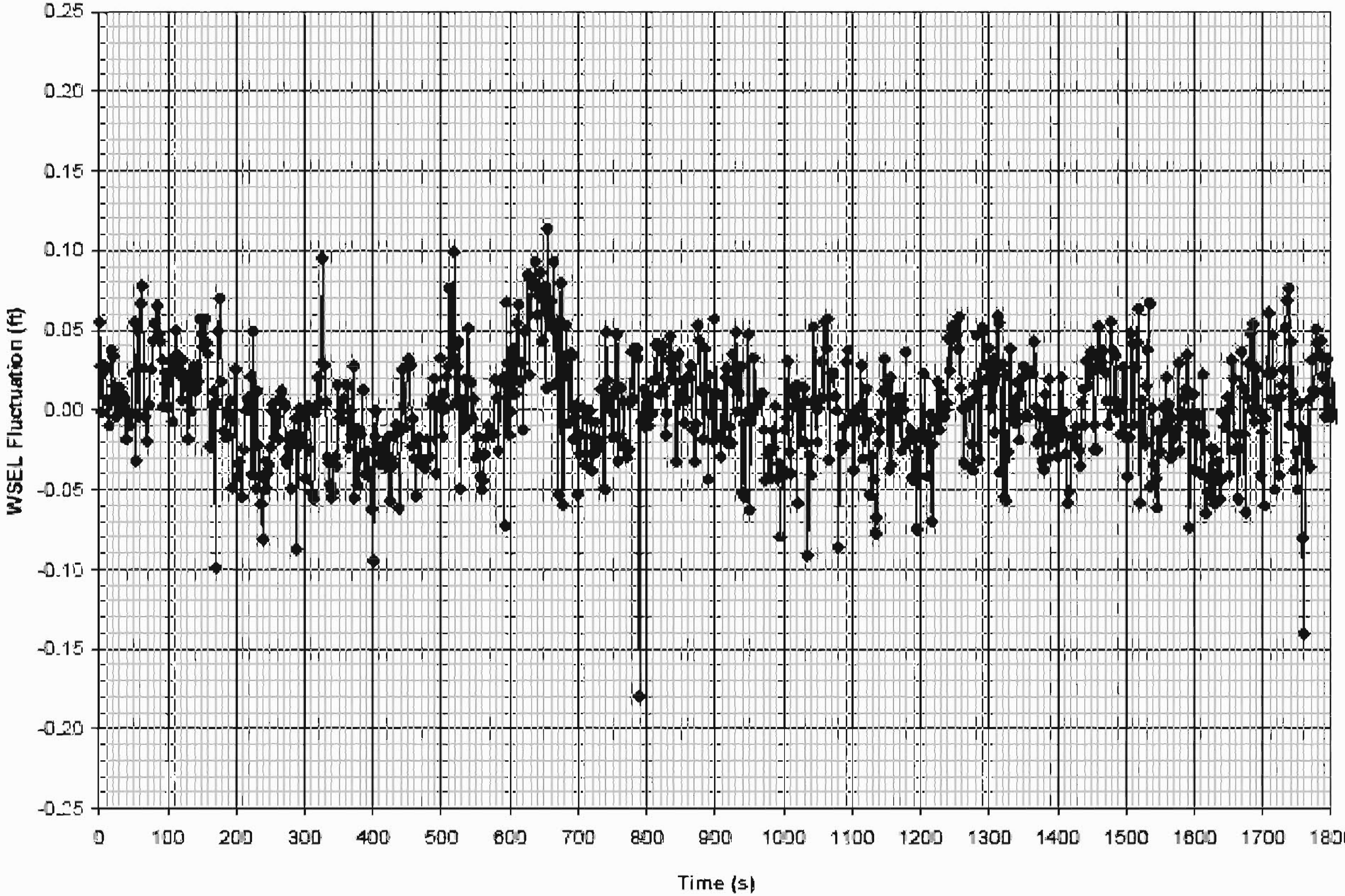
INSURANCE TESTS – DYNAMIC PRESSURE MEASUREMENT LOCATIONS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

PROJECT NUMBER: 09000-419
DATE: 03/24/08
SCALE: 1:8

FIGURE NUMBER: 4-58

FILENAME: Press-Meas-Loc



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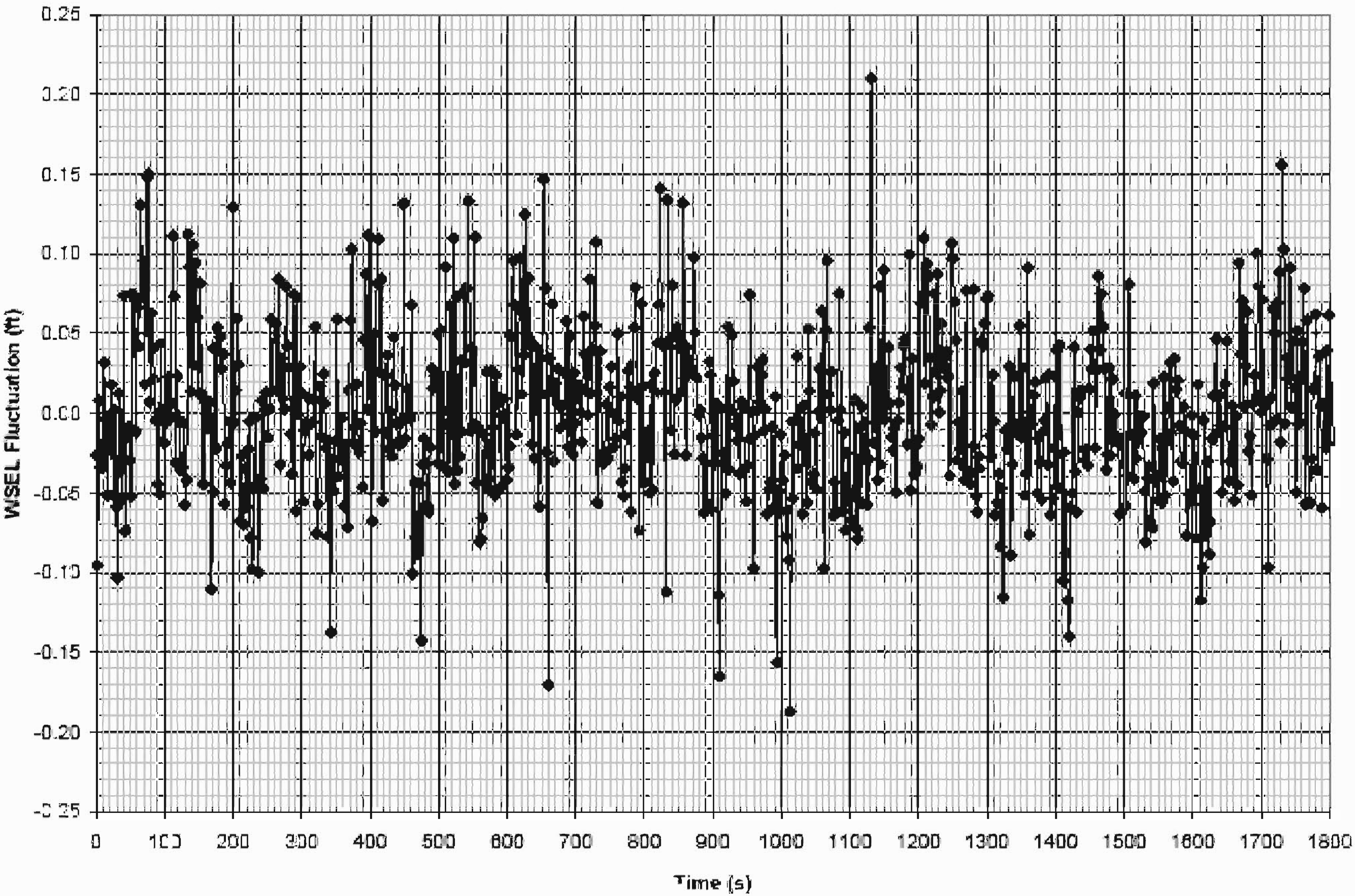
FLUCTUATION IN POOL 8 CENTERLINE WATER SURFACE
INSURANCE TEST NO. 1
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER: 4-59

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	02/21/08	09000-419	LR



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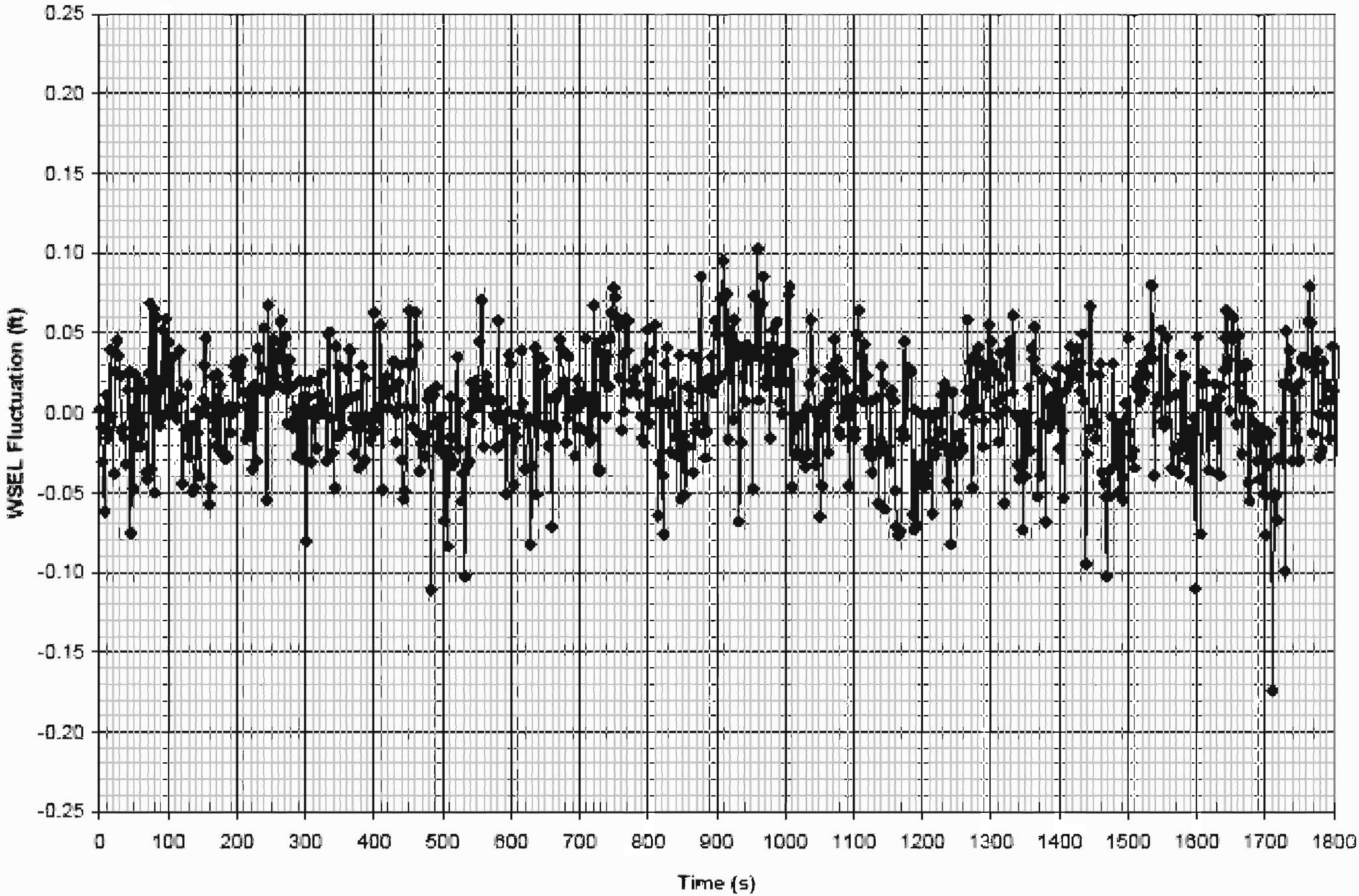
FLUCTUATION IN POOL 8 RIGHT SIDE WATER SURFACE
INSURANCE TEST NO. 1
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-60

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	02/21/08	09000-419	LR



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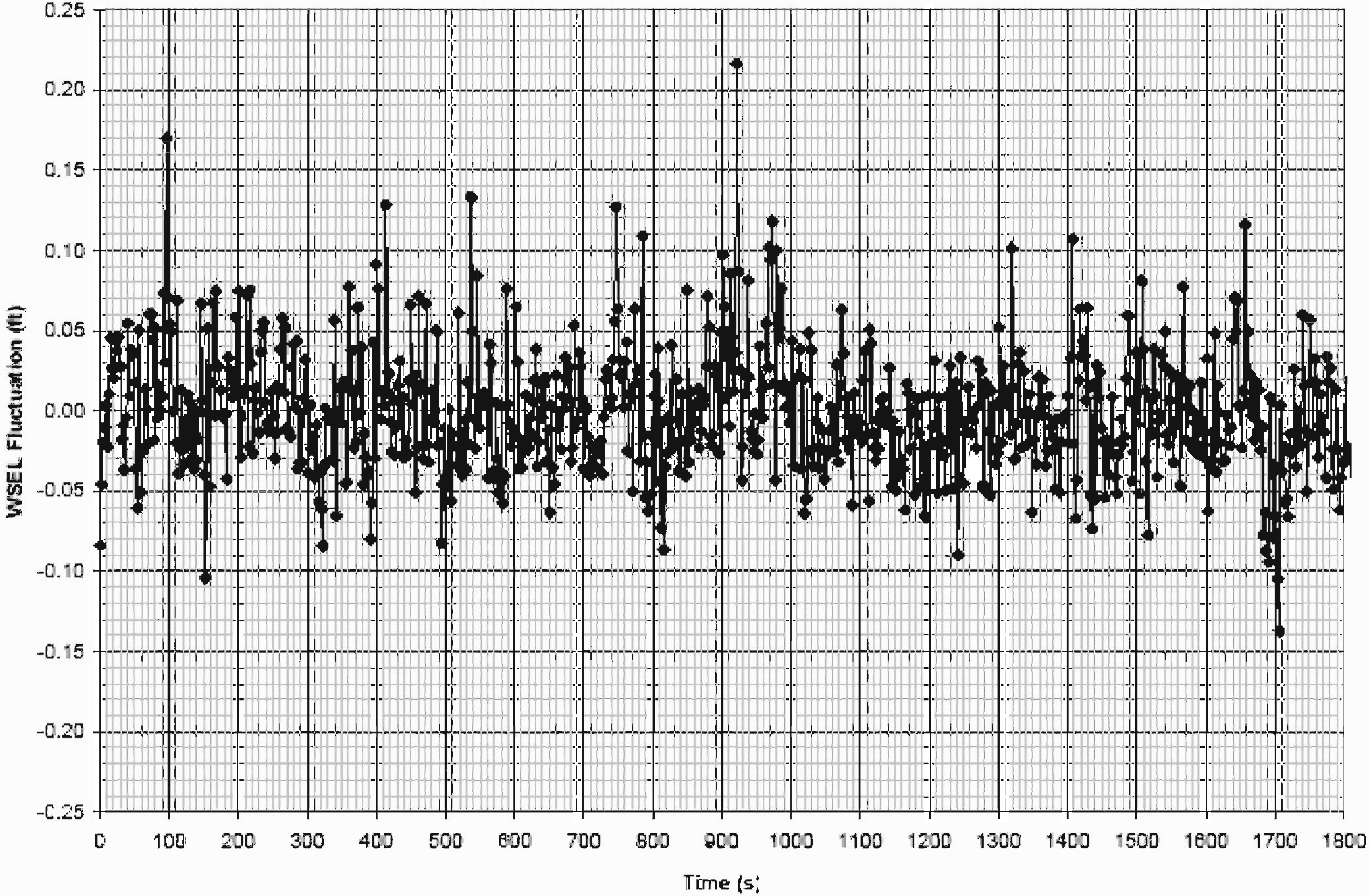
FLUCTUATION IN POOL 16 CENTERLINE WATER SURFACE
INSURANCE TEST NO. 1
John Day North Fish Ladder
U.S. Army Corps of Engineers - Portland District
Portland, Oregon

FIGURE NUMBER: 4-61

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	02/21/08	09000-419	LR



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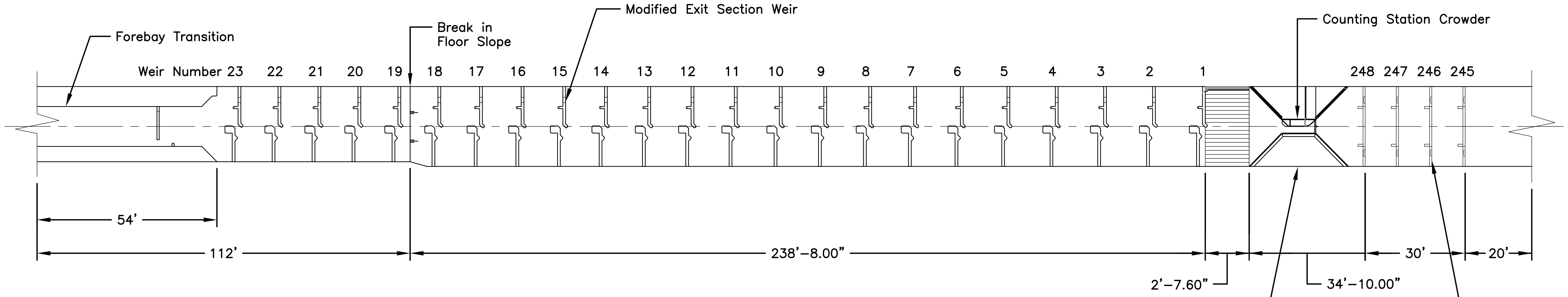
FLUCTUATION IN POOL 16 RIGHT SIDE WATER SURFACE
INSURANCE TEST NO. 1

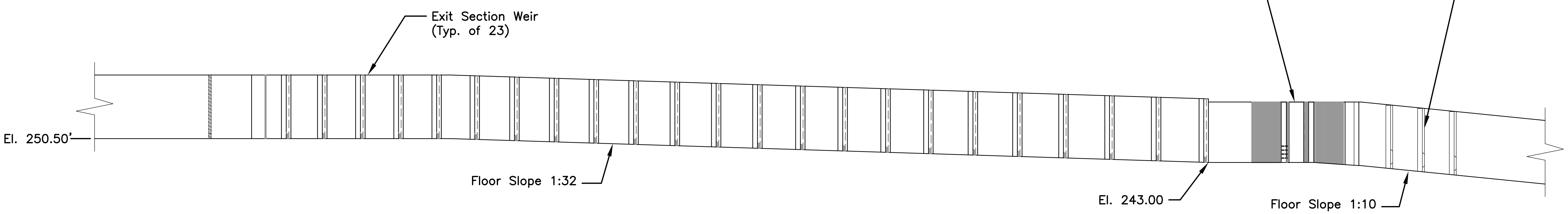
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

FIGURE NUMBER:
4-62

DRAWN BY:	DATE:	PROJECT NUMBER:	CHECKED BY:
SB	02/21/08	09000-419	LR



Plan View



Section at Centerline

Final Modified Weir Stations (prototype feet) - Used for Documentation Tests

Weir	Downstream Baffle		Centerline	Upstream baffle		Weir	Downstream Baffle		Centerline	Upstream baffle	
	D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face
1	0.00	0.83	1.36	1.78	2.61	13	166.50	167.33	167.77	168.10	168.93
2	15.00	15.83	16.36	16.78	17.61	14	179.50	180.33	180.77	181.10	181.93
3	29.67	30.50	30.94	31.45	32.28	15	192.00	192.83	193.27	193.60	194.43
4	44.17	45.00	45.44	45.77	46.60	16	204.50	205.33	205.77	206.10	206.93
5	58.67	59.50	59.94	60.27	61.10	17	217.00	217.83	218.27	218.60	219.43
6	72.67	73.50	73.94	74.27	75.10	18	229.50	230.33	230.77	231.28	232.11
7	86.67	87.50	87.94	88.27	89.10	19	241.50	242.33	242.77	243.28	244.11
8	100.17	101.00	101.44	101.77	102.60	20	253.50	254.33	254.86	255.28	256.11
9	113.67	114.50	114.94	115.27	116.10	21	265.50	266.33	266.86	267.28	268.11
10	127.00	127.83	128.27	128.60	129.43	22	277.50	278.33	278.86	279.28	280.11
11	140.50	141.33	141.77	142.10	142.93	23	289.50	290.33	290.86	291.28	292.11
12	153.50	154.33	154.77	155.10	155.93						

Notes:
1) Dimensions given in prototype units
2) Elevayions given in prototype feet

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA/KM
CHECKED BY: LR
APPROVED BY: CS

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FINAL PROTOTYPE LAYOUT PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers, Portland District
Portland, Oregon

SCALE: 1" = 40'
DATE: 03/25/08
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 5-1

FILENAME: Final Proto Layout

Appendix A

Supplemental Reports

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Memorandum

Date: May 21, 2007

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: JDA Site Visit Trip Notes and Photos

Distribution: Chick Sweeney – ENSR; Jamie Richardson - ENSR; Justin Arnold – ENSR

On Friday, May 11, 2007, Liza Roy of ENSR attended a site visit to the John Day Dam North and South (JDAN and JDAS) fish ladders with Natalie Richards and Steve Schlenker, USACE Portland District, to kick off ENSR's JDAN Ladder Physical Model Study. Bob Cordie, Project Biologist was present during part of the site visit to answer questions about the ladder components and operations.

The purpose of the site visit was to field verify construction drawings of the JDAS exit section weirs, and confirm the location, configuration, and operation of the JDAN count station, Diffuser No. 16, Holey Wall (Weir No. 249), the bulkhead knife gate, the crowder, and the 2-overflow/2-orifice weirs downstream of the count station. Both ladders were in operation during the site visit, with a forebay elevation of 263.2 ft.

We began the site visit at approximately 9:00 AM at the JDAS ladder to observe the JDAS exit weirs in operation, then went to the JDAN ladder for the bulk of the day, and returned to the JDAS ladder just before leaving at 3:45 to confirm a few details. Observations and notes from discussions with Natalie, Steve, and Bob are documented along with photos in the following sections for the JDAS and JDAN ladders, respectively. Conditions during the site visit were sunny and warm.

JDAS Ladder

The JDAS ladder is shown in Photos 1 and 2. The JDAS exit section weirs are numbered 1 through 23, beginning at the downstream end of the exit section and ending with Weir No. 23 at the forebay transition at the upstream end near the exit. The JDAS exit weirs are generally on 13'1" spacing, with some adjustments for construction and beam spacing (16 feet on centerline) within the ladder. We noted that we may need to adjust the spacing for the JDAN weirs for beams as well. In the upper pools, corresponding approximately to weirs 12 through 23, the hydraulics looked reasonably good, but we noticed that very slight short-circuiting seemed to occur in some pools, perhaps those that are adjusted for structural beam spacing. The lower ladder pools, for weirs 1 through 12, appeared to have more

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turbulent conditions than the upper ladder pools. In general, the jet from the weir slot is directed diagonally across the weir pool to the left and downstream and impacts the left bank ladder wall approximately 10 to 11 feet downstream of the weir. We measured the JDAS exit section weir spacings in Table 1 with a tape measure.

Table 1. JDAS Exit Section Approximate Weir Spacing

Weir No.	Spacing	Weir No.	Spacing	Weir No.	Spacing
1	13’1”	9	13’5-1/4”	17	12’10-3/4”
2	13’1”	10	12’11”	18	13’5-1/4”
3	13’1”	11	13’6-1/2”	19	13’2-1/4”
4	13’1-3/4”	12	12’9”	20	13’3-1/8”
5	13’4”	13	13’3-1/4”	21	13’3-1/4”
6	13’1”	14	13’2-3/4”	22	12’11”
7	13’1-1/2”	15	13’2”	23	Not measured – to transition
8	13’3-1/2”	16	13’1-1/4”		

The slot elevation in the JDAS exit section weirs are controlled by flap gates with single or double settings controlled by motors mounted on a grated deck above the ladder as shown in Photo 3. Weirs 17 through 23 have two flap gates and motors and weirs 12 through 16 have a single flap and motor to control the slot elevation. The flap elevations vary from weir to weir and were provided in the information during the proposal process. We will likely model the slot elevation with a fixed piece of acrylic, rather than a movable flap gate.

The movable flap gates for Weirs 12 through 23 are set manually according to the limits shown in Photo 4. Bob Cordie noted that the forebay is typically in the mid-range (262 ft through 265 ft) and that the flap gates are typically in the mid-range position indicated in Photo 4.

We measured from the downstream side of Weir 23 to the downstream side of Weir 1 in the JDAS exit section as 289.5 feet. We also confirmed that the JDAS exit section weirs (Photo 5) are 10 inches wide as shown on the as-built construction drawings, rather than 8 inches wide as shown on the JDAS physical modeling drawings provided with the RFP. Steve and Natalie will provide ENSR with the as-built construction drawings for the JDAS Ladder for the JDAS exit section and weirs for the JDAN Ladder physical model design.

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JDAN Ladder

The JDAN Ladder exit section is shown in Photo 6. As part of the physical modeling scope to be conducted by ENSR, JDAS exit section Weirs 1 through 23 will be modeled in the JDAN exit section, along with the forebay transition structure, Diffuser No. 16, the count station, and four of the two-overflow/two-orifice weirs downstream of the count station (Photo 7). The details of the existing JDAN geometry and operation were confirmed during the site visit as described in the following sections.

Forebay Transition

The forebay transition structure contains two vertical slot weirs and two short stub walls that were not indicated on the drawings that ENSR had during the proposal phase. Natalie and Steve will provide ENSR with the updated as-built drawings.

Holey Wall

The Holey Wall (Weir 249) will be in the physical model in place of JDAS exit section Weir 1 for the baseline model testing.

Diffuser No. 16

During shad migration, the weirs downstream of the count station are operated with 1.3 feet of head instead of 1.0 feet. Additional flow is added to the ladder through Diffuser No. 16 and the exit section operation is not changed.

We noted that the floor elevation on the upstream side of the Holey Wall (Weir 249) is 243.0 feet and the floor elevation at Diffuser No. 16 is flat and at elevation 242.0 feet. As a result, there is a 1 foot stepped drop in the floor elevation across Weir 249 that needs to be included in the model design.

Count Station

ENSR had some questions about the location of the count station relative to Diffuser No. 16 and Weir 248. The location was confirmed in the field and on the as-built drawings. ENSR had a previous version of the JDAN Ladder layout and Natalie and Steve will provide the updated as-built drawings for use in the physical model design.

We took some initial field measurements of the internal components of the count station and found that they did not agree with the dimensions on the as-built drawings. After double-checking measurements, we determined that the overall length of 48 feet for the count station indicated on the as-built drawings was correct, but that the internal dimensions of the count station components did not match the field measurements. The dimensions shown in Figure 1 for the count station picket leads, bulkhead knife gate, and count station ramp gate were obtained in the field and will be used for the model design.

The upstream picket lead members are oriented perpendicular to the flow through the count station (See Photo 8).

The ramp on the upstream and downstream sides of the crowder has vertical sides. The vertical sides will likely need to be changed during the modification testing to have a sloped transition to the count station floor.

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Crowder

The approach to the crowder, looking downstream, is shown in Photo 9 and the crowder opening is shown in Photo 10. The crowder has a minimum opening of 18 inches. The opening was measured to be 24 inches from the crowder to the count window during the site visit. We will model the crowder opening by inserting an acrylic or plywood box to take up the width of the crowder in the count station.

Bulkhead Knife Gate

The bulkhead knife gate is shown in Photo 11. According to Bob Cordie, the bulkhead knife gate is typically operated at the gate setting observed during the site visit. We measured the knife gate setting by marking the water line on the gate and opening the knife gate until the bottom of the gate reached the water surface (46.5 inches submerged). We also measured the water depth with a rod (84 inches) and based on both measurements, the gate opening was approximately 37.5 inches.

Exit Section Weirs

During the site visit we discussed the weir spacing for the JDAS and JDAN Ladder exit sections. The JDAS weirs are spaced to accommodate the structural beams and the JDAN weirs will likely have to be spaced in a similar manner. The weirs will be spaced by setting the downstream face of the North portion of Weir 1 at the current location of the downstream face of the Holey Wall (Weir 249). Steve will provide the weir spacing from downstream face to downstream face (North weir) to ENSR for use in the model design.

Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com

Cc: C. Sweeney – ENSR,
J. Arnold - ENSR

Enclosures:

Figure 1. Count Station Field Measurements
Photo 1: JDAS Ladder exit section, looking downstream
Photo 2: JDAS Ladder and entrance section
Photo 3: JDAS Ladder exit section slot flap gate actuators
Photo 4: JDAS Ladder slot flap gate operations
Photo 5: JDAS Ladder exit section weirs
Photo 6: JDAN Ladder exit section
Photo 7: JDAN Ladder 2-overflow/2-orifice weirs
Photo 8: JDAN Ladder upstream picket lead
Photo 9: JDAN Ladder looking downstream to crowder
Photo 10: JDAN Ladder crowder opening looking downstream
Photo 11: JDAN Ladder bulkhead knife gate

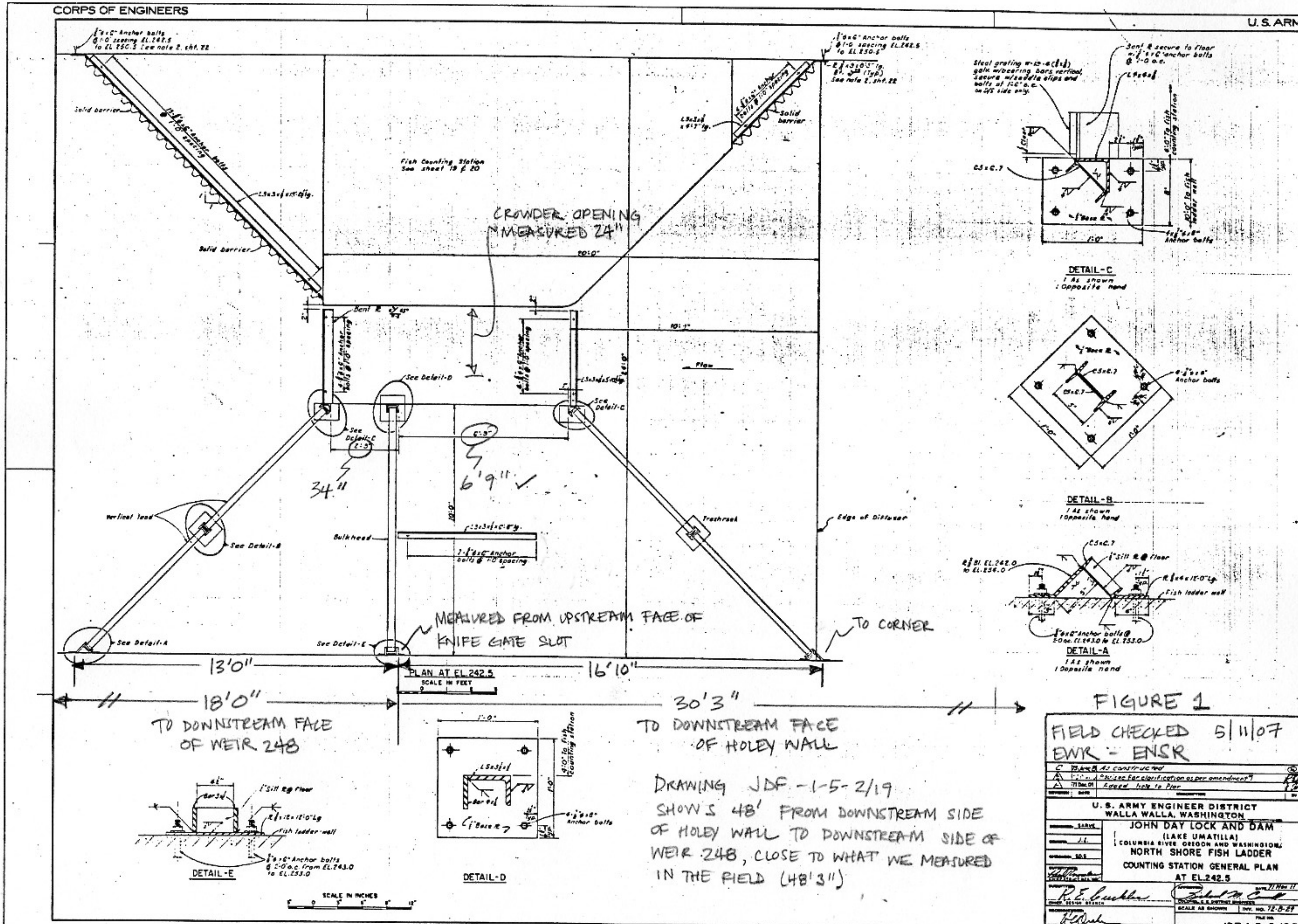
CORPS OF ENGINEERS
U.S. ARMY
Solid barrier
Fish Counting Station See sheet 19 & 20
CROWDER OPENING MEASURED 24"
34"
6'9" ✓
Vertical lead
See Detail-B
See Detail-A
See Detail-D
See Detail-C
See Detail-E
Bulkhead
Trashrack
Edge of Diffuser
Flow
MEASURED FROM UPSTREAM FACE OF KNIFE GATE SLOT
TO CORNER
13'0"
16'10"
PLAN AT EL.242.5
SCALE IN FEET
18'0"
TO DOWNSTREAM FACE OF WEIR 248
30'3"
TO DOWNSTREAM FACE OF HOLEY WALL
DRAWING JDF-1-5-2/19 SHOWS 48' FROM DOWNSTREAM SIDE OF HOLEY WALL TO DOWNSTREAM SIDE OF WEIR 248, CLOSE TO WHAT WE MEASURED IN THE FIELD (48'3")
DETAIL-A
DETAIL-B
DETAIL-C
DETAIL-D
DETAIL-E
Fish ladder wall
SCALE IN INCHES
FIGURE 1
FIELD CHECKED 5/11/07
EWR - ENSR
As constructed
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
JOHN DAY LOCK AND DAM
(LAKE UMATILLA)
COLUMBIA RIVER OREGON AND WASHINGTON
NORTH SHORE FISH LADDER
COUNTING STATION GENERAL PLAN
AT EL.242.5
JDF-1-5-2/25

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Photo 1. JDAS Ladder exit section, looking downstream

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Photo 2: JDAS Ladder and entrance section

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Photo 3: JDAS Ladder exit section slot flap gate actuators

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Photo 4. JDAS Ladder slot flap gate operations

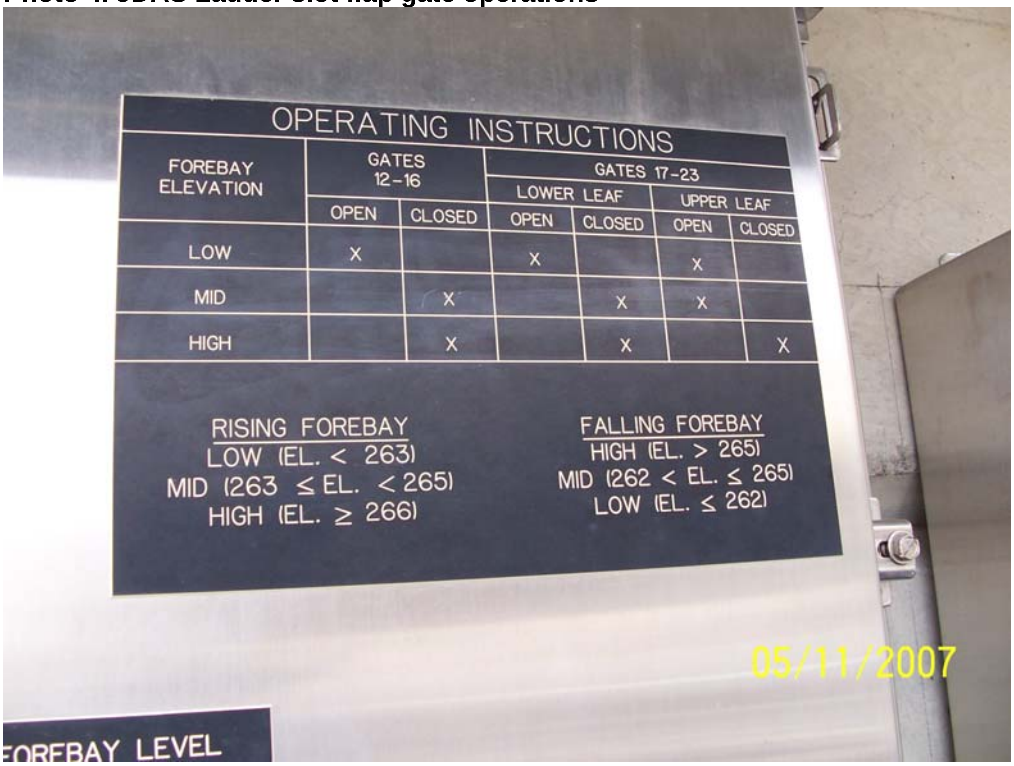

Photo 5. JDAS Ladder exit section weirs

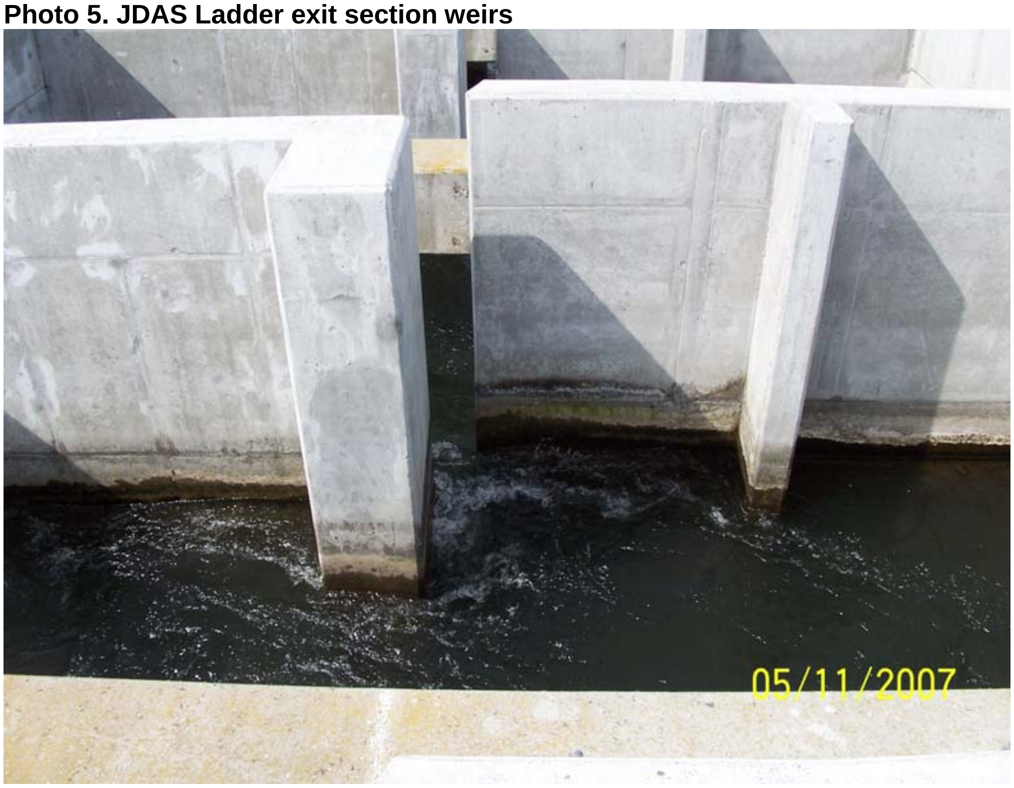

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Photo 6. JDAN Ladder exit section

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Photo 7. JDAN Ladder 2-overflow/2-orifice weirs

Photo 8. JDAN Ladder upstream picket lead

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Photo 9. JDAN Ladder looking downstream to crowder

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Photo 10. JDAN Ladder crowder opening looking downstream

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Photo 11. JDAN Ladder bulkhead knife gate

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Memorandum

Date: July 11, 2007

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: First Site Visit Meeting Minutes

Distribution:				
	C. Budai - USACE	J. Calnon - USACE	T. Adams - USACE	E. Meyer – NOAA Fisheries
	D. Clugston - USACE	C. Sweeney - ENSR	J. Arnold - ENSR	

ENSR hosted a site visit for USACE Portland District staff to witness operation of the 1:5 scale JDAN Ladder physical model in our Physical Hydraulic Modeling Laboratory on July 5 and 6, 2007. These meeting minutes summarize the model test conditions observed, model quality control items addressed, the testing program developed for the modeling, expectations for the next site visit, and action items resulting from the meeting.

Attendees:

Chris Budai – USACE

Jim Calnon – USACE (July 5 only)

Travis Adams – USACE

Natalie Richards – USACE

Steve Schlenker – USACE

Dave Clugston – USACE

Liza Roy – ENSR

Chick Sweeney – ENSR

Justin Arnold – ENSR

Ed Meyer – NOAA Fisheries

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Model Conditions Observed

During the site visit, we observed hydraulic conditions in the 1:5 scale model for the test conditions described in Table 1. The first four conditions were observed on Thursday, July 5, 2007 with the exit section weir slot flaps set for medium forebay conditions and the remaining two were observed on Friday, July 6, 2007 with the exit section weir slot flaps set for low forebay conditions.

Table 1. Model Test Conditions Observed During Site Visit

Test Condition	Forebay Elevation (ft)	Weir Head (ft)	Ladder Flow (cfs)	Diffuser Flow (cfs)	Exit Section Flow (cfs)
1	264	1.0	85	61.9	23.1
2	264	1.3	113	61.9	51.1
3	266	1.0	85	74.1	10.9
4	262	1.0	85	45.7	39.3
5	257	1.0	85	32.7	52.3
6	263	1.0	85	73.2	11.8

Model Design and Quality Control

Liza noted that the modification drawings for the model need to show fillets for the upstream and downstream slopes of the modified count station ramp. The model drawing currently shows a vertical side on the sloped ramp. Steve noted that the drawings should also indicate a 4-inch radius rounding on the slope breaks for the ramp. ENSR will make this correction to the model modification drawings.

The flow distribution through the model diffuser is not currently uniform and some backflow through the diffuser was observed. The model construction was just completed and the final QC check has not been conducted as of the meeting date. We agreed that we will add additional layers of perforated plate during the final QC check to achieve a reasonably uniform flow distribution through the diffuser with no backflow as indicated by dye observation. We will make this change to the model prior to beginning the model testing. We confirmed by conference call with Bob Cordie (TDA USACE Biologist) and a check of drawings that there are bubbler beams in place in the prototype diffuser that should provide a reasonably uniform flow distribution from the diffuser. Therefore, the assumption of uniform flow at the model diffuser should be satisfactory.

Natalie questioned the length of the diffuser in the model and we checked it against field measurements and as-built drawings and confirmed that the model diffuser length is correct within model construction tolerance. The final QC check is being performed on the model prior to baseline testing.

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Justin asked for confirmation of the sill elevations for the slot weirs in the forebay transition. We currently have them configured to sill elevations that are relevant to the JDAS transition, not JDAN and need to confirm the sill elevation for the JDAN transition slots prior to baseline testing.

Travis requested that we indicate the location of ladder struts on the model drawings. We will make this change.

Model Testing Program

We confirmed the desired testing program through the next site visit as described in the following sections. Additional details of the testing program will be provided in the modification proposal provided to Natalie by ENSR as all of the items listed below are not in our original scope.

Pre-Baseline Testing

Document the JDAS weirs 2 through 23 with the Holey Wall in place at one forebay elevation:

- Medium Forebay El. 264 ft, 1.0 ft weir head
- Medium Forebay El. 264 ft, 1.3 ft weir head

Documentation will include dye, photographs, and video, along with velocity data collection at 30 points in the count station. We confirmed the count station velocity data collection locations as shown in Figure 1 during the site visit. The velocity data collection at the count station was added per phone conversation between Steve Schlenker and Liza Roy on July 10, 2007. We will not collect velocity data in Pool 8/9 for this configuration.

Baseline Testing

Document the JDAS weirs 1 through 23 after the Holey Wall has been removed and replaced with a JDAS weir for three forebay elevations:

- Low Forebay El. 257 ft, 1.0 ft weir head
- Low Forebay El. 257 ft, 1.3 ft weir head
- Medium Forebay El. 264 ft, 1.0 ft weir head
- Medium Forebay El. 264 ft, 1.3 ft weir head
- High Forebay El. 268 ft, 1.0 ft weir head
- High Forebay El. 268 ft, 1.3 ft weir head

Documentation will include dye, photographs, and video, along with velocity data collection at 30 points in the count station and 30 points in the pool between weirs 8 and 9. We confirmed the Pool 8/9 velocity data collection locations as shown in Figure 2 during the site visit.

Modification Testing

Construct 23 lamprey friendly weirs per the drawing to be sent to ENSR by Steve Schlenker. Based on our observations during the site visit we decided to change the slot nose on the downstream baffle for the lamprey friendly weirs to try to direct the slot jet at an angle towards the right wall (looking downstream). We observed that some of the pools were beginning to intermittently short-circuit with the

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jet being occasionally directed toward the next slot rather than at an angle toward the right side ladder wall (looking downstream). The group agreed on an approximate configuration for the weir nose to attempt to stabilize the jet direction and Steve agreed to have the change drawn up and sent to ENSR. We also decided to change the weir thickness to 10 inches instead of 12 inches. The plan views are attached as Figures 3 and 4.

ENSR will provide a means of adjusting the location of the triangular flow vane on the downstream face of the upstream baffle in the model on at least three weirs surrounding Pool 8/9. Moving these triangular vanes may impact the recirculation in the pool. We called Kyle McCune (USACE Portland) to get some information on the history of the triangular flow vanes in the JDAS modeling and he noted that there was some uncertainty about their location and effectiveness. He sent several reports to Liza via email and ENSR will review them. The group agreed that having the triangular vanes be adjustable may be valuable during the next site visit.

ENSR will install the 23 lamprey friendly weirs in the model after removing the 23 JDAS weirs, lower the count station ramp, modify the ramp slopes, slope the diffuser panel, install 1' plating on the bottom of the trashrack (to aid lamprey passage) and document conditions for three forebay elevations:

- Low Forebay El. 257 ft, 1.0 ft weir head
- Low Forebay El. 257 ft, 1.3 ft weir head
- Medium Forebay El. 264 ft, 1.0 ft weir head
- Medium Forebay El. 264 ft, 1.3 ft weir head
- High Forebay El. 268 ft, 1.0 ft weir head
- High Forebay El. 268 ft, 1.3 ft weir head

Documentation will include dye and photographs, along with velocity data collection at 30 points in the count station and 30 points in the pool between weirs 8 and 9. Depending on our progress during testing, we may only get through the Medium Forebay tests (1.0 and 1.3 ft weir head) prior to the next site visit. The group agreed that the Medium Forebay was the priority of the three forebay elevations.

Second Site Visit

The second model site visit is currently scheduled for August 13 through 15, 2007. At this site visit we expect to view the baseline configuration with all 23 JDAS weirs in place and have the ability to change the weirs out to observe the modification scenario as described above with the 23 lamprey friendly weirs in place, along with the count station changes. We will also be able to view and discuss the results from the baseline documentation and documentation of the Medium Forebay condition for the modification testing.

During the first site visit, we noted that there is some flow recirculation in the pool upstream of weir 18 where the sidewall tapers to the full ladder width. USACE staff requested that we have a formed piece of wood or acrylic ready for the next site visit that can be inserted at the taper to keep the ladder width constant over the entire pool and fill in the triangular area formed downstream of the taper. We will have this testing piece ready for the next visit.

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Action Items

Liza will provide Natalie with a cost estimate and scope for the additional testing program items that were not in the original proposal scope. Natalie will work on the contracting for these items.

Steve will send ENSR the drawing for the lamprey friendly weirs with the change for the weir slot nose on the downstream baffle. (As of submittal of these minutes, Steve sent ENSR the drawings and they are attached as Figures 3 and 4).

ENSR will install perforated plate in the diffuser chamber to provide a reasonably uniform flow distribution from the diffuser panel. ENSR will finalize the model QC and begin the testing program as described above.

ENSR will modify the count station ramp in the modifications drawings to include fillets along the edges of the ramp and 4 inch radius rounding on the ramp slope breaks.

USACE Portland will confirm the sill elevation in the forebay transition slot weirs. ENSR will install sills to the correct elevation in the model prior to baseline testing.

ENSR will mark the location of the ladder struts on the model drawing based on information provided by Steve Schlenker in his weir spacing spreadsheet.

Thank you all for your participation in the first model site visit. Let me know if you have any questions.

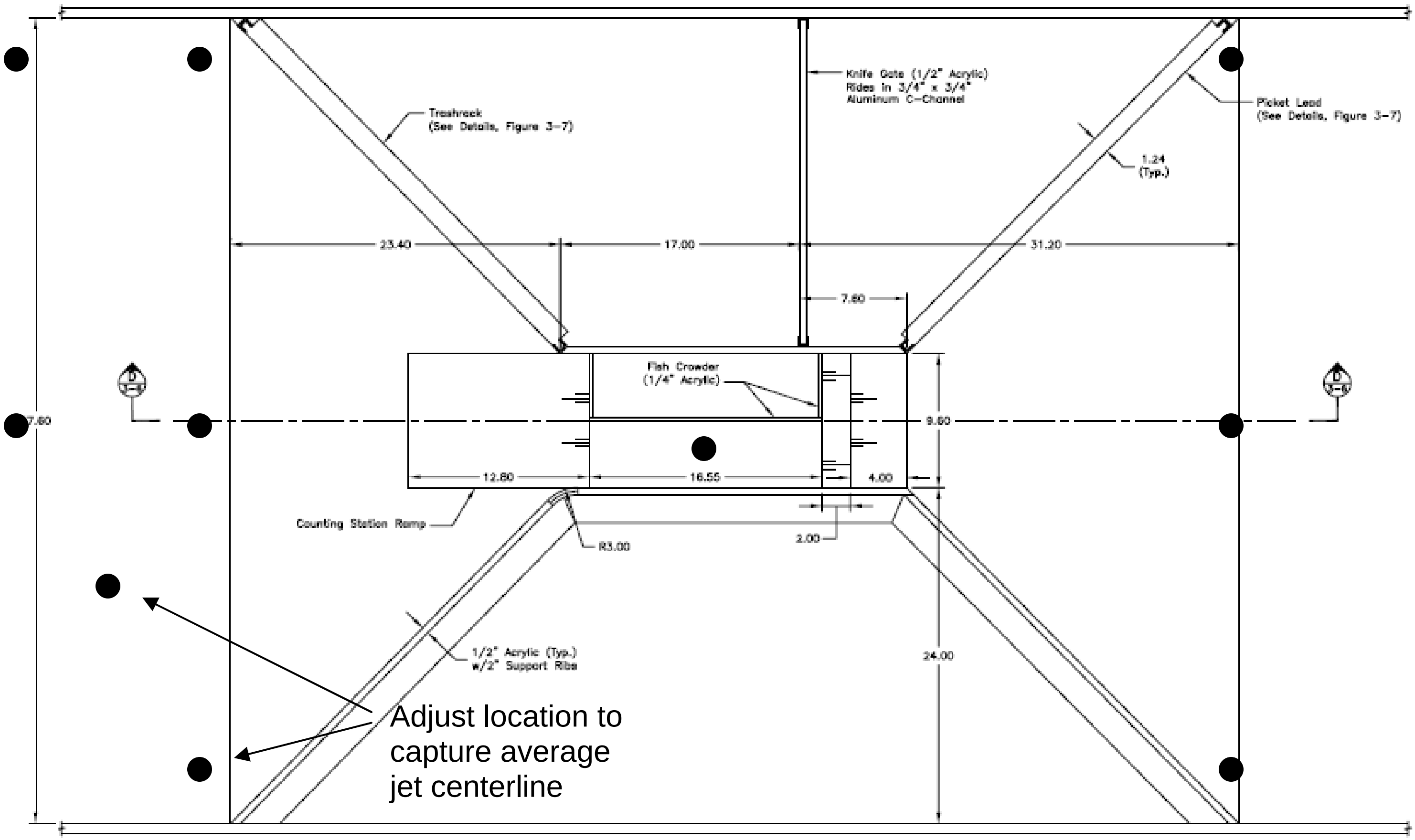
Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com

Enclosures:

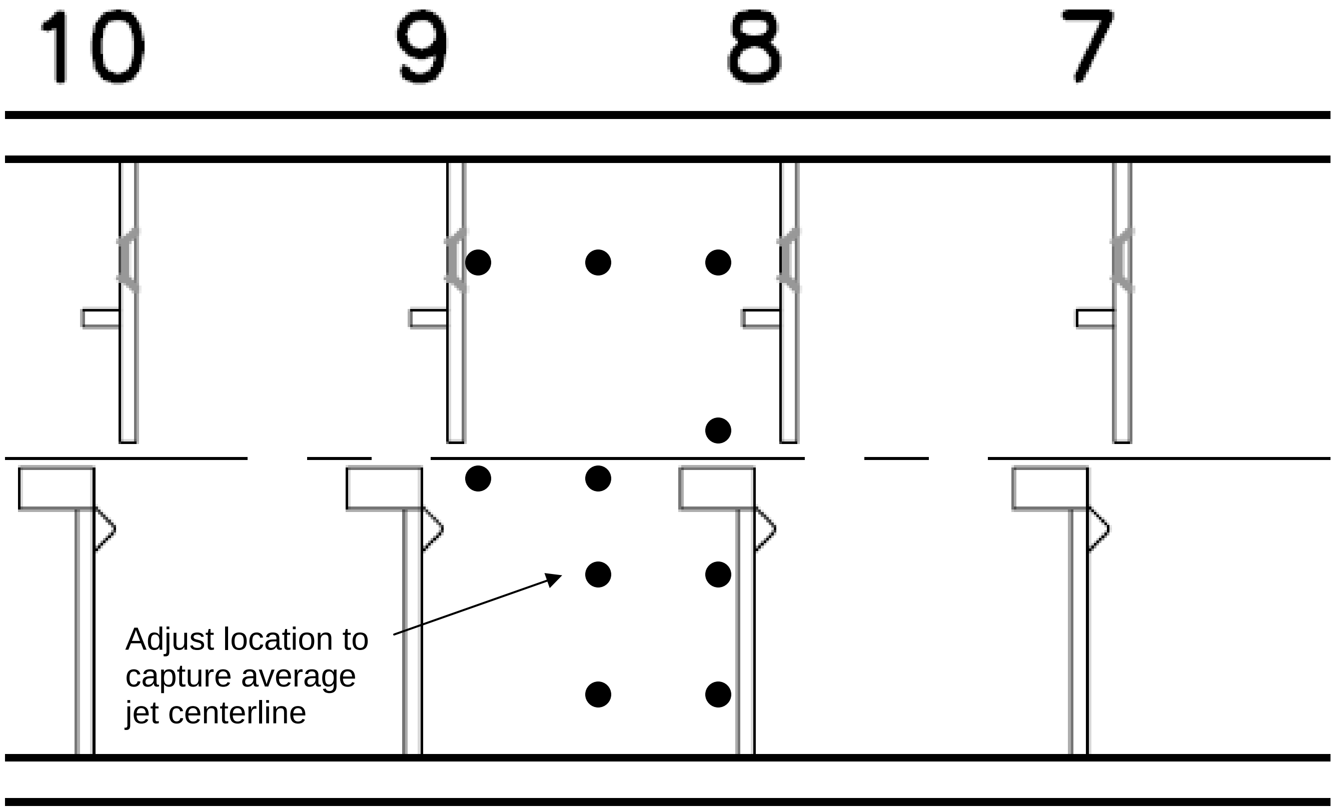
Figure 1: Count Station Velocity Measurement Locations
Figure 2: Pool 8/9 Velocity Measurement Location
Figure 3: Lamprey Friendly Modified Exit Weirs – Plan View 1
Figure 4: Lamprey Friendly Modified Exit Weirs – Plan View 2

Figure 1. Approximate Count Station Velocity Measurement Locations



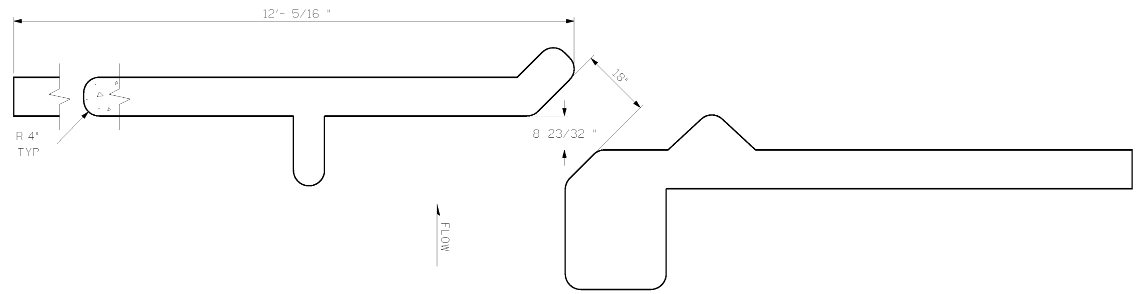
Note: measure velocities at each location at 0.2 d, 0.6 d, and 0.8 d for a total of 30 measurements

Figure 2. Approximate Pool 8/9 Velocity Measurement Locations

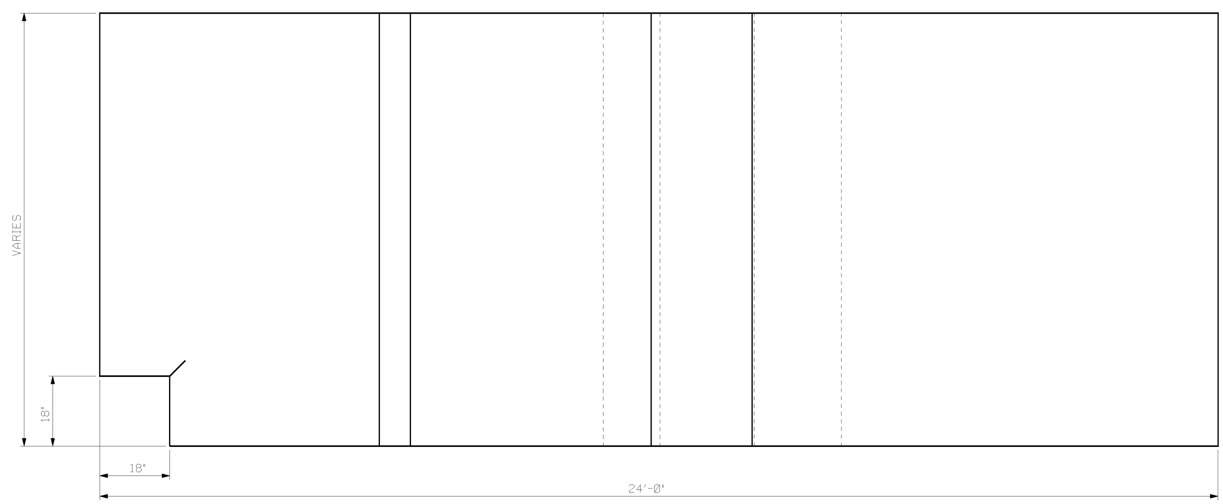


Note: measure velocities at each location at 0.2 d, 0.6 d, and 0.8 d for a total of 30 measurements

Figure 3. Lamprey Friendly Weir - Baffles 1, 2, 3, 21, 22, and 23



LAMPREY FRIENDLY WITHOUT PIT - PLAN



LAMPREY FRIENDLY WITHOUT PIT - ELEVATION
BAFFLES 1, 2, 3, 21, 22 AND 23

NOTES:

1. FOR DIMENSION DETAILS OF EACH WALL SEE DRAWING 1.
2. BAFFLE HEIGHT AND INVERT ELEVATION VARY THROUGH THE ENTIRE LENGTH OF THE CONTROL SECTION.
3. DRAWING IS FOR INFORMATION ONLY.

SCALE: 3/4" = 1'-0"

US Army Corps of Engineers
Portland District

DESIGNED BY:		DATE: 15 MAR 2007
DRAWN BY:	CHECKED BY:	SOLICITATION NO. DACW-
FILE NAME: 2d-jd-n-ladder12dims.dgn		CONTRACT NO. DACW-
SUBMITTED BY:		

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
Portland, Oregon

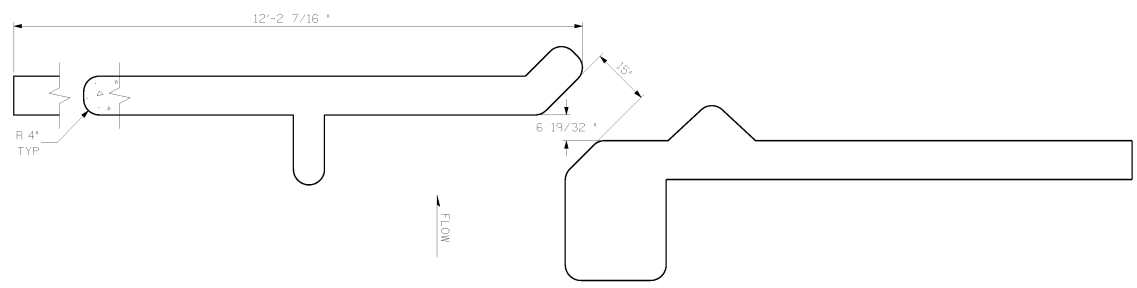
COLUMBIA RIVER OREGON
JOHN DAY NORTH FISH LADDER
NON-OVERFLOW WEIRS

Drawing Number 7
Sheet number:

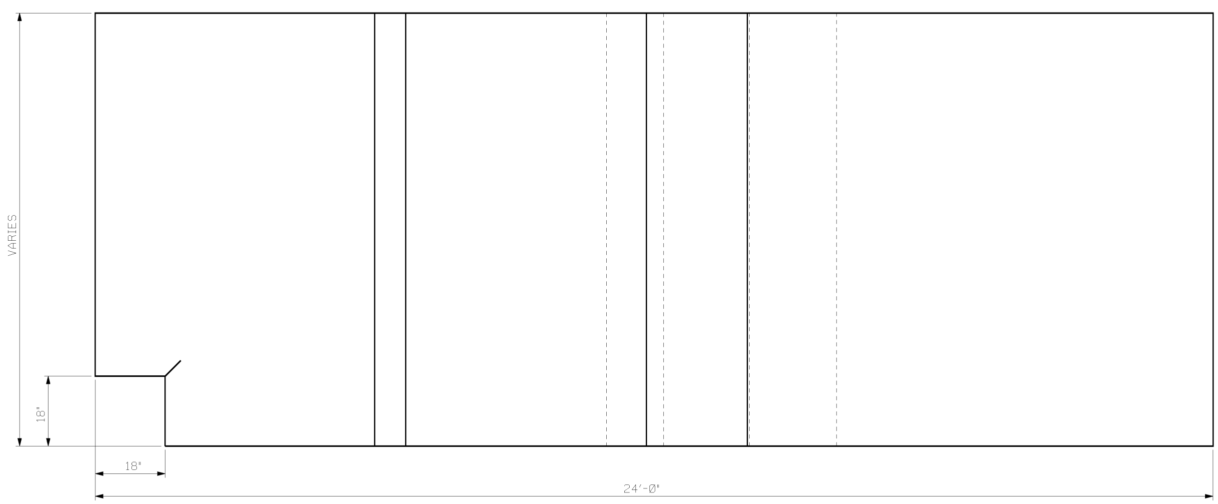
Symbol	Description	Date	Appr.

DRAWING PLOT SIZE: FULL-SIZE(34X22)PLOT
DATE AND TIME PLOTTED: 7/10/2007 3:51:44 PM BY USERNAME: G2ECHEVH (ERIC HOLZAPFEL)
SHEET NAME: STANDARD_DESIGN
DESIGN FILE: D:\HD PROJECTS\JOHN DAY\NORTH LADDER\2D-JD-N-LADDER12DIMS.DGN

Figure 4. Lamprey Friendly Weir - Baffles



LAMPREY FRIENDLY WITHOUT PIT - PLAN



LAMPREY FRIENDLY WITHOUT PIT - ELEVATION
BAFFLES 4 THROUGH 20

SCALE: 3/4" = 1'-0"

NOTES:

1. FOR DIMENSION DETAILS OF EACH WALL SEE DRAWING 1.
2. BAFFLE HEIGHT AND INVERT ELEVATION VARY THROUGH THE ENTIRE LENGTH OF THE CONTROL SECTION.
3. DRAWING IS FOR INFORMATION ONLY.

US Army Corps of Engineers
Portland District

Symbol	Description	Date	Appr.

DESIGNED BY: | DATE: 15 MAR 2007
DRAWN BY: | CHECKED BY: | SOLICITATION NO. DACW-
FILE NAME: 2d-jd-n-ladder12dims.dgn | CONTRACT NO. DACW-
SUBMITTED BY:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
Portland, Oregon

COLUMBIA RIVER OREGON
JOHN DAY NORTH FISH LADDER
NON-OVERFLOW WEIRS

Drawing Number
6
Sheet number:

DRAWING PLOT SIZE: FULL-SIZE(34X22)PLOT

DATE AND TIME PLOTTED: 7/10/2007 3:54:05 PM BY USERNAME: G2ECHEVH (ERIC HOLZAPFEL)

SHEET NAME: STANDARD_DESIGN

DESIGN FILE: D:\HD PROJECTS\JOHN DAY\NORTH LADDER\2D-JD-N-LADDER12DIMS.DGN

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Memorandum

Date: August 22, 2007

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: Second Site Visit Meeting Minutes

Distribution:				
	C. Budai - USACE	J. Calnon - USACE	T. Adams - USACE	E. Meyer – NOAA Fisheries
	M. Langeslay - USACE	K. McCune - USACE	B. Cordie - USACE	T. Yin – USACE
	D. Clugston - USACE	C. Sweeney - ENSR	J. Arnold - ENSR	G. Fredericks – NOAA Fisheries

ENSR hosted a site visit for USACE Portland District and agency staff to witness operation of the 1:5 scale JDAN Ladder physical model in our Physical Hydraulic Modeling Laboratory on August 13 through 15, 2007. These meeting minutes summarize the model test conditions observed, the potential modifications developed during the meeting, expectations for the next site visit, and action items resulting from the meeting.

Attendees:

Chris Budai – USACE

Jim Calnon – USACE

Travis Adams – USACE

Natalie Richards – USACE

Steve Schlenker – USACE

T. Yin – USACE

G. Fredericks – NOAA Fisheries

M. Langeslay – USACE

Dave Clugston – USACE

Liza Roy – ENSR

Chick Sweeney – ENSR

Justin Arnold – ENSR

Ed Meyer – NOAA Fisheries

B. Cordie – USACE

K. McCune – USACE

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Model Conditions Observed

During the site visit, we observed hydraulic conditions in the 1:5 scale model for the test conditions described in Table 1. The first two conditions were observed on Monday, August 13, 2007 with the JDAS Weirs No. 2 through 23 in place with the Holey wall installed in place of Weir No. 1. The exit section weir slot flaps were set for the medium forebay range. We observed dye in the ladder pools and in the count station area.

Table 1. Model Test Conditions Observed During Site Visit

Test Condition	Forebay Elevation (ft)	Weir Head (ft)	Ladder Flow (cfs)	Exit Section (cfs)	Diffuser Flow (cfs)
1	264	1.0	85	61.9	23.1
2	266	1.0	85	74.1	10.9
3	264	1.0	85	61.9	23.1
4	266	1.0	85	74.1	10.3
5	~263.2	1.0	85	61.9	23.1
6	~264.8	1.0	85	79.5	5.5
7	~257	1.0	85	32.7	52.3
8	~268	~1.1	~95	95	0

After observing flow conditions with the Holey wall in place, the laboratory crew changed out the Holey wall and installed the JDAS Weir No. 1, lowered the count station ramp, and sloped the diffuser floor up to meet the downstream edge of Weir No. 1. The exit section weir slot flaps were set for medium forebay conditions for tests 3 and 4. After observation of dye in the ladder pools and in the count station, we ended the meeting for the day, drained the model, and the laboratory crew installed the 23 lamprey friendly weirs for observation on Tuesday, August 14, 2007.

Tuesday afternoon we observed the model operation with the 23 lamprey friendly weirs in place with the modified count station and sloped diffuser for tests 5 through 7. It was noted during setup of the model tests that as the flows for each test condition were set, the forebay elevation was lower than measured with the JDAS weirs in place. Based on these preliminary observations we expect that the lamprey friendly weirs are more hydraulically efficient than the JDAS weirs due to the rounded edges on the orifice and slot openings. This will likely result in a need to refine the gate flap elevations for the upstream exit section weir slots for the low, medium, and high forebay operating ranges. After testing with the medium flaps in place for tests 5 and 6, we removed the sills in the upper slots for the low forebay range operation and observed the model at approximately low forebay elevation 257 ft for test 7. During the low forebay operation we observed that the two slotted weirs in the exit section transition to the forebay had a significant head drop over the fixed sills and that the depth on the sills was approximately equal to the sill elevation (~2.5 ft). Some potential adjustment to this area was discussed during the meeting to allow more flow through the ladder during low flows. After the meeting was

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adjourned for the day, we reinstalled the slot flaps for the lamprey friendly weirs for the high forebay operating range.

Wednesday morning the model was set for test condition 8 at forebay elevation approximately 268 ft. Because the lamprey friendly weirs are more efficient than the JDAS weirs, more flow passes through the ladder at forebay elevation 268 ft. We set the ladder flows to approximately 95 cfs, with all flow through the exit section and zero flow through the diffuser, and the forebay elevation was approximately 267.9 ft. We observed dye at the ladder pools and count station, observed some changes to the triangular fin on the downstream face of the right weir baffle, and observed the stability of the weir jet in the ladder pools and the flow through the orifice in the left baffle.

Model Modification and Testing Program

Based on the observations during the site visit, the following modifications may be made to the model during the testing program prior to the final site visit. The details of the modifications and testing program will be confirmed with the USACE project staff.

- Move the orifice from the wall position to the same location as in the JDAS weirs, with the 4" radius rounding to limit some of the pass-through flow that was observed in the model and allow for approach to the orifice from either side,
- Raise the entire count station floor by 1 foot, tapering to the existing elevation downstream of the picket to simplify changes in floor elevation from the crowder ramp and the diffuser slope,
- Fix the crowder opening and develop farings for the upstream and downstream edges to limit flow separation,
- Adjust the gate flap elevations in the weir slots based on the performance of the lamprey friendly weirs over a range of forebay elevations,
- Install a 12" lamprey "sidewalk" of solid plate over the left bank side of the diffuser approaching the orifice to facilitate lamprey passage, and/or
- Remove the stub walls and slotted weirs in the transition section from the exit section to the forebay and narrow the section to approximately 5 ft to increase velocities.

Final Site Visit

The final model site visit was rescheduled for November 19 and 20, 2007. At this site visit we expect to view the model configuration to date with all 23 weirs in place, along with desired modifications to the count station. We will be able to review the model modification development and model results to date.

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Action Items

ENSR and USACE will have a scoping meeting to determine the next steps for testing.

ENSR will continue with the data processing and QC for the baseline tests and transmit the results of the tests to date to USACE Portland District.

USACE Portland District will confirm the as-built flap gate configurations for the weir slots. Some questions arose during the site visit as to the height of the L-shape on the as-built weirs. Jim Calnon may be able to obtain this information.

ENSR will send some of the model overview photos taken prior to testing to Natalie so she can use them in the FFDRWG presentation.

Thank you all for your participation in the second model site visit. Let me know if you have any questions.

Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com

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Memorandum

Date: November 18, 2007

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: October 23-24, 2007 Site Visit Meeting Minutes

Distribution: C. Budai - USACE; T. Adams - USACE; D. Clugston – USACE; C. Sweeney - ENSR; J. Arnold – ENSR

ENSR hosted a site visit for USACE Portland District to witness operation of the 1:5 scale JDAN Ladder physical model in our Physical Hydraulic Modeling Laboratory on October 23 through 24, 2007. These meeting minutes summarize the model test conditions observed, the potential modifications developed during the meeting, expectations for the next site visit, and action items resulting from the meeting.

Attendees:

Chris Budai – USACE

Natalie Richards– USACE

Steve Schlenker – USACE

Travis Adams – USACE

Dave Clugston – USACE

Liza Roy – ENSR

Justin Arnold – ENSR

Updates to the Physical Model

The following modifications were made to the physical model prior to the site visit and were in place on October 23, 2007.

1. Orifice on weirs 2 through 23 moved away from wall to JDAS location. Weir 1 orifice remains at the left wall.
2. Exit channel to forebay modified with elliptical transition to narrow the channel to 5 feet wide. Slotted weirs and stub walls were removed as shown in the first attached model drawing.

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3. Count Station
    a. Raised floor of count station by 1 foot to eliminate the crowder ramp, sloped diffuser
    b. Added a solid lamprey “sidewalk” over the diffuser (12” wide to 18” wide at the orifice opening in weir 1)
    c. Reduced the crowder length to 4’ 7” per correction from USACE Portland District
    d. Designed and installed farings for the upstream and downstream side of the crowder for 24” and 18” opening positions as shown in the second attached model drawing
4. Weir triangles (on the downstream face of the right weir baffle) were moved to a new position closer to the right wall per direction from USACE Portland District.

Model Conditions Observed

Steve Schlenker arrived at the ENSR laboratory on Monday, October 22, 2007 prior to the full site visit to work with ENSR staff on sill settings and review water level data collected during the previous week. We determined that there is a potential need to widen Weirs No. 18 through 20 to maintain the pool depth criterion during the full range of forebay elevations. USACE will confirm with agency personnel.

During the site visit, we planned to observe hydraulic conditions in the 1:5 scale model for the following test conditions, depending on time available and team preference:

1. Max FB 268 ft – High Sills, Q = 85 cfs (full ladder flow at ladder head = 1ft)
2. FB 265.2 ft – High Sills, Q = 61.2 cfs (min Q to meet criteria at high sills)
3. Median FB 264 ft – Medium Sills, Q = 65.4 cfs
4. FB 266.7 ft – Medium Sills, Q = 85 cfs (Max flow at medium sills)
5. FB 261.5 ft – Medium Sills, Q = 45 cfs (Min Q in criteria with medium sills)
6. Minimum FB 257 ft – No Sills, Q = 35.5 cfs
7. FB 264.4 ft – No Sills, Q = 85 cfs

We observed the following test conditions on with the model updated as described above and the count station crowder at the 24 inch open position:

Test 1: Max FB 268 ft – High Sills, Q = 85 cfs. We observed dye in the count station and pool 10. Approach to the crowder appeared reasonably smooth with the crowder farings in place with minimal separation on the downstream side as flow expands to the overflow weirs. The dye in pool 10 dispersed over the entire pool, with a slight upwelling on the right side wall. Dye in the orifice did not shoot through to the next orifice as it did when the orifice openings were against the wall in the previous weir configuration. Moving the orifice away from the wall appears to have improved hydraulic conditions for the orifice openings. Some upwelling was observed in the pools upstream of Weirs No. 22 and 23. We expect to adjust the upper weir sills to a lower elevation for the next day’s tests based on preliminary calculations from Steve Schlenker and this may improve the upwelling in the upper pools.

Test 2: FB 265.2 ft – High Sills, Q = 61.2 cfs. Flow from the revised exit channel to the forebay comes through the narrowed exit channel and expands to the pool upstream of Weir No. 23. As it expands

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along the left angled transition wall, the flow separates from the angled wall and a recirculation zone sets up on the left side above the orifice. A vortex with an observable dye core formed off the left angled transition wall below the surface and extended through the Weir No. 23 slot. Attempts were made to break up the recirculation and prevent the vortex formation using a triangular splitter (vertical piece with horizontal cross-section an equilateral triangle 3.5 " model scale on edge). The splitter was found to be reasonably effective at some but not all forebay elevations.

Test 4: FB 266.7 ft – Medium Sills, Q = 85 cfs. We removed the high forebay sills to set the sills at medium forebay configuration and set flows for Test 4 first, rather than Test 3. Some short-circuiting was observed in the pools downstream of Weir No. 7. In general, the pools with sills appeared to have more favorable hydraulic conditions. The vortex was present in the pool upstream of Weir No. 23 as described for Test 2 conditions.

Test 5: FB 261.5 ft – Medium Sills, Q = 45 cfs. During this test condition, no stable vortex formed in the pool upstream of Weir No. 23, but some swirling was observed along the left angled transition wall.

Test 7: FB 264.4 ft – No Sills, Q = 85 cfs. We removed the medium sills to set the sills at low forebay configuration and set flows for Test 7 first, rather than Test 6. A standing wave was observed in the crowder, but dye observed approaching the count station showed reasonably smooth flow patterns through the crowder. The flow condition in the crowder appeared stable. Approach to the crowder appeared reasonably smooth with the crowder farings in place with minimal separation on the downstream side as flow expands to the overflow weirs. All the weir pools exhibited some short-circuiting with dye injected in the slot dispersing over approximately the right hand 2/3 of the pool only. Dye released into the orifice remained left of the slot, but appeared to mixed reasonably well before passing through the next orifice and slot.

Test 6: Minimum FB 257 ft – No Sills, Q = 35.5 cfs. The standing wave in the crowder was not present in this test condition. The weir pools were relatively quiescent. No significant vortex formation was observed in the exit channel, but some swirling was present and a small vortex formed off the left baffle block into the slot.

After the low forebay tests were completed, we made the following changes during lunch on October 24, 2007. We changed out the crowder to the 18-inch opening, moved the triangles to position them 1/3 of the distance from the slot opening to the right wall from the right wall, reinstalled the sills for high forebay range, and adjusted the upstream sills as shown in Table 1. We also prepared several pieces for use in the model to modify the exit channel to prevent vortex formation. The afternoon was spent working on a modification for the exit channel for the next site visit.

Table 1. Sill height modifications

Weir No.	High Forebay Sill Height (ft)	Adjusted High Forebay Sill Height (ft)
10	1.00	1.00
11	1.50	1.50
12	1.75	2.00
13	2.25	2.50
14	2.50	3.25
15	3.00	3.75
16	3.50	4.00
17	4.00	4.25

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18	4.50	4.75
19	5.00	5.50
20	6.00	6.00
21	6.75	6.50
22	7.75	7.00
23	8.50	7.50

Test 1: Max FB 268 ft – High Sills, Q = 85 cfs. Test 1 conditions were set for the revised model configuration and dye was observed in the count station. A slight standing wave was observed in the 18-inch open crowder, but dye released into the crowder appeared to flow through the crowder relatively smoothly. Some short-circuiting was observed in the lower ladder pools. At pool 9 and upstream to pool 17, the flow appeared to be diving down slightly through the slot and upwelling slightly at the right wall. Dye released in the slot dispersed over slightly more than 2/3 of the pool. Pools upstream of Weir No. 17 did not have the upwelling on the right wall. The vortex was observed in the exit channel as described previously for other high flow conditions. We tried a variety of fillets, triangular splitter shapes, blocking off the right hand dead area upstream of the right Weir No. 23 baffle, and streamlining the exit channel approach to the slot.

Model Modification and Testing Program

Based on the observations during the site visit, the project team agreed on modifications for the exit channel. However, the following week, further discussion with the USACE project team resulted in agreement on a slightly different configuration shown in the third attached model drawing. The revised exit channel transition includes an angled 5 foot wide channel from the forebay trashrack with a streamlined approach to Weir No. 23. ENSR will modify the physical model to include the revised exit channel transition prior to the next site visit.

Additional Site Visit

An additional site visit was scheduled for November 8 through 9, 2007 for a portion of the USACE project team to view the modifications to the exit channel prior to the final scheduled site visit on November 19 and 20, 2007.

Action Items

ENSR and USACE will work on contracting for model construction labor units for the modifications and for the additional site visit.

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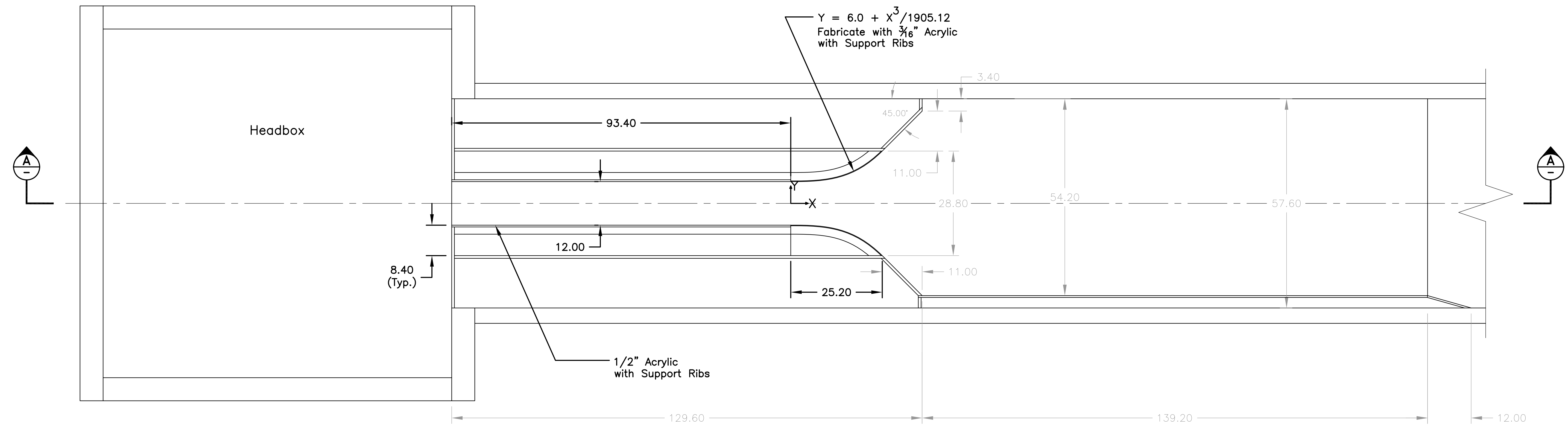
USACE will confirm whether Weirs No. 18 through 20 need to have wider slots (18" wide) at low flows to meet the pool depth criterion.

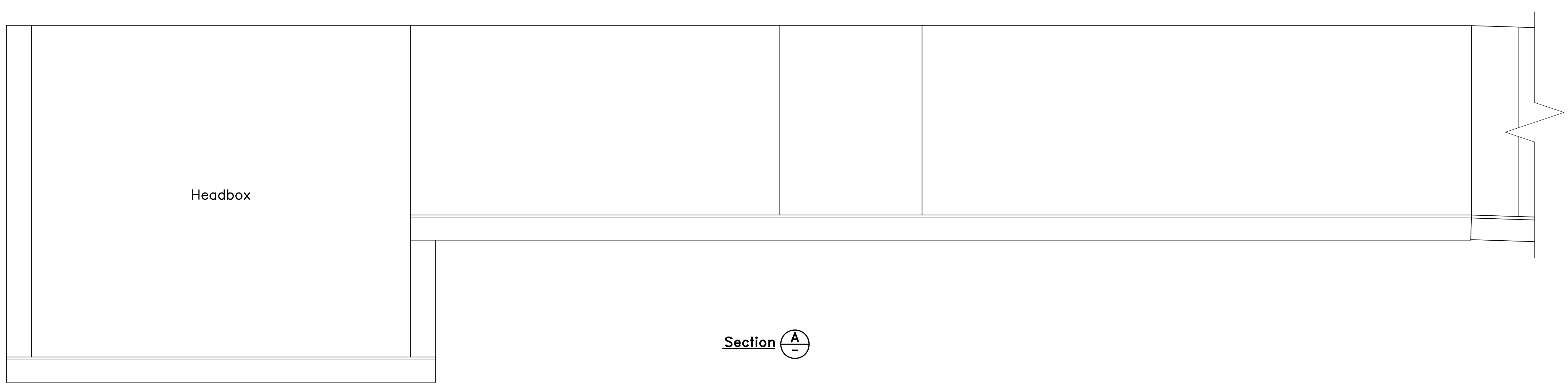
Thank you all for your participation in the model site visit. Let me know if you have any questions.

Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com



Plan View



Section A

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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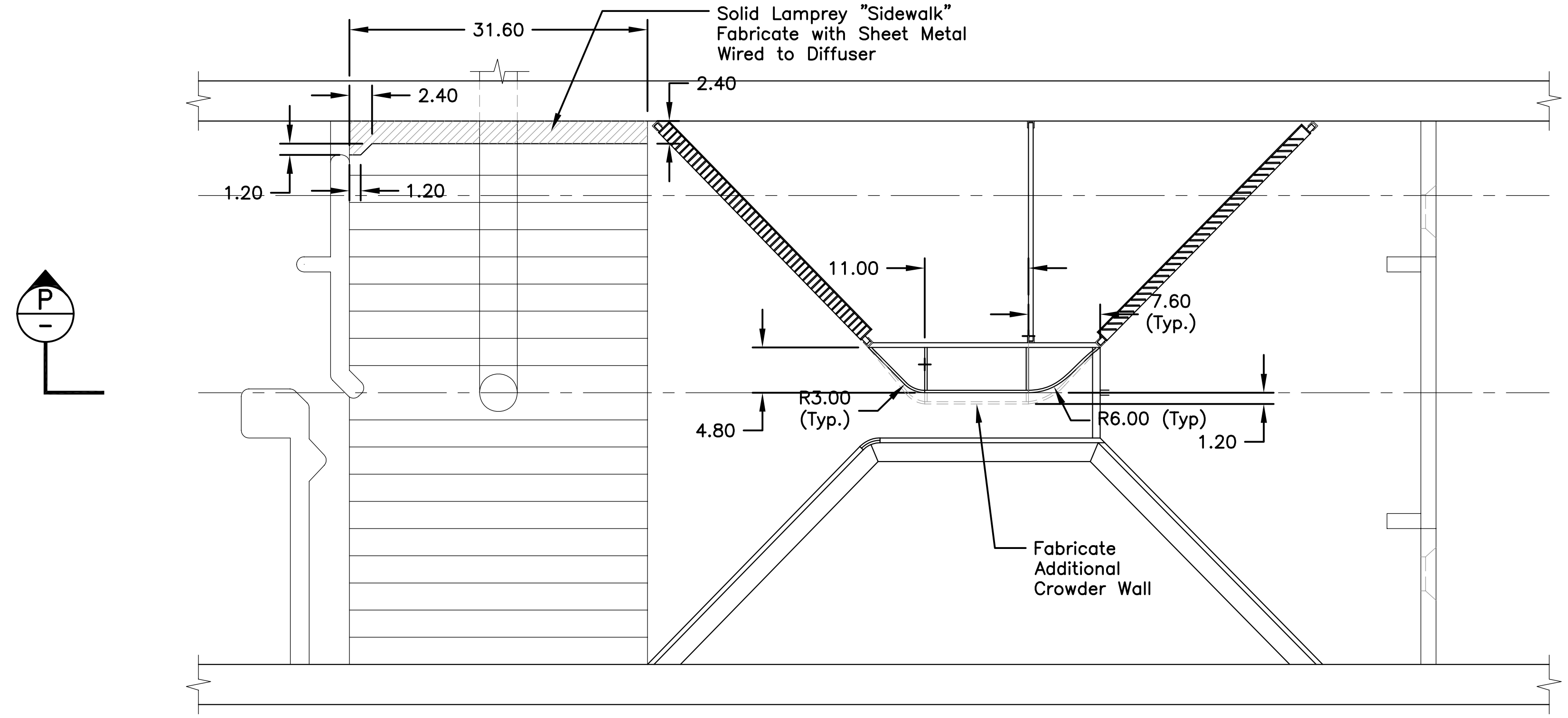
FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

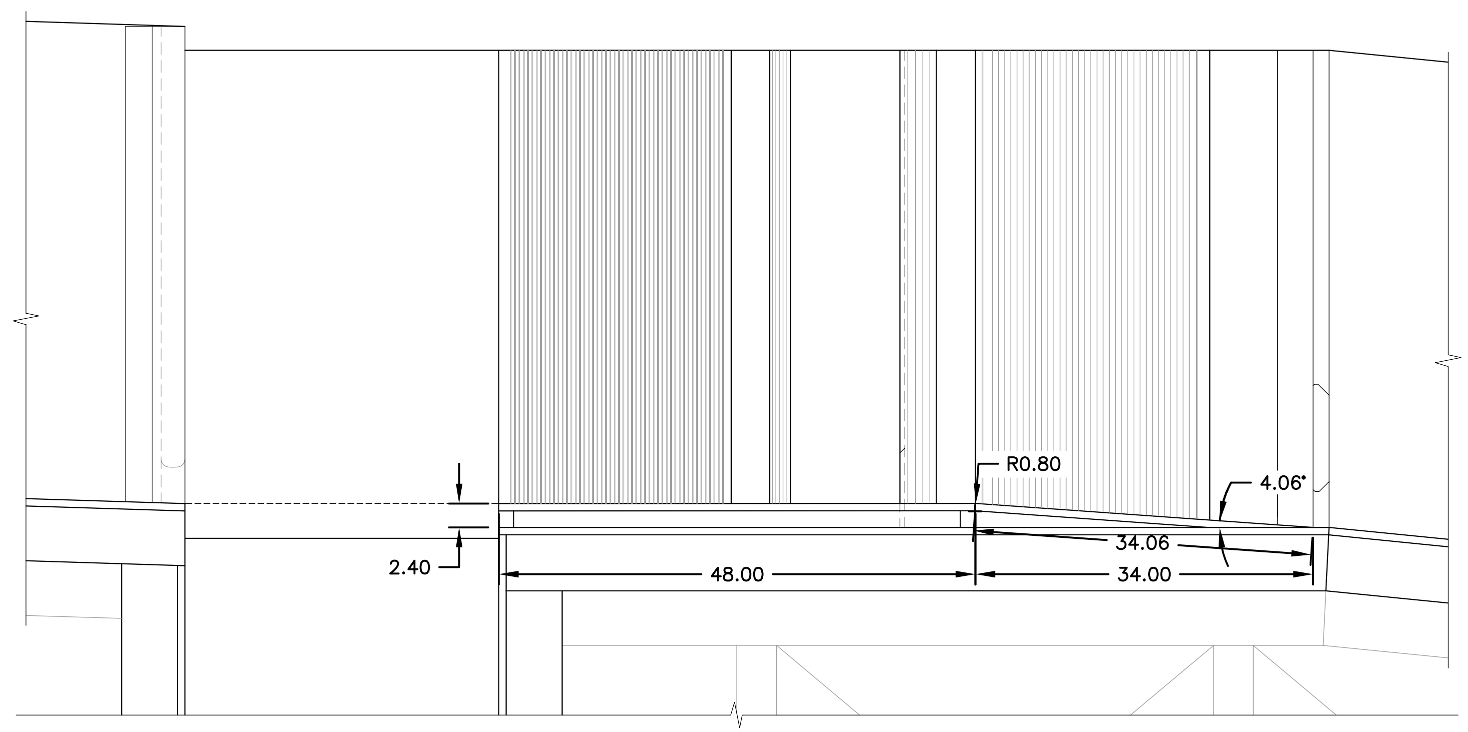
PROJECT NUMBER: 09000-419
DATE: 09/17/07
SCALE: 1:30

FIGURE NUMBER: 3–18

FILENAME: For–Trans–Det–Rev



Plan View



Section P –

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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MODIFIED COUNTING STATION DETAILS – PLAN VIEW

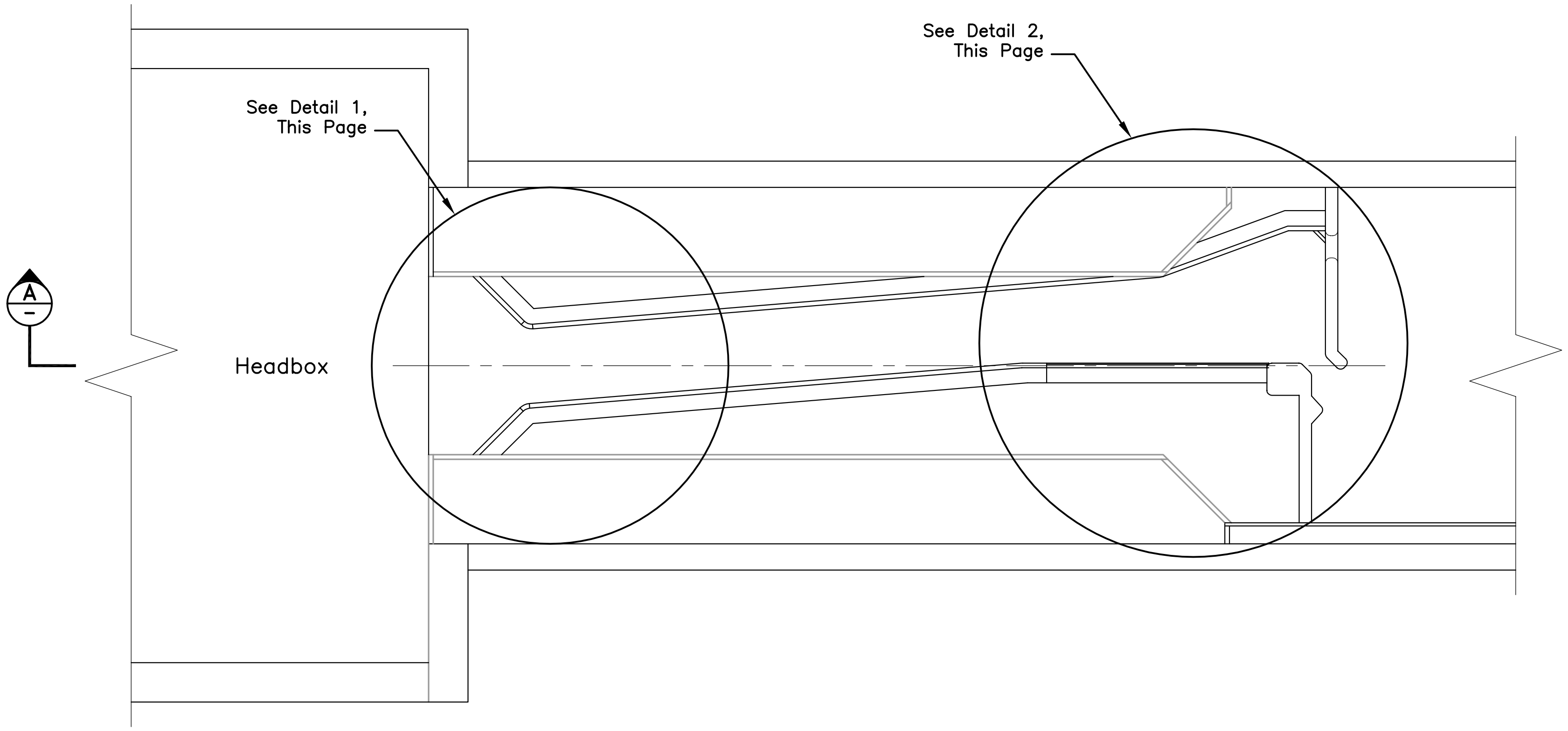
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:20
DATE: 10/08/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: 3-19

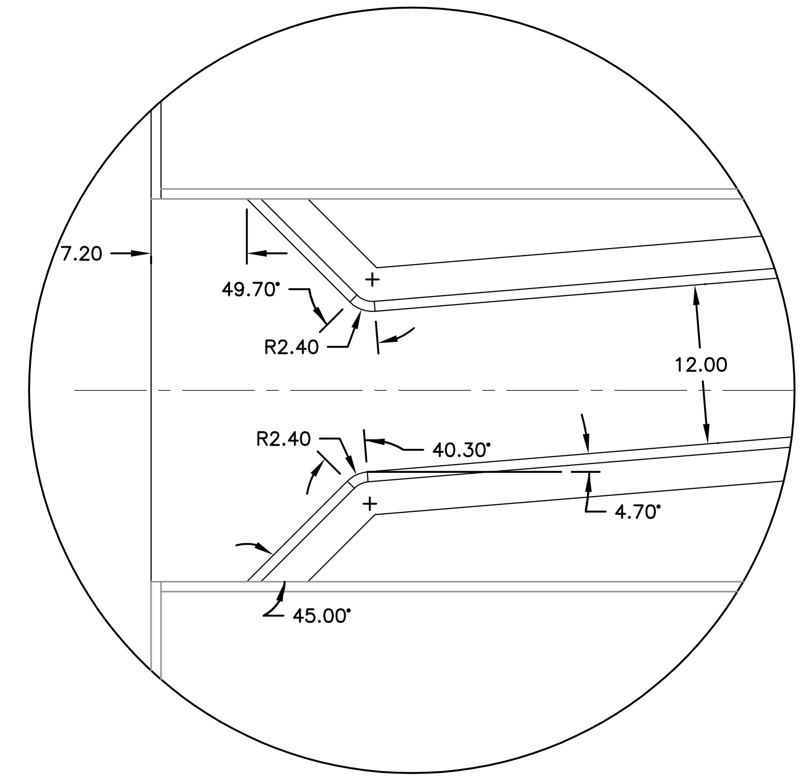
FILENAME: CSta-Mod2

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5



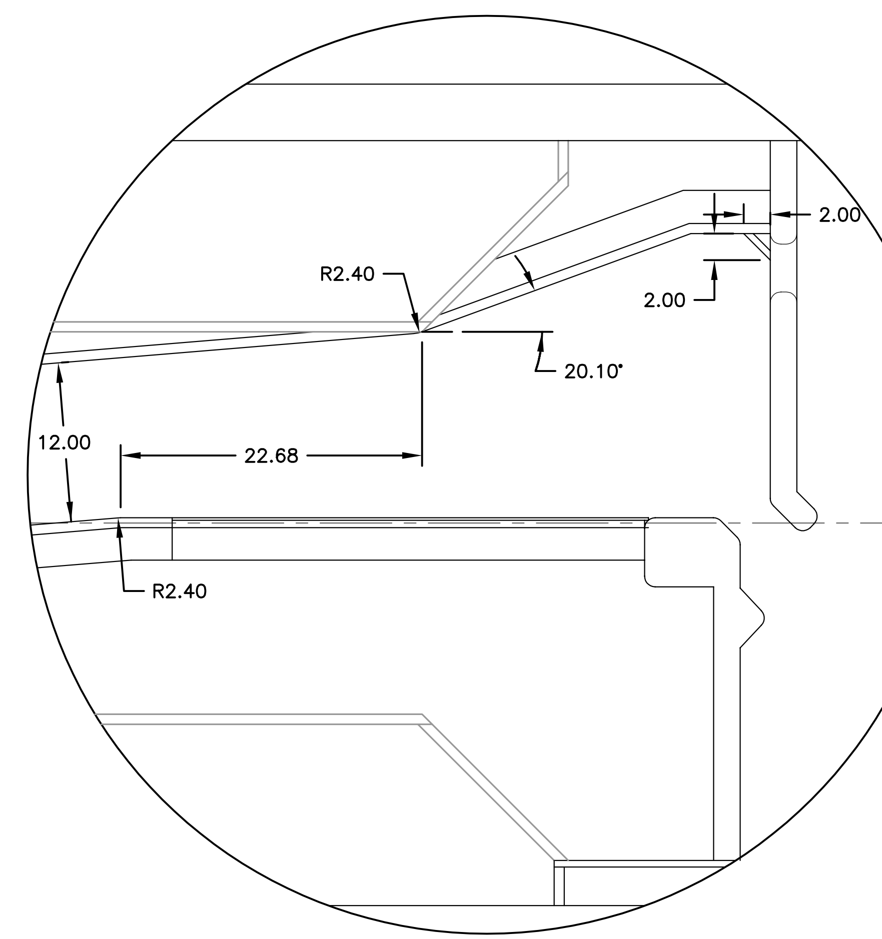
Plan View

Section A



Detail 1 – Plan View at Transition Inlet

(Scale = 1:15)



Detail 2 – Plan View at Weir 23

(Scale = 1:15)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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MODIFIED FOREBAY TRANSITION PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

SCALE: 1:30
DATE: 11/05/07
PROJECT NUMBER: 09000-419

FIGURE NUMBER: X-X

FILENAME: For-Trans-Rev4

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Memorandum

Date: November 18, 2007

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: November 8-9, 2007 Site Visit Meeting Minutes

Distribution:	C. Budai - USACE	T. Adams - USACE	D. Clugston – USACE
	C. Sweeney – ENSR	J. Arnold – ENSR	

ENSR hosted a site visit for USACE Portland District to witness operation of the 1:5 scale JDAN Ladder physical model in our Physical Hydraulic Modeling Laboratory on November 8 through 9, 2007. These meeting minutes summarize the model test conditions observed, the potential modifications developed during the meeting, expectations for the next site visit, and action items resulting from the meeting.

Attendees:

Natalie Richards – USACE

Steve Schlenker – USACE

Justin Arnold - ENSR

Dave Clugston – USACE

Liza Roy – ENSR

Updates to the Physical Model

The following modifications were made to the physical model prior to the site visit and were in place on November 8, 2007.

1. Exit channel to forebay modified with angled transition channel as shown in the first attached model drawing.
2. Weir sills were replaced to start testing at high forebay conditions during the witness test.

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Model Conditions Observed

We observed the following test conditions on with the model updated as described above and the count station crowder at the 18 inch open position. Most of our observations were made in the exit channel upstream of Weir No. 23.

First Test: Max FB 268 ft – High Sills, Q = 85 cfs. With the modified angled exit channel in place, a vortex formed on the left angled wall just below the surface and extended through the slot. We tried placing a triangular splitter (3.5" model scale, on edge) vertically on the angled wall in several locations, but the vortex either formed to one side of the splitter or significant swirling was observed. We constructed a large fillet to streamline the flow from the angled wall to the slot and remove the recirculation area to the left above the orifice. The fillet fills the space above the orifice and streamlines flow to the slot, but extends above the exit from the orifice. The fillet is shown in the second attachment. At this forebay elevation and flow, the fillet provided adequate hydraulic conditions with a blunt bottom at approximately 22" model below the water surface (elevation ~ 258.8 ft). If the fillet was raised higher swirling off the bottom edge of the fillet resulted from the flow splitting between the slot and orifice.

Second Test: FB 266.7 ft – Medium Sills, Q = 85 cfs. We removed the high sills to set the sills for medium forebay range. The large fillet shown in the second attachment was installed at the same elevation as in the first test and hydraulic conditions looked satisfactory. Some swirling was present along the bottom edge of the fillet, but no vortex formed. Flow at the surface expanded along the length of the left wall, curved along the fillet and entered the slot.

Third Test: FB 264 ft – Medium Sills, Q = 65.4 cfs. With the fillet set at the same bottom elevation as the first test (258.8 ft), an intermittent vortex formed just upstream of the bottom edge of the fillet, but did not extend to the slot. We moved the fillet down incrementally and determined that moving the fillet down toward the top of the orifice improved hydraulic conditions considerably. Moving the fillet even with the top of the orifice (~252 ft) streamlined flow into the orifice and the slot, improving the flow split between the two and minimizing the recirculation that was present upstream and above the orifice when the fillet was at higher elevations.

Fourth Test: FB 264.4 ft – Low Sills, Q = 85 cfs. We removed the medium sills to set sills for low forebay range. The fillet was set approximately 2 feet above the orifice and conditions appeared satisfactory upstream of the orifice and slot during this test.

Overnight, after the fourth test, we removed the angled exit channel and installed a modified version of the existing exit channel configuration as shown in the third attached model drawing. This configuration consists of the existing condition with the upstream slotted baffle and stub wall removed, leaving only the downstream slotted baffle and stub wall in place. In addition, we cut an 18" x 18" orifice along the left wall side of the slotted baffle. While changing out the exit channel, we moved the weir triangles on Weirs No. 2 through 18 to the halfway point between the slot and the right wall. The sills were reinstalled for high forebay range. Testing continued on Friday, November 9th as follows.

Fifth Test: Max FB 268 ft – High Sills, Q = 85 cfs. The jet from the slotted baffle passed through the slot, deflected off the stub wall and switched between slight short-circuiting through the slot and hugging the left angled transition wall. The jet condition was somewhat transient. When short-circuiting, the jet deflected off the stub wall, short-circuited through the slot and promoted a counter-clockwise recirculation along the left angled transition wall and some unstable circulating upstream of the orifice at depth. When the transient conditions resulted in the jet hugging the left wall, the flow along the left wall resulted in some swirling along the wall. We added a series of filler pieces to fill the area to the left of the

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angled transition wall and take up dead space, but none of the modifications improved hydraulics. We installed a stub wall halfway between the existing stub wall and the baffle slot to deflect the jet across to the left angled wall and were successful at improving the jet stability and eliminating the transient short-circuiting. The swirling and minor vortex formation along the left wall were eliminated by installing a triangular vortex splitter as shown in the third attached model drawing.

Sixth Test: FB 266.7 ft – Medium Sills, Q = 85 cfs. With the existing stub wall in place, the transient short circuiting was observed as for the fifth test. We moved the stub wall upstream half the distance to the slot as in the fifth test and improved the stability of the jet deflection. The triangular vortex splitter was effective at the same location during this test as in the fifth test.

Since the last site visit, USACE confirmed that Weirs No. 18 through 20 will need to have 18" slots to ensure pool depth criterion is met.

Model Modifications

Based on the observations during the site visit, no major modifications will be made to either exit channel configuration for the final site visit. The following minor modifications to the exit channel will be made, along with changes to Weir No. 18 through 20 slot widths, and other preparation for the final site visit:

- Move triangles on downstream face of right weir baffle (Weirs 2 through 23) to the location specified in Jim Calnon's sketch to accommodate the sill gate flaps.

- In the exit channel section, fix the stub wall halfway between the existing stub wall location and the slotted baffle wall as shown in the third attached model drawing. If material thickness permits, round the stub by routering. Install the vortex splitting triangle we developed on the left angled wall after routering the downstream point of the triangle to round.

- Make an acrylic version of the wooden fillet we developed during the witness test as shown in the second attached model drawing. The replacement needs to have vertical adjustability to bring the bottom of the fillet from even with the orifice to about 3' prototype above the orifice during the witness test and should be mountable.

- Weir slots: Weirs 18, 19, 20 need to have the left baffle removed, noses removed, noses cut down to make the slots 18" wide, noses reattached, left baffles reinstalled,

- Fabricate and install 3 new sill sets for weirs 18-20 to accommodate the wider slot with a 3" wide l-shape on the mid-range sill.

- Reinstall all sills prior to the witness test.

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Final Site Visit

The final site visit is scheduled for November 19 and 20, 2007. ENSR will send out a draft agenda for the site visit. We assume the model will be configured in the modified existing exit channel configuration shown in the third attached model drawing unless we hear from USACE by Wednesday, November 14, 2007 by the end of the day to give us adequate time to reinstall the angled channel.

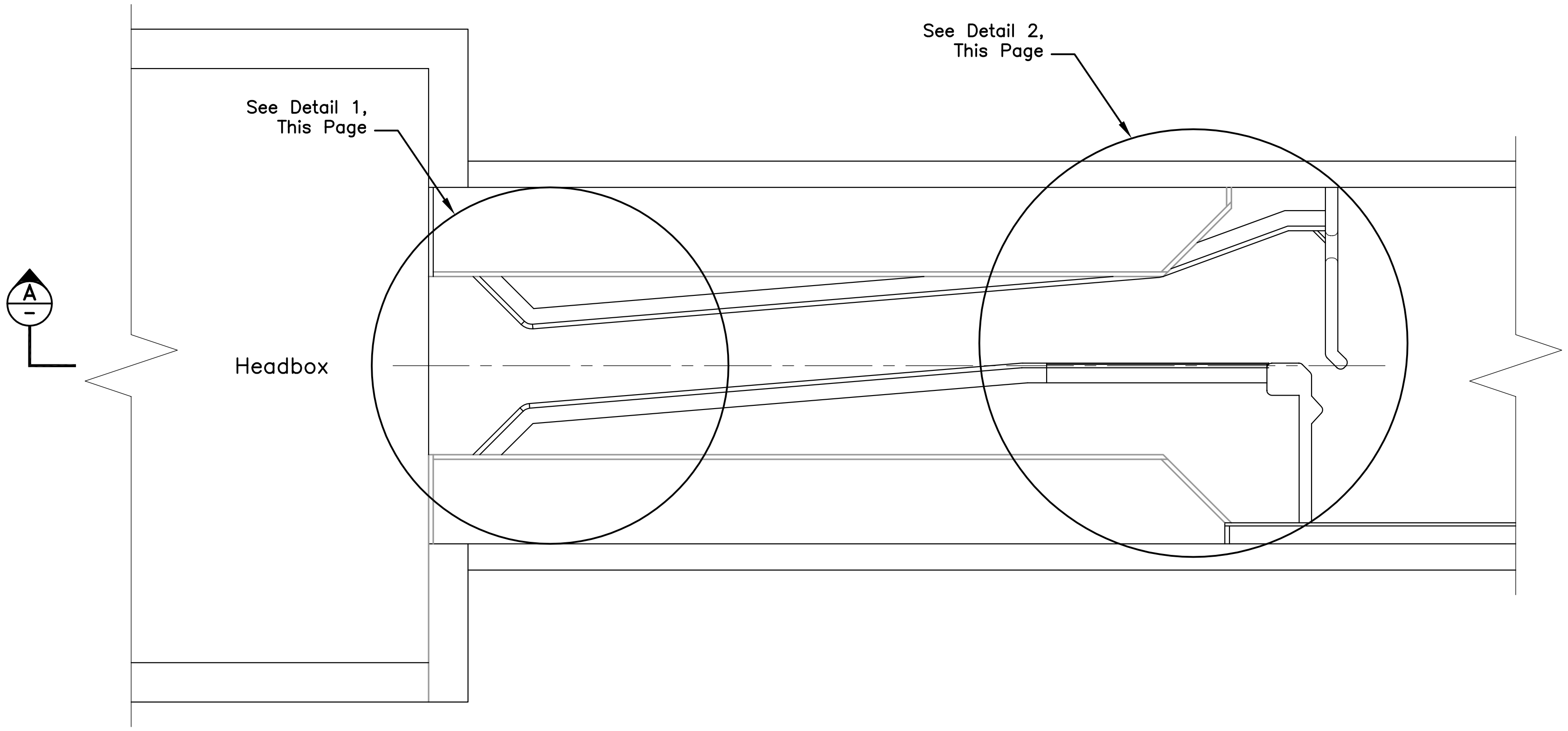
Action Items

ENSR and USACE will work on contracting for model construction labor units for the modifications.

Thank you all for your participation in the model site visit. Let me know if you have any questions.

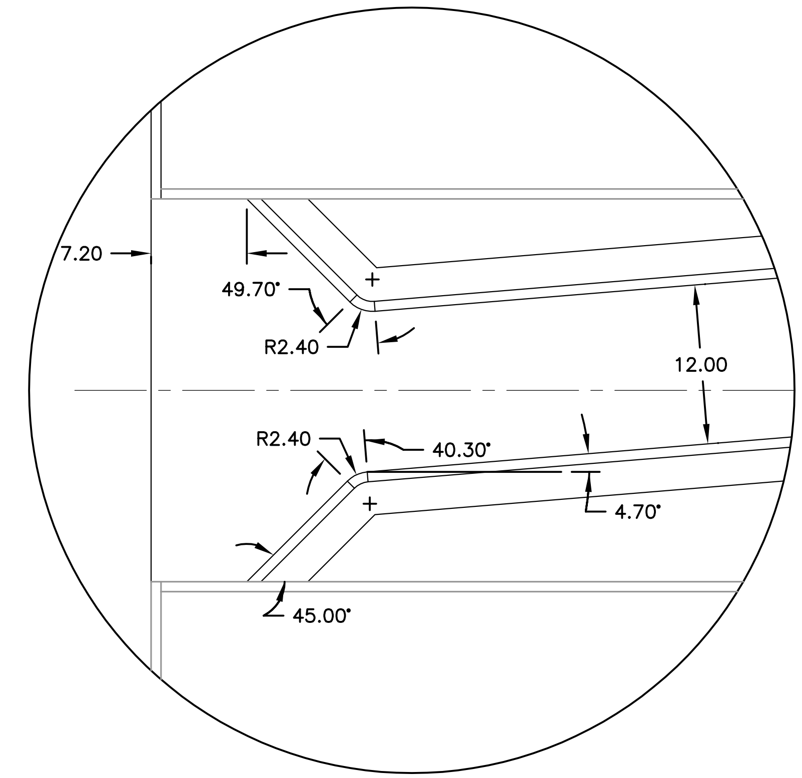
Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com

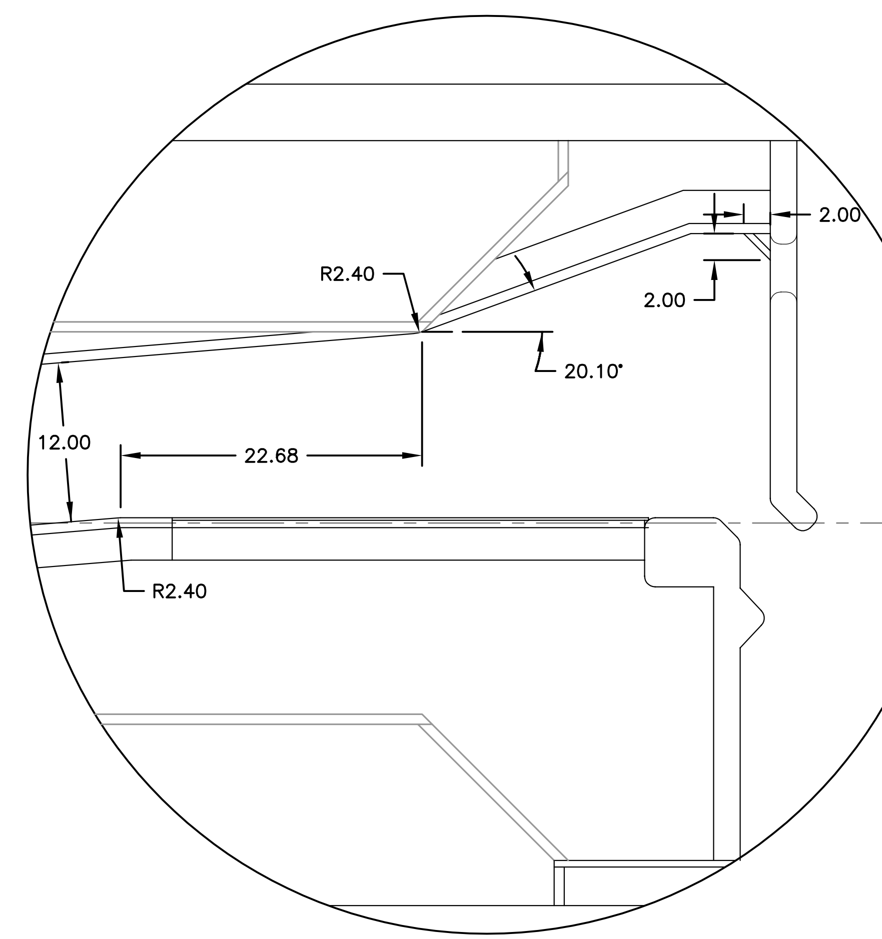


Plan View

Section A



Detail 1 – Plan View at Transition Inlet
(Scale = 1:15)



Detail 2 – Plan View at Weir 23
(Scale = 1:15)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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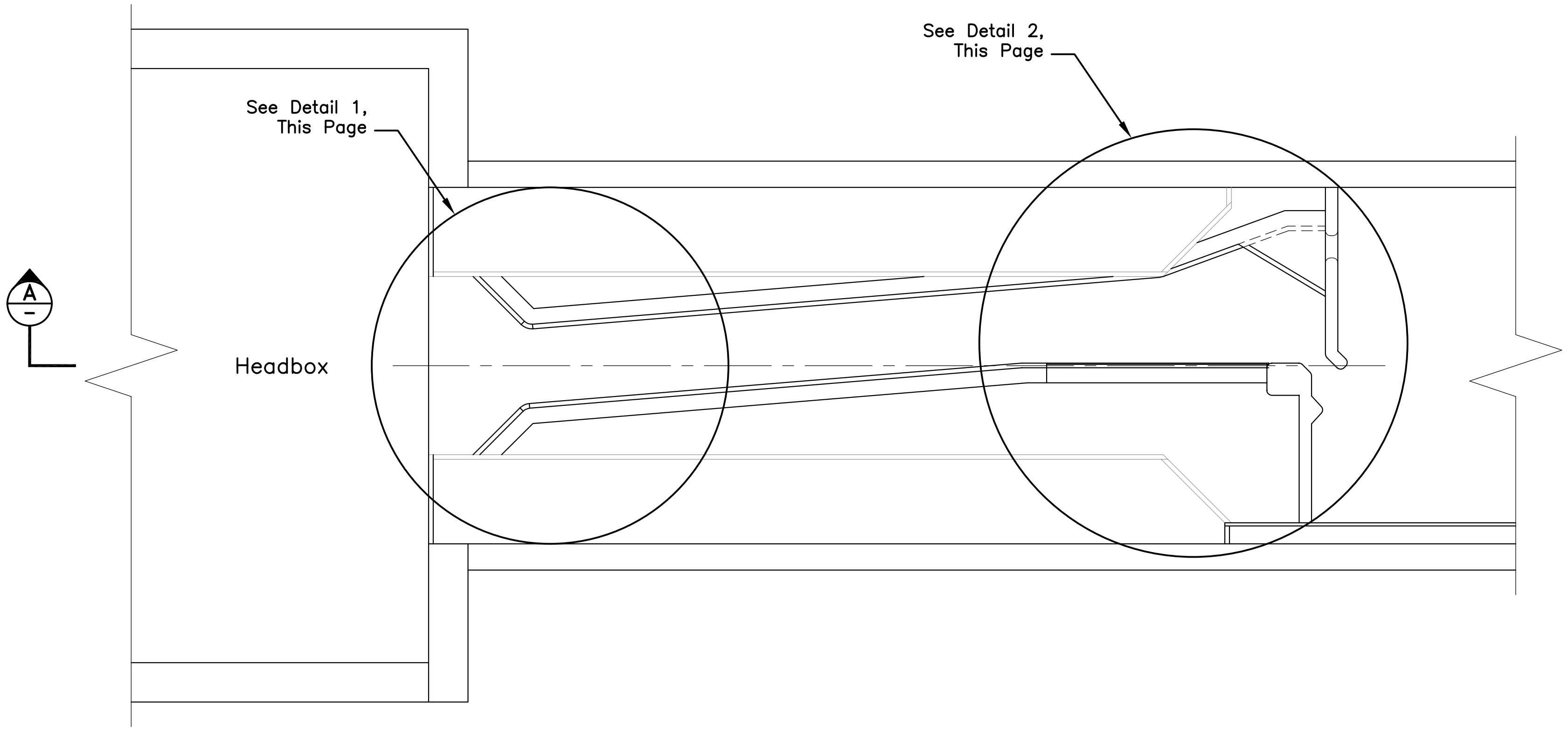
MODIFIED FOREBAY TRANSITION PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

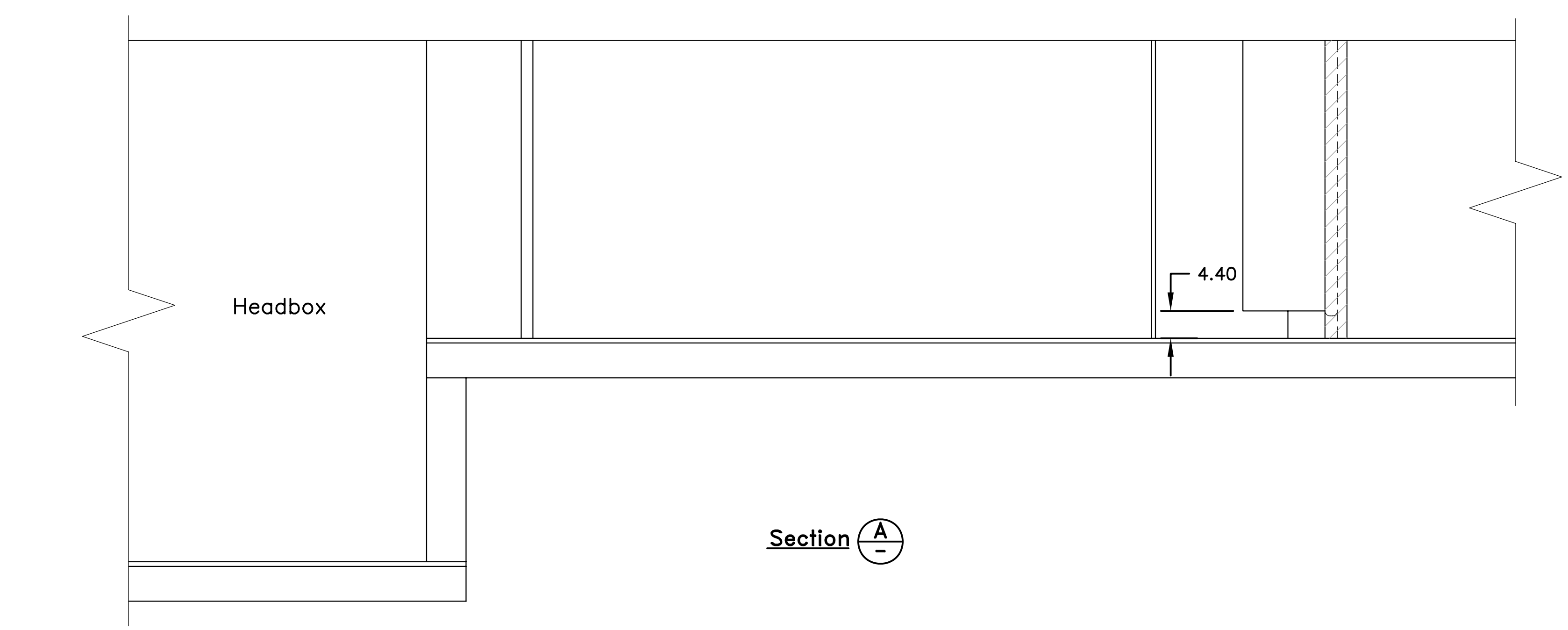
PROJECT NUMBER: 09000-419
DATE: 11/05/07
SCALE: 1:30

FIGURE NUMBER: X–X

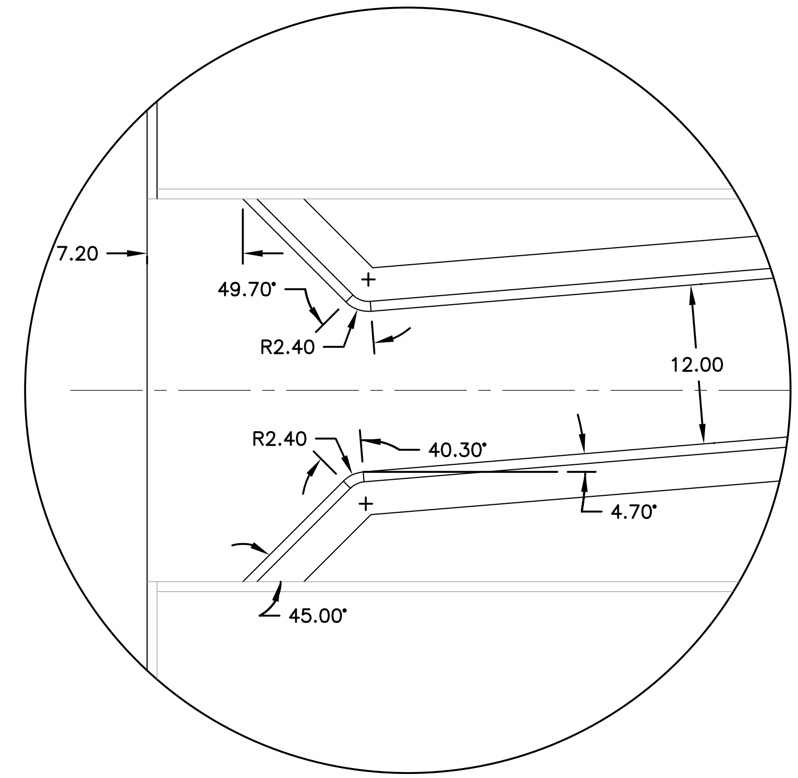
FILENAME: For–Trans–Rev4



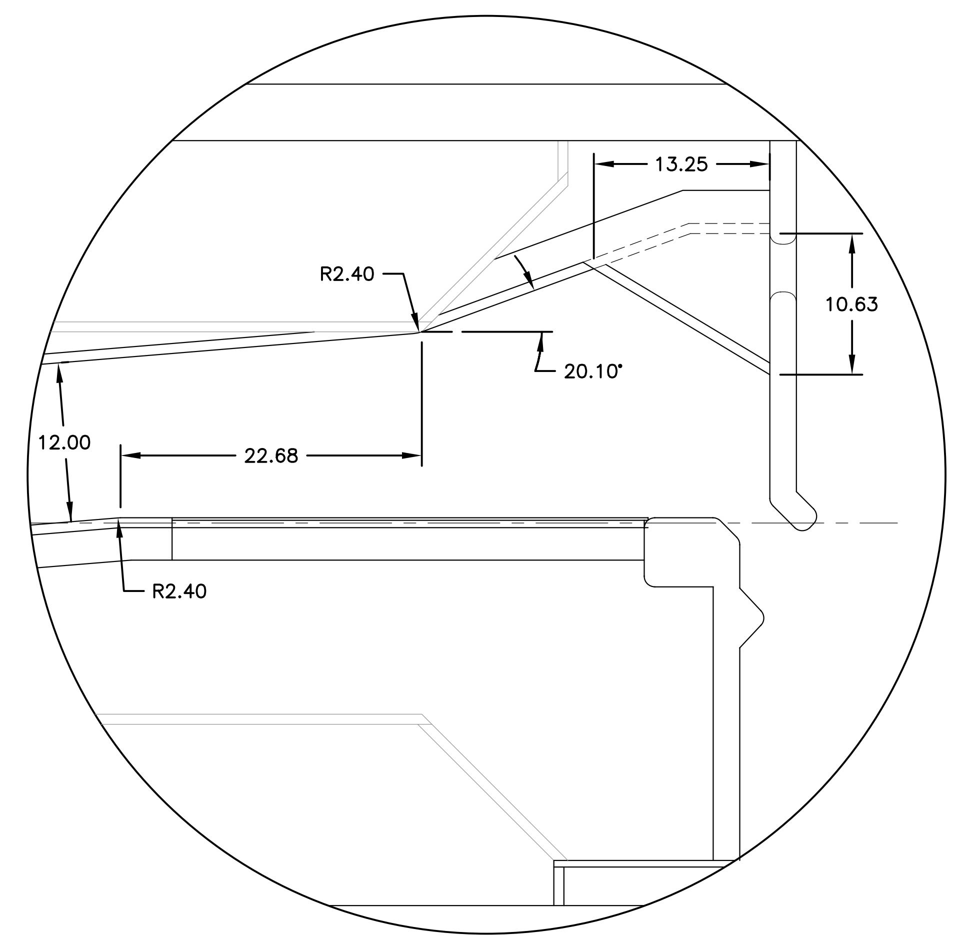
Plan View



Section A



Detail 1 – Plan View at Transition Inlet
(Scale = 1:15)



Detail 2 – Plan View at Weir 23
(Scale = 1:15)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS		
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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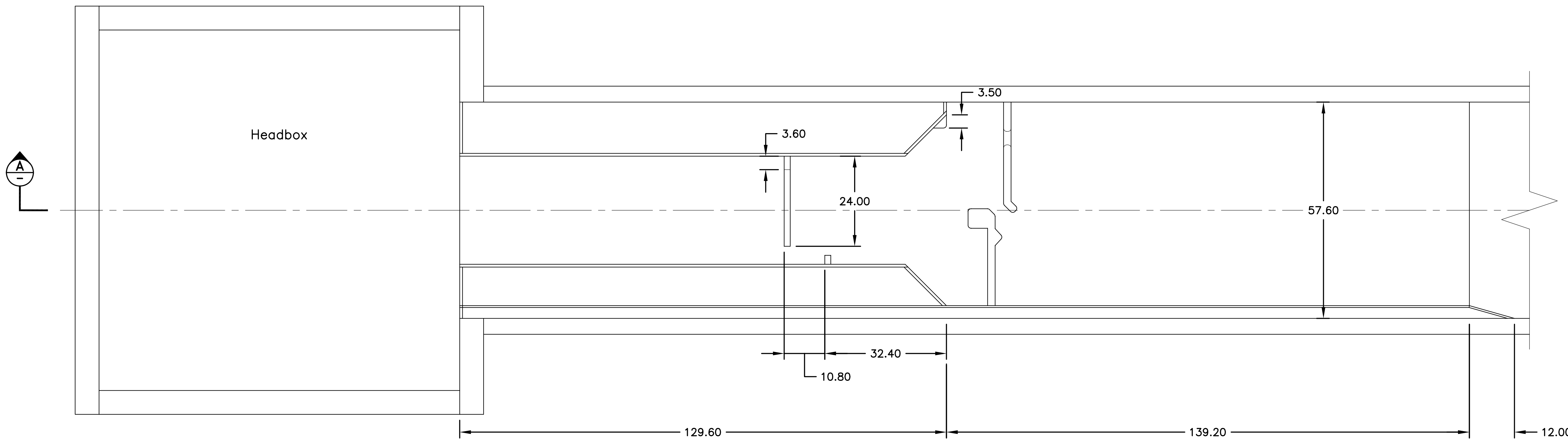
MODIFIED FOREBAY TRANSITION PLAN AND SECTION

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

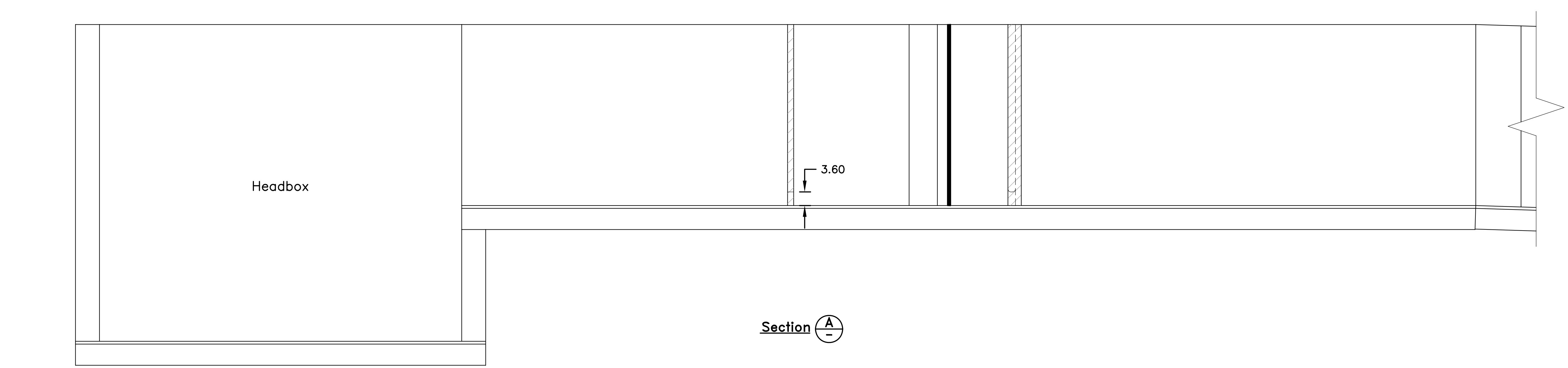
PROJECT NUMBER: 09000-419
DATE: 11/13/07
SCALE: 1:30

FIGURE NUMBER: X-X

FILENAME: For-Trans-Rev5



Plan View



Section A

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS

NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

PROJECT NUMBER: 09000-419
DATE: 11/13/07
SCALE: 1:30

FIGURE NUMBER: X–X

FILENAME: For–Trans–Rev6

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Memorandum

Date: February 22, 2008

To: Natalie Richards, Steve Schlenker – USACE Portland District

From: Liza Roy – ENSR

Subject: November 19-20, 2007 Site Visit Meeting Minutes

Distribution: C. Budai - USACE; T. Adams - USACE; D. Clugston – USACE; C. Sweeney – ENSR; J. Arnold – ENSR

ENSR hosted a site visit for USACE Portland District and Agency personnel to witness operation of the 1:5 scale JDAN Ladder physical model in our Physical Hydraulic Modeling Laboratory on November 19 through 20, 2007. These meeting minutes summarize the model test conditions observed, the potential modifications developed during the meeting, and action items resulting from the meeting.

Attendees:

Natalie Richards – USACE

Steve Schlenker – USACE

Jim Calnon – USACE

Travis Adams – USACE

Dave Clugston - USACE

Gary Fredericks – NOAA Fisheries

Ed Meyer – NOAA Fisheries

Liza Roy – ENSR

Justin Arnold – ENSR

Updates to the Physical Model

1. Orifice on Weirs No. 2 through 23 were moved away from wall to JDAS location. Weir No. 1 orifice remained at the left wall.
2. Two modifications for the exit channel to the forebay were developed in the physical model:

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a. See First Attachment for model drawing of the modified existing exit channel to forebay. We removed the upstream slotted baffle and stub wall from the existing exit channel and left the downstream slotted baffle and stub wall in place. An 18” by 18” orifice was cut in the slotted baffle at the left wall. Through testing in the model, we moved the stub wall closer to the baffle slot by half the existing distance to train the jet from the slot towards the left angled wall and improve jet stability and hydraulics upstream of the orifice. In addition, we added a triangular structure to the left angled wall to prevent vortex formation on the left wall into the slot.

b. See Second Attachment for model drawing of a new configuration for the exit channel to forebay. We developed an angled channel from the existing trashrack to the expansion just upstream of Weir No. 23 with a 5 foot width to increase channel velocities. The right wall extends to the right baffle block to train flow to the slot. The left wall tapers to the left of the orifice. A large fillet extending down to the upper edge of the orifice trains the surface flow to the slot, prevents formation of a vortex on the left angled wall, and provides streamlined flow into the orifice. This alternative was not viewed during the witness test, as the first alternative was considered favorable.

3. Count Station

   a. Raised floor of count station by 1 foot to eliminate the crowder ramp and sloped diffuser

   b. Added a solid lamprey “sidewalk” over the diffuser (12” wide to 18” wide at the orifice opening in Weir No. 1)

   c. Reduced the crowder length to 4’ 7” per correction from USACE Portland District

   d. Designed and installed fairings for the upstream and downstream side of the crowder for 24” and 18” opening positions

4. Weir triangles (on the downstream face of the right weir baffle) were moved to a new position to accommodate the sill gate flaps per direction from USACE Portland District.

5. Weirs No. 18, 19, 20 slots have been widened to 18”.

Test Conditions Demonstrated and Significant Observations

Monday, November 19, 2007:

The model was configured as described above, with the following exceptions:

- Count station crowder at 18” open

- Exit channel to forebay was demonstrated in the modified existing configuration as shown in the First Attachment with the single slotted baffle and stub wall.

Test 1:

FB 268’, high sills, Q = 85 cfs (FB at 268.5’ in model)

We observed dye in the exit channel to the forebay and hydraulic conditions appeared satisfactory.

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We observed dye in the count station and noticed some swirling through the crowder. The swirling was caused by flow from the Weir No. 1 slot jet impacting the crowder fairing and rolling. The bulkhead knife gate was initially set at 8" open. We raised knife gate by 4", then lowered it to about 4" open; both seemed to improve the swirling slightly but did not eliminate the tendency.

Test 2:

FB 265.2', high sills, Q = 61.2 cfs

Pools 1 through 9 exhibited some short-circuiting. These are the pools with no sills. Pools upstream of 14, 15, and 16 were a little sloshy on the right wall (about 1" +/-).

We observed dye in the exit channel and hydraulics looked good, with no apparent concerns.

We observed dye in Pool 8. Moving the orifice away from the wall helped with slowing velocities down from orifice to orifice.

At the crowder we looked at a range of knife gate openings again to assess the impact on swirling through the crowder: 4" open, less swirling than Test 1; 8" open, slightly less swirling; 12" open looked even better. It was difficult to say which looked best, but we realized there is adjustability and that it may be best left to operators.

Test 3:

FB 266.7', medium sills, Q = 85 cfs (FB at 267.4' in model)

The exit channel to the forebay looked good. The pools were short-circuiting downstream of Weir No. 10, Ed noted that hydraulics looked better with sills and asked if we could put 1' sills all the way down to weir No. 1. These 1' sills were discussed further during the afternoon and Steve conducted a preliminary check on the flows with the 1' sills in place with the USACE spreadsheet model. The 1' sills were installed for testing on the second day.

Test 4:

FB 264.8', medium sills Q = 65.4 cfs

The exit channel to the forebay looked good. The pools downstream of Weir No. 10 were short-circuiting. We looked at dye in the count station with 12" open and 8" open knife gate and discussed options for a flow vane in the crowder or count station.

Test 5:

FB 262.5' (MIP), medium sills, Q = 54 cfs

We observed dye in the count station for the 8" knife gate opening and discussed options for a flow vane to straighten flow in the crowder.

Tuesday, November 20, 2007:

Test 1:

FB 268.1', high sills with 3" sills in Weirs No. 1-9, Q ~ 81 cfs

The 3" sills didn't have much effect on the short-circuiting in Weirs No. 1 through 9. The 3" sills were installed in error overnight and were corrected to 1' sills during the morning.

Test 1 (repeat):

FB 268.1', high sills with 1' sills in Weirs No. 1-9, Q ~ 81 cfs

All pools have good jet circulation with no short-circuiting. The count station jet from Weir No. 1 looked better with sill at Weir No. 1, but still has swirling through the crowder. We tried installing a plywood

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baffle upstream of the right wall of the crowder and in line with the crowder wall to make the crowder symmetrical, but it didn't work very well. A second baffle iteration was twice as long and worked reasonably well to split flow to crowder and rack, but still resulted in some rotation through the crowder.

Test 2:

FB 262.5' (MIP), medium sills with 1' sills in Weirs No. 1-9, Q = 52.6 cfs

All pools had good jet circulation, with no short-circuiting. In the count station crowder we added a series of horizontal baffles to the face of the upstream fairing to limit swirling (4 baffles, adjustable, about the width of the straight section of fairing). All agreed the goal was to keep them out of the flow path even with the crowder edge. A min 18" spacing in the vertical was recommended for further development. We decided we would do further refinement on these flow vanes after the meeting.

Test 3:

FB 262.5' (MIP), all weirs with 1' sills, Q = 67 cfs, (FB at 262.4' in model)

Pools from Weirs No. 1-12 looked good, with no short-circuiting. Upstream of Weir No. 12 the pools were slightly short-circuiting, but these are low head pools.

Test 4:

FB 257' (MOP), all weirs with 1' sills, Q = 32.5 cfs

Upstream of Weir No. 17 the pools were short-circuiting, but this was a low-energy condition.

Test 5:

FB 257' (MOP), no sills, Q = 36 cfs

Minor short-circuiting was observed in most of the exit section pools, but this was a low-energy condition.

Test 6:

FB 262.5' (MIP), no sills, Q = 73.5 cfs

Some short-circuiting was observed in most of the exit section pools, but the conditions were stable and consistent along the exit section. It was noted that during the documentation testing we will likely test for MIP forebay elevation rather than 264.0'.

Further Testing

We discussed conducting a set of modification tests to document the operating range for the latest sill settings as follows:

- No sills

  FB 257' Q = ? Find flow

  FB ? Q = 85 cfs Find forebay elevation in the model

- 1' sills

  FB 257' Q = ? Find flow

  FB ? Q = 85 cfs Find Forebay elevation in the model

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- High sills

  FB 261' Q = ? from Steve

  FB ? Q = 85 cfs Find forebay elevation in the model

Based on the results of the modification water level tests, we may be able to eliminate the medium sills and replace them with the 1' sills, leaving only three sill settings (no sills, 1' sills, and high sills) for the full forebay operating range. Steve will provide estimated flow rates for the forebay conditions above as a target for the tests outlined above and ENSR will finalize the testing program with USACE.

ENSR will also conduct modification tests to optimize the crowder baffle/flow vanes at FB 264.4 – no sills, Q = 85 cfs. Then we will put a couple 1' sills in place in the lower weirs to double check performance of the flow vane with the 1' sills installed. The goals of the flow vane modification are to minimize swirling in the crowder, minimize the extension of the vanes into the downstream flow path, incorporate rounded edges, and keep the vanes at a minimum of 18" spacing if possible to minimize the potential for injury to fish.

Following these modifications, ENSR will complete the documentation testing on the final design. Thank you all for your participation in the model site visit. Let me know if you have any questions.

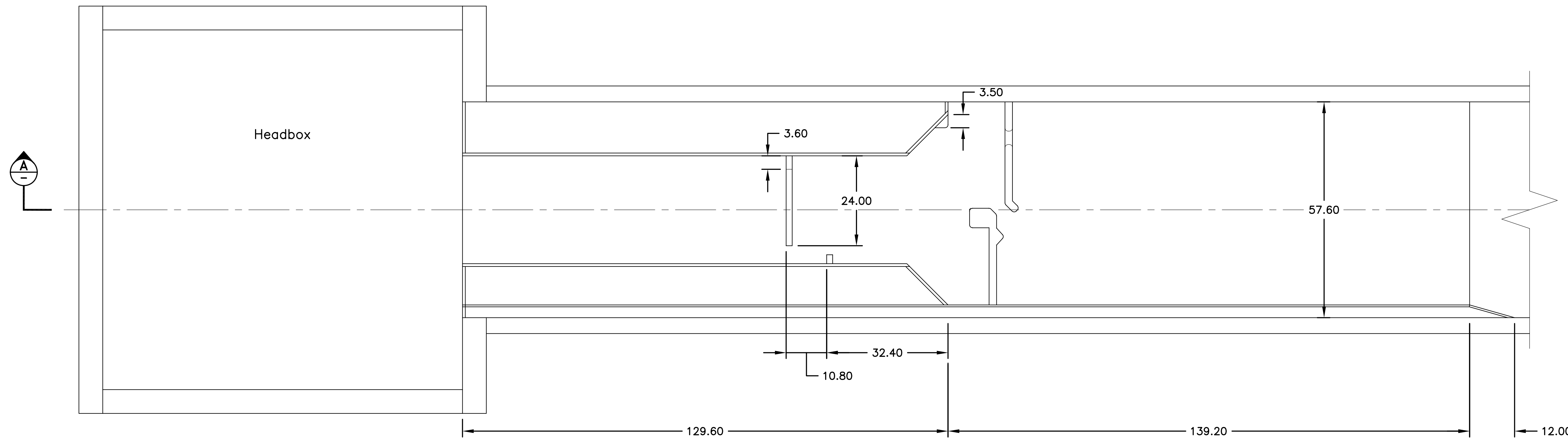
Sincerely yours,

Elizabeth W. Roy, P.E.
Senior Project Manager
lroy@ensr.aecom.com

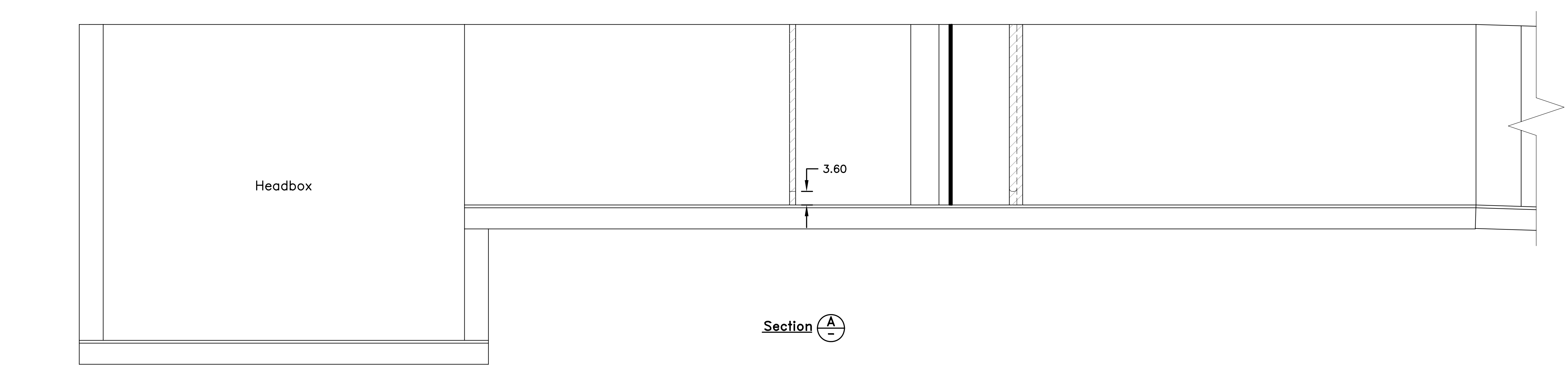
Attachments:

Modified Existing Exit Channel to Forebay

Angled Exit Channel to Forebay Modification



Plan View



Section A

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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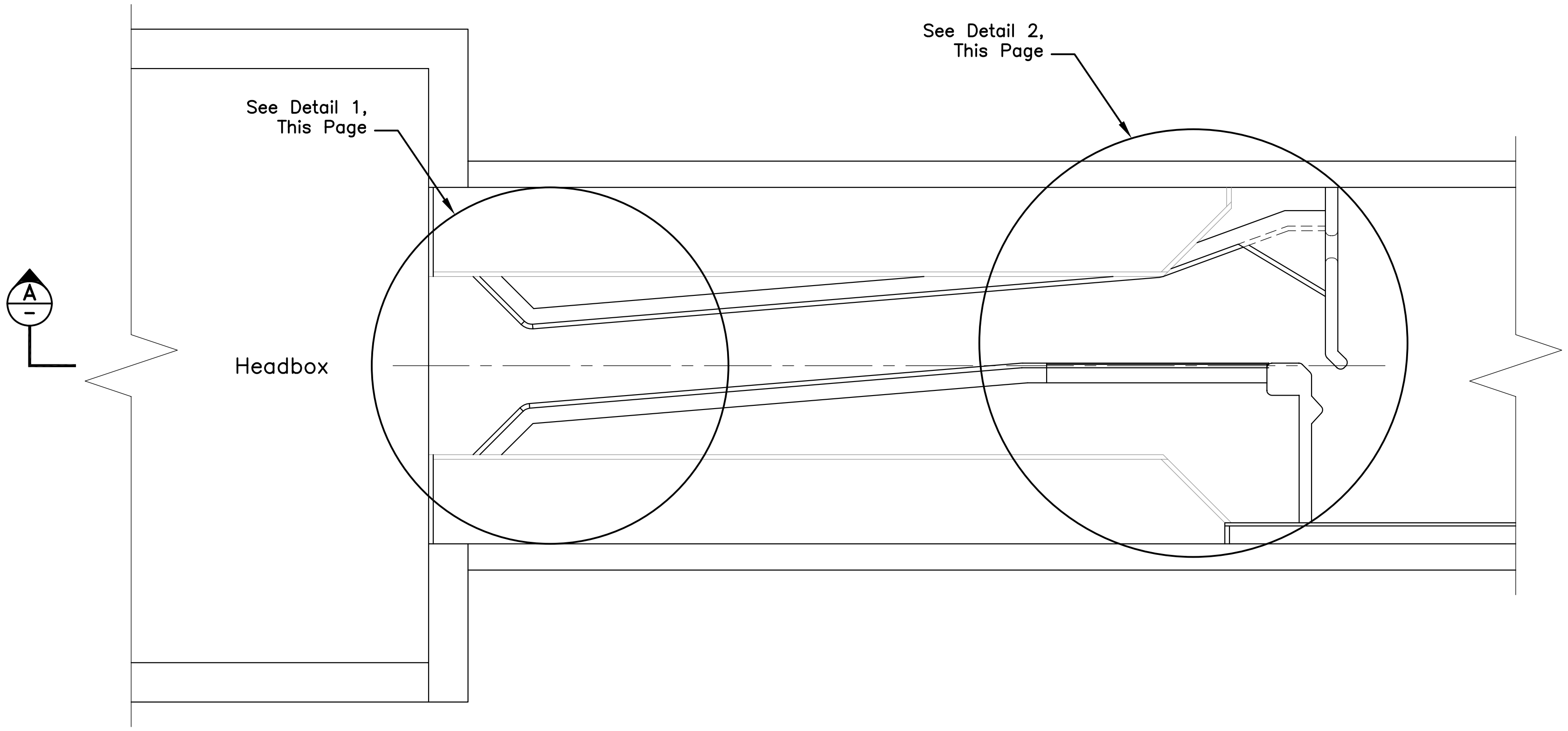
FOREBAY/TRANSITION DETAILS

John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

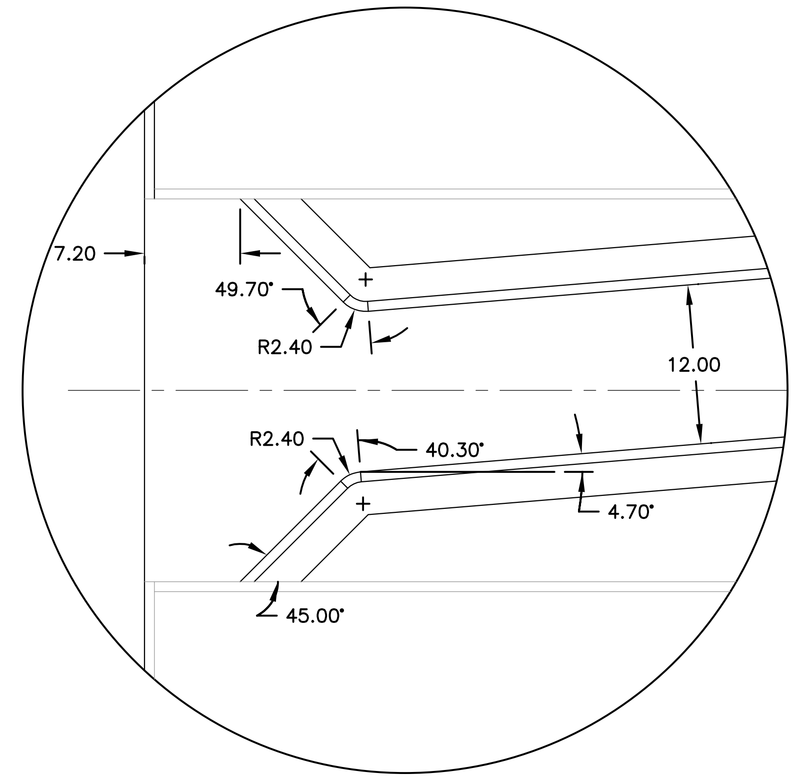
PROJECT NUMBER: 09000-419
DATE: 11/13/07
SCALE: 1:30

FIGURE NUMBER: X-X

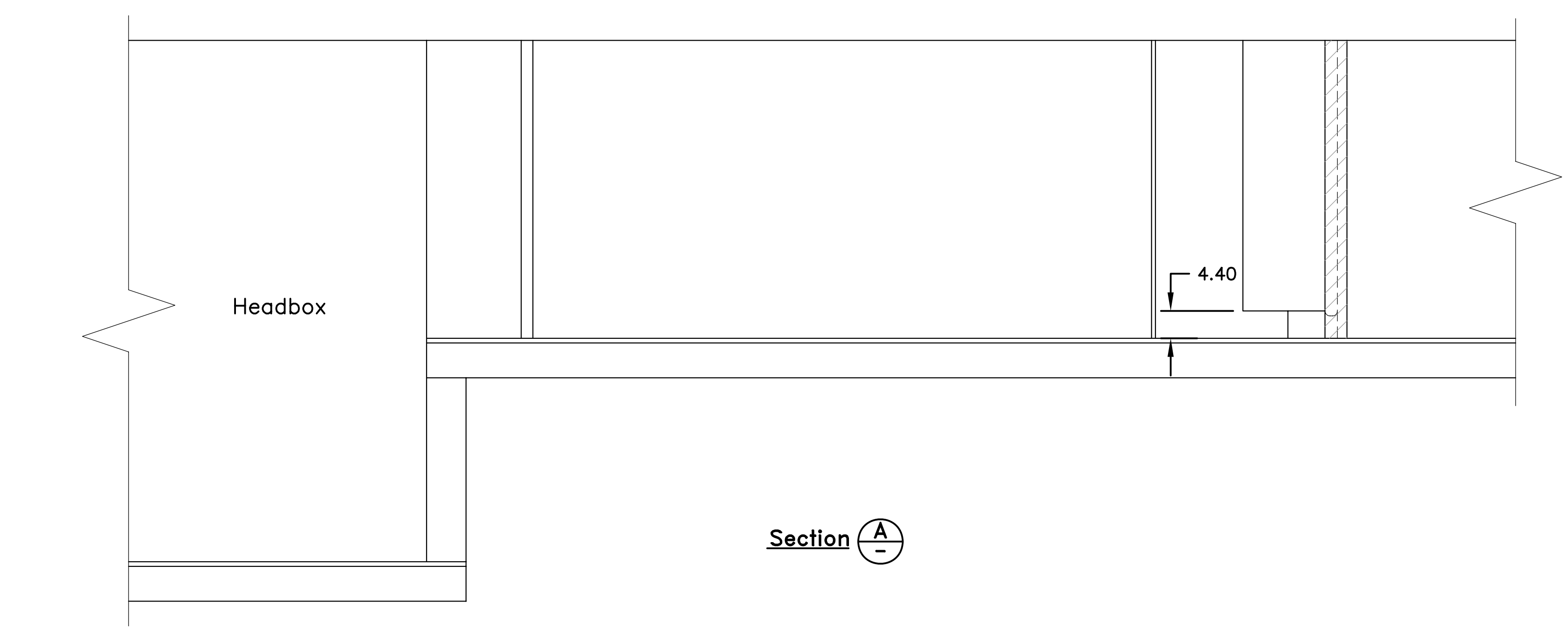
FILENAME: For-Trans-Rev6



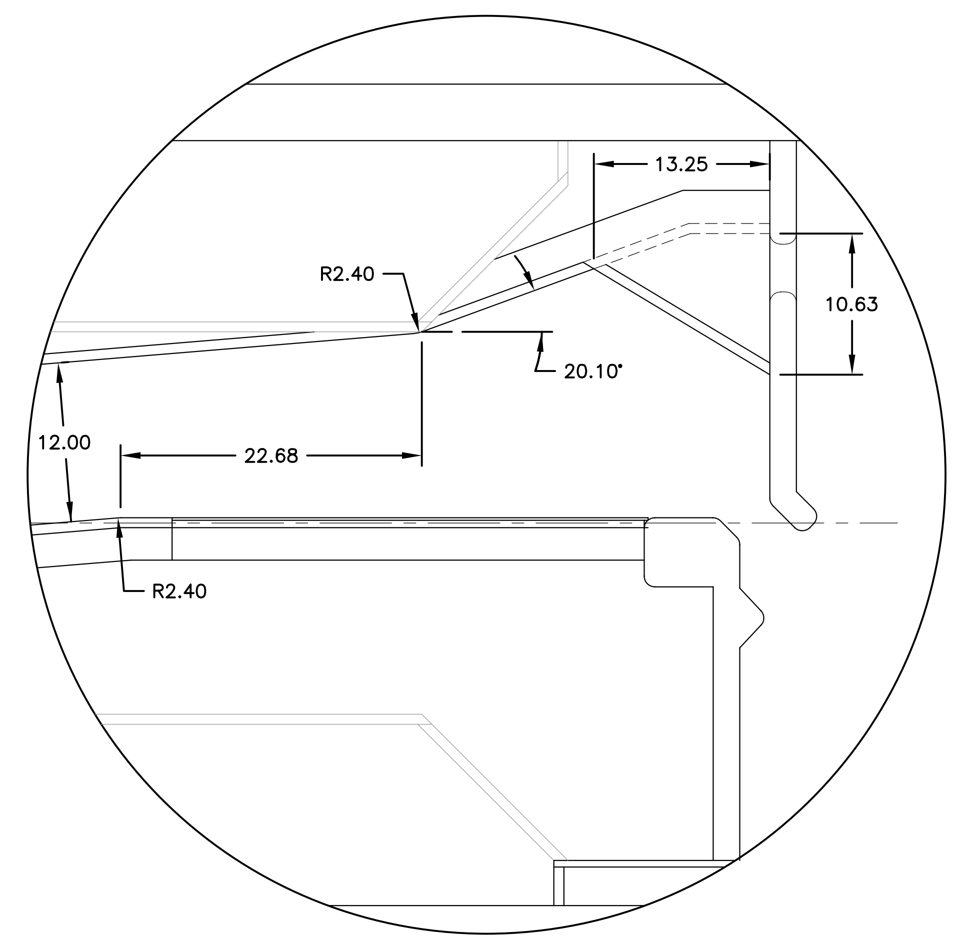
Plan View



Detail 1 – Plan View at Transition Inlet
(Scale = 1:15)



Section A



Detail 2 – Plan View at Weir 23
(Scale = 1:15)

Notes:
1) Dimensions given in model inches
2) Model to prototype scale = 1:5
3) Weirs not shown for clarity

REVISIONS			
NO:	DESCRIPTION:	DATE:	BY:

DESIGNED BY: JA
DRAWN BY: KM/JA
CHECKED BY: LR
APPROVED BY: CS

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MODIFIED FOREBAY TRANSITION
PLAN AND SECTION
John Day North Fish Ladder
U.S. Army Corps of Engineers – Portland District
Portland, Oregon

PROJECT NUMBER: 09000-419
DATE: 11/13/07
SCALE: 1:30

FIGURE NUMBER:
X–X

FILENAME:
For–Trans–Rev5

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Memorandum

Date: December 11, 2007

To: Natalie Richards, Steve Schlenker

From: Liza Roy

Subject: JDAN Ladder Crowder Flow Vane Update

Distribution: Justin Arnold – ENSR

This memo summarizes the modifications we studied in the JDAN ladder model to eliminate the overall swirling observed in the crowder during the site visit on November 19-20, 2007. During the witness test we installed a series of 4 horizontal flow vanes on the face of the upstream crowder faring to attempt to eliminate the vertical flow on the faring that set up swirl through the crowder. Of the following modifications, Modification 6 proved to be the most promising at reducing the overall swirl in the crowder while keeping the "footprint" of the vanes out of the downstream flow path to the crowder to prevent fish injury.

All Flow Vane Mod Tests performed under the following conditions:

Q_{TOTAL} = 85cfs

$Q_{DIFFUSER}$ = 0 cfs

Knife gate open to 8" (model)

24" (proto) crowder opening

1' (proto) sills installed in weirs 1-4, except for Mod 1

Mod 1 (Photos 4 – 8)

Four flow vanes at 15" spacing. 15"x27½ " vanes with rounded D/S nose.

- Generally effective to diffuse strong downwelling on fairing.
- Strong flow compartmentalization on upper vanes

Mod 2 (Photos 9 – 12)

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Four flow vanes at 15” spacing. 8”x27½ “ vanes with sharp tapered D/S nose.

- Same general results as with Mod 1.
- No major upwelling or downwelling on fairing. Only local compartmentalization between each vane
- Slight upwelling tendency in lower vane
- Swirl generated between each vane persists throughout crowder (true of all mods)

Mod 3 (Photos 13 – 16)

Use Mod 2 vanes, but with all rounded edges. Install at a spacing of 18”.

- Vanes still effective for upper two chambers
- For bottom chambers, slight upwelling around D/S nose

Mod 4 (Photos 17 – 21)

Four flow vanes at 15” spacing. 12”x27½ “ vanes with rounded D/S nose and edges.

- No substantial improvement over Mod 2
- Swirl from each chamber persists through crowder

Mod 5 (Photos 22 – 26)

Use vanes from Mod 4. Four flow vanes. 15” spacing for top 3, bottom vane 11¼ “ from crowder floor.

- “Chamber sized” swirl still persist through crowder. Especially in lower two chambers

Mod 6 (Photos 27 – 31)

Four flow vanes at 15” spacing. Use vanes from Mod 2, except rounded D/S nose and rounded edges.

- Intermittent swirl local to each vane persists through length of crowder. Especially for lower vanes
- No coherent, constant swirl pattern across depth of crowder

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Photo 1 Dye on fairing without flow vanes. Note circulation in crowder channel.

Photo 2 Dye on fairing without flow vanes.

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Photo 3 Dye on fairing without flow vanes.

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Photo 4 Flow through upper portion of water column in fish crowder. Mod 1 flow vane installed.

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Photo 5 Flow through mid-upper portion of water column in fish crowder. Mod 1 flow vane installed.

Photo 6 Flow through mid portion of water column in fish crowder. Mod 1 flow vane installed.

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Photo 7 Flow through mid-lower portion of water column in fish crowder. Mod 1 flow vane installed.

Photo 8 Flow through lower portion of water column in fish crowder. Mod 1 flow vane installed.

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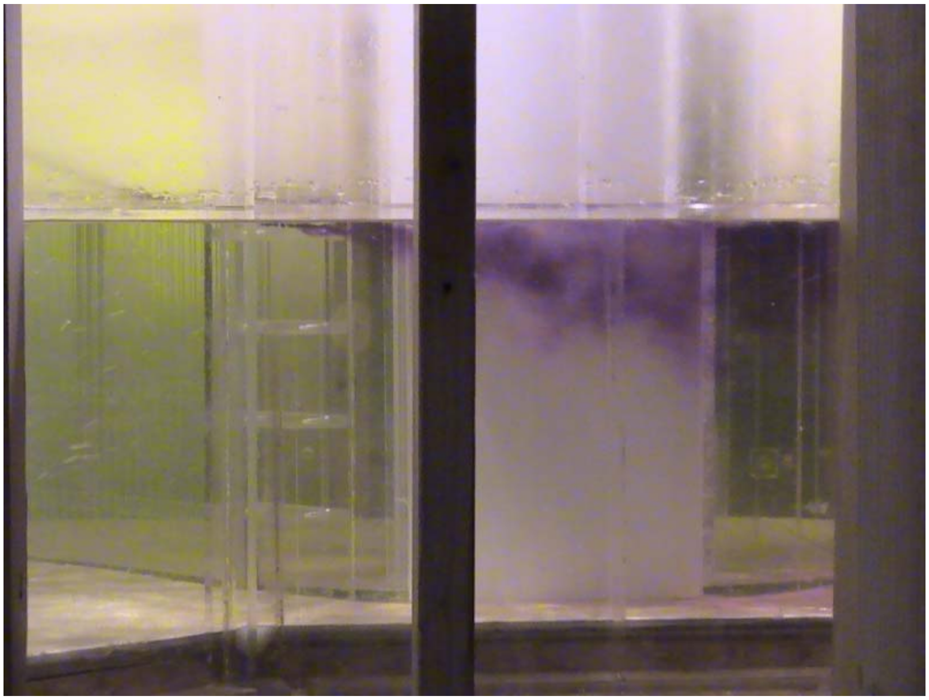

Photo 9 Flow through upper portion of water column in fish crowder. Mod 2 flow vane installed.

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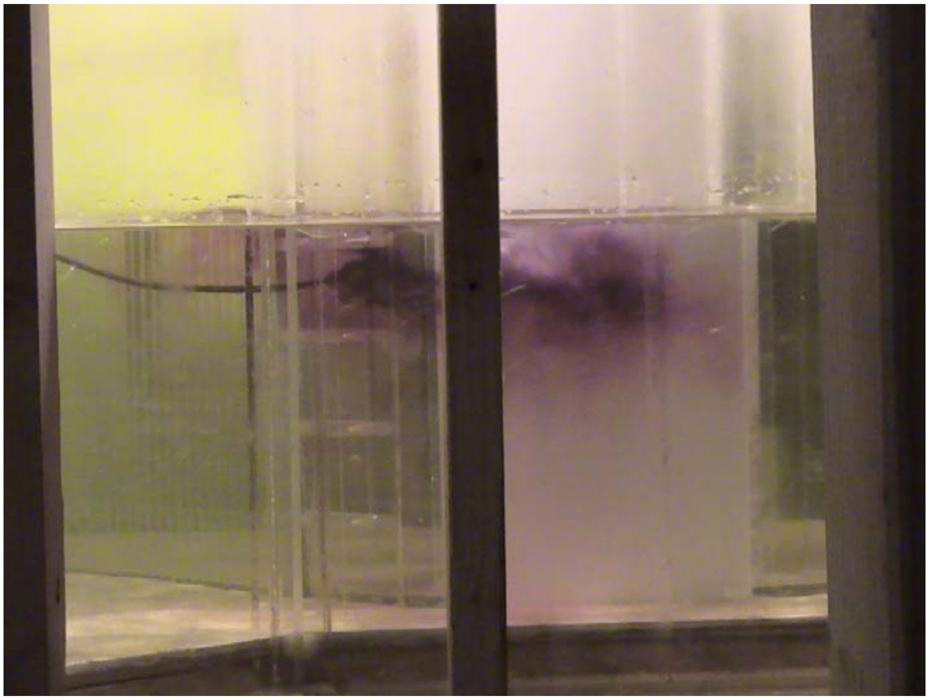

Photo 10 Flow through mid-upper portion of water column in fish crowder. Mod 2 flow vane installed.

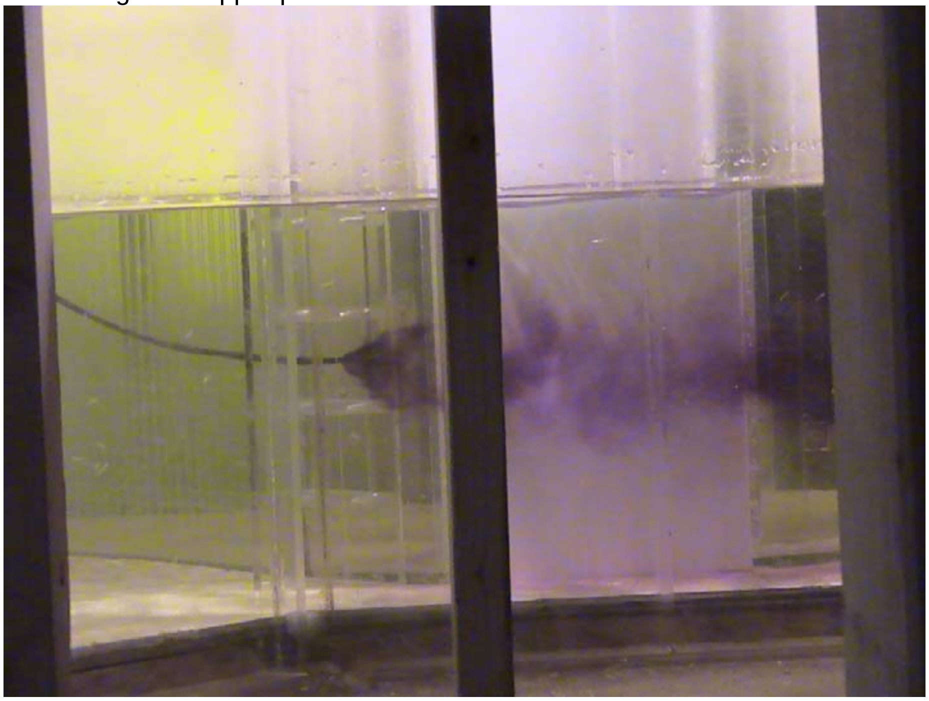

Photo 11 Flow through mid portion of water column in fish crowder. Mod 2 flow vane installed.

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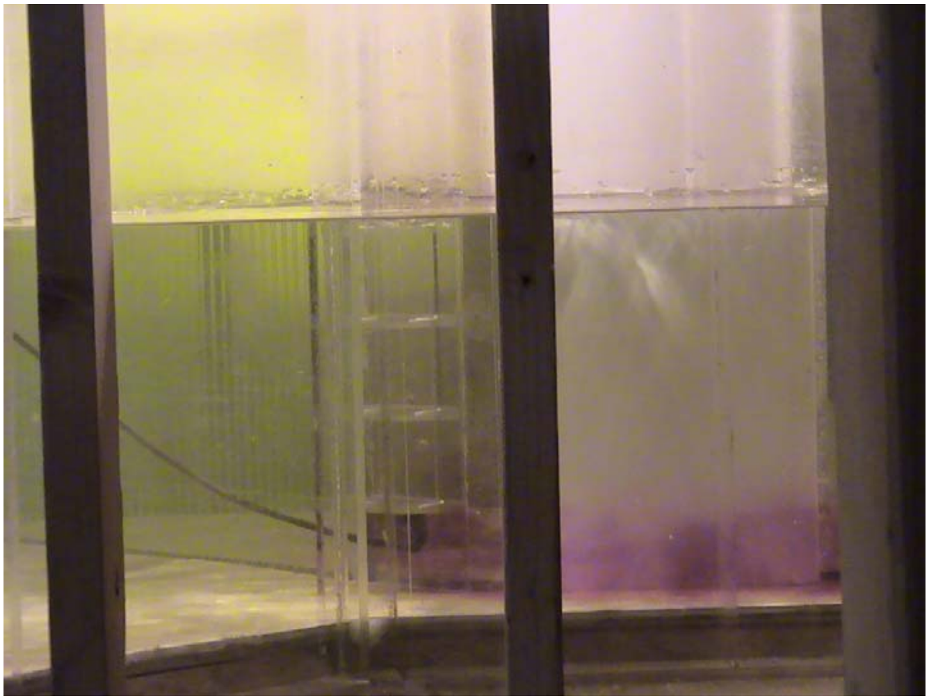

Photo 12 Flow through lower portion of water column in fish crowder. Mod 2 flow vane installed.

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Photo 13 Flow through upper portion of water column in fish crowder. Mod 3 flow vane installed.

Photo 14 Flow through mid-upper portion of water column in fish crowder. Mod 3 flow vane installed.

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Photo 15 Flow through mid-lower portion of water column in fish crowder. Mod 3 flow vane installed.

Photo 16 Flow through lower portion of water column in fish crowder. Mod 3 flow vane installed.

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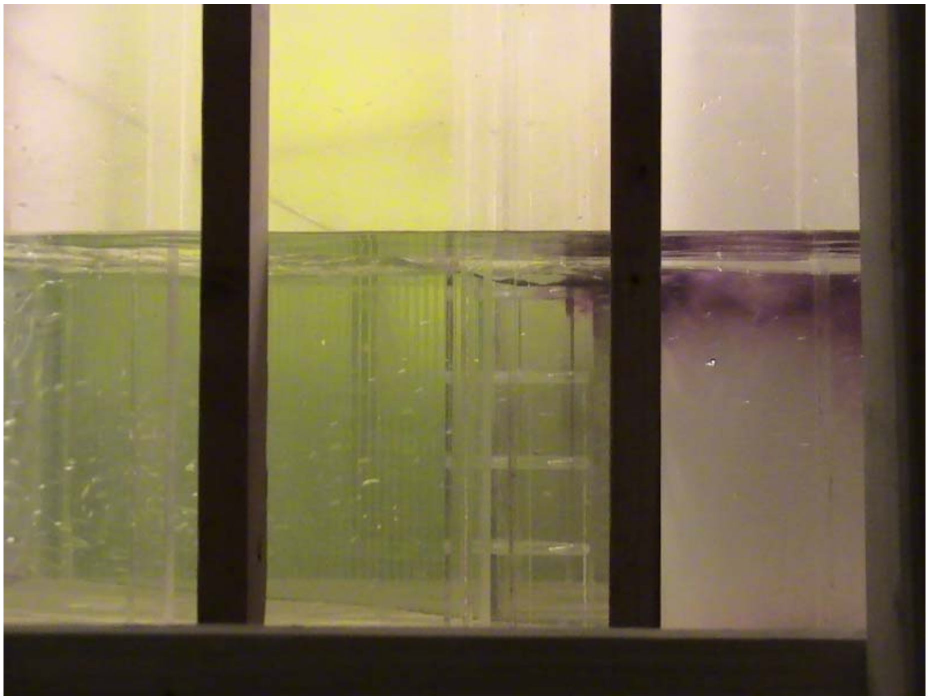

Photo 17 Flow through upper portion of water column in fish crowder. Mod 4 flow vane installed.

Photo 18 Flow through mid-upper portion of water column in fish crowder. Mod 4 flow vane installed.

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Photo 19 Flow through mid portion of water column in fish crowder. Mod 4 flow vane installed.

Photo 20 Flow through mid-lower portion of water column in fish crowder. Mod 4 flow vane installed.

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Photo 21 Flow through lower portion of water column in fish crowder. Mod 4 flow vane installed.

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Photo 22 Flow through upper portion of water column in fish crowder. Mod 5 flow vane installed.

Photo 23 Flow through mid-upper portion of water column in fish crowder. Mod 5 flow vane installed.

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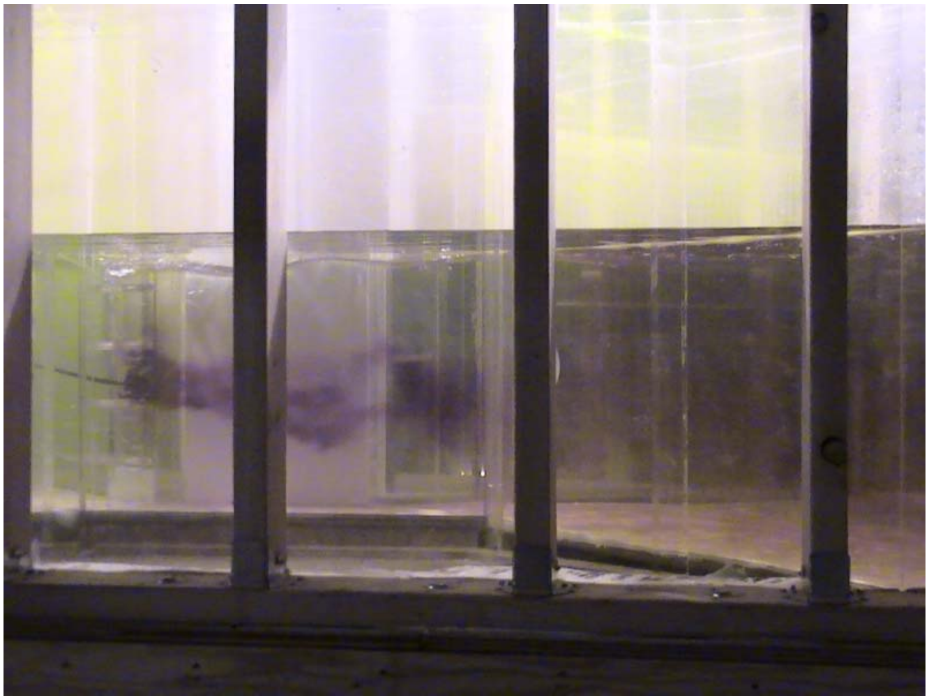

Photo 24 Flow through mid portion of water column in fish crowder. Mod 5 flow vane installed.

Photo 25 Flow through mid-lower portion of water column in fish crowder. Mod 5 flow vane installed.

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Photo 26 Flow through lower portion of water column in fish crowder. Mod 5 flow vane installed.

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Photo 27 Flow through upper portion of water column in fish crowder. Mod 6 flow vane installed.

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Photo 28 Flow through mid-upper portion of water column in fish crowder. Mod 6 flow vane installed.

Photo 29 Flow through mid portion of water column in fish crowder. Mod 6 flow vane installed.

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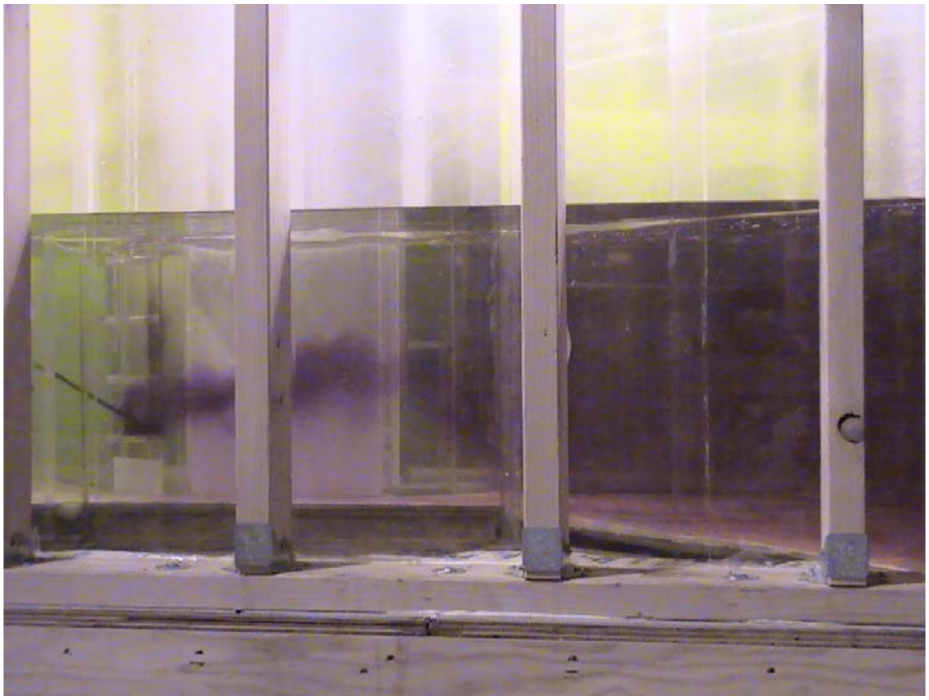

Photo 30 Flow through mid-lower portion of water column in fish crowder. Mod 6 flow vane installed.

Photo 31 Flow through lower portion of water column in fish crowder. Mod 6 flow vane installed.

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Sincerely yours,

Elizabeth W. Roy, P.E.

Senior Project Manager
lroy@ensr.aecom.com

Appendix B

Raw Data Appendix

(Contained on CD)

MEMORANDUM FOR THE RECORD Date- July 9, 2007

SUBJECT-Trip Report for ENSR Shake-down model visit- July 5-6, 2007

Purpose- To review the John Day North (JDAN) 1:5 Fish Ladder Physical Model to assure that the model is simulating flow at the prototype JDAN before testing is started.

In Attendance-Travis Adams, Chris Budai, Jim Calnon, Dave Clugston, Natalie Richards, Ed Meyers (NOAA) and ENSR-Liza Roy, Justin Arnold, Chick Sweeney, Maritz (Student)

Conditions- Hot and sunny

Details of the Field Visit

We left Portland at 7:00 am and drove to Redmond, WA arriving at 11:00, reviewed the model until 5:00 then started in again at 8:00 working until 2:30 arriving back to Portland at 6:30 pm.

The ladder consisted of 23 weirs with the holey wall in place at weir 249, count station, 4 weirs below the count station.

11:00-12:00 July 5, 2007-FB 264 with ladder at 1' head-85 cfs split 61.9 cfs exit section and 23.1 cfs diffuser.

Tentative velocity pool location was pool 4

After lunch 7/5/2007-FB 264' ladder at 1.3' head-113 cfs split 61.9 cfs exit section and 51.1 cfs diffuser, FB 266 with ladder at 1' head-85 cfs split 74.1 exit section and 10.9 cfs diffuser.

The velocity pool location was switched to pool between weirs 8 and 9 due to the addition of the vertical end sill at the furthest pool down the ladder. This will help determine possible energy dissipation and sloshing problems.

When we observed the diffuser operation to see the affect of the holey wall, the flow was not uniform. In conjunction with the "holey wall", the diffuser was thought to contribute to the fish and them falling back down the ladder. There was a great deal of discussion about what to do with the diffuser and many options were discussed:

-Moving the diffuser to underneath the knife gate,

-Moving the diffuser to the ladder side all next to the knife gate.

-Providing a vertical diffuser adjacent to the new jet coming out of weir 23 or 249.

-Redoing the model diffuser box in order to get the exact configuration out in the field.

-Modification of the contract was discussed with Rowena and she discussed it with Ken Piper (CT).

-The exact configuration of the diffuser was difficult to determine from the model drawing provided from the COE. What exactly was that configuration? We worked with Jason Chase and Bob Cordie to provide the latest and greatest 7/6/2007.

We decided that it was important to collect data at the low forebay (257) and the high forebay (268) at 1' (salmon) and 1.3' (shad). This is a contract Modification that Natalie/Steve and Liza need to negotiate. We have tentative approval to continue with this testing starting July 16 from Ken Piper (CT).

The Baseline mid-range forebay of 264 at 1' and 1.3' is being tested July 9-13, 2007.

Baseline is defined as 23 JDAS weirs with the count station and the 4 overflow weirs downstream.

Modification is defined as 23 lamprey friendly weirs that Steve modified July 6, 2007 and will be drawn by CADD by Eric Holzapfel July 9, 2007 to be emailed to Liza Roy.

<u>July 6, 2007</u>-FB 262 with ladder at 1' head- 32.7 cfs exit ladder and 52.3 cfs for the diffuser, FB 257 with ladder at 1' head

Discussion Questions and Ladder observation:

1) What was baseline since we are not modeling the existing weir configuration because it is not working well?
2) What affect the diffuser is having on the fish moving down the ladder. (TDAN falling back down the ladder.)
3) The redesign of the lamprey modified weirs. (see the attached drawing from Eric with the changes) Since the contractor had not started this acrylic work, this will not be a modification to the contract.
4) We chatted with Kyle McCune about the triangular piece that was installed to keep upwelling to a minimum. We notice in this model that it is a component in the flow short circuiting (move directly from vertical slot to vertical slot, which is not good for dissipation of energy and may cause sloshing at downstream weirs.
5) The addition of the 2 forebay elevations.
6) With the higher the forebay, the possibility of more short circuiting occurs.

<u>Confirmation of the following occurred:</u>

1) Location for the 30 velocity measurements each at the count station (see attached scanned drawing- to be provided when scanning is completed) and between weirs 8 and 9.
2) Diffuser no. 16 is a bubbler system with uniform flow, which was confirmed by Bob Cordie and the drawing was provided by Jason Chase (DS) The physical model will be modified to provide uniform flow by adding perforated plate, which increases headloss.
3) The transition at pool 20 will be changed from a triangle to a straight piece.
4) Confirmed the physical measurements of the count station acrylic in the model.
5) The testing and what we anticipated before the August 13-15, 2007 model visit with agencies.

<u>Recommendations-</u>

1) The model appears to accurately reflect what we observed in the JDAS prototype.

2) We will use this model to make further improvements to the ladder weir design, specifically:

a) Focus the vertical slot gate jet toward the corner and

b) Account for the beams to minimize short circuiting of the flow, which reduces energy dissipation and increases the possibility of sloshing in the pools near the count station.

3) This model will be used to reduce/eliminate the confusing flow that exists at the holey wall (weir 249) by replacing this weir with a newly designed lamprey friendly weir.

4) The lamprey friendly weir will be more efficient. How that will affect the energy dissipation aspects in the pools is unclear at this time.

Respectfully Submitted by,
Natalie Richards, PE
July 16, 2007
TL JDAN

Final Meeting Minutes-ENSR MODEL AGENCY VISIT
John Day North Fishladder Exit Section & Count Station
August 13-15, 2007

Purpose- To provide Regional Fishery Biologist an opportunity to review the JDAS and lamprey friendly weirs in the 1:5 Fish Exit ladder for John Day North (JDAN)

In Attendance- COE-Travis Adams, Chris Budai, Jim Calnon, Dave Clugston, Bob Cordie, Mike Langeslay, Kyle McCune, Natalie Richards, Steve Schlenker, Thareth Yin, NMFS-Gary Fredricks, Ed Meyers, ENSR-Liza Roy, Justin Arnold, Maritza Gonzalez, Chick Sweeney

Day 1 (8/13/07)
7:00-11:00- Drive Portland to Redmond, WA
11:00-Reviewed agenda with team
12:00- Viewed JDAS weirs (2003 Interim Configuration 2007) with holey wall, existing count station and diffuser at:

- **FB 264 11:30 am Observations:**
  - Pool 16-17- Jet stable into the corner
  - Pool 15- Jet near vertical slot block
  - Pool 7- Jet at vertical sill
  - Diffuser 16- perforated plate was added and the distribution of flow looks good.
- **FB 262 (lower range of median vertical sills) 12:00 pm Observations:**
  - Jet near wall or in corner occurs in pools 15 and 6
  - Short circuiting of pool with respect to energy dissipation occurs in pools 5
  - Transient conditions where jet moves between corner to a short circuit in pool 4
- **FB 266 (upper range of median vertical sills) 12:30 pm Observations:**
  - Checked plan sheets concerning the holey wall and confirmed that the model is correct.
  - Short circuiting occurs periodically for example at pool 14

At lunch, the water entrance/fish exit from the forebay was discussed

- Add orifice under vertical slot south side for lamprey?
- Add orifice south side 2nd west wall?
- Take out stub wall so lampreys have a direct line to the entrance and forebay?
- Take out both walls completely and taper water entrance/fish exit?
- The head difference is low in this area so lamprey may not need orifices.
- Straight piece will be added to the north side of pool 19 and it needs to be trimmed for the lamprey friendly weir

1:00-4:00-Change out holey for new weir 1, revised count station, sloped diffuser, bottom 12" of trash rack blocked

Discussions about the Fish Entrance/Water Exit/AWS during model change:

- Steve and Natalie provided handouts to explain the AWS and the tiered approach to providing a solution. (Figures 1-6)
- Steve presented fish entrances to meet the biological criteria and discussed the need to upgrade the pumps in order to provide the flow which requires more power than we currently have.
- Jim Calnon explained that the new motors would be VFD, variable frequency drive, and running the least amount of pumps needed. These new pumps motors and shaft would increase the revolutions per minute from 116 to 137.5.

- ~ $2-4 million per year is a reasonable expectation to shoot for SCT funding. A turbine to generate power and provide more flow at approximately $25M may be way too much.
- At JDAS, there is currently 1 penstock and 3 pumps that run flow in that ladder. Can something of a similar manner be completed at JDAN?
- Redundancy is needed

<u>What are the fish issues at JDAN ladder?</u>

- Long delays 5-15 days to pass
- Heavy metal leaching from the aluminum plant
- Dissolved Gas level 130%

<u>At the Fish entrance and Transition Pool, the following topics were discussed:</u>

- Lamprey passage is end of May through Oct with the peak at June and they generally move at night. (So salmon and lamprey will probably not be vying for the same orifice.)
- A false wall to reduce the width at the entrance from 29' to 24' may be needed at the Lamprey Passage System (LPS) so that salmon are not affected.
- Providing a rock insert to encourage lamprey movement
- Bonneville and Willamette Falls have LPS that we can learn from.
- Configure the exit to one side for lamprey or provided a jet through the center.

<u>Raise floor at count station 1' for the 1:5 Model and JDAN</u>

- Structural issues- raising the bubbler beams, changing the knife gate, transition leading edge of crowder with a quarter circle.
- There is flow passing behind (south of) the crowder which is approximately 10" wide which was not modeled. This detail was not found in the plan sheets.

<u>5:35 pm-Viewed JDAS weirs with new configuration at:</u>

- **FB 264 Observations**
    - Jet at south wall notice ripples at pool 16 and 3 (Figure 7)
    - Vortex trying to form upstream at vertical slot weir 1 (Figure 8)
    - Upwelling at the north wall where the jet impacts (Figure 9)
    - Short circuiting of pool 2
    - Notice "bouncing' of the water surface profile (wsp) at weir 1 which means that energy is being transferred to downstream pools. The wsp is pretty uniform at pools 20-23. (Figure 10)
- **FB 268 (upper range of median vertical sills) observations**
    - Noticed "bouncing" of the wsp at weir 1 and more uniform at pool 20-23
    - Vortex trying to form at vertical slot weir 1

Change out model for new lamprey friendly weir overnight until noon 8/14/07

<u>Day 2 (8/14/07)</u>
<u>9:30-1:30 Discuss about the count station area.</u>

- Fix width to say 24"
- Provide rounded crowder flow inlet with a triangular outlet to protect fish from being hurt on sharp edges
- Raise the area behind the pickette lead and trash rack
- Energy dissipation issues?
- Knife gate would need to be adjusted but there were no mechanical show stoppers
- Provide 12" strip over diffuser for lamprey to make way to the orifice.

- Need feedback from the counters about the fixed location of the crowder- Bob will talk with supervisors
    - Clean glass with mechanical equipment making it easier to see fish
    - Add more lighting

Discussion about water entrance/fish exit taper- Take out east most wall and taper to west wall?

1:55-5:30-View lamprey friendly weir configuration weirs, revised count station, sloped diffuser at:

- **FB 264 1:30 pm Observations-**
    - Lamprey friendly weirs are more efficient which affect the forebay by 0.8' and flow in the model.
    - There is more turbulence, upwelling near the vertical slot and energy dissipation in the upper weirs 18-23 and the whole pool is utilized to dissipate energy. (Figures 11,18)
    - At Pool 1 short circuiting is occurring.
    - Dye through orifice goes straight through and moves rapidly. (Figures 12-17)
    - The wsp slopes toward the north east corner due to the impinging vertical slot jet and some upwelling also occurs in the pools at the southwest corner probably due to the orifice jet
    - Pool 11- upwelling
    - Pool 10- no upwelling
    - Pool 9- short circuiting (Figure 13)
- **FB 268 3:40 pm Observations**

Ed and Steve worked with wooden triangle against south wall to slow down orifice flow which sends jet to vertical slot now also. This is not the case without it in that the whole jet stays on the south side of the pools.

- **FB 258 5:20 pm Observations**
    - The pools are very calm and short circuiting was observed throughout the ladder.
    - The energy drop was only 257-249/23 weirs =0.35 ft/pool
    - At the count station, the dye stayed on the north side of the pool into the crowder.
    - Pools 14, 13, 12, 11, 6, 5, 2, 1- short circuiting
    - Pools 10, 9, 8, 7- nice jet against wall
    - Pools 4, 3- split at block

Day 3- install FB 268 vertical slots

Day 3 (8/15/07)
8:00-10:30-Discussions during model change

- Structural Analysis- Travis Adams,
- Next site visit,
- Model Changes
    - Water entrance transition to gradual taper,
    - Raising the floor at Count Station
    - Fillets in the upwelling count station area

Structural Analysis- In 1956, the weirs were an overflow/orifice configuration, which weighed 17 Kips. The design of the floor slab varies from 1' (at the deepest depth of water) to 1'-6" at the count station which has the shallowest depth. The Code allowable stress was 90 psi. In 1960, the allowable stress was reduced to 45 psi. For some reason, the ladder design only accounts for the 1.7*Dead Load for the moment calculations. The current USACE Code is (1.7*DL + 1.4*LL)*1.3.

The serpentine configuration was introduced in the 1970's and no design calculation can be found as to what this weight does to the allowable stress.

The new weir weighs between 47 Kips at 8' high to 67 Kips for a 15' high weir. At the new size, the longitudinal direction of the ladder can be utilized in order to carry the load; however the access with its respective beam has not been factored in yet. Also, the pier capacity has not been checked. The team discussed using 3' freeboard. Since the weirs are so heavy, what materials can be used to reduce the weight? Fiberglass? Stainless steel?

Next Visit- Nov 19-20 or Oct 29-30/Nov 1-2- Gary will provide Dave his schedule

Model Changes -

- Move orifices to the JDAS configurations except for weir 1 which will stay in the corner
- Count station false floor with transition to the orifice at weir 248
- Taper crowder edges and assess fixing the count station
- Transition of the water in from the forebay- With current configuration, the fixed vertical sill limits how low the forebay can go. FB 257 was difficult to achieve.
- Vertical slot have an L-shape to them and they need to be adjusted for the increase efficiency related to the lamprey friendly rounding.
- Addition of a 12" plate at the count station orifice downstream weir 249.
- Several of the changes affect one another and iterations may be needed in order to come to a stable condition.

Additional Criteria-

- Standard criteria for velocities and head
- Lightweight
- Short circuiting is bad when sloshing occurs
- Freeboard of 3'
- Cheap- $2-4 M per year
- Fewest mechanical parts
- Minimum of upwelling which can encourage delay and jumping
- Minimize obstructions and floor lips
- Consistent flow patterns
- Guard against sharp edges at the actuator

<u>10:30-11:30 Lamprey Friendly Weirs FB 268 Observations:</u>

- Pools 4, 5- short circuit
- Pool 6- toward corner
- Pools 8, 9, 10, 11, 12 13, 14, 15, 16- Transient between jet against the north wall and short circuiting
- Pool- 17- jet on north wall distributes energy across the pool before going downstream
- Ladder was 95 cfs with no diffuser flow
- Steve, Ed and Jim moved triangle at vertical slot to see how it affected the jet location- This was covered in the JDAS report 8/2002

11:30-12:30-Finalized last details.

12:45-Left ENSR arrived in Portland/Vancouver area 4:00

Next site visit- need Nixon Meter mounted at the test section orifice to check velocities

Next FFDRWG- Sept 27- 20 minute presentation

- Overview of work
- Forebay entrance recommendation
- Pictures of the revised lamprey friendly weir
- What changed with respect to JDAS weirs
- Ladder and model pictures

Recommendations- The lamprey friendly weirs are, as expected, more energy efficient than the JDAS weirs, which has many affects on the overall design. All the changes are interactive and need to be carefully assessed within the ENSR Contract situation.

Action Items:

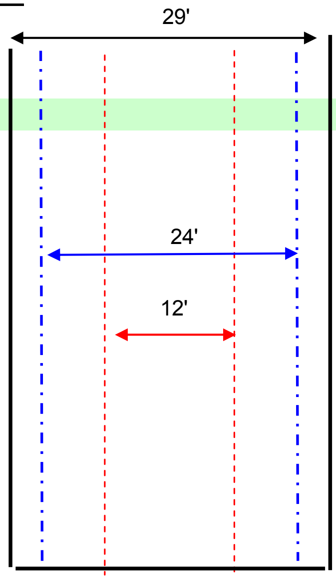
1) Discuss contract modifications implication for the changes provided above.
2) Jim Calnon will work with ENSR to provide the "L-shape" vertical slot inserts
3) Steve Schlenker will work with Natalie and Liz on 1) and the water entrance/fish exit changes
4) Natalie will prepare the presentation for the next FFDRWG meeting.

Respectfully Submitted by,
Natalie Richards, PE
TL JDANFL
August 17, 2007

John Day North Fishway
ESTIMATION OF FLOWS & CHANNEL VELOCITIES FOR FIXED WEIRS WITH UNIFORM WIDTH

Assummed Entrance Head =	1.5 feet
Existing Entrance width =	12 feet
Assumed Fixed Weir Coefficient	0.8 if sumergence < 8'
Assumed Fixed Weir Coefficient	0.85 if sumergence > 8'
Invert =	150 feet
Cha width	29 feet
rounded ra	0.50 feet

	FIXED ENTRANCE WEIR **24 feet width** equivalent width of 2 entrances			**FIXED ENTRANCE WEIR** **12 feet width** equivalent width of 1 entrance weir width		
TW (ft)	24 Entrance Width	Q cfs)	**Cha. Vel**[1] **V** (ft/s)	12 Entrance Width	Q cfs)	**Cha. Vel**[1] **V** (ft/s)
155	24	1187	6.3	12	603	3.2
156	24	1419	6.5	12	721	3.3
157	24	1660	6.7	12	843	3.4
158	24	1907	6.9	12	968	3.5
159	24	2161	7.1	12	1097	3.6
160	24	2422	7.3	12	1230	3.7
161	24	2688	7.4	12	1351	3.7
162	24	2959	7.6	12	1459	3.7
163	24	3235	7.7	12	1567	3.7
164	24	3517	7.8	12	1675	3.7
165	24	3803	7.9	12	1783	3.7
166	24	4093	8.1	12	1891	3.7
167	24	4387	8.2	12	1999	3.7
168	24	4686	8.3	12	2107	3.7
169	24	4988	8.4	12	2215	3.7
170	24	5294	8.5	12	2323	3.7
171	24	5603	8.6	12	2431	3.7
172	24	5917	8.7	12	2539	3.7



[1] Channel Velocity at downstream end of Diffuser 1 (≈ 25' u/s of entrance weir)

Figure 1- 24 and 12 foot Fish Entrance calculations

Fixed Weir Optimized for Max Channel Velocity = 4 ft/s

	Opening Width of Entrance				Channel Velocity	
TW (ft)	W at TW elev (ft)	Ave W (ft)	Ave CD	Q Cfs	d/s Diff 1 (ft/s)	u/s Diff 2 (ft/s)
155	14.0	14.0	0.38	699	3.7	0.5
156	14.0	14.0	0.39	829	3.8	
157	14.0	14.0	0.40	959	3.9	
158	14.0	14.0	0.40	1089	4.0	1.0
159	14.0	14.0	0.41	1220	4.0	
160	14.0	14.0	0.41	1350	4.0	
161	13.3	13.9	0.41	1472	4.1	1.4
162	12.5	13.8	0.41	1585	4.0	
163	11.8	13.7	0.41	1690	4.0	
164	11.0	13.5	0.40	1787	4.0	1.6
165	10.3	13.3	0.40	1875	3.9	
166	9.5	13.1	0.39	1954	3.9	1.7
167	8.8	12.9	0.38	2025	3.8	
168	8.0	12.6	0.38	2089	3.7	
169	8.0	12.4	0.37	2153	3.6	
170	8.0	12.2	0.36	2218	3.6	
171	8.0	12.0	0.36	2282	3.5	
172	8.0	11.8	0.35	2346	3.4	

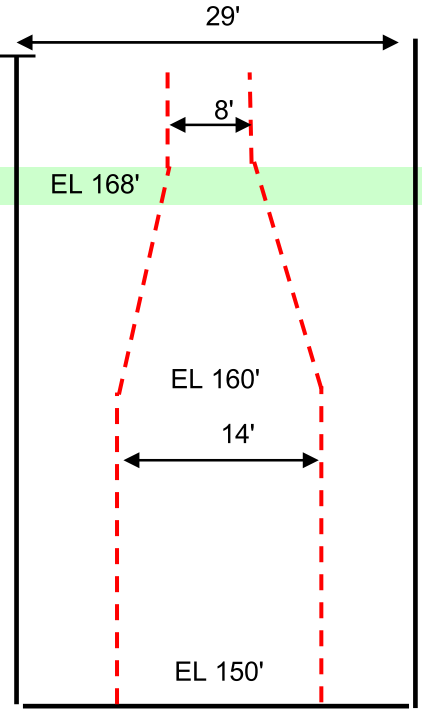


Figure 2- 14 foot Fish Entrance Calculations

Fixed Weir Optimized for Max Channel Velocity = 5 ft/s

TW (ft)	Opening Width of Entrance: W at TW elev (ft)	Ave W (ft)	Ave CD	Q Cfs	Channel Velocity: d/s Diff 1 (ft/s)	u/s Diff 2 (ft/s)	
155	17.0	17.0	0.46	853	4.5	0.5	
156	17.0	17.0	0.48	1020	4.7		
157	17.0	17.0	0.49	1186	4.8		
158	17.0	17.0	0.50	1353	4.9	1.1	
159	17.0	17.0	0.51	1520	5.0		
160	17.0	17.0	0.51	1687	5.1		
161	15.8	16.9	0.52	1838	5.1	1.5	(est)
162	14.5	16.7	0.51	1974	5.0		
163	13.3	16.5	0.51	2096	5.0		
164	12.0	16.2	0.50	2204	4.9	1.7	(est)
165	10.8	15.9	0.49	2298	4.8		
166	9.5	15.5	0.48	2377	4.7	1.8	(est)
167	8.3	15.1	0.46	2443	4.6		
168	7.0	14.7	0.45	2500	4.4		
169	7.0	14.3	0.44	2556	4.3		
170	7.0	14.0	0.43	2612	4.2		
171	7.0	13.7	0.42	2668	4.1		
172	7.0	13.4	0.41	2725	4.0		

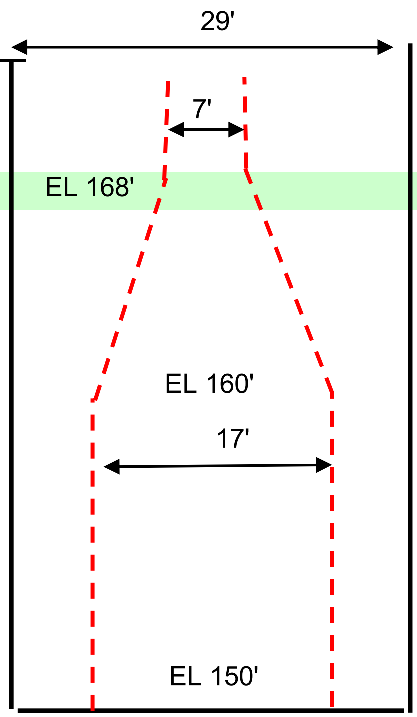


Figure 3- 17 foot Fish Entrance Calculations

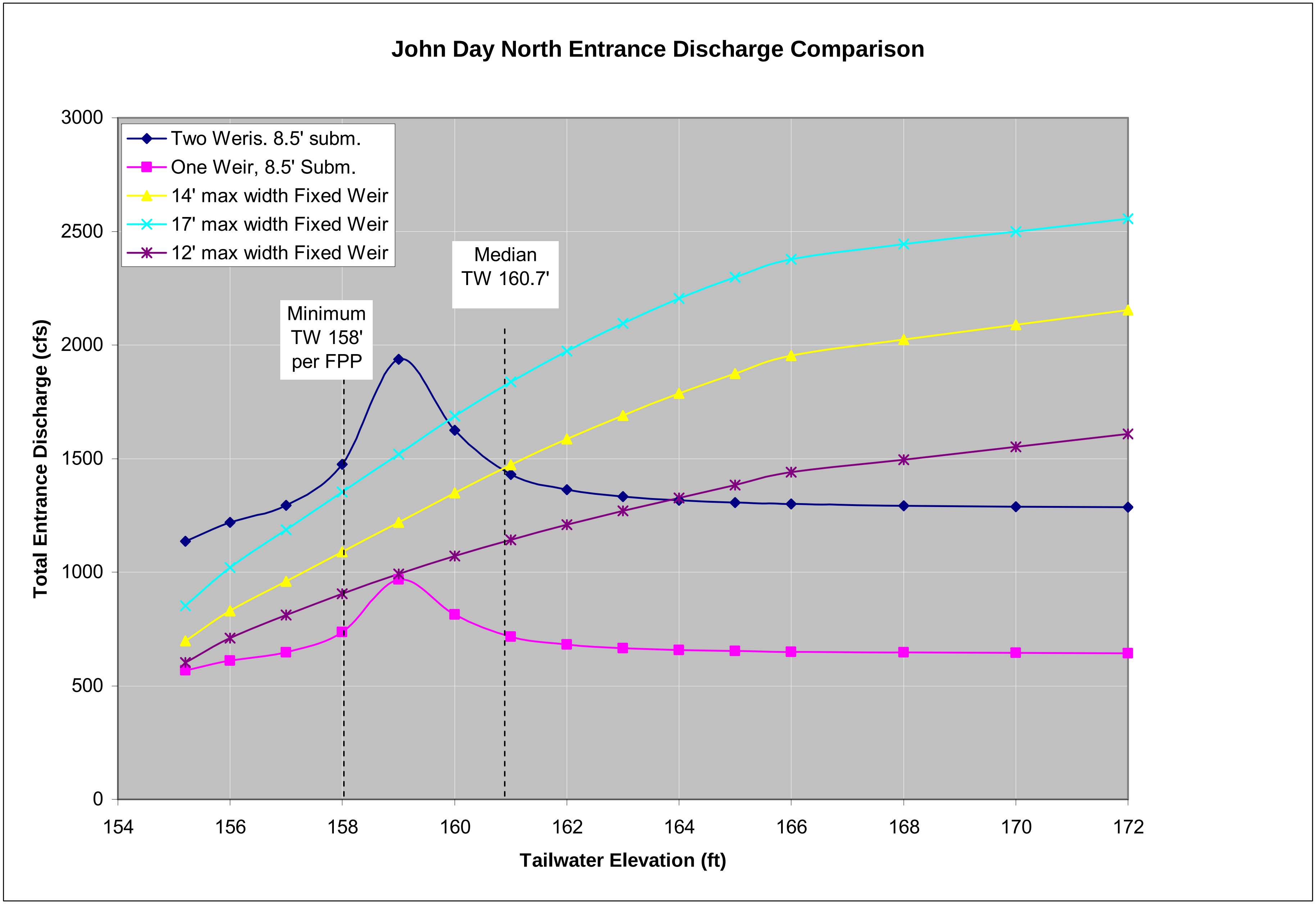


Figure 5- Comparison of Fish Entrance Openings

Figure 6- AWS OPTION TIERS

OPTIONS	FLOW REQUIRED	ESTIMATED COSTS	SCHEDULE for IMPLEMENTATION	CRITERIA MET
Ladder modification:				
Removal of 3 weirs				
Cut off Stovepipes				
Cut off orifice in Stovepipe				
Key Hole Fish Entrance				
Ladder modification and new motors (with shaft replacement):				
Ladder modification, new motors and impeller:				
Ladder modification, new motors, impeller, Turbine (general or run pumps):				

Figure 7- JDAS Weirs -vertical slot and orifice jets energy dissipation characteristics

Figure 8- JDAS Weirs-Vortex weir 1upstream the count station at FB 268

Figure 9- JDAS Weirs-Upwelling SW wall around pool 4

Figure 10- JDAS weirs-“Bouncing” profile pools 1-5 and more stable upstream pools

Figure 11- Lamprey friendly Weirs- Pool 18 notice distribution of the jet

Figure12- Lamprey Friendly Weir- Notice orifice jet moving quickly along bottom

Figure 13- Short circuiting path not utilizing full pool to dissipate energy

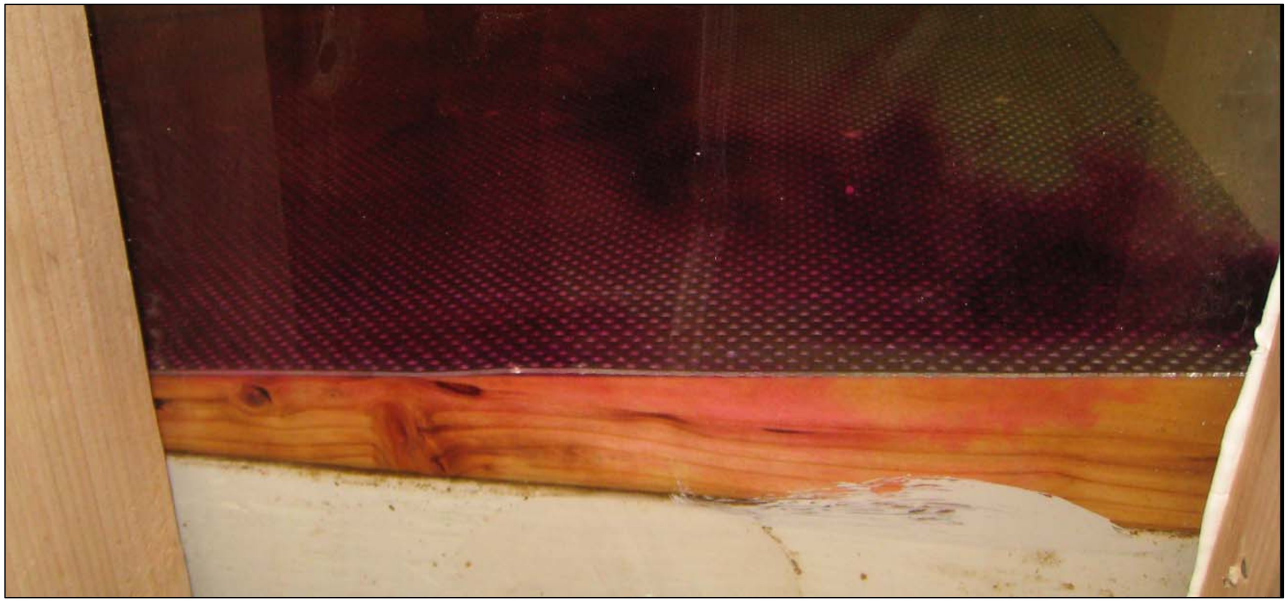


Figure 14-Lamprey Friendly Weirs-Orifice over slope diffuser plate toward the crowder

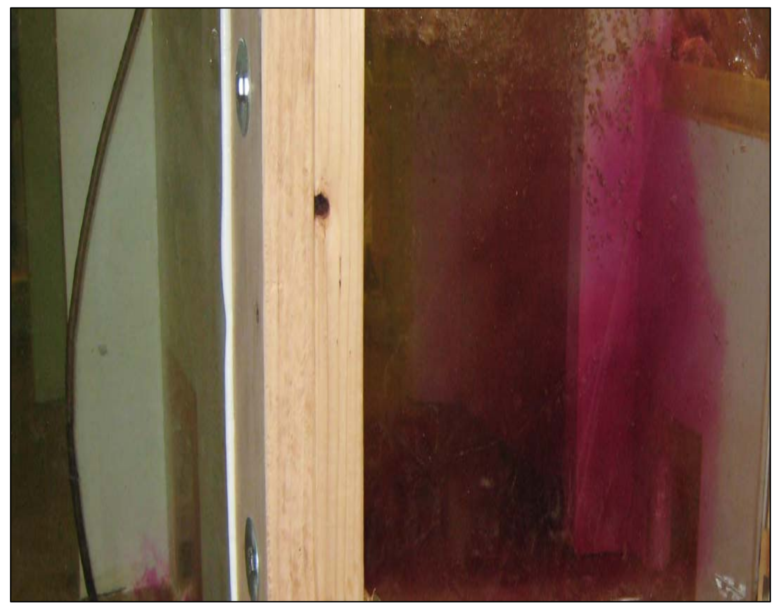


Figure 15- Downstream of the count station to weir 248 looking at the orifice jet speed and influence from the overflow weir jet

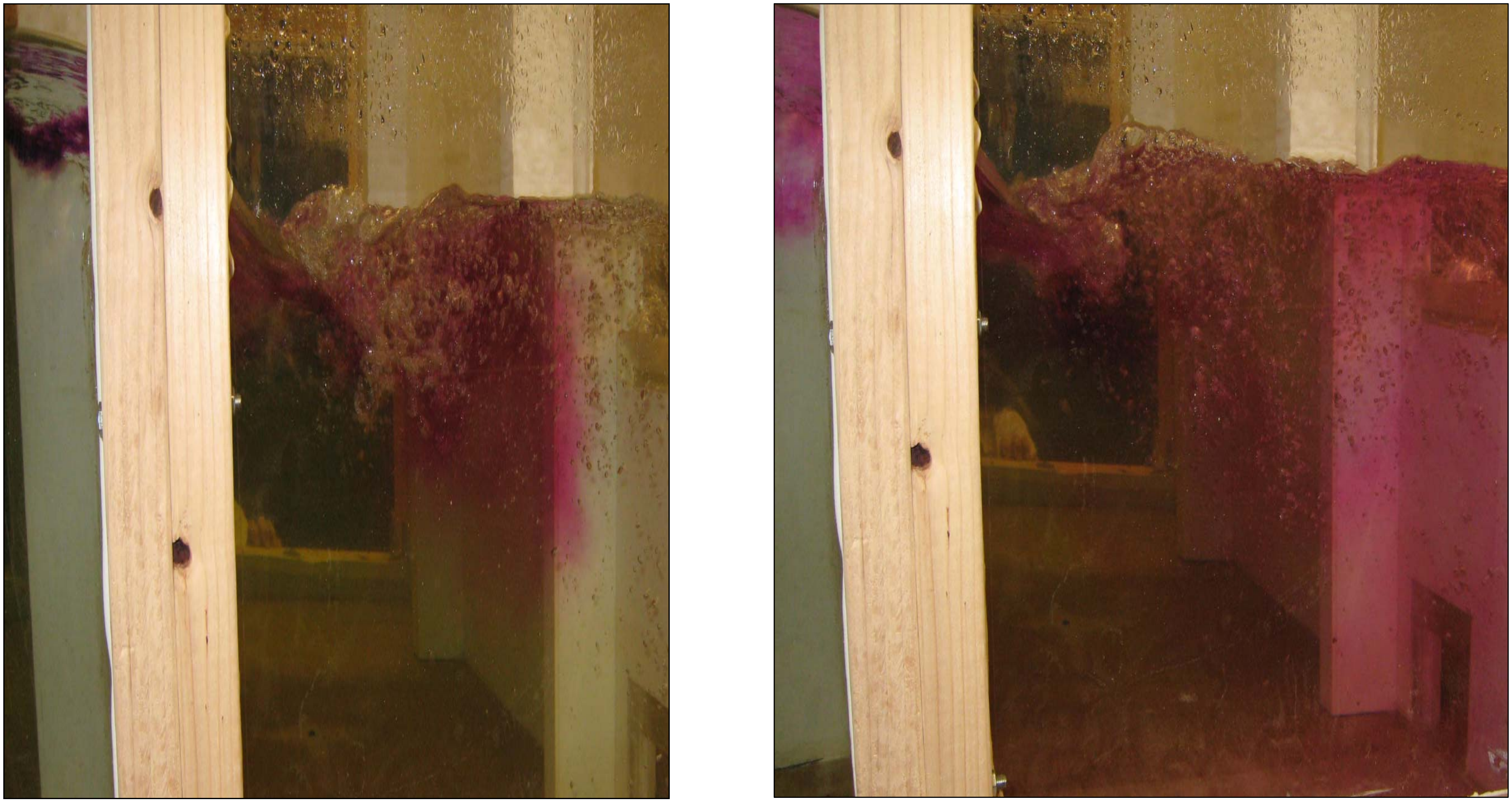


Figure 16- Weir 248 downstream of the count station-Affects on orifice jet north side

Figure 17- Overflow jet affect on the orifice jet at pool 248 and 247 south side

Figure 18- Pool 18 Lamprey Friendly Weir-Progression of energy dissipation which occurs in the pool before going downstream

JDAN 1:5 Physical Hydraulic Model
ENSR Laboratory PDT Site Visit - 10/23-24/2007
Trip Report

In Attendance-

Chris Budai, Dave Clugston, Travis Adams, Steve Schlenker, Natalie Richards- **USACE**

Liza Roy, Justin Arnold, John- **ENSR**

Trip Report Prepared by:

Natalie Richards, PM (former TL, EC-HD) ; Stephen Schlenker, TL, EC-HD

Executive Summary

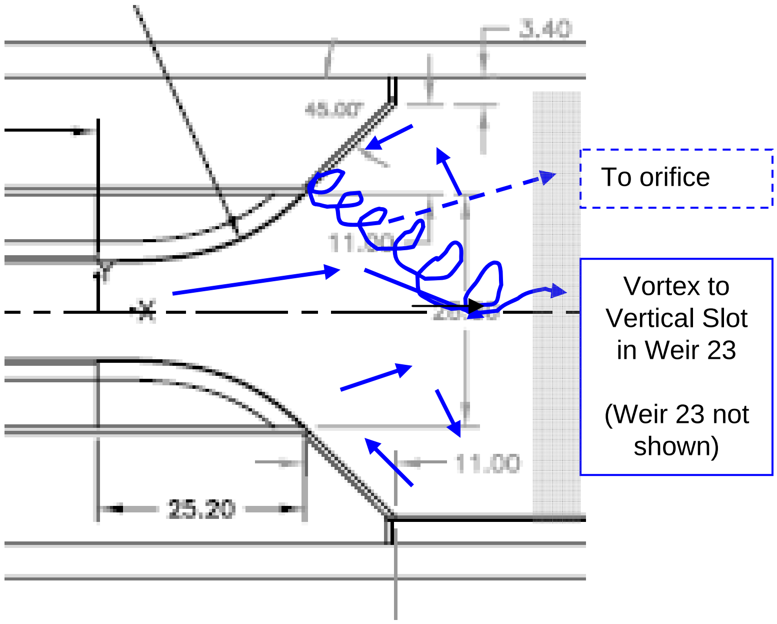
The Product Development Team (PDT) visited the ENSR lab to view new features in the 1:5 scaled Physical Model of the Exit Section at John Day North Fishway. Primary new features included the following items:

New Features since Previous Visit (Agency Visit -- Aug 13-15, 2007)

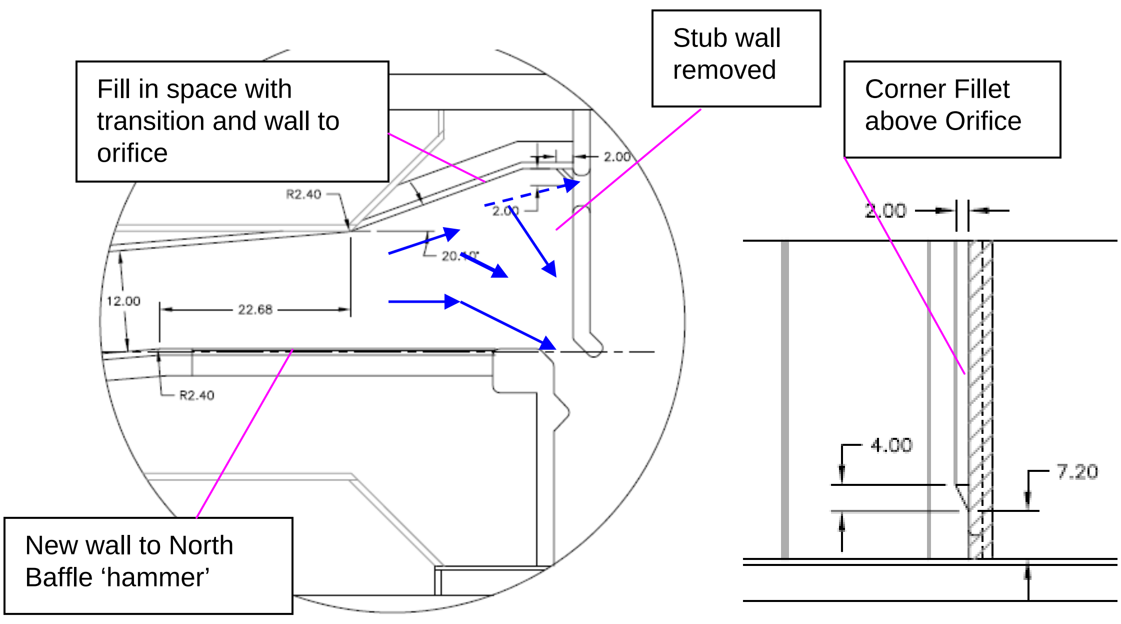
1. Orifice on weirs 2 through 23 moved away from wall to JDAS location. Weir 1 orifice remains at the left wall.
2. Exit channel to forebay modified with elliptical transition to narrow the channel to 5 feet wide. Slotted weirs and stub walls were removed.
3. Count Station
    a. Raised floor of count station by 1 foot to eliminate the Crowder ramp, sloped diffuser
    b. Added a solid lamprey “sidewalk” over the diffuser (12” wide to 18” wide at the orifice opening in weir 1)
    c. Reduced the Crowder length to 4’ 7” per correction from USACE Portland District
    d. Designed and installed farings for the upstream and downstream side of the Crowder for 24” and 18” opening positions.
4. Weir triangles (on the downstream face of the right weir baffle) were moved to a new position closer (about 60-65%) to the right wall per direction from USACE Portland District.

Orifice repositioning (Item 1) corrected against the tendency for high, undiffused velocities to transmit through a string of orifices. The tendency for energy accumulation in downstream orifices was mitigated or diminished. This did lead to slightly more turbulence in the pools.

The new elliptical exit transition (Item 2 see figure below) to Forebay had problems with vortex formation upstream of weir 23. The vortexes usually formed in south side wall, either off the elliptical transition or in the south corner above the orifice. The ENSR & PDT attempted several methods to deal with the vortex problems—initially with a triangle down the south sidewall or in south transition corner.



The triangles worked more or less but Dave wanted a more channelized approach to direct fish to the exit to the orifice and slot without the triangles. Several variations of approach were tried by arranging pieces of plywood. A general concept emerged with shaping the channel to match with the orifice opening and 'hammer' of the north baffle of weir 23. In addition, it was agreed to remove the stub wall adjacent to the orifice in the south baffle and add a fillet in the corner above the orifice (see figures below in inches model scale).



Detail 2 – Plan View at Weir 23
(Scale = 1:15)

The count station changes (item 3) showed significant improvement in hydraulic conditions. The eddies around the front and back of the Crowder were reduced in scale. Flow passed cleanly through Crowder slot. One minor observation was the tendency for a standing wave to form against the upstream faring under high flow conditions (85 cfs).

Weir triangle positions (Item 4) still need to be worked out. The initial position (60-65%) looked okay for all pools except the narrower upstream pools where upwelling occurred against north wall. Moving the triangles back (33% of distance between slot and wall) helped the narrow upper pools, but caused upwelling in the middle pools, lower pools were not affected. Solution may call for different locations for different pools.

An additional issue was raised with respect to the system meeting depth criteria (>5') at all pools at Minimum Operating Pool (MOP) 257 feet. Based on the new ENSR water level data, the current system of vertical slots would have depths above 5 feet only in the downstream end of all pools whereas at least 13 pools would not be above 5 feet in the center of the pools. Steve used ENSR's data to recalibrate the NWP 1-D exit channel model to estimate the changes required to meet the depth criteria: Change weirs 18-20 from 15" to 18" slot widths (Table 1 in back shows proposed change in weir slot widths.) Dave was unable to confirm with NOAA on whether this change would be required. (Per NOAA criteria: Guidelines "should"- Minimum Pool 8' long, 6' wide, 5' deep with volume= YQH/4ft/lbs/ft^3 pg 6).

The ENSR test data showed that the system can be operated with 3 sill settings (High sills, medium sill and No sills). (There were NWP-HD concerns that the more hydraulically efficient Lamprey-friendly weirs might actually require 4 settings). The estimated range of operation for each setting is shown below (subject to future refinement to increase dead-band width):

Tentative vertical sill operations	**Forebay Dead-band (ft)**
No sills- 257 (Q=35.5) to 263.3 (Q=85)	1.0 feet
Medium Sills 262.3 (51) to 266.7 (Q=85 cfs)	1.3 feet
High Sills- 265.4 (62 cfs) to 268 (Q=85 cfs)	

To provide more uniform head drops at high flow conditions, the high sills were revised. The sills in the upper most pools would be lowered and the middle and lower pools were raised. ENSR changed the sills during Day 2 and flows at Maximum Forebay 268 (85 cfs) and Forebay 265.2 were repeated (See Table 2 in back).

Close-out Meeting: PDT and ENSR decided to make an additional interim PDT trip to ENSR on Nov 7-9, 2007 to make sure the exit transition will work without vortex problems.

Natalie and Liza to discuss Options that will be executed to complete the transition work and possibly the 3 weirs at 20, 19, 18 from 15" to 18".

Structural shear load of the Forebay Exit is carried primarily the sidewalls for the exit section channel. However further finite element analyses required to verify new system will not cause undue structural shearing loads.

Transitions (or dead bands) between no, medium and high sills may still need to be refined and Jim Calnon may join Dave and Steve on the Nov 8-9 trip to check the Forebay Exit Transition.

Photos are located at:

\\nwd\nwp\ETDS\Columbia\JohnDay\North_Fish_Ladder\Adult_Passage_Improvements\Design_Documentation_Report\ENSR-Model\ENSR_Photos_23-24_Oct_2007

Test Conditions Demonstrated:

DAY 1: 10/23/07

1. **Max FB 268 ft – High Sills, Q = 85 cfs (full ladder at ladder head = 1ft) 1:30-2:07**

Observations-Max sills and Q

Triangle on wall (south corner) to eliminate horizontal vortex in upstream transition to weir 23

Triangles on weirs were located about 60-65% from slot opening to north wall; performance is okay except in upper pools with narrower width, where upwelling is noted in north wall.

Crowder Farings appear workable mechanically, but need to be checked by EC-DM (Rounded corner design will limit range of Crowder motion to openings to between 18 – 30 inches from previous maximum width of 36 inches—which is never used in field.)

2. **Median FB 264 ft – Medium Sills, Q = 65 cfs 2:40-3:00**

Observations- Vertical Sills at pool 9

Pools 23 to 21 dissipation good before moving through slots

Volume changes to 24' to 22' wide.

Short circuiting pools 8 to 1

Need orifice and transition for fish- Dave Clugston concern with dead zone. → moved in plywood to transition the dead spaces.

3. **FB 266.8 ft – Medium Sills, Q = 85 cfs (Max flow at medium sills) ~3:30-4:15 pm**

Observations-

Short Circuiting pools 8-1

Concerned about dead space at orifice in the transition.

Difficult to develop vortex

Added wood and triangle (partially down in the flow) to break vortex.

4. **FB 264 ft – Medium Sills, Q = 65 cfs (Med Forebay with medium sills) ~4:45-5:15 pm**

Observations- FB 266.7 Medium Sills Q max

5. **FB 261.5 ft – Medium Sills, Q = 45 cfs (Min Q in criteria with medium sills) 5:15-6:00 pm**

Observations- FB 266.7 Medium Sills Q max

Discussion Items:

1. Vortex formation in the exit channel to forebay at weir 23
2. Location of triangles on right weir baffles

3. Options for adjusting pool depths to meet criteria (widen slots at u/s end)?
4. Confirm constructability of farings as designed, discuss operating range of motion

DAY 2: 10/24/07

6. FB 264.4- No sills Q=85 cfs, no sills 8:00-9:30 am

Observations- dye release at pool 7 shows short circuiting of pools, extra energy in the form of a wave at the crowder, vortex tries to form at the overflow weirs #248.

At Transition with no sills at vertical and orifice on the floor, orifice flow goes upstream instead of downstream, vortex tries to form but can't.

In general, go to no sill at a lower forebay. Readjust the range of the medium sills. (Don't want to oscillate back and forth with the sill actuators.)

Bouncing Water Surface Profile but no significant surging

7. Minimum FB 257 ft – No Sills, Q = 35.5 cfs 10:00-10:10 am

Crowder looked much better much calmer,

Short circuiting throughout but energy transference across pools is quite low,

Vortex formed near transition baffle at vertical slot

Observations-

Short circuiting pools 7-1.

Adding plywood to channelize flow in exit transition. Vortex tough to form (good thing)

10/24/2007 other options to look at after lunch:

1) Shift of the weir triangle- shift ½ way from where we are now toward the slot.
2) Transition-Adjust existing by taking out the wall with vertical sill and keeping the second baffle but taking out the vertical sill to account for 257 low forebay.
3) 18" crowder with appropriate farings
4) Readjust energy throughout the system with vertical modified sills-high sills.

8. FB 268- High Sills Q=85 cfs, High Sills (modified settings) 2:00-3:15 pm

Changes:

18" Crowder was installed with farings.

High sill settings were modified to provide more even distribution of weir head and reduce the head drop at the upper most pools. The uppermost sills were lowered and the mid to bottom sills were raised.

Triangles moved to 1/3 of the distance to between slot opening and wall (closer to opening)

Several configurations evaluated at transition using pieces of plywood and lots of hands and feet to hold them in place.

Flow was more turbulent through 18" open Crowder and maximum 85 cfs—notably a standing wave against upstream fairing (where jet from vertical slot reflects off corner and impinges faring). However, no fatal flaws in flow through slot, and the vertical slide gate can be adjusted in field to reduce flow through slot.

Triangle position causes significant upwelling midway against north wall in middle weirs, works better for upper weirs where channel is narrower & was not an issue for d/s weirs.

At the exit transition, several configurations were tested by arranging pieces of plywood to more effectively channelize the approach to weir 23. The baffle or stub wall adjacent to the orifice was recognized to be part of the problem. When the dead space between the baffle and south wall was closed off with a small plywood strip, the vortices did not appear.

9. **FB 265.3 - High Sills Q=61.2 cfs, High Sills (modified) 3:30-4:00 pm**

   Pool short circuiting- pools 1-7 and not short circuiting- 8-23. Small wave through Crowder. Team worked on Forebay Exit Transition--> may increase the channel to 5' 8'' and shift it to align with the vertical slot hammer head. Checked some of the transition options to verify if there is a potentially workable one that still performed okay, which they did.

Table 1- Proposed Change in Weirs Slots to meet 5-feet depth criteria

	Slot Width (in)	
Weir No	**current**	**Proposed**
23	18	18
22	18	18
21	18	18
20	15	**18**
19	15	**18**
18	15	**18**
17	15	15
16	15	15
15	15	15
14	15	15

NOTES:
Weir 23 is most upstream weir
'Proposed' will raise center average depth
above 5' in all pools at MOP 257

Table 2- Revised High Sill settings

	Sill Height (ft)			Sill Height (ft)	
Weir	Previous	Revised	Weir	Previous	Revised
1	0.0	0.0	12	1.75	2.00
2	0.0	0.0	13	2.25	2.50
3	0.0	0.0	14	2.50	3.25
4	0.0	0.0	15	3.00	3.75
5	0.0	0.0	16	3.50	4.00
6	0.0	0.0	17	4.00	4.25
7	0.0	0.0	18	4.50	4.75
8	0.0	0.0	19	5.00	5.50
9	0.0	0.0	20	6.00	6.00
10	1.00	1.00	21	6.75	6.50
11	1.50	1.50	22	7.75	7.00
			23	8.50	7.50

MEMORANDUM TO THE FILES 1/31/2007

FROM: Stephen Schlenker, CENWP-EC-HD
Natalie Richards, CENWP-PM
Dave Clugston, CENWP-PM-E

SUBJECT: Trip Report for Nov 19-20, 2007 Agency Site Visit to ENSR 1:5 Physical Model of John Day North Fish Ladder Exit Section and Count Station .

1) ATTENDEES:

Corps of Engineers -Portland District

Natalie Richards, CENWP- PM, *Project PM*
Dave Clugston, CENWP-PM-E, *Biologist*
Jim Calnon, CENWP-EC-DM, *Mechanical Engineer*
Travis Adams, CENWP-EC-DS, *Structural Engineer*
Steve Schlenker, CENWP-EC-HD, *Hydraulic Engineer, Project TL*

Agency Visitors

Gary Fredericks, NOAA, *Biologist*
Ed Meyer, NOAA, *Hydraulic Engineer*

ENSR

Liza Roy, *Contractor Project Lead*
Justin Arnold, *Model PI*

2) SUMMARY TRIP RECORD:

Day 1	*11/19/2007*	*Corps of Engineers (PDT) & Agencies traveled to Redmond, WA.*			*AM*
	Pre-meeting with Liza Roy				
	*Viewed 1:5 JDAN Exist Section model with new exit transition, modified Count Station with **18**" Count Slot opening, and ladder head = 1 ft, No sills in weirs 1-9*				*PM*
		High Sills,	*Forebay 268' (max FB),*	*Flow = 85 cfs (max flow),*	
		High Sills,	*Forebay 265.2',*	*Flow = 61.2 cfs,*	*1230*
		Medium Sills,	*Forebay 267.4',*	*Flow = 85 cfs,*	
		Medium Sills,	*Forebay 264.8',*	*Flow = 65.4 cfs,*	*1525*
		Medium Sills,	*Forebay 262.5' (MIP),*	*Flow = 54 cfs,*	*1620*
Day 2	*11/20/2007*				
	*Viewed 1:5 JDAN Exist Section model with new exit transition, modified Count Station with **24**" Count Slot opening, and ladder head = 1 ft. <u>Added 12" sills in weirs 1-9</u>*				*AM*
		High Sills,	*Forebay 268' (max FB),*	*Flow = 81 cfs,*	*0915*
		Medium Sills,	*Forebay 262.5' (MIP),*	*Flow = 52.6 cfs,*	*1010*
		1-foot sills (all),	*Forebay 262.5' (MIP),*	*Flow = 67 cfs,*	
		1-foot sills,	*Forebay 257 (MOP),*	*Flow = 32.5 cfs,*	*1300*
		No sills,	*Forebay 257 (MOP),*	*Flow = 36 cfs,*	
		No sills,	*Forebay 262.5' (MIP),*	*Flow = 73.5 cfs*	*1430*
	Closeout Meetings with NOAA and ENSR				
	Visitors return to Portland				

3) ACTION ITEMS

- CENWP prepare trip report to document final design configuration
- ENSR investigate horizontal vanes for Count Slot intake
- ENSR start modification testing at No Sills and 1-foot sills
- CENWP provide ENSR modified Medium sill settings to replace High sill settings
- NOAA provide trip report for agency perspective
- CENWP prepare data for presentation for Jan 11 2008 FDRWG meeting

4) SUMMARY OF FINAL MODEL CHANGES FROM PREVIOUS AGENCY VISIT (8/13/2007)

1. Exit Transition (See Plate 2 in attachments at end of report)
    a. Remove existing baffle (east-most) with 2-foot opening slot and 2.5 foot sill. Baffle is the most upstream (east-most) with slot on south side.
    b. Modify remaining existing baffle with 2 foot slot
        i. Cut out 2.5 foot sill to match invert (EL 250.5 ft)
        ii. Move existing 8-inch vertical stub-wall upstream by 4.5 feet; the distance of the stub-wall downstream of the existing baffle will be reduced from an existing distance of 9 feet to 4.5 feet.
        iii. Add 18-inch X 18 inch orifice in bottom corner of baffle against south wall (opposite wall from existing vertical slot opening).
    c. Add (rounded) triangle to downstream corner of 45-degree transition on south side.
    d. Remove 8-inch baffle on upstream side of proposed weir 23 (most upstream of new weirs)
2. Weirs & Pools (See Plates 1, 3 & 4)
    a. North Baffles: Move triangle on north baffle 6-inches to the north (to make room for sill leaves & actuators)
    b. South Baffles: Move orifice back to JDAS location from flush with south sidewall to 4 feet CL from south sidewall for weirs 2-23 (Weir 1 orifice stays flush with wall).
    c. Add 1-foot sill with actuators for Weirs 2-9
    d. Widen slots for Weirs 18-20 from 15-inches to 18 inches, so that the six most upstream weirs (18-23) will have 18-inch slots. L shaped sills to be added to Weirs 18-20 for medium and high sill settings.
3. Count Station (See Plates 1, 5, 6, & 7)
    a. Add 12-inch wide strip (steel plate) for lamprey passage over Diffuser 16 along south sidewall to guide Lamprey orifice in weir 1.
    b. Raise Count station floor 1 foot to match invert (EL 243.0) at weir 1
        i. Horizontal grade runs from downstream end of weir 1 on upstream end to downstream end of count slot
        ii. Gradual slope from grade-break located at downstream end of count slot to match invert (~ EL 242 feet) at existing ladder weir 248.
    c. Transition Farings added to upstream and down stream end of count slot Crowder.
        i. Upstream end has 3-inch radius corner, downstream 6-inch radius corner.
        ii. Farings will have adjustable lengths in straight section for Crowder motion.
    d. Horizontal vanes (spaced 18" apart) added to upstream faring (ENSR refined design post trip—See Plate 7)

5) POST-TRIP CHANGES:

1. COE modified (raised) medium sill setting design to eliminate high sill settings; ENSR verified revised settings with lab tests.
2. ENSR refined horizontal vanes concept on upstream fairing of Crowder (Plate 7).
3. COE removed 1-foot sill actuator from Weir 1 with Agency concurrence.

6) SYNOPSIS

An Agency Model Trip was conducted November 19-20 2007 at ENSR Laboratory to establish the final design configuration of the John Day North Fish Ladder (JDAN) Exit Section & Count Station.

The visitors viewed the full range of Forebay levels (257 – 268) and sill settings (high, medium and 1-foot sills and no sills). Particular emphasis was placed on Forebay 262.5 or Minimum Irrigation Pool (MIP), replacing the historical median (264) as the normal operation.

The primary changes from the previous Agency trip (conducted 8/13-15, 2007) included:

Exit Transition – modify exiting downstream baffle and removed the upstream one (see item 1 in above list of changes). These changes were made to reduce head losses though the existing baffles at low Forebay levels, provide better Lamprey passage, and prevent vortexing upstream of weir 23.

Weir pools — moved triangle 6" north (2a above), moved orifices back to JDAS location (2 b), widened Weirs 18-20 (#2d). The orifices were moved away from the sidewall back to the standard location so that there would be more adequate energy dissipation of the orifice flow between pools.

Count Station – Lamprey strip over diffuser (3a), raised count station floor (3b), and count slot transition Farings (3c). These changes would provide more seamless surfaces and hydraulic conditions for both salmon and lamprey.

The above changes were accepted by both Agencies and PDT. Some additional refinements were made during the trip to alleviate concerns about vertical circulation at the upstream end of the Count Station slot and to provide more consistent flow patterns through the pools:

Weir Pools – Added 1 foot sills for weirs 2-9 for medium to high sill settings (2c) so that the flow patterns would not change between the pools upstream of weir 10 and downstream of weir 10. The upstream pools had a more structured flow pattern with the slot jet directed toward the northwest corner of the pool. The downstream (sill-less) pools had a more diffuse, variable flow pattern with short-circuiting.

Count Station – Horizontal slats were added at the upstream faring for the Crowder (3d) to prevent the vertical circulation at the upstream end of the Count Station Slot.

Post trip changes included a modification to raise the medium sill settings (to eliminate the previous high sill setting and avoid ending up with a cumbersome operation of four sill settings), the removal of the 1-foot sill in weir 1 (to prevent excessive head drop (> 1 foot) going into the Count Station pool), and ENSR's refinement of the horizontal slats concept for the Crowder. The final sill settings are the following (See also Table 6):

Sill Setting	Min FB	Max FB
High	261.5	268
Low (1')	257	265
No Sills	257	264

In summary, the COE and Agency participants agreed that the proposed modifications to the Exit Section and Count Station will augment and speed the Salmon and Lamprey passage. For forebay levels below 264, there will be three sill settings for which the field biologists can choose for preferred passage—thus offering greater flexibility in operation.

7) BACKGROUND

The Portland District is preparing a Design Document Report for the modification of the JDAN exit Section and Count Station. The purpose of the modifications is to improve salmon passage times (by eliminating fish jumping and delay), eliminate cases where fish double back through the Count Station, and improve Lamprey passage accessibility. Towards these ends, the COE has completed five model site visits to the ENSR model:

Date	Visitors	Purpose
July 5-6, 2007	PDT + one NMFS rep.	Model take-off (View JDAS modified Baseline (existing Count Station with JDAS weirs)
August 13-15, 2007	Agency & PDT	View JDAS-modified baseline and new JDAN Lamprey friendly weirs
October 23-24, 2007	PDT	View revisions in inlet transition, orifice relocation in weirs, & CS mods
November, 7-8, 2007	PDT	Revise inlet transition to eliminate vortex problems
November, 19-20, 2007	Agency & PDT	Regional approval and final adjustments (CS and Sills) as needed

During the first trip in July, the PDT viewed the John Day South (JDAS) modified baseline model. This included the Existing Count Station & Weir 249 (holey wall), the JDAS Weirs 1-23 inserted in the place of the actual existing weirs and the two existing Forebay transition baffles with 2.5-feet high sills. Model geometry corrections and adjustments were identified for the future agency trip. Ed Meyer, hydraulic engineer for National Marine Fisheries Service (NMFS), also attended the site visit.

During the August agency trip, the Agencies viewed the JDAS modified baseline system & the proposed Lamprey friendly system with Count Station improvements:

- Lamprey-friendly weirs based on JDAS design with rounded corners (4" radius) and orifice in sidewall
- Count Station with lowered ramps and weir 249 (holey wall) replace by Lamprey-friendly weir #1.

The visitors found that the Lamprey-friendly weirs showed promise but needed refinements. Ed Meyer also suggested raising the Count Station floor one foot to provide a more seamless invert surface through Count station slot up to the invert on weir 249 (or the new weir 1). After the August agency trip, the PDT & ENSR proceeded to implement revisions agreed upon during the August trip (see list in Synopsis). In addition, some geometry corrections (provided by Bob Cordie) were made in the Count Station to properly position the location of the Crowder.

In the October trip, most changes showed the improved hydraulic/biological improvements, however the narrowed streamlined transition to the forebay had vortex problems upstream of weir 23. The intent was to reduce the width to the Forebay in order to increase the outlet velocity from 0.8 ft/s to 2 ft/s and the reduce headloss upstream of weir 23 at low Forebay levels. After several unsatisfactory attempts to eliminate the vortexing problem, the PDT decided to return in November 7-8 to tackle the problem.

During the November 7-8 trip, the PDT refined the design of the narrow channel configuration to eliminate the vortexing. However the solution required some unorthodox geometry (fish moving through the orifice would exit through a short tunnel)—leaving an uncertainty about how the agencies might react to the solution. Given this, the PDT returned to the existing forebay transition baffles, modifying them by eliminating the 2.5-foot sills, removing the upstream baffle, and adding an orifice in the remaining baffle. Dave solved the primary vortex problem by moving the stub-wall 4.5 feet upstream and closer to the existing 2-foot slot opening. This prevented the tendency for reverse flow to occur along the face of the south (45˚) transition. The remaining minor vortexing was solved by disrupting lateral circulation with a rounded triangle on the downstream (south-west) corner of the same transition, and by removing the 8-inch baffle on the upstream face of weir 23. At the close of the PDT trip, the PDT had two feasible forebay transitions. The PDT decided to first show the Region the less radical alteration, the modifications of the existing forebay transition baffles, with the provision to show the more extensive modifications of the narrowed channel on the second day of the site visit.

During the same Nov 7-8 trip, the PDT also experimented with the location of the triangles on the back side of the north baffles of the new Lamprey weirs. Moving the triangle northward (about 2/3 of distance between slot opening and north wall) moved the jet deflection point (off the backside of the baffle) further north. This change caused the jet to be directed against the approximate midpoint (midway between weirs) of north sidewall, resulting in undesirable upwelling at the point of impact. The PDT shifted the triangles back to the south (or center towards the slots) as far as possible without interfering with the future sill actuators. At this location, the slot jet is directed primarily towards the NW corner of the pool – creating a longer travel distance for more effective energy dissipation and placing the inevitable upwelling in a more desirable downstream location.

8) EXIT SECTION CRITERIA:

Adult Salmon Criteria:

- The hydraulic drop per pool shall be between 0.5 and 1.0 feet in the exit channel section (0.2 feet of head drop is permitted under low Forebay conditions).
- Minimum pool depth is 5 feet.

- Ladder head should be 1.0 foot (± 0.1 feet). If the shad fish numbers exceed 5000 fish per day at the North Fishway Counting Station, then the ladder head should be raised to 1.3 feet (± 0.1 feet)[1].
- Channel velocities should be between 1.5 - 4 feet per second (ft/s), 2 ft/s optimum;
- Diffuser efflux velocities ≤ 0.5 feet/s.

Lamprey Criteria:

- 4–inches minimum radius rounding on all outside corners (> 180 degree in change in bearing in any surface) of fish passage openings—wherever weir opening is not flush with sidewall or orifice opening is not flush with floor.
- Ramping to raised orifices or along side wall to indented weirs may be needed to assure Lamprey or salmon passage.
- Diffuser gratings with maximum ¾ inch openings.

9) TESTING PROCEDURES:
ENSR set up the model conditions to meet the target Forebay level and discharge rate. After the target Forebay was reached, they would allow the model to settle for about 15 minutes. Then the visitors could view the entire model moving up from the Count Station, past the weirs and ultimately the forebay transition section. Most viewing took place on the north side of the model; however the viewers could also see the model from the other side, either from below or on a ladder or elevated platform. Liza, Justin and/or other ENSR staff were on hand to provide dye at requested locations. Natalie took photos of the dye. Sometimes, ENSR staff changed the Count Station slide gate opening to alter the flow conditions in the Count Station. ENSR would also insert structural changes at the request of a visitor and also offer solutions to perceived problems.

10) TEST OBSERVATIONS & DISCOURSE

<table>
<tr><td colspan="4">TEST OBSERVATIONS:</td></tr>
<tr><td colspan="2">Day 1</td><td>11/19/2007</td><td></td></tr>
<tr><td colspan="3">Viewed 1:5 JDAN Exist Section model with new exit transition, modified Count Station with 18” Count Slot opening, and ladder head = 1 ft, No sills in weirs 1-9</td><td>PM</td></tr>
<tr><td>Test 1</td><td>High Sills (no sills Weirs 1-9)</td><td>Forebay 268 (max FB)</td><td>Flow = 85 cfs (max flow)</td></tr>
<tr><td colspan="4">a. Both Ed & Gary noted some vertical circulation, or swirl, at the upstream end of the counting slot that might cause issues. Vertical circulation caused by stagnation point where vertical slot jet ultimately impacts the upstream CS fairing.
b. Ed noted difference in flow patterns between pools with and without sills.
c. Ed and Gary saw no problems with Exit Transition (i.e. ‘boring’).

SJS observations: Some testing of Slide gate behind picket lead at CS to alleviate potential circulation pattern at count slot intake. Opening gate more or less than the default 8 inches seemed to help.</td></tr>
</table>

[1] A combined exit channel flow and diffuser flow of 85 cfs is required for 1.0 ladder head; the combined exit and diffuser flow for 1.3 feet ladder head is 113 cfs.

a. 8″ open (current setting in field)- strongest swirl b. 12″ open – less swirl with less slot flow & reduced velocity (from 3.5 ft/s to 2 ft/s) through Count Slot; c. 4″ open – less swirl than 8″ with more slot flow and increased velocities (from 3.5 to 6 ft/s) through CS slot NAR observations: a. Transition- Dead zone north, orifice against south wall- Flow conditions- good- There were no concerns expressed about the Fish Exit section throughout the review. b. Pool 8 & 9 to pool 1- short circuiting c. Crowder- cork screw vortex as jet interacts with south east faring- Not a desirable condition, could affect doubling back- adjusted knife gate south of Crowder to 3 positions (4″, 8″ (original setting) and 12″ open) d. in which some improvement was noticed at 12″ i. Issues- velocity at picket lead ii. Running Shad with 1.3				
2	High Sills (no sills Weirs 1-9)	Forebay 265.2	Flow = 61.2 cfs	1230
Agencies had same observations as previous test. SJS: CS Slide gate was operated between 4″, 8″ and 12″: a. 4″ open – less swirl but tighter coil than in test 1 b. 8″ open (currently in field) - a bit more swirl, slower & wider. c. 12″ open – less swirl mostly near surface, probably best setting d. Pools 14-17 are sloshy –estimate 6″ oscillation prototype NAR Observations: a. Sloshy Pools 14-17 b. Pools 10-1 short circuiting c. Crowder- 8″- more cork screw at slower rate--> raise to 12″ helped				
3	Medium Sills (no sills Weirs 1-9)	Forebay 267.4	Flow = 85 cfs	
NAR Observations: a. Short Circuiting Pools 8 to 9 transition for sill to no sill b. May not need high sills c. No sloshing d. Like hydraulics with vertical slot SJS – generally good conditions				
4	Medium Sills (no sills Weirs 1-9)	Forebay 264.8	Flow = 65.4 cfs	1525
NAR Observations: a. Good Movement through the orifice at Exit Transition b. Cork screw at Crowder- think about a turning vane				
5	Medium Sills (no sills Weirs 1-9)	Forebay 262.5 (MIP)	Flow = 54 cfs	1620
NAR Observations: a. Looked at 8″ slide gate opening at Crowder				

<table>
<tr><td></td><td>Day 2</td><td colspan="2">11/20/2007</td><td></td></tr>
<tr><td colspan="4">Viewed 1:5 JDAN Exist Section model with new exit transition, modified Count Station with 24" Count Slot opening, and ladder head = 1 ft. <u>Added 12" sills in weirs 1-9</u></td><td>AM</td></tr>
<tr><td>6</td><td>High Sills (1' sills weirs 2-9)</td><td>Forebay 268 (max FB)</td><td>Flow = 81 cfs</td><td>0915</td></tr>
<tr><td colspan="5">Agencies noted more consistent pool hydraulics for pools 1-8 with 1' sills added.
ENSR installed projecting baffle from u/s faring to move stagnation point upstream and reduce vertical circulation at CS slot intake. It provided some improvement but vertical circulation still a concern. Jim suggested alternative idea with horizontal vanes.

NAR Observations:
a. 1' sill helps establish jet into corner
b. Still need to meet shad head = 1.3
c. 4" knife gate- some upwelling in corner- not good</td></tr>
<tr><td>7</td><td>Medium Sills (1' sills weirs 1-9)</td><td>Forebay 262.5 (MIP)</td><td>Flow = 52.6 cfs</td><td>1010</td></tr>
<tr><td colspan="5">ENSR installed horizontal vanes per Jim's suggestions on upstream faring for Count Slot. It eliminated vertical circulation (horizontal oscillations remain between slot intake and picket lead area, but not a concern). Agencies liked Jim's solution.

SJS- slightly sloshy pools 14-17

NAR Observations:
a. 1' sill help establish flow jet
b. Looked at knife gate at 12"
c. Fixed the cork screw vortex with a ladder with horizontal protrusions which do not extend into the Crowder and disrupted the upward vortex movement-->ENSR to refine shape and provide pictures of dye releases' to Dave--> FFDRWG
d. Fillet in the north corner at weir 249- possibly later</td></tr>
<tr><td>8</td><td>1-foot sills (all)</td><td>Forebay 262.5 (MIP)</td><td>Flow = 67 cfs</td><td></td></tr>
<tr><td colspan="5">NAR Observations:
a. Many short circuiting pools- 21-20, 20-19, 19-18, 18-17, 16-17, 15-16, 15-14
b. Looked at 8" knife gate with respect to the Crowder and ladder- good
SJS- short circuiting in pools 10-23, & 8.</td></tr>
<tr><td>9</td><td>1-foot sills</td><td>Forebay 257 (MOP)</td><td>Flow = 32.5 cfs</td><td>1300</td></tr>
<tr><td colspan="5">NAR Observations:
a. Short circuiting Pools 22-23, 21-21, 21-20, 19-20 to 17-18
b. No dye releases
c. Rest looked good
SJS: Very low flow in exit channel; condition is quiet & energy dissipation is not an issue</td></tr>
<tr><td>10</td><td>No sills</td><td>Forebay 257 (MOP)</td><td>Flow = 36 cfs</td><td></td></tr>
<tr><td colspan="5">NAR Observations:
a. Transient flow for pool 10-11, 12-13 all other short circuiting- not bad thing because it provides a path for fish to follow
b. Calm through count station
SJS: Low flow in exit channel; condition is quiet & energy dissipation is not an issue</td></tr>
</table>

11	No sills	Forebay 262.5' (MIP)	Flow = 73.5 cfs	1430
SJS and JC Observations: a. some short-circuiting seen in all pools, but conditions appear stable and favorable: a. pools hydraulics are consistent between pools b. Vertical slot jets are diffusing out of slot c. Energy is effectively dissipating with the diffusing (widening jets) d. Pool conditions look biologically favorable				

During the Test 1 with High Sills and 85 cfs exit discharge, the Agency representatives looked hard at the count station, the weir pools and the forebay transition. The following observations drove the agenda for primary areas of concern during the remainder of the trip:

1. At the intake of the Count slot, there a condition of vertical swirl. The Agency representatives were concerned this might be a location where salmon might hold. They have seen a tendency for salmon to hold at both ends of the count slots at other projects.
2. For the weir pools, Ed observed that there were distinctly different flows patterns between pools upstream and downstream of weir 9. Weirs 10-23 had sills of various heights; Weirs 1-9 did not have sills. For salmon progressing up the exit channel, the distinct change in the hydraulic conditions between the pools represents a potential impediment or cause of delay to salmon passage.
3. The Agency representatives saw no issues with the Forebay transition.

a) Resolution of Problem 1 – Vertical swirl in Count Station Intake

The swirl condition (See Photo 1 and Photo 2) at the Count Slot intakes was generated by a standing wave, or stagnation point, against the upstream faring. The vertical slot jet from Weir 1 rides along the north wall of the upper Count Station pool, around the 45 degree wall bend, and into the count slot. The volume of flow from the vertical slot, which will grow with flow entrainment, may be more or less than the flow through the Count Slot and will depend on diffuser flow. With an 18-inch opening in the Count Slot and the maximum exit channel discharge 85 cfs, not all of the approach flow from the vertical slot will enter the count slot. A significant percentage will wrap around the upstream fairing into trashrack area. With the inevitable fluctuations in the standing wave at the u/s faring, there will also be changes in horizontal flow directions along the face of the faring, pulsing back and forth between Count Slot and back towards the trashrack.

The group tried altering the slide gate opening. The slide gate controls the flow through the picket lead and trashrack, and by doing this, determines the residual discharge through Count Slot. The existing setting (measured in the field) was 8". The group tried varying the opening 4" in each direction:

- 8" Slide Gate opening results in about 3.5 ft/s in Count Slot (at 85 cfs ladder flow)
- 4" Slide Gate opening results in about 6 ft/s in Count Slot (at 85 cfs ladder flow)
- 12" Slide Gate opening results in about 2 ft/s in Count Slot (at 85 cfs ladder flow)

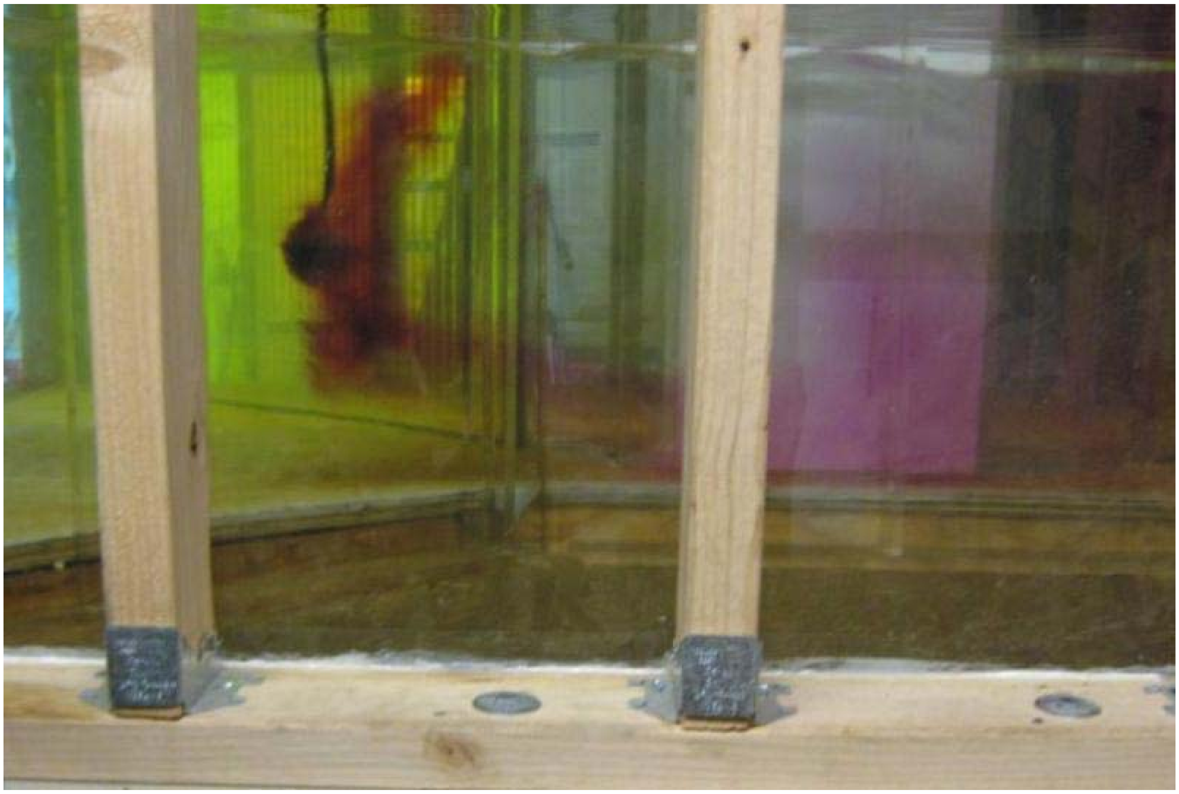


Photo 1 – Circulating dye on Upstream Faring without Flow Vanes (NAR photo 11/20/07)

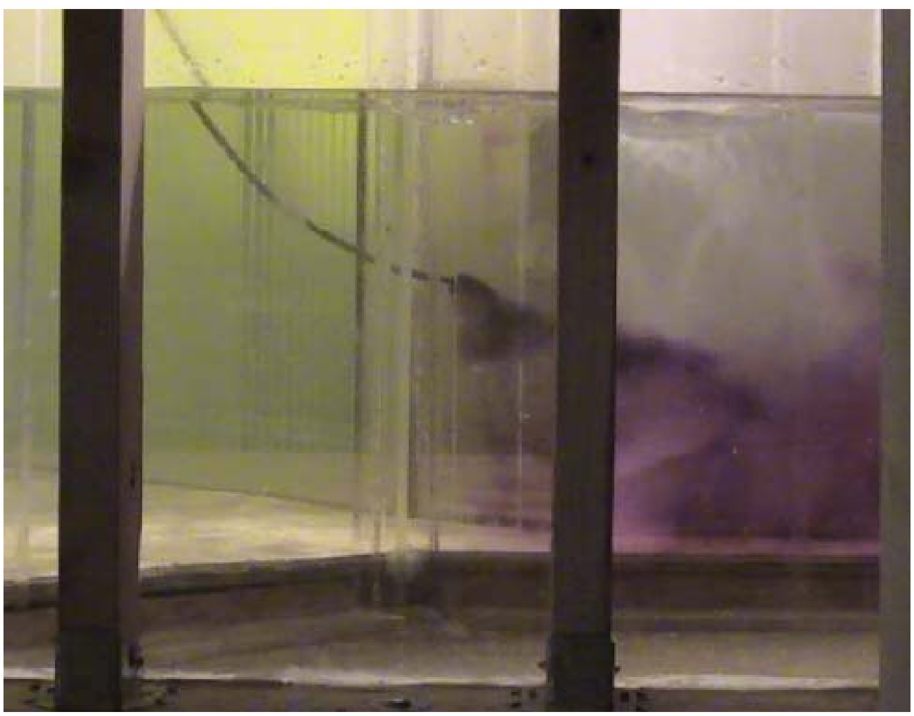


Photo 2 – Circulating dye on Upstream Faring without Flow Vanes (Excerpt from ENSR memo on JDAN Ladder Crowder Vane Update, Dec11 2008)

The 8" opening seemed to create the worst conditions of swirl (unfortunately, this opening provides the normal or optimum velocity through the slot: 3 – 3.5 ft/s). The 4" opening, while increasing slot velocity, seemed to improve the swirl but creates a tighter, smaller coil. The 12" setting reduced the swirl and slot velocity, probably the best setting (Velocities will also need to be checked to make sure the velocities through the picket lead do not exceed 1 ft/s, per NMFS criteria). Dave, Gary & Ed suggested that the Fish Field Unit explore gate openings in field to see how salmon respond. The swirl issue did not change much as the exit flows were reduced during subsequent tests during Day 1.

Returning to the Count Slot on Day 2, the slot was widened to 24 inches and it was anticipated that the swirl problem would diminish. This was not the case. The group decided that simply adjusting the slide gate was insufficient. One idea was an upstream projecting vertical plate attached to the upstream faring to move the stagnation point away form the slot intake. Several versions were tried with shorted members (12") attached at either end of the faring. None of the 12" extension did much. A longer extension (24 - 36 Inches) was attached on the north end of the faring, flush with the south sidewall of the slot, was tried with more success—at moving the swirl more upstream and more out of the slot intake. It probably did more to reduce the lateral pulsing, which was not a concern. (Dave thought the upstream end of this device might be attached a pivot post to make it more structurally sound.) However, this alternative was not satisfactory as far as mitigating the vertical swirl. Jim suggested a horizontal vane solution. The vanes would be attached to the upstream faring and would work to suppress the vertical circulation. ENSR rapidly fabricated & installed some rectangular pieces to simulate the design. Both Gary & Ed found this to be an effective solution that eliminated the vertical swirl (See Photo 3 and Plate 7). They specified criteria to meet in the final design to which ENSR could develop the design after the trip (completed and documented in ENSR Memo on JDAN Ladder Crowder Vane Update, Dec11 2008).

Photo 3 – Dye on Upstream Faring with Recommended Flow Vane Design (Excerpt from ENSR memo on JDAN Ladder Crowder Vane Update, Dec11 2008)

b) Resolution to Problem 2 –Difference in Pool Hydraulics

For the pools with the sills, the flow patterns were more structured such that the vertical slot jet was consistently directed toward the NW corner (see left pool between Weirs 9 & 10 in Figure 1). The presence of the bottom sill helps concentrate the flow to pass directly over (or normal to the axis of) the weir. This usually results in a more concentrated and consistent jet pattern that is desirable from an energy dissipation perspective.

For pool without the sills, the flow pattern is characterized by short-circuiting between vertical slots (see right pool between Weirs 8 & 9 in Figure 1). Short-circuiting is an issue inherited from the previous John Day South Exit Study conducted at NHC lab in 2001. It was considered an indicator of insufficient energy dissipation. Energy dissipation became a major concern, when they encountered ladder instability in the form of heavy seiching in the first tests at NHC lab. However with the Lamprey weir study, there are plenty of cases of short-circuiting but little or no evidence of ladder instability. One reason that short-circuiting does not appear to problem in the Lamprey friendly weirs is likely the diffusive nature of the vertical jet discharge. Because of the rounded corners around the opening of the slot, the outlet jet through the slot is not contracted, less concentrated and more flaring with radial distance from the slot. Natalie diligently noted locations of short-circuiting during most tests. Both Gary and Steve doubt the short-circuiting is a biological problem as long as the system does not become unstable. However, the change in hydraulic conditions between pools with and without sills does represent a risk that merits concern.

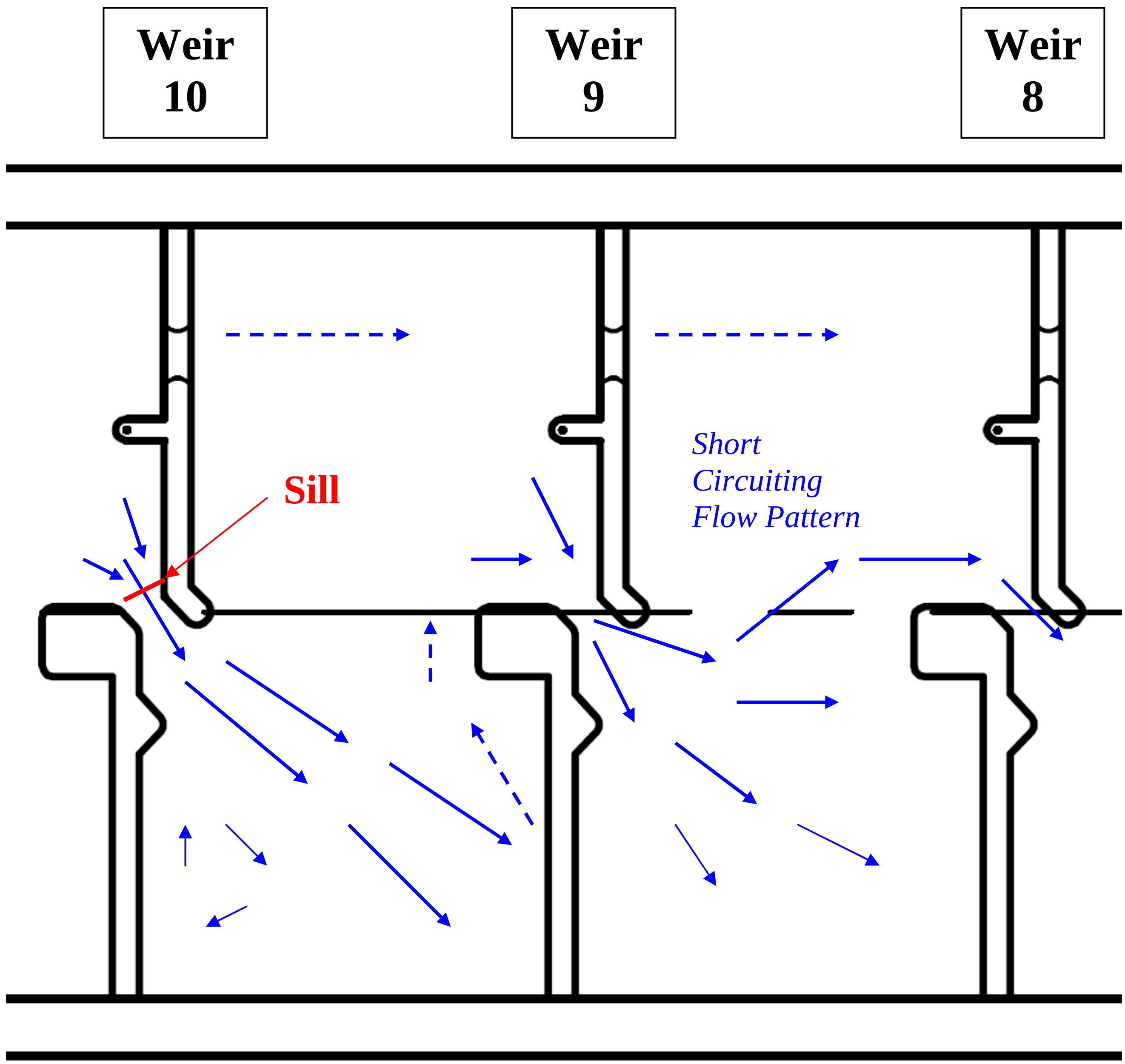


Figure 1 - Comparison of Pool Flow Patterns With Sill and Without Sill in Upstream Weir

To address the issue of different pool hydraulics, Ed proposed a solution to include low sills (12 inches high) for the remainder of the weirs that previously did not have sills: Weirs 1-9. Initially, the group talked about trying 3-inch sills, but ultimately reasoned they probably wouldn't be sufficient. Since some members of the group were uncertain about the hydraulics of no sill conditions, there was considerable discussion about making the 1-foot sills permanent. Steve & Natalie pressed for leaving No Sills as an operational option since the exit flow rate would be about 7 cfs higher at MOP and there would be fewer low Forebay conditions where shad flow requirements (~113 cfs) couldn't be met by the combination of available diffuser flow and exit channel flow. Also several, including

Gary, thought that the observed flow pattern with pools without sills was not necessarily a problem for fish passage, only the change in pool hydraulics part way up. Ultimately, the group decided put actuators on all 1 foot sills.

After Day 1, 12-inch sills were placed in Weirs 1-9 by ENSR overnight. The results on Day 2 were more consistent pool hydraulics all the way down for the Medium and High sill settings. Since some members of the group were ambivalent about the hydraulics of the No sill conditions, a setting for 1-foot sills down the entire ladder was created as an Operational Alternative to No Sills. Steve did not want to eliminate the No Sills operation as it offered better operational capability of handling shad ladder flows at minimum forebay levels. Dave liked the option of having better Lamprey passage with flush inverts through both orifice and slot at low forebay levels. When the No Sill setting was run in Tests 10 & 11, the group (sans Gary who had to leave before the last test) found that, while there were different hydraulic conditions and elements of short circuiting; the No Sill operation appeared stable, consistent between pools and acceptable biologically.

This left four possible sill settings (No Sill, 1-foot Sills, Medium sills, & High Sills) or three sill leaves for all weirs upstream of Weir 9. Jim, Travis & Natalie were concerned about such a prospect, but Jim thought he could make it work (with difficulty). Liza, Natalie & Steve revisited the fact that FB level was up to 267.4 feet in Test 3 (85 cfs) at the Medium Sills (without 1-foot sills in Weirs 1-9). With the addition of 1-foot sills, the FB would go even higher at 85 cfs. They agreed to evaluate the possibility of raising the medium sill sufficiently to handle max FB 268 at 85 cfs and thereby eliminate an extra setting. EC-HD would incorporate the latest ENSR coefficients into the EC-HD 1-D model to best estimate the new sill settings and ENSR would test during the modification tests. The ENSR tests ultimately proved out and the final number of settings was reduced back to three (No Sills, 1-Foot Sills, and High Sills) with two sill leaves for weirs upstream of Weir 9.

After the trip, there arose some question whether or not to have a sill in Weir 1. The differences in count station pool hydraulics were subtle. Steve & Liza advocated for keeping it out since a sill would create excessive head differences across Weir 1. The ENSR data proved that the head drop would be excessive (1.2 -1.4 feet), but when the sill was remove the head drop at Weir 1 fell back within criteria (<1 foot). Steve coordinated the removal of the sill from Weir 1 with Dave & Ed. (See section 12) for sill settings (Table 4 and Table 5) applied during the tests and Table 6 for the final settings; See also Section 13) on Exit and Sill Operations.)

11) POST TRIP TESTING

a) Modification Tests

After this trip, ENSR performed modification tests to verify the sill settings, water surface elevations, head drops across the weirs. This was done to develop/finalize the high sill settings and to determine the range of Forebay levels and discharge rates for all three settings. The water surface level, depth and head drop data from the above listed tests are listed in Attachment 2 of the Appendix. One of the results from these tests was the removal of the 1-foot sill in Weir 1, since the tests showed that the head drop (going into the Count Station pool) would exceed head criteria unless the sill were removed from Weir 1.

Table 1 – ENSR Modification Tests

ENSR MODIFICATION TESTS			
Forebay	Ladder Head	Sill Setting	Est. Flow Rates
257	1	No Sills	38.2
264	1	No Sills	85
257	1	1' Sills	31.8
264.6	1	1' Sills	85
261	1	High Sills	36
268	1	High Sills	85

The detailed data from the ENSR modifications test is presented in Attachment 2 at the end of the report.

b) Documentation Tests

ENSR will also perform documentation tests of selected forebay/flow conditions. These tests will include photo documentation of the dye releases in pool between 7 and 8 and in the Count Station. Velocities will be recorded in 30 locations in each of those two pools. The water surface elevation for all pools will also be recorded. The following table contains the documentation test conditions (Forebay, Exit channel discharge and sill setting):

Table 2 – ENSR Documentation Tests

ENSR DOCUMENTATION TESTS 12/2007			
Forebay	Ladder Head	Sill Setting	Est. Flow Rates
257	1.3	No Sills	38.2
262.5	1	No Sills	72.2
262.5	1	1' Sills	68.1
262.5	1	High Sills	45.8
262.5	1.3	High Sills	45.7
268	1	High Sills	85
261	1	High Sills	36
268	1	High Sills	85

c) Insurance Tests

ENSR will perform Insurance tests for 1-foot increments of forebay levels within the proposed operating range of each sill setting. The purpose of these tests is to verify there are no particular conditions of hydraulic stability within the ranges of operations. ENSR will collect standard water level data for all pools and time series data in Pools 8 (between Weirs 8 & 9) and Pool 16. The time series data will be collected to determine if these are any indications of excessive sloshing or long period waves in the system. The time series data will be collected two places in the pool: middle and NW corner (where vertical slot jet meets the north sidewall).

Table 3 – Insurance Tests

ENSR INSURANCE TESTS JAN-FEB/2008

No Sills		1' Sills		High Sills	
Forebay (ft)	**Flow Rates (cfs)**	**Forebay (ft)**	**Flow Rates (cfs)**	**Forebay**	**Est. Flow Rates**
257	38.4	257	31.8		
258	44.3	258	37.7		
259	50.8	259	44.0		
260	57.2	260	50.5		
261	63.7	261	57.8	261	33.4
262	70.4	262	65.0	262	39.6
262.5	73.8	262.5	68.8	262.5	42.9
263	77.2	263	72.8	263	46.2
264	84.1	264	81.4	264	53.1
		265	89.0	265	60.4
				266	68.0
				267	76.0
				268	85.0

Ladder head = 1 foot in all tests

12) SILL SETTINGS AND WEIR SLOT OPENING WIDTHS

a) Sill Settings Viewed During Agency Site Visit (Changed After Trip)

The Preliminary sill settings viewed during the site visit were the settings shown in Table 4. These were the High and Medium settings viewed during Day 1. (Note that both settings have no sills in Weirs 1-9.) The slots had been widened from 15-inches to 18-inches in Weirs 18-20 to reduce system headlosses and maintain 5 feet pool depths in MOP (FB 257) operations.

After Day 1, 12-inch sills were placed in Weirs 1-9 to provide more consistent pool hydraulics all the way down. Since some of the Agency persons were uncertain about the hydraulic of the No sill conditions, a setting for 1-foot sills down the entire ladder was created as an Operational Alternative to No Sills. The settings viewed during Day 2 are shown in Table 5 . Note that the high and medium settings have 1-foot sills for Weirs 2-8. Also note that there are four settings. There also was some question whether or not to have a sill in Weir 1. The differences in count station pool hydraulics were subtle. Steve & Liza advocated for keeping it out since it would create excessive head differences across Weir 1.

Table 4 – Sill Settings During Day 1 Agency Site Visit (Nov 19 2007)

JDAN SETTINGs - 11/19/07

Weir	No Sills (FB <264 ft)		Medium Setting (262.3 -266.7 ft)		HIGH Sills (265.2 - 268 ft)		Number of Sill Operating Controls
	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	
1	1.50	0	1.50	0.00	1.50	0.00	none
2	1.50	0.00	1.50	0.00	1.50	0.00	none
3	1.50	0.00	1.50	0.00	1.50	0.00	none
4	1.25	0.00	1.25	0.00	1.25	0.00	none
5	1.25	0.00	1.25	0.00	1.25	0.00	none
6	1.25	0.00	1.25	0.00	1.25	0.00	none
7	1.25	0.00	1.25	0.00	1.25	0.00	none
8	1.25	0.00	1.25	0.00	1.25	0.00	none
9	1.25	0.00	1.25	0.00	1.25	0.00	none
10	1.25	0.00	1.25	1.00	1.25	1.00	one
11	1.25	0.00	1.25	1.25	1.25	1.50	two
12	1.25	0.00	1.25	1.50	1.25	2.00	two
13	1.25	0.00	1.25	1.75	1.25	2.50	two
14	1.25	0.00	1.25	2.00	1.25	3.25	two
15	1.25	0.00	1.25	2.25	1.25	3.75	two
16	1.25	0.00	1.25	2.50	1.25	4.00	two
17	1.25	0.00	1.25	2.75	1.25	4.25	two
18	1.50	0.00	1.25	3.00	1.25	4.75	two
19	1.50	0.00	1.25	3.25	1.25	5.50	two
20	1.50	0.00	1.25	4.00	1.25	6.00	two
21	1.50	0.00	1.25	4.50	1.25	6.50	two
22	1.50	0.00	1.25	5.25	1.25	7.00	two
23	1.50	0.00	1.25	5.75	1.25	7.50	two

1.5-foot vertical slots are narrowed by 3 inches by Medium Sills at Weirs 18-23

Table 5 - Sill Settings at During Day 2 of Agency Site Visit (Nov 20 2007)

JDAN SETTING 11/20/07

Weir	No Sills (FB <264 ft)		Low Sills (1') (FB <264.6 ft)		Medium Setting (262.3 -266.7 ft)		HIGH Sills (265.2 - 268 ft)		Number of Sill Operating Controls
	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	
1	1.50	0	1.50	0	1.50	0.00	1.50	0.00	none
2	1.50	0.00	1.50	1.00	1.50	1.00	1.50	1.00	one
3	1.50	0.00	1.50	1.00	1.50	1.00	1.50	1.00	one
4	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
5	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
6	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
7	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
8	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
9	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
10	1.25	0.00	1.25	1.00	1.25	1.00	1.25	1.00	one
11	1.25	0.00	1.25	1.00	1.25	1.25	1.25	1.50	three
12	1.25	0.00	1.25	1.00	1.25	1.50	1.25	2.00	three
13	1.25	0.00	1.25	1.00	1.25	1.75	1.25	2.50	three
14	1.25	0.00	1.25	1.00	1.25	2.00	1.25	3.25	three
15	1.25	0.00	1.25	1.00	1.25	2.25	1.25	3.75	three
16	1.25	0.00	1.25	1.00	1.25	2.50	1.25	4.00	three
17	1.25	0.00	1.25	1.00	1.25	2.75	1.25	4.25	three
18	1.50	0.00	1.50	1.00	1.25	3.00	1.25	4.75	three
19	1.50	0.00	1.50	1.00	1.25	3.25	1.25	5.50	three
20	1.50	0.00	1.50	1.00	1.25	4.00	1.25	6.00	three
21	1.50	0.00	1.50	1.00	1.25	4.50	1.25	6.50	three
22	1.50	0.00	1.50	1.00	1.25	5.25	1.25	7.00	three
23	1.50	0.00	1.50	1.00	1.25	5.75	1.25	7.50	three

1.5-foot vertical slots are narrowed by 3 inches by Medium Sills at Weirs 18-23

changed from pre-trip

b) Final Sill Settings

After the site visit, the Medium and High settings were merged into one sill setting. This was done since it became apparent that the Medium setting (with the 1' sills added) was nearly capable of handling the maximum Forebay 268 at max flow 85 cfs (At this flow, the forebay at Medium Sills was 267.3 feet). This provided an opportunity to eliminate a setting to avoid the prospect of four sill settings, or three sill operations, which would represent an extremely cumbersome design to the PDT.

ENSR data were incorporated into the EC-HD 1-D model of the exit section to determine the settings. After the COE provided ENSR the new settings, ENSR verified them in their modifications tests to assure that the new settings would limit the discharge to 85 cfs at Maximum Forebay 268 and assure that the pool heads were at or under 1 foot. When the results came back with a head drop across Weir 1 of 1.2 -1.4 feet, Liza and Steve decided it was best to remove the sill at Weir 1. When that was done, the head drop fell to 0.85 feet in the model. Steve coordinated the removal of the sill from Weir 1 with Dave & Ed.

The final sill settings (based on COE and ENSR work completed after the trip) and weir slot opening widths are shown in the following in Table 6.

Table 6—Final Sill Settings (Dec 21 2008)

JDAN Settings 12/21/08

Weir	No Sills (FB <264 ft)		Low Sills (1') (FB <264.6 ft)		HIGH Sills (FB: 261-268 ft)		Number of Sill Operating Controls
	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	Slot Width (ft)	Sill Height (ft)	
1	1.50	0	1.50	0	1.50	0	none
2	1.50	0	1.50	1.00	1.50	1.00	one
3	1.50	0	1.50	1.00	1.50	1.00	one
4	1.25	0	1.25	1.00	1.25	1.00	one
5	1.25	0	1.25	1.00	1.25	1.00	one
6	1.25	0	1.25	1.00	1.25	1.00	one
7	1.25	0	1.25	1.00	1.25	1.00	one
8	1.25	0	1.25	1.00	1.25	1.00	one
9	1.25	0	1.25	1.00	1.25	1.75	two
10	1.25	0	1.25	1.00	1.25	2.25	two
11	1.25	0	1.25	1.00	1.25	2.50	two
12	1.25	0	1.25	1.00	1.25	2.75	two
13	1.25	0	1.25	1.00	1.25	3.00	two
14	1.25	0	1.25	1.00	1.25	3.25	two
15	1.25	0	1.25	1.00	1.25	3.50	two
16	1.25	0	1.25	1.00	1.25	3.75	two
17	1.25	0	1.25	1.00	1.25	4.00	two
18	1.50	0	1.50	1.00	1.25	4.25	two
19	1.50	0	1.50	1.00	1.25	4.75	two
20	1.50	0	1.50	1.00	1.25	5.25	two
21	1.50	0	1.50	1.00	1.25	5.50	two
22	1.50	0	1.50	1.00	1.25	5.75	two
23	1.50	0	1.50	1.00	1.25	6.00	two

1.5-foot vertical slots are narrowed by 3 inches by High Sills at Weirs 18-23

13) EXIT CHANNEL & SILL OPERATION

The new sill setting arrangement offers three different setting choices at MIP 262.5, and two choices at MOP 257. If shad flow (ladder head = 1.3 feet, Ladder Q = 123 cfs) occurs at low forebay then the No Sill operation may be best to handle low Forebay conditions.

The following figure shows the rating curves for exit channel discharge rates versus forebay elevation for each sill setting.

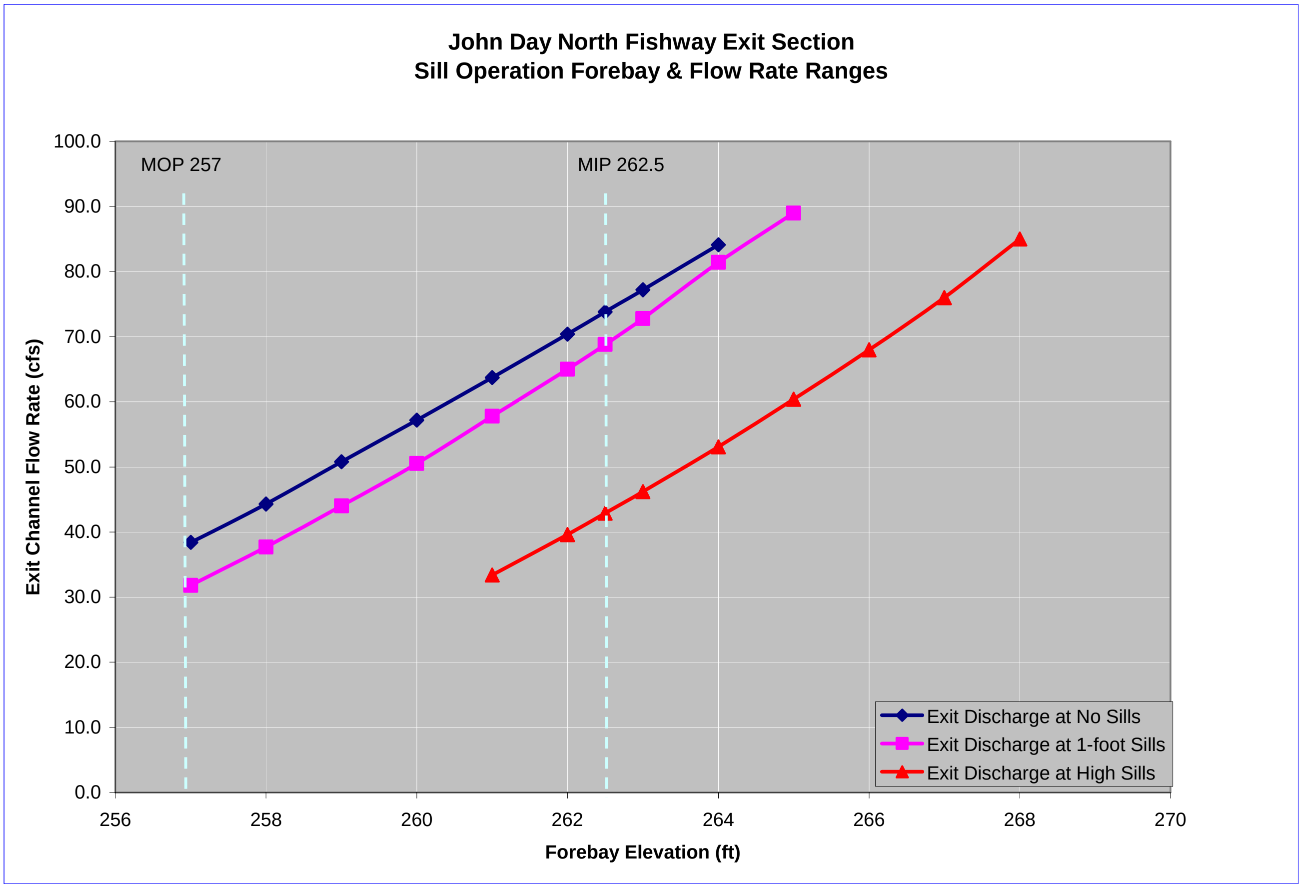


Figure 2 – Discharge Rate Versus Forebay Elevation for Each Sill Operation

The following table contains the maximum and minimum Forebay and discharge rate for each sill setting. Included with the table is the maximum ladder head (up to the target 1.3 feet for shad) that is possible for the minimum operating forebay for the given sill setting. At shad flow ladder head (1.3 feet), the total ladder flow must be 113 cfs and the diffuser 16 must be able to supply the difference between 113 cfs and the exit channel (Figure 2). The shad flow deficit—the extra flow that is needed to reach shad ladder head 1.3 feet—is also listed for the minimum operating Forebay at the given sill setting.

Table 7 – Sill Operation Ranges and Ladder Performance at Minimum Operation for each Sill Setting

Sill Operation Ranges					Ladder Performance at Min Forebay for Setting	
Sill Setting	Min Forebay (ft)	Min Exit Discharge (cfs)	Max Forebay (ft)	Max Exit Discharge (cfs)	Max Ladder Head (ft)	Shad Flow Deficit (cfs)
No Sills	257	38.2	264.1	85	1.2	9.9
1' Sills	257	31.8	264.5	85	1.13	16.5
High Sills	261	33.4	268	85	1.3	0

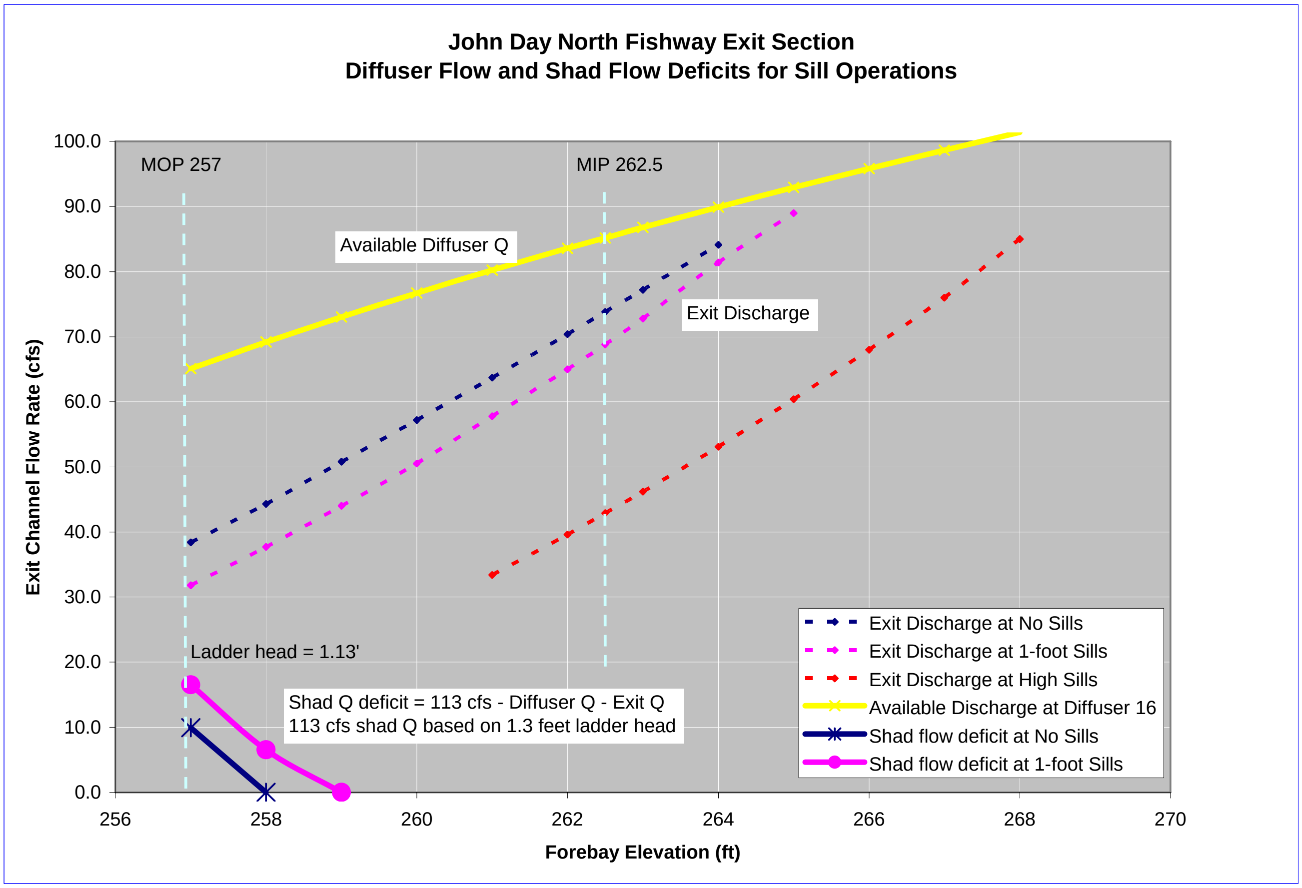


Figure 3 – Estimated Available Diffuser Flow and Shad Ladder Flow Deficit for Each Sill Setting

14) CLOSEOUT MEETING

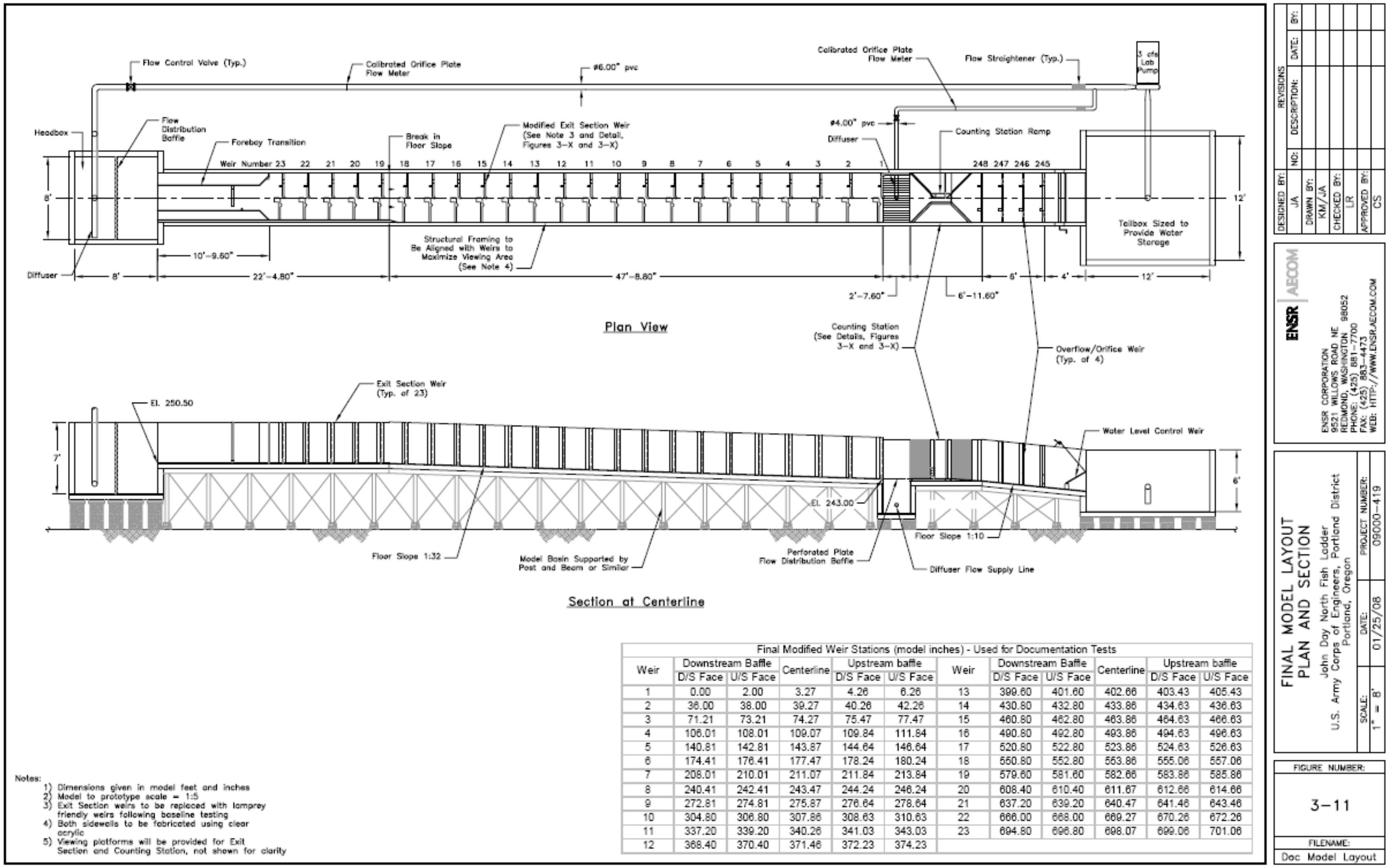
The Agency representatives found the final configuration of the proposed Exit Section and Count Station acceptable. The last concern—the vertical circulation at the intake of the Count Slot—was effectively mitigated by the horizontal vanes in one of the last tests. Criteria were established: the vanes shall not protrude into the opening of the slot and the vanes must have rounded edges. ENSR was tasked with developing a refined design. The Region would accept the ENSR findings and recommendations, assuming the criteria were met. The visitors also agreed that the new 1-foot sills in Weirs 2-9 shall have actuators to allow the possibility of a No-Sill Operation at lower Forebay elevations.

Natalie (PM) & Steve (EC-HD) and Liza (ENSR) worked out details of remaining tests and High Sill setting modifications.

15) CONCLUSION & RECOMENDATIONS

The proposed configuration developed in this model study is ready move forward into DDR design. The proposed system will provide improved passage for both Salmon and Lamprey, plus provide operational flexibility—particularly at Minimum Irrigation Pool (MIP) 262.5 feet) and lower Forebay levels.

ATTACHMENT 1: Final Configuration of John Day North Fish Ladder (Plates 1-7)



Final Modified Weir Stations (model inches) - Used for Documentation Tests

Weir	Downstream Baffle		Centerline	Upstream baffle		Weir	Downstream Baffle		Centerline	Upstream baffle	
	D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face		D/S Face	U/S Face
1	0.00	2.00	3.27	4.26	6.26	13	399.60	401.60	402.66	403.43	405.43
2	36.00	38.00	39.27	40.26	42.26	14	430.80	432.80	433.86	434.63	436.63
3	71.21	73.21	74.27	75.47	77.47	15	460.80	462.80	463.86	464.63	466.63
4	106.01	108.01	109.07	109.84	111.84	16	490.80	492.80	493.86	494.63	496.63
5	140.81	142.81	143.87	144.64	146.64	17	520.80	522.80	523.86	524.63	526.63
6	174.41	176.41	177.47	178.24	180.24	18	550.80	552.80	553.86	555.06	557.06
7	208.01	210.01	211.07	211.84	213.84	19	579.60	581.60	582.66	583.86	585.86
8	240.41	242.41	243.47	244.24	246.24	20	608.40	610.40	611.67	612.66	614.66
9	272.81	274.81	275.87	276.64	278.64	21	637.20	639.20	640.47	641.46	643.46
10	304.80	306.80	307.86	308.63	310.63	22	666.00	668.00	669.27	670.26	672.26
11	337.20	339.20	340.26	341.03	343.03	23	694.80	696.80	698.07	699.06	701.06
12	368.40	370.40	371.46	372.23	374.23						

Plate 1 – Plan and Profile of John Day North Fishway Exist Section and Count Station 1:5 Model; ENSR Drawing 3-11

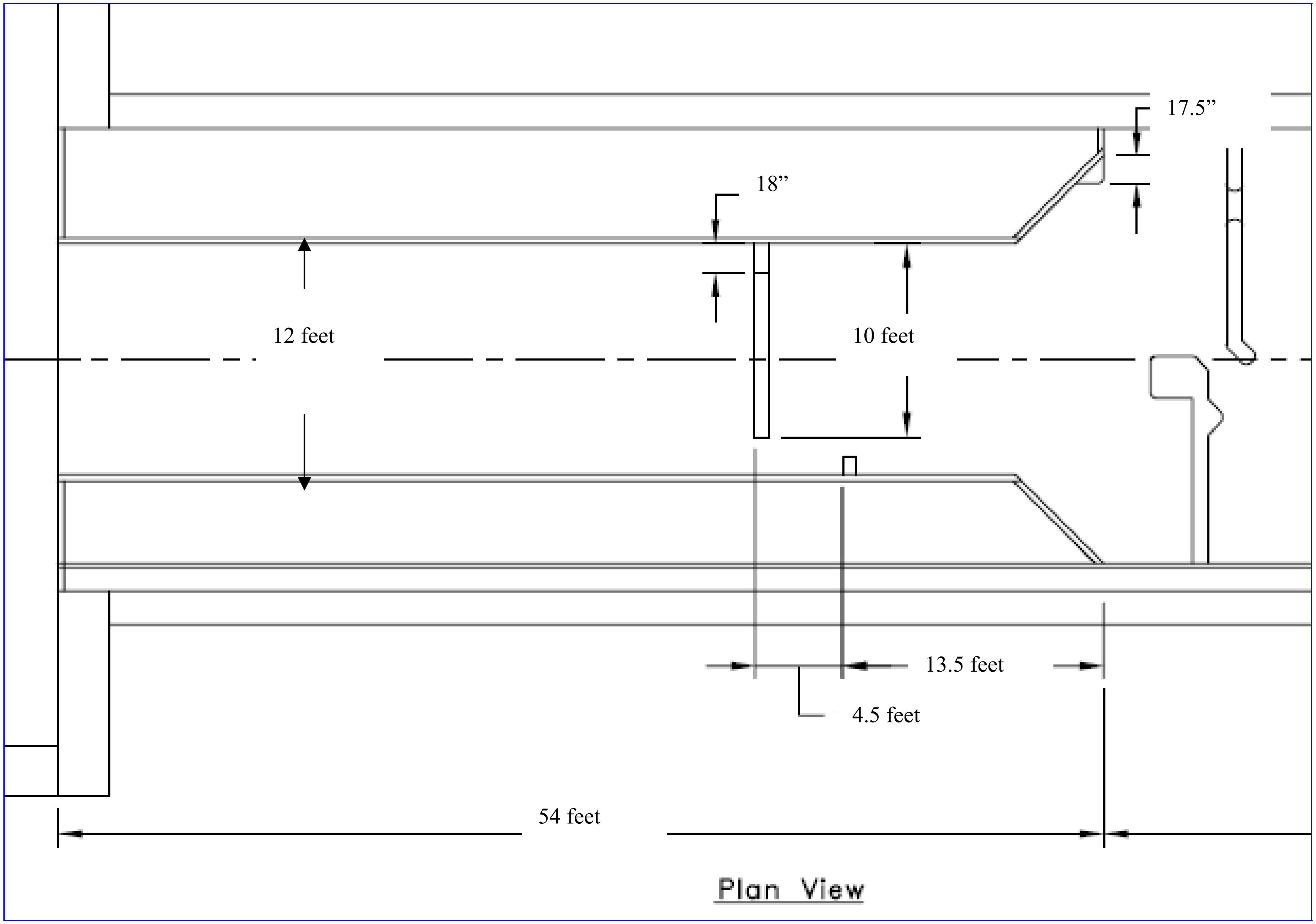


Plate 2 – Exit Transition- Plan View --excerpt from model drawing provided by ENSR, modified to include prototype dimensions

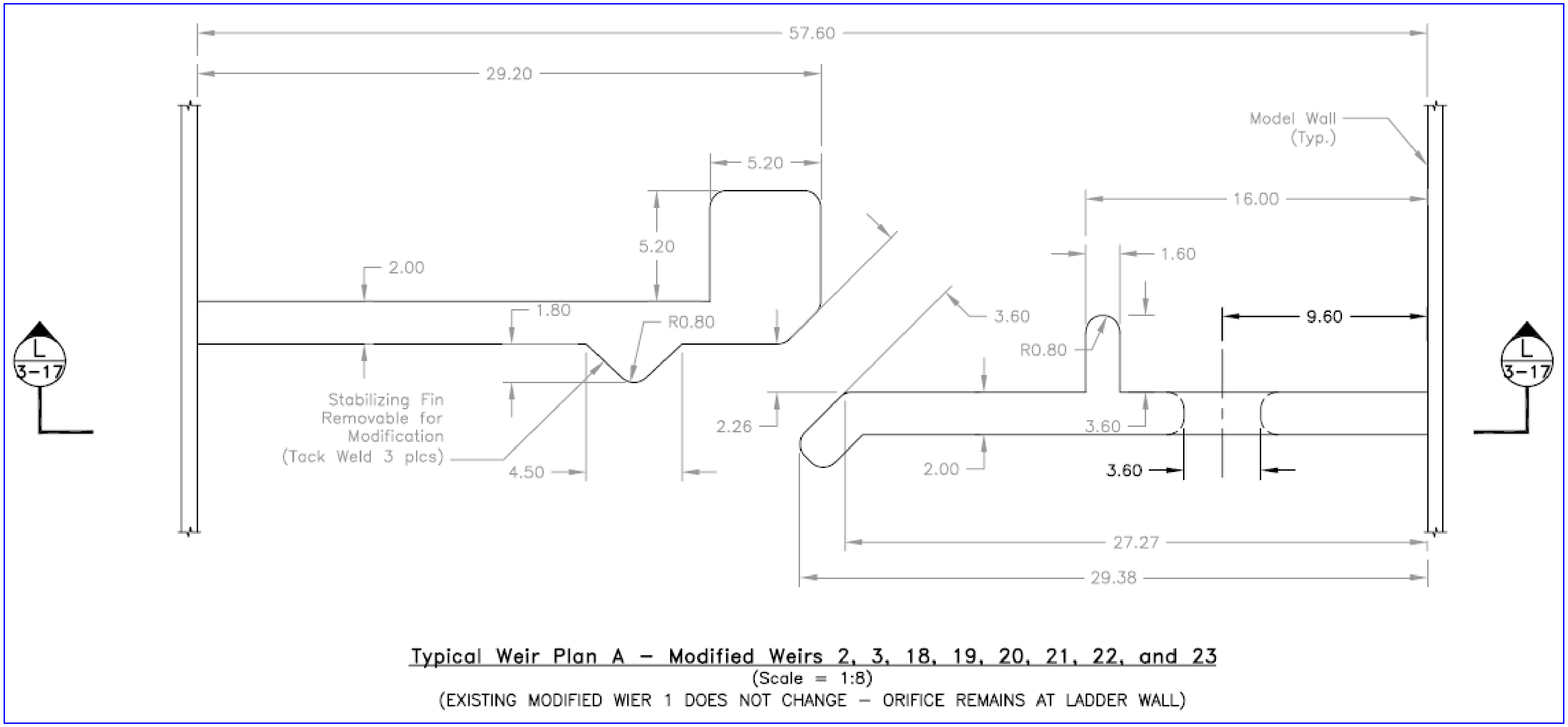


Plate 3 – 18-inch Weir Configuration, Plan View (Weirs 2, 3, 18 -23) —Excerpt from Model Drawing 3-16 provided by ENSR (Inches Model Scale: 1:5),

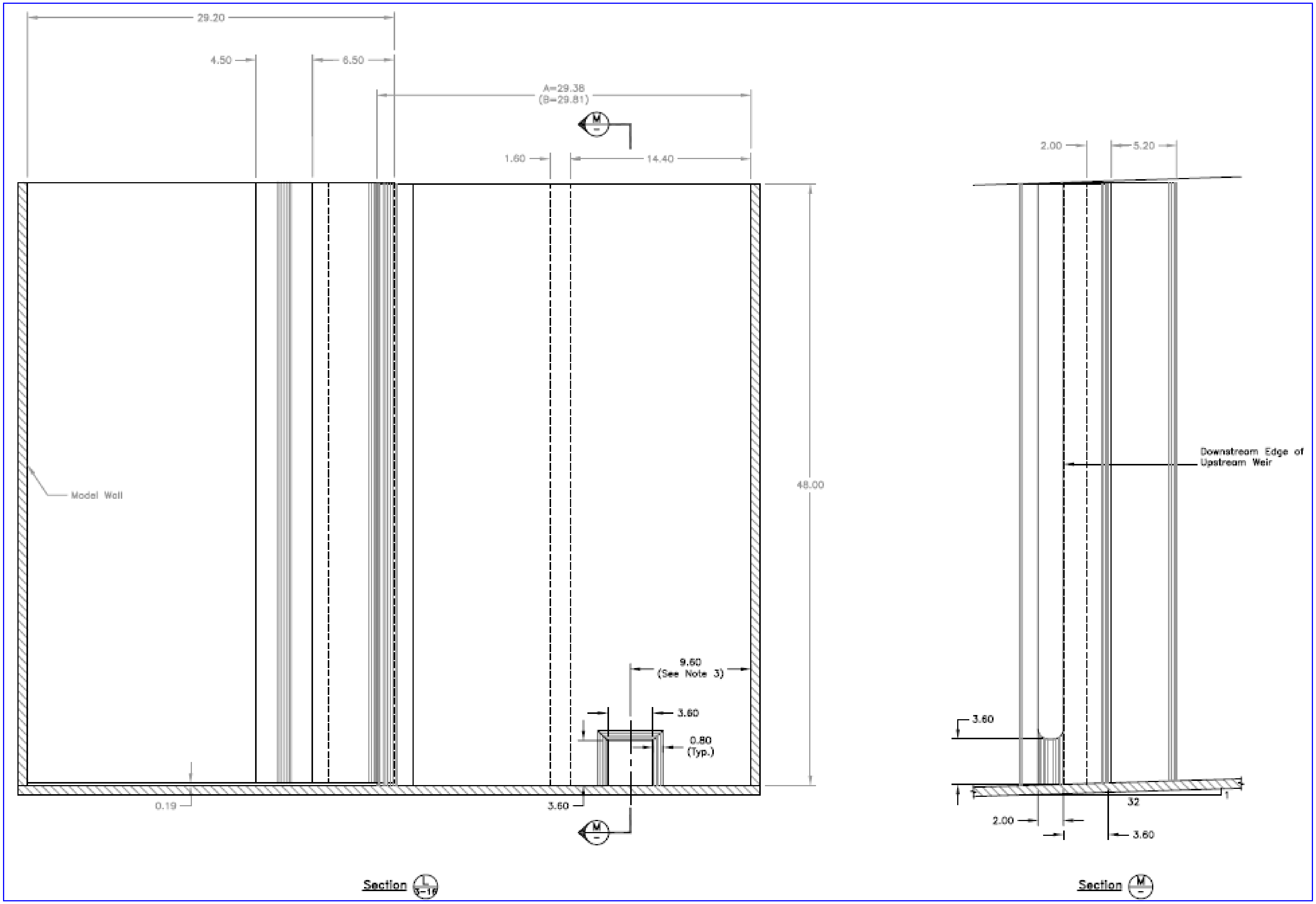


Plate 4 – 18-inch Weir Configuration, Elevation View (Weirs 2, 3, 18 -23)—Excerpt from Model Drawing 3-16 provided by ENSR (Inches Model Scale: 1:5)

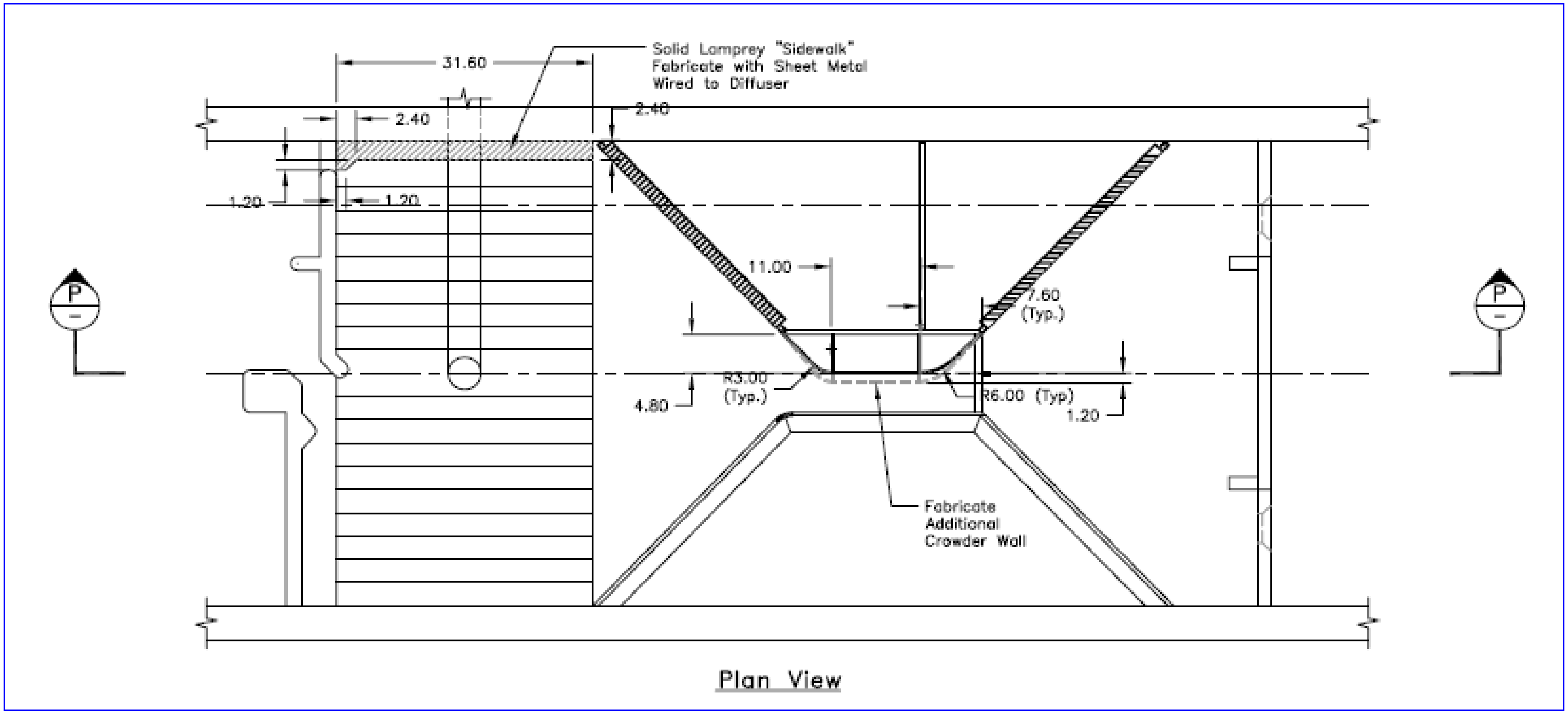


Plate 5 – Count Station – Plan View Excerpt from Model Drawing 3-19 provided by ENSR (Inches Model Scale: 1:5)

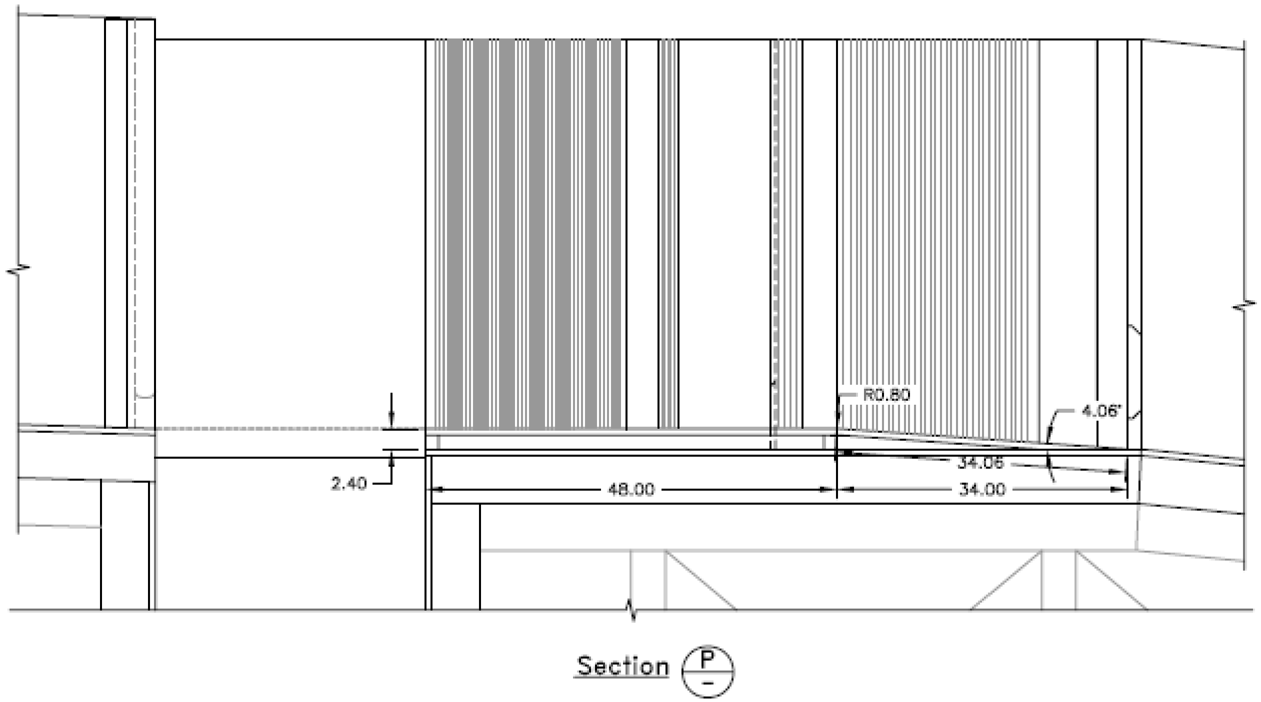
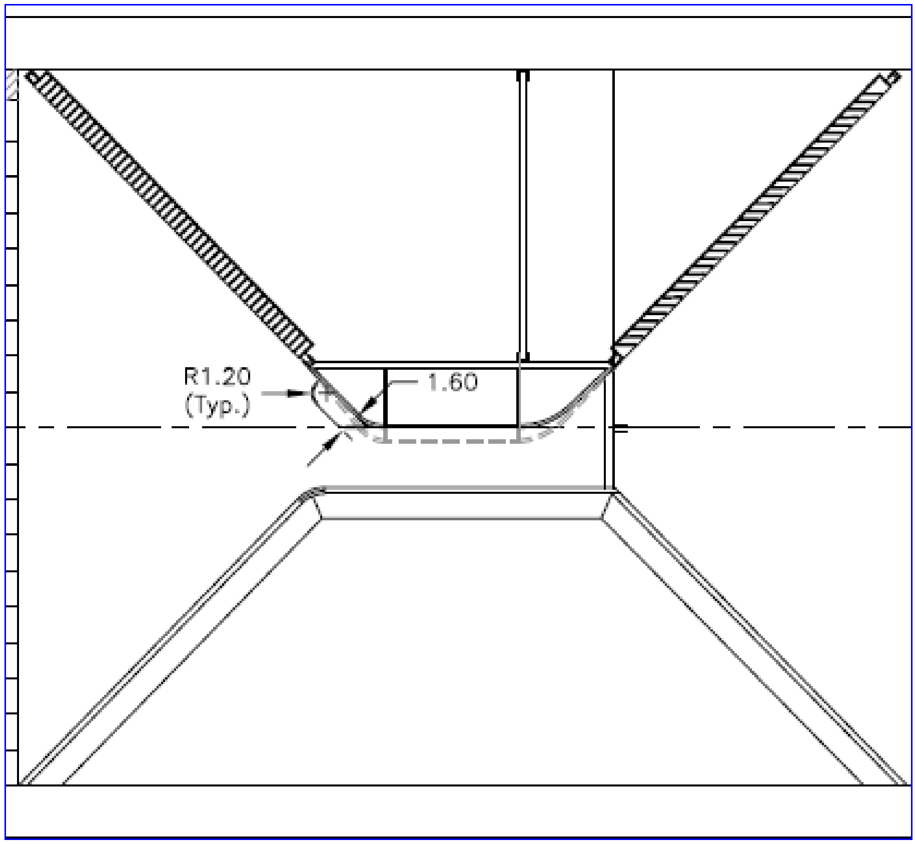
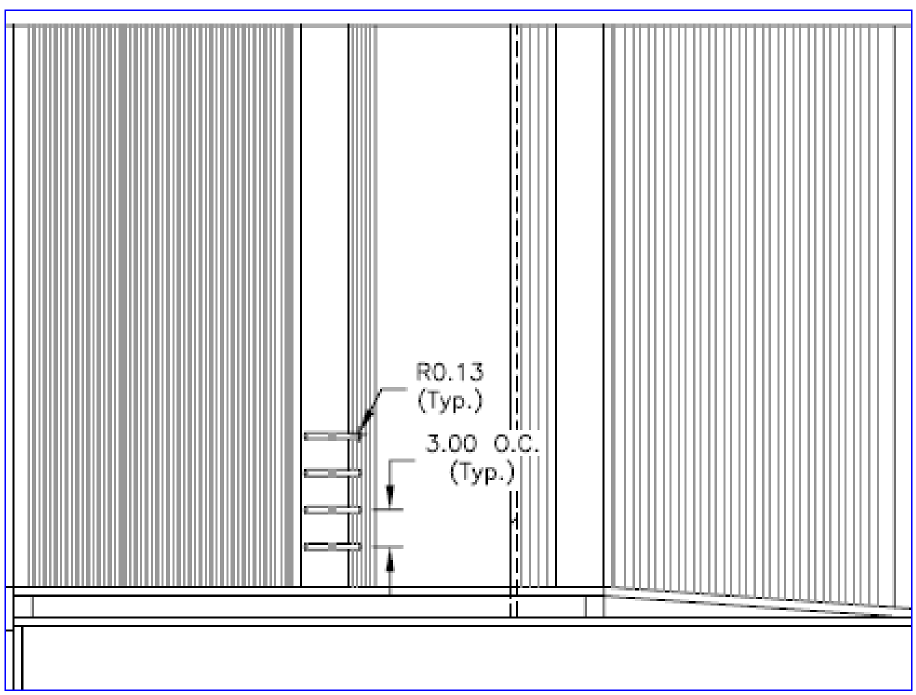


Plate 6 – Count Station – Elevation View —Excerpt from Model Drawing 3-19 provided by ENSR (Inches Model Scale: 1:5)



a. Plan View



b. Elevation View

Plate 7 – Horizontal Slats on Upstream Faring of Crowder—Excerpt from Model Drawing 3-20 provided by ENSR (Inches Model Scale: 1:5)

ATTACHMENT 2: ENSR Data from Modification Tests

Condition 1: No Sills, Forebay = 257.1 feet; Exit Discharge = 38.4 cfs

Flow Setup

Test Condition	-
Weir Head	1.0
Qtotal	85.01
Qexit (cfs)	38.41
Qdiffuser (cfs)	46.60
FB Slot Config.	NONE

	Head Drop	depth	assumed orifice CD
min	0.19	4.98	**0.8**
max	0.48	6.48	
median	0.35	5.14	Ave
			0.87

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	257.07	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.08	6.57	
ES	0.09	256.98	250.50	250.50	**2.00**	13.0	N/A	13.0	2.96	ES2 (D/S)	0.19	6.48	0.70
23	0.28	256.79	250.50	250.50	**1.50**	9.4	2.25	11.68	3.29	23	0.21	6.29	0.92
22	0.49	256.58	250.50	250.50	**1.50**	9.1	2.25	11.37	3.38	22	0.25	6.08	0.84
21	0.75	256.32	250.50	250.50	**1.50**	8.7	2.25	10.99	3.50	21	0.19	5.82	1.05
20	0.94	256.13	250.50	250.50	**1.50**	8.5	2.25	10.70	3.59	20	0.31	5.63	0.80
19	1.25	255.82	250.50	250.50	**1.50**	8.0	2.25	10.23	3.75	19	0.39	5.32	0.73
18	1.64	255.43	250.25	250.25	**1.50**	7.8	2.25	10.02	3.83	18	0.37	5.05	0.79
17	2.01	255.06	249.86	249.86	1.25	6.5	2.25	8.76	4.38	17	0.42	5.01	0.86
16	2.43	254.64	249.46	249.46	1.25	6.5	2.25	8.7	4.40	16	0.37	4.98	0.94
15	2.80	254.27	249.07	249.07	1.25	6.5	2.25	8.75	4.39	15	0.32	5.01	1.03
14	3.11	253.96	248.68	248.68	1.25	6.6	2.25	8.85	4.34	14	0.48	5.08	0.77
13	3.59	253.48	248.27	248.27	1.25	6.5	2.25	8.76	4.38	13	0.39	5.01	0.90
12	3.98	253.09	247.86	247.86	1.25	6.5	2.25	8.78	4.37	12	0.42	5.02	0.85
11	4.40	252.67	247.45	247.45	1.25	6.5	2.25	8.77	4.38	11	0.42	5.01	0.85
10	4.83	252.24	247.03	247.03	1.25	6.5	2.25	8.77	4.38	10	0.33	5.00	1.01
9	5.15	251.92	246.61	246.61	1.25	6.6	2.25	8.89	4.32	9	0.43	5.10	0.83
8	5.58	251.49	246.19	246.19	1.25	6.6	2.25	8.9	4.33	8	0.38	5.09	0.91
7	5.96	251.11	245.76	245.76	1.25	6.7	2.25	8.94	4.30	7	0.38	5.14	0.90
6	6.33	250.74	245.32	245.32	1.25	6.8	2.25	9.02	4.26	6	0.30	5.20	1.01
5	6.64	250.43	244.88	244.88	1.25	6.9	2.25	9.19	4.18	5	0.38	5.33	0.86
4	7.02	250.05	244.43	244.43	1.25	7.0	2.25	9.29	4.14	4	0.32	5.40	0.95
3	7.34	249.73	243.97	243.97	**1.50**	8.6	2.25	10.90	3.52	3	0.28	5.54	0.84
2	7.62	249.45	243.51	243.51	**1.50**	8.9	2.25	11.16	3.44	2	0.26	5.71	0.84
1	7.88	249.19	243.04	243.04	**1.50**	9.2	2.25	11.47	3.35	1	0.32		0.72
247	9.21	247.86	241.00	247.00	6.00	5.19	4.50	9.69	8.77	247	0.99		
246	10.20	246.87	240.00	246.00	6.00	5.22	4.50	9.72	8.75	246	1.11		
245	11.31	245.76	239.00	245.00	6.00	4.59	4.50	9.09	9.35	245	N/A		

Condition 2: No Sills; Forebay = 264.2 feet; Exit Discharge = 85 cfs

Flow Setup					
Test Condition	-				assumed
Weir Head	1.0		Head Drop	depth	orifice CD
Qtotal	85.01	min	0.29	7.11	**0.8**
Qexit (cfs)	85.02	max	0.96	13.61	
Qdiffuser (cfs)	-0.01	median	0.62	10.66	Ave
FB Slot Config.	NONE				0.84

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	264.17	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.06	13.67	
ES	0.06	264.11	250.50	250.50	**2.00**	27.2	N/A	27.2	3.12	ES2 (D/S)	0.31	13.61	0.63
23	0.37	263.80	250.50	250.50	**1.50**	20.0	2.25	22.20	3.83	23	0.31	13.30	0.86
22	0.69	263.49	250.50	250.50	**1.50**	19.5	2.25	21.73	3.91	22	0.29	12.99	0.93
21	0.97	263.20	250.50	250.50	**1.50**	19.1	2.25	21.30	3.99	21	0.35	12.70	0.85
20	1.32	262.85	250.50	250.50	**1.50**	18.5	2.25	20.78	4.09	20	0.41	12.35	0.80
19	1.73	262.44	250.50	250.50	**1.50**	17.9	2.25	20.16	4.22	19	0.47	11.94	0.76
18	2.20	261.97	250.25	250.25	**1.50**	17.6	2.25	19.83	4.29	18	0.47	11.60	0.78
17	2.67	261.50	249.86	249.86	1.25	14.6	2.25	16.80	5.06	17	0.54	11.45	0.86
16	3.22	260.96	249.46	249.46	1.25	14.4	2.25	16.6	5.12	16	0.52	11.30	0.90
15	3.74	260.44	249.07	249.07	1.25	14.2	2.25	16.46	5.17	15	0.55	11.17	0.88
14	4.29	259.89	248.68	248.68	1.25	14.0	2.25	16.26	5.23	14	0.64	11.01	0.82
13	4.93	259.25	248.27	248.27	1.25	13.7	2.25	15.97	5.32	13	0.63	10.77	0.84
12	5.56	258.62	247.86	247.86	1.25	13.4	2.25	15.69	5.42	12	0.59	10.55	0.89
11	6.15	258.02	247.45	247.45	1.25	13.2	2.25	15.46	5.50	11	0.76	10.36	0.78
10	6.91	257.26	247.03	247.03	1.25	12.8	2.25	15.04	5.65	10	0.62	10.02	0.91
9	7.53	256.64	246.61	246.61	1.25	12.5	2.25	14.79	5.75	9	0.76	9.82	0.83
8	8.29	255.89	246.19	246.19	1.25	12.1	2.25	14.4	5.91	8	0.80	9.49	0.83
7	9.08	255.09	245.76	245.76	1.25	11.7	2.25	13.91	6.11	7	0.74	9.12	0.90
6	9.82	254.35	245.32	245.32	1.25	11.3	2.25	13.54	6.28	6	0.88	8.81	0.84
5	10.70	253.48	244.88	244.88	1.25	10.7	2.25	12.99	6.54	5	0.81	8.37	0.92
4	11.51	252.66	244.43	244.43	1.25	10.3	2.25	12.54	6.78	4	0.90	8.01	0.91
3	12.41	251.76	243.97	243.97	**1.50**	11.7	2.25	13.94	6.10	3	0.91	7.56	0.80
2	13.32	250.85	243.51	243.51	**1.50**	11.0	2.25	13.26	6.41	2	0.96	7.11	0.82
1	14.28	249.90	243.04	243.04	**1.50**	10.3	2.25	12.53	6.78	1	0.90	6.62	0.91
247	16.13	248.04	241.00	247.00	6.00	6.25	4.50	10.75	7.91	247	1.00		
246	17.13	247.05	240.00	246.00	6.00	6.28	4.50	10.78	7.89	246	1.20		
245	18.33	245.84	239.00	245.00	6.00	5.05	4.50	9.55	8.90	245	N/A		

Condition 3: 1-foot Sills; Forebay = 257.1 feet; Exit Discharge = 31.8 cfs

Flow Setup

Test Condition	-					assumed
Weir Head	1.0			Head Drop	depth	orifice CD
Qtotal	85.01		min	0.16	5.03	**0.8**
Qexit (cfs)	31.75		max	0.44	6.57	
Qdiffuser (cfs)	53.25		median	0.36	5.18	Ave
FB Slot Config.	1-FT					0.83

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	257.07	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.03	6.57	
ES	0.03	257.04	250.50	251.50	**2.00**	11.1	N/A	11.1	2.87	ES2 (D/S)	0.16	6.54	0.74
23	0.19	256.88	250.50	251.50	**1.50**	8.1	2.25	10.33	3.07	23	0.25	6.38	0.76
22	0.44	256.63	250.50	251.50	**1.50**	7.7	2.25	9.95	3.19	22	0.24	6.13	0.81
21	0.68	256.39	250.50	251.50	**1.50**	7.3	2.25	9.59	3.31	21	0.19	5.89	0.99
20	0.87	256.20	250.50	251.50	**1.50**	7.1	2.25	9.31	3.41	20	0.27	5.70	0.81
19	1.14	255.93	250.50	251.50	**1.50**	6.6	2.25	8.89	3.57	19	0.44	5.43	0.63
18	1.58	255.49	250.25	251.25	**1.50**	6.4	2.25	8.62	3.69	18	0.36	5.12	0.75
17	1.94	255.13	249.86	250.86	1.25	5.3	2.25	7.60	4.18	17	0.43	5.08	0.79
16	2.37	254.70	249.46	250.46	1.25	5.3	2.25	7.6	4.21	16	0.41	5.04	0.83
15	2.78	254.29	249.07	250.07	1.25	5.3	2.25	7.53	4.22	15	0.36	5.03	0.90
14	3.14	253.93	248.68	249.68	1.25	5.3	2.25	7.56	4.20	14	0.42	5.05	0.82
13	3.56	253.51	248.27	249.27	1.25	5.3	2.25	7.56	4.20	13	0.38	5.04	0.88
12	3.93	253.14	247.86	248.86	1.25	5.3	2.25	7.60	4.18	12	0.38	5.07	0.87
11	4.31	252.76	247.45	248.45	1.25	5.4	2.25	7.64	4.16	11	0.42	5.11	0.80
10	4.73	252.34	247.03	248.03	1.25	5.4	2.25	7.64	4.15	10	0.38	5.10	0.86
9	5.11	251.96	246.61	247.61	1.25	5.4	2.25	7.69	4.13	9	0.39	5.15	0.84
8	5.49	251.58	246.19	247.19	1.25	5.5	2.25	7.7	4.10	8	0.42	5.18	0.78
7	5.92	251.15	245.76	246.76	1.25	5.5	2.25	7.74	4.10	7	0.34	5.18	0.90
6	6.26	250.81	245.32	246.32	1.25	5.6	2.25	7.86	4.04	6	0.30	5.27	0.97
5	6.56	250.51	244.88	245.88	1.25	5.8	2.25	8.03	3.95	5	0.31	5.41	0.92
4	6.87	250.20	244.43	245.43	1.25	6.0	2.25	8.22	3.86	4	0.32	5.55	0.86
3	7.20	249.87	243.97	244.97	**1.50**	7.4	2.25	9.61	3.31	3	0.26	5.68	0.81
2	7.46	249.61	243.51	244.51	**1.50**	7.7	2.25	9.90	3.21	2	0.23	5.87	0.83
1	7.69	249.38	243.04	244.04	**1.50**	8.0	2.25	10.26	3.10	1	0.28	6.10	0.70
Ct. Sta.	7.98	249.09	243.00	243.00	12.00	73.1	0.00	73.14	1.16				
248	7.98	249.09	242.00	248.00	6.00	6.6	4.50	11.07	7.68	248	1.07		
247	9.04	248.03	241.00	247.00	6.00	6.18	4.50	10.68	7.96	247	1.02		
246	10.06	247.01	240.00	246.00	6.00	6.09	4.50	10.59	8.03	246	1.07		
245	11.13	245.94	239.00	245.00	6.00	5.64	4.50	10.14	8.38	245	N/A		

Condition 4: 1-foot Sills; Forebay = 264.6 feet; Exit Discharge = 85 cfs

Flow Setup

Test Condition	-					assumed
Weir Head	1.0		Head Drop	depth		orifice CD
Qtotal	85.01	min	0.15	7.34		**0.8**
Qexit (cfs)	85.01	max	1.36	14.06		
Qdiffuser (cfs)	0.00	median	0.59	11.07		Ave
FB Slot Config.	1-FT					0.90

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	264.56	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.05	14.06	
ES	0.05	264.52	250.50	251.50	**2.00**	26.0	N/A	26.0	3.26	ES2 (D/S)	0.15	14.02	0.98
23	0.20	264.37	250.50	251.50	**1.50**	19.3	2.25	21.55	3.94	23	0.39	13.87	0.78
22	0.59	263.97	250.50	251.50	**1.50**	18.7	2.25	20.96	4.06	22	0.35	13.47	0.86
21	0.94	263.62	250.50	251.50	**1.50**	18.2	2.25	20.44	4.16	21	0.38	13.12	0.85
20	1.32	263.25	250.50	251.50	**1.50**	17.6	2.25	19.87	4.28	20	0.42	12.75	0.83
19	1.73	262.83	250.50	251.50	**1.50**	17.0	2.25	19.25	4.42	19	0.57	12.33	0.72
18	2.31	262.26	250.25	251.25	**1.50**	16.5	2.25	18.76	4.53	18	0.56	11.88	0.74
17	2.87	261.69	249.86	250.86	1.25	13.5	2.25	15.80	5.38	17	0.53	11.64	0.94
16	3.40	261.16	249.46	250.46	1.25	13.4	2.25	15.6	5.44	16	0.59	11.50	0.90
15	3.99	260.58	249.07	250.07	1.25	13.1	2.25	15.38	5.53	15	0.51	11.31	0.99
14	4.50	260.07	248.68	249.68	1.25	13.0	2.25	15.24	5.58	14	0.52	11.19	0.99
13	5.02	259.54	248.27	249.27	1.25	12.8	2.25	15.09	5.63	13	0.64	11.07	0.89
12	5.66	258.90	247.86	248.86	1.25	12.6	2.25	14.80	5.74	12	0.78	10.84	0.81
11	6.45	258.12	247.45	248.45	1.25	12.1	2.25	14.33	5.93	11	0.52	10.46	1.07
10	6.97	257.60	247.03	248.03	1.25	12.0	2.25	14.21	5.98	10	0.66	10.36	0.94
9	7.63	256.94	246.61	247.61	1.25	11.7	2.25	13.91	6.11	9	0.71	10.12	0.92
8	8.34	256.22	246.19	247.19	1.25	11.3	2.25	13.5	6.27	8	0.79	9.83	0.90
7	9.13	255.44	245.76	246.76	1.25	10.8	2.25	13.10	6.49	7	0.86	9.47	0.89
6	9.99	254.58	245.32	246.32	1.25	10.3	2.25	12.57	6.76	6	0.59	9.04	1.16
5	10.58	253.98	244.88	245.88	1.25	10.1	2.25	12.38	6.87	5	0.89	8.88	0.93
4	11.48	253.09	244.43	245.43	1.25	9.6	2.25	11.83	7.19	4	1.03	8.44	0.90
3	12.50	252.06	243.97	244.97	**1.50**	10.6	2.25	12.89	6.59	3	0.98	7.87	0.84
2	13.48	251.08	243.51	244.51	**1.50**	9.9	2.25	12.11	7.02	2	0.97	7.34	0.91
1	14.45	250.12	243.04	244.04	**1.50**	9.1	2.25	11.37	7.48	1	1.36	6.84	0.80
Ct. Sta.	15.81	248.76	243.00	243.00	12.00	69.1	0.00	69.12	1.23				
248	15.81	248.76	242.00	248.00	6.00	4.6	4.50	9.06	9.39	248	1.06		
247	16.87	247.70	241.00	247.00	6.00	4.20	4.50	8.70	9.77	247	0.96		
246	17.83	246.73	240.00	246.00	6.00	4.41	4.50	8.91	9.54	246	1.21		
245	19.04	245.53	239.00	245.00	6.00	3.18	4.50	7.68	11.07	245	N/A		

Condition 4: High Sills; Forebay = 261.1 feet; Exit Discharge = 33.8 cfs

Flow Setup

Test Condition	-
Weir Head	1.0
Qtotal	85.01
Qexit (cfs)	33.84
Qdiffuser (cfs)	51.17
FB Slot Config.	HIGH

	Head Drop	depth	assumed orifice CD
min	0.16	5.46	**0.8**
max	0.75	10.61	
median	0.52	6.49	Ave 0.77

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	261.11	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.03	10.61	
ES	0.03	261.08	250.50	250.50	**2.00**	21.2	N/A	21.2	1.60	ES2 (D/S)	0.16	10.58	0.42
23	0.19	260.92	250.50	256.50	**1.25**	5.5	2.25	7.78	4.35	23	0.36	10.42	0.95
22	0.54	260.57	250.50	256.25	**1.25**	5.4	2.25	7.64	4.43	22	0.49	10.07	0.78
21	1.03	260.08	250.50	256.00	**1.25**	5.1	2.25	7.34	4.61	21	0.48	9.58	0.85
20	1.51	259.60	250.50	255.75	**1.25**	4.8	2.25	7.06	4.79	20	0.64	9.10	0.72
19	2.15	258.96	250.50	255.25	**1.25**	4.6	2.25	6.88	4.92	19	0.67	8.46	0.72
18	2.82	258.29	250.25	254.50	**1.25**	4.7	2.25	6.98	4.85	18	0.75	7.91	0.65
17	3.58	257.53	249.86	253.86	1.25	4.6	2.25	6.84	4.95	17	0.64	7.48	0.76
16	4.22	256.89	249.46	253.21	1.25	4.6	2.25	6.8	4.94	16	0.61	7.23	0.79
15	4.82	256.29	249.07	252.57	1.25	4.6	2.25	6.89	4.91	15	0.62	7.02	0.77
14	5.44	255.67	248.68	251.93	1.25	4.7	2.25	6.92	4.89	14	0.70	6.79	0.69
13	6.14	254.97	248.27	251.27	1.25	4.6	2.25	6.87	4.93	13	0.63	6.49	0.76
12	6.77	254.34	247.86	250.61	1.25	4.7	2.25	6.91	4.90	12	0.67	6.27	0.72
11	7.43	253.68	247.45	249.95	1.25	4.7	2.25	6.90	4.90	11	0.61	6.02	0.77
10	8.05	253.06	247.03	249.28	1.25	4.7	2.25	6.98	4.85	10	0.69	5.82	0.70
9	8.73	252.38	246.61	248.36	1.25	5.0	2.25	7.27	4.65	9	0.52	5.56	0.81
8	9.25	251.86	246.19	247.19	1.25	5.8	2.25	8.1	4.18	8	0.38	5.46	0.86
7	9.63	251.48	245.76	246.76	1.25	5.9	2.25	8.14	4.16	7	0.38	5.50	0.86
6	10.01	251.10	245.32	246.32	1.25	6.0	2.25	8.22	4.11	6	0.40	5.56	0.81
5	10.41	250.70	244.88	245.88	1.25	6.0	2.25	8.27	4.09	5	0.35	5.60	0.88
4	10.76	250.35	244.43	245.43	1.25	6.2	2.25	8.41	4.03	4	0.36	5.70	0.85
3	11.12	249.99	243.97	244.97	**1.50**	7.5	2.25	9.78	3.46	3	0.31	5.79	0.76
2	11.43	249.68	243.51	244.51	**1.50**	7.7	2.25	10.00	3.39	2	0.26	5.93	0.83
1	11.70	249.41	243.04	243.04	**1.50**	9.6	2.25	11.80	2.87	1	0.19	6.13	0.82
Ct. Sta.	11.89	249.22	243.00	243.00	12.00	74.6	0.00	74.65	1.14				
248	11.89	249.22	242.00	248.00	6.00	7.3	4.50	11.82	7.19	248	1.09		
247	12.97	248.14	241.00	247.00	6.00	6.81	4.50	11.31	7.51	247	1.05		
246	14.02	247.09	240.00	246.00	6.00	6.51	4.50	11.01	7.72	246	0.93		
245	14.95	246.16	239.00	245.00	6.00	6.93	4.50	11.43	7.43	245	N/A		

slot narrowed 3" with high sill leaf

Condition 4: High Sills; Forebay = 268.1 feet; Exit Discharge = 85 cfs

Flow Setup

Test Condition	-					assumed
Weir Head	1.0		Head Drop			orifice CD
Qtotal	85.01	min	0.26	7.26		**0.8**
Qexit (cfs)	85.00	max	1.09	17.64		
Qdiffuser (cfs)	0.00	median	0.80			Ave
FB Slot Config.	HIGH					0.86

Tap #	W/S Diff. From Forebay (ft)	WSEL (ft)	Slot Elev. (ft)	Sill Elev. (ft)	Slot Width (ft)	Slot Area (ft^2)	Orifice Area (ft^2)	Total A (ft^2)	V_{avg} (proto fps)	Baffle/Weir	Headloss (proto ft)	Ave pool Depth (ft)	**CD** weir slot
Forebay	0.00	268.14	N/A	N/A	N/A	N/A	N/A		N/A	ES1 (U/S)	0.04	17.64	
ES	0.04	268.11	250.50	250.50	**2.00**	35.2	N/A	35.2	2.41	ES2 (D/S)	0.26	17.61	0.53
23	0.30	267.84	250.50	256.50	**1.25**	14.2	2.25	16.43	5.17	23	0.50	17.34	0.92
22	0.81	267.34	250.50	256.25	**1.25**	13.9	2.25	16.11	5.28	22	0.63	16.84	0.83
21	1.44	266.71	250.50	256.00	**1.25**	13.4	2.25	15.64	5.44	21	0.63	16.21	0.86
20	2.07	266.08	250.50	255.75	**1.25**	12.9	2.25	15.16	5.61	20	0.81	15.58	0.77
19	2.88	265.27	250.50	255.25	**1.25**	12.5	2.25	14.77	5.75	19	0.91	14.77	0.74
18	3.79	264.36	250.25	254.50	**1.25**	12.3	2.25	14.57	5.83	18	1.01	13.98	0.71
17	4.80	263.35	249.86	253.86	1.25	11.9	2.25	14.11	6.02	17	0.69	13.29	0.93
16	5.48	262.66	249.46	253.21	1.25	11.8	2.25	14.1	6.05	16	0.72	13.00	0.90
15	6.20	261.94	249.07	252.57	1.25	11.7	2.25	13.96	6.09	15	0.74	12.67	0.90
14	6.94	261.21	248.68	251.93	1.25	11.6	2.25	13.85	6.14	14	0.75	12.33	0.90
13	7.69	260.46	248.27	251.27	1.25	11.5	2.25	13.73	6.19	13	0.81	11.98	0.87
12	8.50	259.65	247.86	250.61	1.25	11.3	2.25	13.55	6.28	12	0.75	11.58	0.92
11	9.25	258.90	247.45	249.95	1.25	11.2	2.25	13.43	6.33	11	0.89	11.24	0.84
10	10.14	258.00	247.03	249.28	1.25	10.9	2.25	13.15	6.46	10	0.80	10.76	0.92
9	10.94	257.20	246.61	248.36	1.25	11.1	2.25	13.30	6.39	9	0.84	10.38	0.88
8	11.78	256.36	246.19	247.19	1.25	11.5	2.25	13.7	6.20	8	0.77	9.96	0.90
7	12.55	255.60	245.76	246.76	1.25	11.0	2.25	13.30	6.39	7	0.80	9.62	0.91
6	13.35	254.80	245.32	246.32	1.25	10.6	2.25	12.85	6.62	6	0.83	9.26	0.93
5	14.18	253.97	244.88	245.88	1.25	10.1	2.25	12.36	6.88	5	0.89	8.87	0.93
4	15.07	253.08	244.43	245.43	1.25	9.6	2.25	11.81	7.19	4	0.99	8.42	0.92
3	16.06	252.09	243.97	244.97	**1.50**	10.7	2.25	12.93	6.58	3	1.09	7.89	0.78
2	17.15	251.00	243.51	244.51	**1.50**	9.7	2.25	11.98	7.10	2	1.07	7.26	0.87
1	18.22	249.93	243.04	243.04	**1.50**	10.3	2.25	12.58	6.76	1	0.85	6.65	0.94
Ct. Sta.	19.07	249.08	243.00	243.00	12.00	72.9	0.00	72.94	1.17				
248	19.07	249.08	242.00	248.00	6.00	6.5	4.50	10.97	7.75	248	1.09		
247	20.16	247.99	241.00	247.00	6.00	5.93	4.50	10.43	8.15	247	1.00		
246	21.16	246.99	240.00	246.00	6.00	5.93	4.50	10.43	8.15	246	1.12		
245	22.27	245.87	239.00	245.00	6.00	5.24	4.50	9.74	8.73	245	N/A		

slot narrowed 3" with high sill leaf

Appendix G Item 3 – CENWP-EC-HD - One Dimensional Model Results

a – Insurance Test Simulations for High Sills:

Simulation 1 - High Sills, Forebay = 261, Q = 33.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**CD (33 cfs) COEFFICIENTS**			0.8	0.42		250.5	
	Q =	33.4	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		4.16	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.00	2.92	3.60	2	1
	Cd_{sow} =	NA	**Forebay =**	**261.0**	Baffles =	23	22	22		0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.20	5.96	6.16	0.20	NA	orifice	0.82
2	16.20	243.51	251.95	1.50	1.00	249.20	249.47	4.69	4.96	0.27	4.96	orifice	0.83
3	30.78	243.96	252.86	1.50	1.00	249.47	249.80	4.51	4.83	0.33	4.83	orifice	0.76
4	45.28	244.41	253.77	1.25	1.00	249.80	250.17	4.38	4.75	0.37	4.75	orifice	0.85
5	59.78	244.87	254.68	1.25	1.00	250.17	250.52	4.30	4.66	0.36	4.66	orifice	0.88
6	73.78	245.31	255.55	1.25	1.00	250.52	250.93	4.22	4.63	0.41	4.63	orifice	0.81
7	87.78	245.74	256.43	1.25	1.00	250.93	251.31	4.19	4.57	0.38	4.57	orifice	0.86
8	101.28	246.16	257.27	1.25	1.00	251.31	251.70	4.15	4.54	0.39	4.54	orifice	0.86
9	114.78	246.59	258.11	1.25	1.75	251.70	252.23	3.36	3.89	0.53	2.22	orifice	0.81
10	128.11	247.00	258.95	1.25	2.25	252.23	252.92	2.98	3.67	0.69	1.63	orifice	0.70
11	141.61	247.43	259.79	1.25	2.50	252.92	253.55	3.00	3.62	0.62	1.45	orifice	0.77
12	154.61	247.83	260.60	1.25	2.75	253.55	254.22	2.96	3.63	0.67	1.32	orifice	0.72
13	167.61	248.24	261.42	1.25	3.00	254.22	254.84	2.98	3.61	0.63	1.20	orifice	0.76
14	180.61	248.64	262.23	1.25	3.25	254.84	255.55	2.95	3.65	0.70	1.12	orifice	0.69
15	193.11	249.03	263.01	1.25	3.50	255.55	256.17	3.01	3.63	0.62	1.04	orifice	0.77
16	205.61	249.43	263.79	1.25	3.75	256.17	256.77	2.99	3.60	0.61	0.96	orifice	0.79
17	218.11	249.82	264.57	1.25	4.00	256.77	257.42	2.96	3.60	0.64	0.90	orifice	0.76
18	230.61	250.21	265.35	1.25	4.25	257.42	258.17	2.96	3.71	0.75	0.87	orifice	0.65
19	242.61	250.50	266.10	1.25	4.75	258.17	258.85	2.92	3.60	0.68	0.76	orifice	0.72
20	254.70	250.50	266.86	1.25	5.25	258.85	259.50	3.10	3.75	0.65	0.71	orifice	0.72
21	266.70	250.50	267.61	1.25	5.50	259.50	259.98	3.50	3.98	0.48	0.72	orifice	0.85
22	278.70	250.50	268.36	1.25	5.75	259.98	260.47	3.73	4.22	0.49	0.73	orifice	0.78
23	290.70	250.50	269.11	1.25	6.00	260.47	260.83	3.97	4.33	0.36	0.72	orifice	0.95
				2.21									
Exit Slot	303.849	250.50	tunnel	2.21	0.01	260.83	261.01	10.50	10.50	0.18	1049.85	orifice	0.42
Exit Slot	317.001	250.50	tunnel	12.00	0.01	261.01	261.01	10.50	10.50	0.00	1050.02	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 2 - High Sills, Forebay = 262, Q = 39.6 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**Ave (33 - 49 cfs)**	**COEFFICIENTS**			0.8	0.44		250.5	
	Q =	39.6	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			4.83	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.00		3.65	4.37	2	1
	Cd_{sow} =	NA	**Forebay =**	**262.00**	Baffles =	23		22	13		0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.26	5.96	6.22	0.26	NA	orifice	0.84
2	16.20	243.51	251.95	1.50	1.00	249.26	249.63	4.76	5.12	0.36	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	1.00	249.63	250.05	4.66	5.08	0.42	NA	orifice	0.76
4	45.28	244.41	253.77	1.25	1.00	250.05	250.51	4.63	5.09	0.46	NA	orifice	0.86
5	59.78	244.87	254.68	1.25	1.00	250.51	250.94	4.64	5.08	0.44	NA	orifice	0.89
6	73.78	245.31	255.55	1.25	1.00	250.94	251.43	4.64	5.12	0.48	NA	orifice	0.83
7	87.78	245.74	256.43	1.25	1.00	251.43	251.87	4.68	5.13	0.45	NA	orifice	0.87
8	101.28	246.16	257.27	1.25	1.00	251.87	252.32	4.71	5.15	0.45	NA	orifice	0.87
9	114.78	246.59	258.11	1.25	1.75	252.32	252.90	3.98	4.56	0.58	2.61	orifice	0.82
10	128.11	247.00	258.95	1.25	2.25	252.90	253.63	3.65	4.38	0.73	1.94	orifice	0.73
11	141.61	247.43	259.79	1.25	2.50	253.63	254.29	3.70	4.37	0.66	1.75	orifice	0.78
12	154.61	247.83	260.60	1.25	2.75	254.29	254.98	3.71	4.40	0.69	1.60	orifice	0.75
13	167.61	248.24	261.42	1.25	3.00	254.98	255.64	3.75	4.40	0.66	1.47	orifice	0.78
14	180.61	248.64	262.23	1.25	3.25	255.64	256.36	3.75	4.46	0.72	1.37	orifice	0.72
15	193.11	249.03	263.01	1.25	3.50	256.36	256.99	3.82	4.46	0.64	1.27	orifice	0.79
16	205.61	249.43	263.79	1.25	3.75	256.99	257.61	3.82	4.44	0.62	1.18	orifice	0.80
17	218.11	249.82	264.57	1.25	4.00	257.61	258.26	3.80	4.45	0.65	1.11	orifice	0.78
18	230.61	250.21	265.35	1.25	4.25	258.26	259.05	3.81	4.59	0.79	1.08	orifice	0.65
19	242.61	250.50	266.10	1.25	4.75	259.05	259.75	3.80	4.50	0.70	0.95	orifice	0.73
20	254.70	250.50	266.86	1.25	5.25	259.75	260.42	4.00	4.67	0.67	0.89	orifice	0.72
21	266.70	250.50	267.61	1.25	5.50	260.42	260.92	4.42	4.92	0.49	0.89	orifice	0.85
22	278.70	250.50	268.36	1.25	5.75	260.92	261.43	4.67	5.18	0.51	0.90	orifice	0.79
23	290.70	250.50	269.11	1.25	6.00	261.43	261.80	4.93	5.30	0.37	0.88	orifice	0.95
				2.20									
Exit Slot	303.849	250.50	tunnel	2.20	0.01	261.80	261.99	11.48	11.48	0.20	1148.48	orifice	0.44
Exit Slot	317.001	250.50	tunnel	12.00	0.01	261.99	262.00	11.49	11.49	0.00	1148.68	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 3 - High Sills, Forebay = 262.5, Q = 42.9 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**Ave (42 - 49 cfs) COEFFICIENTS**			0.8	0.45		250.5		
	Q =	42.9	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		5.18	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.00	4.00	4.74	2		1
	Cd_{sow} =	NA	**Forebay =**	**262.51**	Baffles =	23	19	10			0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.30	5.96	6.26	0.30	NA	orifice	0.85
2	16.20	243.51	251.95	1.50	1.00	249.30	249.71	4.79	5.21	0.41	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	1.00	249.71	250.18	4.75	5.22	0.47	NA	orifice	0.76
4	45.28	244.41	253.77	1.25	1.00	250.18	250.69	4.77	5.28	0.51	NA	orifice	0.87
5	59.78	244.87	254.68	1.25	1.00	250.69	251.17	4.82	5.30	0.48	NA	orifice	0.89
6	73.78	245.31	255.55	1.25	1.00	251.17	251.69	4.86	5.38	0.52	NA	orifice	0.84
7	87.78	245.74	256.43	1.25	1.00	251.69	252.17	4.94	5.42	0.48	NA	orifice	0.87
8	101.28	246.16	257.27	1.25	1.00	252.17	252.64	5.00	5.48	0.47	NA	orifice	0.87
9	114.78	246.59	258.11	1.25	1.75	252.64	253.25	4.30	4.91	0.61	2.81	orifice	0.82
10	128.11	247.00	258.95	1.25	2.25	253.25	253.99	4.00	4.74	0.74	2.11	orifice	0.74
11	141.61	247.43	259.79	1.25	2.50	253.99	254.68	4.06	4.75	0.69	1.90	orifice	0.78
12	154.61	247.83	260.60	1.25	2.75	254.68	255.38	4.09	4.79	0.70	1.74	orifice	0.77
13	167.61	248.24	261.42	1.25	3.00	255.38	256.05	4.14	4.81	0.67	1.60	orifice	0.79
14	180.61	248.64	262.23	1.25	3.25	256.05	256.77	4.15	4.87	0.72	1.50	orifice	0.74
15	193.11	249.03	263.01	1.25	3.50	256.77	257.41	4.23	4.88	0.65	1.39	orifice	0.79
16	205.61	249.43	263.79	1.25	3.75	257.41	258.04	4.24	4.87	0.63	1.30	orifice	0.81
17	218.11	249.82	264.57	1.25	4.00	258.04	258.69	4.23	4.88	0.65	1.22	orifice	0.79
18	230.61	250.21	265.35	1.25	4.25	258.69	259.50	4.24	5.04	0.81	1.19	orifice	0.66
19	242.61	250.50	266.10	1.25	4.75	259.50	260.22	4.25	4.97	0.72	1.05	orifice	0.73
20	254.70	250.50	266.86	1.25	5.25	260.22	260.89	4.47	5.14	0.68	0.98	orifice	0.73
21	266.70	250.50	267.61	1.25	5.50	260.89	261.40	4.89	5.40	0.50	0.98	orifice	0.85
22	278.70	250.50	268.36	1.25	5.75	261.40	261.92	5.15	5.67	0.52	0.99	orifice	0.79
23	290.70	250.50	269.11	1.25	6.00	261.92	262.30	5.42	5.80	0.38	0.97	orifice	0.95
				2.19									
Exit Slot	303.849	250.50	tunnel	2.19	0.01	262.30	262.50	11.99	11.99	0.21	1199.21	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	262.50	262.50	11.99	11.99	0.00	1199.42	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 4 - High Sills, Forebay = 263.0, Q = 46.2 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**Ave (33 - 62 cfs)**	**COEFFICIENTS**			0.8	0.46		250.5	
	Q =	46.2	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			5.51	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.00		4.34	5.09	2	1
	Cd_{sow} =	NA	**Forebay =**	**263.00**	Baffles =	23		15	0		0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.34	5.96	6.30	0.34	NA	orifice	0.86
2	16.20	243.51	251.95	1.50	1.00	249.34	249.80	4.83	5.30	0.46	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	1.00	249.80	250.33	4.84	5.36	0.52	NA	orifice	0.77
4	45.28	244.41	253.77	1.25	1.00	250.33	250.88	4.91	5.46	0.55	NA	orifice	0.87
5	59.78	244.87	254.68	1.25	1.00	250.88	251.40	5.01	5.53	0.52	NA	orifice	0.90
6	73.78	245.31	255.55	1.25	1.00	251.40	251.94	5.09	5.64	0.55	NA	orifice	0.85
7	87.78	245.74	256.43	1.25	1.00	251.94	252.46	5.20	5.71	0.51	NA	orifice	0.88
8	101.28	246.16	257.27	1.25	1.00	252.46	252.96	5.29	5.79	0.50	NA	orifice	0.87
9	114.78	246.59	258.11	1.25	1.75	252.96	253.59	4.62	5.25	0.63	3.00	orifice	0.83
10	128.11	247.00	258.95	1.25	2.25	253.59	254.34	4.34	5.09	0.75	2.26	orifice	0.76
11	141.61	247.43	259.79	1.25	2.50	254.34	255.05	4.42	5.12	0.71	2.05	orifice	0.79
12	154.61	247.83	260.60	1.25	2.75	255.05	255.75	4.47	5.17	0.71	1.88	orifice	0.78
13	167.61	248.24	261.42	1.25	3.00	255.75	256.44	4.52	5.20	0.68	1.73	orifice	0.79
14	180.61	248.64	262.23	1.25	3.25	256.44	257.16	4.54	5.27	0.73	1.62	orifice	0.75
15	193.11	249.03	263.01	1.25	3.50	257.16	257.82	4.63	5.28	0.65	1.51	orifice	0.80
16	205.61	249.43	263.79	1.25	3.75	257.82	258.45	4.64	5.28	0.64	1.41	orifice	0.82
17	218.11	249.82	264.57	1.25	4.00	258.45	259.11	4.64	5.29	0.65	1.32	orifice	0.80
18	230.61	250.21	265.35	1.25	4.25	259.11	259.93	4.65	5.48	0.82	1.29	orifice	0.66
19	242.61	250.50	266.10	1.25	4.75	259.93	260.66	4.68	5.41	0.73	1.14	orifice	0.73
20	254.70	250.50	266.86	1.25	5.25	260.66	261.35	4.91	5.60	0.69	1.07	orifice	0.73
21	266.70	250.50	267.61	1.25	5.50	261.35	261.87	5.35	5.87	0.51	1.07	orifice	0.85
22	278.70	250.50	268.36	1.25	5.75	261.87	262.39	5.62	6.14	0.53	1.07	orifice	0.80
23	290.70	250.50	269.11	1.25	6.00	262.39	262.78	5.89	6.28	0.39	1.05	orifice	0.95
				2.18									
Exit Slot	303.849	250.50	tunnel	2.18	0.01	262.78	263.00	12.49	12.49	0.21	1248.60	orifice	0.46
Exit Slot	317.001	250.50	tunnel	12.00	0.01	263.00	263.00	12.49	12.49	0.00	1248.83	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 5 - High Sills, Forebay = 264.0, Q = 53.1 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**(4* 33 + 3* 85 cfs)/7**	**COEFFICIENTS**		0.8	0.48		250.5		
	Q =	53.1	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		6.20	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	4.92	5.49	2		1
	Cd_{sow} =	NA	**Forebay =**	**264.00**	Baffles =	23	1	0			0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.42	5.96	6.39	0.42	NA	orifice	0.87
2	16.20	243.51	251.95	1.50	1.00	249.42	250.00	4.92	5.49	0.57	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	1.00	250.00	250.63	5.03	5.67	0.63	NA	orifice	0.77
4	45.28	244.41	253.77	1.25	1.00	250.63	251.27	5.21	5.86	0.64	NA	orifice	0.88
5	59.78	244.87	254.68	1.25	1.00	251.27	251.86	5.40	6.00	0.59	NA	orifice	0.91
6	73.78	245.31	255.55	1.25	1.00	251.86	252.48	5.56	6.17	0.61	NA	orifice	0.86
7	87.78	245.74	256.43	1.25	1.00	252.48	253.05	5.73	6.30	0.57	NA	orifice	0.88
8	101.28	246.16	257.27	1.25	1.00	253.05	253.60	5.88	6.44	0.56	NA	orifice	0.88
9	114.78	246.59	258.11	1.25	1.75	253.60	254.28	5.27	5.95	0.68	3.40	orifice	0.84
10	128.11	247.00	258.95	1.25	2.25	254.28	255.05	5.03	5.80	0.77	2.58	orifice	0.79
11	141.61	247.43	259.79	1.25	2.50	255.05	255.80	5.13	5.87	0.74	2.35	orifice	0.80
12	154.61	247.83	260.60	1.25	2.75	255.80	256.52	5.21	5.93	0.72	2.16	orifice	0.81
13	167.61	248.24	261.42	1.25	3.00	256.52	257.22	5.28	5.99	0.71	2.00	orifice	0.81
14	180.61	248.64	262.23	1.25	3.25	257.22	257.96	5.33	6.06	0.73	1.87	orifice	0.78
15	193.11	249.03	263.01	1.25	3.50	257.96	258.63	5.42	6.10	0.67	1.74	orifice	0.82
16	205.61	249.43	263.79	1.25	3.75	258.63	259.28	5.45	6.11	0.65	1.63	orifice	0.84
17	218.11	249.82	264.57	1.25	4.00	259.28	259.94	5.47	6.13	0.66	1.53	orifice	0.83
18	230.61	250.21	265.35	1.25	4.25	259.94	260.80	5.48	6.34	0.86	1.49	orifice	0.67
19	242.61	250.50	266.10	1.25	4.75	260.80	261.56	5.55	6.31	0.76	1.33	orifice	0.73
20	254.70	250.50	266.86	1.25	5.25	261.56	262.28	5.81	6.53	0.71	1.24	orifice	0.74
21	266.70	250.50	267.61	1.25	5.50	262.28	262.81	6.28	6.81	0.53	1.24	orifice	0.85
22	278.70	250.50	268.36	1.25	5.75	262.81	263.36	6.56	7.11	0.55	1.24	orifice	0.80
23	290.70	250.50	269.11	1.25	6.00	263.36	263.76	6.86	7.26	0.41	1.21	orifice	0.94
				2.17									
Exit Slot	303.849	250.50	tunnel	2.17	0.01	263.76	263.99	13.48	13.48	0.23	1348.01	orifice	0.48
Exit Slot	317.001	250.50	tunnel	12.00	0.01	263.99	263.99	13.48	13.48	0.00	1348.28	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 6 - High Sills, Forebay = 265.0, Q = 60.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		(3* 33 + 4* 85 cfs)/7	COEFFICIENTS			0.8	0.49		250.5	
	Q =	60.4	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			6.89	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		5.01	5.70	2	1
	Cd_{sow} =	NA	Forebay =	265.00	Baffles =	23		0	0		0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.52	5.96	6.48	0.52	NA	orifice	0.89
2	16.20	243.51	251.95	1.50	1.00	249.52	250.21	5.01	5.70	0.69	NA	orifice	0.85
3	30.78	243.96	252.86	1.50	1.00	250.21	250.95	5.25	5.99	0.74	NA	orifice	0.77
4	45.28	244.41	253.77	1.25	1.00	250.95	251.68	5.54	6.27	0.73	NA	orifice	0.89
5	59.78	244.87	254.68	1.25	1.00	251.68	252.35	5.82	6.49	0.67	NA	orifice	0.91
6	73.78	245.31	255.55	1.25	1.00	252.35	253.03	6.05	6.72	0.67	NA	orifice	0.88
7	87.78	245.74	256.43	1.25	1.00	253.03	253.66	6.28	6.91	0.63	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	253.66	254.26	6.49	7.10	0.61	NA	orifice	0.88
9	114.78	246.59	258.11	1.25	1.75	254.26	254.99	5.93	6.65	0.72	3.80	orifice	0.85
10	128.11	247.00	258.95	1.25	2.25	254.99	255.77	5.73	6.51	0.78	2.89	orifice	0.82
11	141.61	247.43	259.79	1.25	2.50	255.77	256.55	5.84	6.62	0.78	2.65	orifice	0.81
12	154.61	247.83	260.60	1.25	2.75	256.55	257.28	5.97	6.70	0.73	2.44	orifice	0.84
13	167.61	248.24	261.42	1.25	3.00	257.28	258.01	6.04	6.78	0.74	2.26	orifice	0.82
14	180.61	248.64	262.23	1.25	3.25	258.01	258.75	6.12	6.86	0.74	2.11	orifice	0.81
15	193.11	249.03	263.01	1.25	3.50	258.75	259.44	6.22	6.91	0.69	1.97	orifice	0.84
16	205.61	249.43	263.79	1.25	3.75	259.44	260.11	6.27	6.93	0.67	1.85	orifice	0.85
17	218.11	249.82	264.57	1.25	4.00	260.11	260.77	6.29	6.96	0.67	1.74	orifice	0.85
18	230.61	250.21	265.35	1.25	4.25	260.77	261.67	6.32	7.21	0.90	1.70	orifice	0.68
19	242.61	250.50	266.10	1.25	4.75	261.67	262.47	6.42	7.22	0.80	1.52	orifice	0.73
20	254.70	250.50	266.86	1.25	5.25	262.47	263.20	6.72	7.45	0.74	1.42	orifice	0.75
21	266.70	250.50	267.61	1.25	5.50	263.20	263.76	7.20	7.76	0.55	1.41	orifice	0.86
22	278.70	250.50	268.36	1.25	5.75	263.76	264.33	7.51	8.08	0.57	1.40	orifice	0.81
23	290.70	250.50	269.11	1.25	6.00	264.33	264.76	7.83	8.26	0.43	1.38	orifice	0.94
				2.16									
Exit Slot	303.849	250.50	tunnel	2.16	0.01	264.76	264.99	14.48	14.48	0.24	1448.37	orifice	0.49
Exit Slot	317.001	250.50	tunnel	12.00	0.01	264.99	265.00	14.49	14.49	0.00	1448.67	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 7 - High Sills, Forebay = 265.0, Q = 68.0 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		Ave (55 - 85 cfs)	COEFFICIENTS			0.8	0.51		250.5		
	Q =	68.0	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			7.59	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		5.12	5.93	2		1
	Cd_{sow} =	NA	Forebay =	266.00	Baffles =	23		0	0			0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.62	5.96	6.58	0.62	NA	orifice	0.91
2	16.20	243.51	251.95	1.50	1.00	249.62	250.43	5.12	5.93	0.81	NA	orifice	0.86
3	30.78	243.96	252.86	1.50	1.00	250.43	251.29	5.47	6.33	0.86	NA	orifice	0.78
4	45.28	244.41	253.77	1.25	1.00	251.29	252.11	5.88	6.69	0.82	NA	orifice	0.90
5	59.78	244.87	254.68	1.25	1.00	252.11	252.85	6.24	6.99	0.74	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	252.85	253.58	6.55	7.27	0.73	NA	orifice	0.90
7	87.78	245.74	256.43	1.25	1.00	253.58	254.27	6.84	7.52	0.69	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	254.27	254.93	7.10	7.76	0.66	NA	orifice	0.89
9	114.78	246.59	258.11	1.25	1.75	254.93	255.69	6.59	7.35	0.76	4.20	orifice	0.86
10	128.11	247.00	258.95	1.25	2.25	255.69	256.48	6.44	7.22	0.79	3.21	orifice	0.86
11	141.61	247.43	259.79	1.25	2.50	256.48	257.30	6.55	7.37	0.82	2.95	orifice	0.82
12	154.61	247.83	260.60	1.25	2.75	257.30	258.04	6.72	7.45	0.74	2.71	orifice	0.87
13	167.61	248.24	261.42	1.25	3.00	258.04	258.79	6.80	7.56	0.76	2.52	orifice	0.84
14	180.61	248.64	262.23	1.25	3.25	258.79	259.54	6.90	7.64	0.74	2.35	orifice	0.84
15	193.11	249.03	263.01	1.25	3.50	259.54	260.24	7.00	7.71	0.70	2.20	orifice	0.86
16	205.61	249.43	263.79	1.25	3.75	260.24	260.93	7.07	7.75	0.68	2.07	orifice	0.87
17	218.11	249.82	264.57	1.25	4.00	260.93	261.60	7.11	7.78	0.67	1.95	orifice	0.88
18	230.61	250.21	265.35	1.25	4.25	261.60	262.53	7.14	8.07	0.93	1.90	orifice	0.69
19	242.61	250.50	266.10	1.25	4.75	262.53	263.36	7.28	8.11	0.83	1.71	orifice	0.74
20	254.70	250.50	266.86	1.25	5.25	263.36	264.12	7.61	8.37	0.76	1.60	orifice	0.76
21	266.70	250.50	267.61	1.25	5.50	264.12	264.70	8.12	8.70	0.58	1.58	orifice	0.86
22	278.70	250.50	268.36	1.25	5.75	264.70	265.29	8.45	9.04	0.59	1.57	orifice	0.82
23	290.70	250.50	269.11	1.25	6.00	265.29	265.74	8.79	9.24	0.45	1.54	orifice	0.93
				2.15									
Exit Slot	303.849	250.50	tunnel	2.15	0.01	265.74	265.99	15.48	15.48	0.25	1548.10	orifice	0.51
Exit Slot	317.001	250.50	tunnel	12.00	0.01	265.99	265.99	15.48	15.48	0.00	1548.43	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 8 - High Sills, Forebay = 267.0, Q = 76.0 cfs, Total Ladder Q = 85 cfs

Forebay Calcs		**LAMPREY WEIRS**		**Ave (70 - 85 cfs)**	**COEFFICIENTS**		0.8	0.53		250.5			
		Q =	76.0	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.28	12			
		Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.23	6.17	2			1
		Cd_{sow} =	NA	**Forebay =**	**267.0**	Baffles =	23	0	0				0.65

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.73	5.96	6.70	0.73	NA	orifice	0.92
2	16.20	243.51	251.95	1.50	1.00	249.73	250.67	5.23	6.17	0.94	NA	orifice	0.86
3	30.78	243.96	252.86	1.50	1.00	250.67	251.65	5.71	6.68	0.97	NA	orifice	0.78
4	45.28	244.41	253.77	1.25	1.00	251.65	252.55	6.23	7.14	0.91	NA	orifice	0.91
5	59.78	244.87	254.68	1.25	1.00	252.55	253.37	6.68	7.50	0.82	NA	orifice	0.93
6	73.78	245.31	255.55	1.25	1.00	253.37	254.15	7.06	7.84	0.78	NA	orifice	0.91
7	87.78	245.74	256.43	1.25	1.00	254.15	254.89	7.40	8.15	0.74	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	254.89	255.60	7.72	8.44	0.71	NA	orifice	0.89
9	114.78	246.59	258.11	1.25	1.75	255.60	256.40	7.26	8.06	0.80	4.61	orifice	0.87
10	128.11	247.00	258.95	1.25	2.25	256.40	257.20	7.15	7.94	0.79	3.53	orifice	0.89
11	141.61	247.43	259.79	1.25	2.50	257.20	258.05	7.27	8.13	0.86	3.25	orifice	0.83
12	154.61	247.83	260.60	1.25	2.75	258.05	258.79	7.47	8.21	0.74	2.99	orifice	0.89
13	167.61	248.24	261.42	1.25	3.00	258.79	259.58	7.56	8.34	0.78	2.78	orifice	0.85
14	180.61	248.64	262.23	1.25	3.25	259.58	260.32	7.68	8.43	0.75	2.59	orifice	0.87
15	193.11	249.03	263.01	1.25	3.50	260.32	261.04	7.79	8.51	0.72	2.43	orifice	0.88
16	205.61	249.43	263.79	1.25	3.75	261.04	261.74	7.87	8.57	0.70	2.28	orifice	0.89
17	218.11	249.82	264.57	1.25	4.00	261.74	262.42	7.93	8.60	0.68	2.15	orifice	0.90
18	230.61	250.21	265.35	1.25	4.25	262.42	263.39	7.96	8.93	0.97	2.10	orifice	0.70
19	242.61	250.50	266.10	1.25	4.75	263.39	264.26	8.14	9.01	0.87	1.90	orifice	0.74
20	254.70	250.50	266.86	1.25	5.25	264.26	265.05	8.51	9.30	0.79	1.77	orifice	0.76
21	266.70	250.50	267.61	1.25	5.50	265.05	265.65	9.05	9.65	0.60	1.76	orifice	0.86
22	278.70	250.50	268.36	1.25	5.75	265.65	266.26	9.40	10.01	0.61	1.74	orifice	0.83
23	290.70	250.50	269.11	1.25	6.00	266.26	266.74	9.76	10.24	0.48	1.71	orifice	0.93
				2.14									
Exit Slot	303.849	250.50	tunnel	2.14	0.01	266.74	267.00	16.49	16.49	0.26	1648.62	orifice	0.53
Exit Slot	317.001	250.50	tunnel	12.00	0.01	267.00	267.00	16.49	16.49	0.00	1648.98	orifice	

a – Insurance Test Simulations for High Sills (cont.):

Simulation 9 - High Sills, Forebay = 268.0, Q = 84.3 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**					0.8	0.55		250.5	
	Q =	84.3	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.98	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.35	6.42	2	1
	Cd_{sow} =	NA	**Forebay =**	**268.0**	Baffles =	23	0	0		

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.85	5.96	6.81	0.85	NA	orifice	0.94
2	16.20	243.51	251.95	1.50	1.00	249.85	250.92	5.35	6.42	1.07	NA	orifice	0.87
3	30.78	243.96	252.86	1.50	1.00	250.92	252.01	5.96	7.05	1.09	NA	orifice	0.78
4	45.28	244.41	253.77	1.25	1.00	252.01	253.00	6.60	7.58	0.99	NA	orifice	0.92
5	59.78	244.87	254.68	1.25	1.00	253.00	253.89	7.13	8.02	0.89	NA	orifice	0.93
6	73.78	245.31	255.55	1.25	1.00	253.89	254.71	7.58	8.41	0.83	NA	orifice	0.93
7	87.78	245.74	256.43	1.25	1.00	254.71	255.51	7.97	8.77	0.80	NA	orifice	0.91
8	101.28	246.16	257.27	1.25	1.00	255.51	256.27	8.35	9.11	0.76	NA	orifice	0.90
9	114.78	246.59	258.11	1.25	1.75	256.27	257.11	7.94	8.77	0.84	NA	orifice	0.88
10	128.11	247.00	258.95	1.25	2.25	257.11	257.91	7.86	8.65	0.80	3.85	orifice	0.92
11	141.61	247.43	259.79	1.25	2.50	257.91	258.80	7.98	8.87	0.89	3.55	orifice	0.84
12	154.61	247.83	260.60	1.25	2.75	258.80	259.55	8.22	8.97	0.75	3.26	orifice	0.92
13	167.61	248.24	261.42	1.25	3.00	259.55	260.35	8.31	9.12	0.81	3.04	orifice	0.87
14	180.61	248.64	262.23	1.25	3.25	260.35	261.10	8.46	9.21	0.75	2.83	orifice	0.90
15	193.11	249.03	263.01	1.25	3.50	261.10	261.83	8.57	9.30	0.73	2.66	orifice	0.90
16	205.61	249.43	263.79	1.25	3.75	261.83	262.55	8.66	9.38	0.72	2.50	orifice	0.90
17	218.11	249.82	264.57	1.25	4.00	262.55	263.23	8.74	9.42	0.68	2.35	orifice	0.93
18	230.61	250.21	265.35	1.25	4.25	263.23	264.24	8.78	9.78	1.01	2.30	orifice	0.71
19	242.61	250.50	266.10	1.25	4.75	264.24	265.15	8.99	9.90	0.91	2.08	orifice	0.74
20	254.70	250.50	266.86	1.25	5.25	265.15	265.96	9.40	10.21	0.81	1.95	orifice	0.77
21	266.70	250.50	267.61	1.25	5.50	265.96	266.60	9.96	10.60	0.63	1.93	orifice	0.86
22	278.70	250.50	268.36	1.25	5.75	266.60	267.23	10.35	10.98	0.63	1.91	orifice	0.83
23	290.70	250.50	269.11	1.25	6.00	267.23	267.73	10.73	11.23	0.51	1.87	orifice	0.92
				2.13									
Exit Slot	303.849	250.50	tunnel	2.13	0.01	267.73	268.00	17.49	17.49	0.26	1748.52	orifice	0.55
Exit Slot	317.001	250.50	tunnel	12.00	0.01	268.00	268.00	17.49	17.49	0.00	1748.91	orifice	

b – Insurance Test Simulations for Low Sills:

Simulation 1 - Low Sills, Forebay = 257, Q = 33.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL FB 257 COEFFICIENTS**			0.8	0.75		Invert at exit =	250.5	
	Q =	31.75	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		4.55	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	3.83	4.22	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**257.0**	Baffles =	23	22	19			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	1.00	249.00	249.29	4.96	5.25	31.75	32.41	0.6580	0.29	NA	orifice	0.72
2	16.20	243.51	251.95	1.50	1.00	249.29	249.53	4.79	5.03	31.75	31.75	0.0001	0.24	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	1.00	249.53	249.80	4.57	4.84	31.75	31.75	0.0001	0.27	4.84	orifice	0.81
4	45.28	244.41	253.77	1.25	1.00	249.80	250.13	4.38	4.71	31.75	31.75	0.0001	0.33	4.71	orifice	0.86
5	59.78	244.87	254.68	1.25	1.00	250.13	250.44	4.26	4.58	31.75	31.75	0.0002	0.32	4.58	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	250.44	250.75	4.14	4.44	31.75	31.75	0.0004	0.30	4.44	orifice	0.97
7	87.78	245.74	256.43	1.25	1.00	250.75	251.10	4.01	4.35	31.75	31.75	0.0001	0.35	4.35	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	251.10	251.53	3.93	4.36	31.75	31.75	0.0001	0.43	4.36	orifice	0.78
9	114.78	246.59	258.11	1.25	1.00	251.53	251.92	3.94	4.33	31.75	31.75	0.0001	0.39	4.33	orifice	0.84
10	128.11	247.00	258.95	1.25	1.00	251.92	252.30	3.91	4.29	31.75	31.75	0.0008	0.38	4.29	orifice	0.86
11	141.61	247.43	259.79	1.25	1.00	252.30	252.72	3.87	4.29	31.75	31.75	0.0001	0.42	4.29	orifice	0.80
12	154.61	247.83	260.60	1.25	1.00	252.72	253.10	3.89	4.27	31.75	31.75	0.0005	0.38	4.27	orifice	0.87
13	167.61	248.24	261.42	1.25	1.00	253.10	253.47	3.86	4.24	31.75	31.75	0.0006	0.38	4.24	orifice	0.88
14	180.61	248.64	262.23	1.25	1.00	253.47	253.89	3.83	4.24	31.75	31.75	0.0001	0.42	4.24	orifice	0.82
15	193.11	249.03	263.01	1.25	1.00	253.89	254.25	3.85	4.22	31.75	31.75	0.0001	0.37	4.22	orifice	0.90
16	205.61	249.43	263.79	1.25	1.00	254.25	254.66	3.83	4.24	31.75	31.75	0.0001	0.41	4.24	orifice	0.83
17	218.11	249.82	264.57	1.25	1.00	254.66	255.09	3.85	4.28	31.75	31.75	0.0001	0.43	4.28	orifice	0.79
18	230.61	250.21	265.35	**1.50**	1.00	255.09	255.45	3.89	4.25	31.75	31.75	0.0001	0.36	4.25	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	255.45	255.89	3.95	4.39	31.75	31.75	0.0000	0.44	4.39	orifice	0.63
20	254.70	250.50	266.86	**1.50**	1.00	255.89	256.17	4.39	4.67	31.75	31.75	0.0009	0.28	4.67	orifice	0.81
21	266.70	250.50	267.61	1.50	1.00	256.17	256.36	4.67	4.86	31.75	31.75	-0.0003	0.19	4.86	orifice	0.99
22	278.70	250.50	268.36	1.50	1.00	256.36	256.61	4.86	5.11	31.75	31.75	0.0001	0.24	NA	orifice	0.81
23	290.70	250.50	269.11	1.50	1.00	256.61	256.86	5.11	5.36	31.75	31.75	0.0001	0.25	NA	orifice	0.76
				15.18	2.35											
Exit Slot	303.849	250.50	tunnel	2.35	0.01	256.86	256.98	6.47	6.47	31.75		0.0000	0.12	646.66	orifice	0.75
Exit Slot	317.001	250.50	tunnel	12.00	0.01	256.98	256.98	6.47	6.47	31.75		-0.0002	0.00	647.06	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 2 - Low Sills, Forebay = 258, Q = 37.7 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		1' SILL (Ave 32- 44 cfs) COEFFICIENTS			0.8	0.78		Invert at exit =	250.5		
	Q =	37.7	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		5.33	Exit width =	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01	4.56	4.98	Trash Rack K =	2		1
	Cd_{sow} =	NA	Forebay =	258.00	Baffles =	23	17	1				0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.57	6.26	6.53	37.7	37.70	0.0001	0.27	NA	orifice	0.75
2	16.20	243.51	251.95	1.50	1.00	249.57	249.87	5.06	5.36	37.7	37.70	0.0006	0.30	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	1.00	249.87	250.20	4.91	5.23	37.7	37.70	0.0002	0.33	NA	orifice	0.81
4	45.28	244.41	253.77	1.25	1.00	250.20	250.60	4.78	5.18	37.7	37.70	0.0001	0.40	NA	orifice	0.87
5	59.78	244.87	254.68	1.25	1.00	250.60	250.97	4.73	5.11	37.7	37.70	0.0002	0.38	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	250.97	251.32	4.67	5.01	37.7	37.70	0.0001	0.34	NA	orifice	0.99
7	87.78	245.74	256.43	1.25	1.00	251.32	251.72	4.58	4.98	37.7	37.70	0.0001	0.40	4.98	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	251.72	252.20	4.56	5.04	37.7	37.70	0.0000	0.48	NA	orifice	0.79
9	114.78	246.59	258.11	1.25	1.00	252.20	252.63	4.61	5.04	37.7	37.70	0.0001	0.43	NA	orifice	0.85
10	128.11	247.00	258.95	1.25	1.00	252.63	253.05	4.63	5.05	37.7	37.70	0.0001	0.42	NA	orifice	0.87
11	141.61	247.43	259.79	1.25	1.00	253.05	253.49	4.62	5.07	37.7	37.70	0.0000	0.44	NA	orifice	0.83
12	154.61	247.83	260.60	1.25	1.00	253.49	253.91	4.66	5.08	37.7	37.70	0.0001	0.42	NA	orifice	0.86
13	167.61	248.24	261.42	1.25	1.00	253.91	254.31	4.67	5.07	37.7	37.70	0.0001	0.40	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	1.00	254.31	254.74	4.67	5.10	37.7	37.70	0.0000	0.43	NA	orifice	0.84
15	193.11	249.03	263.01	1.25	1.00	254.74	255.13	4.71	5.09	37.7	37.70	0.0001	0.38	NA	orifice	0.91
16	205.61	249.43	263.79	1.25	1.00	255.13	255.56	4.70	5.13	37.7	37.70	0.0000	0.43	NA	orifice	0.84
17	218.11	249.82	264.57	1.25	1.00	255.56	256.00	4.74	5.18	37.7	37.70	0.0000	0.44	NA	orifice	0.81
18	230.61	250.21	265.35	1.50	1.00	256.00	256.38	4.79	5.17	37.7	37.70	0.0001	0.38	NA	orifice	0.75
19	242.61	250.50	266.10	1.50	1.00	256.38	256.84	4.88	5.34	37.7	37.70	0.0000	0.46	NA	orifice	0.64
20	254.70	250.50	266.86	1.50	1.00	256.84	257.13	5.34	5.63	37.7	37.70	0.0006	0.29	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	257.13	257.34	5.63	5.84	37.7	37.70	-0.0001	0.21	NA	orifice	0.97
22	278.70	250.50	268.36	1.50	1.00	257.34	257.59	5.84	6.09	37.7	37.70	0.0001	0.26	NA	orifice	0.82
23	290.70	250.50	269.11	1.50	1.00	257.59	257.86	6.09	6.36	37.7	37.70	0.0001	0.27	NA	orifice	0.76
				17.20	2.30											
Exit Slot	303.849	250.50	tunnel	2.30	0.01	257.86	257.98	7.47	7.47	37.7		0.0000	0.12	747.29	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	257.98	257.99	7.48	7.48	37.7		-0.0001	0.00	747.71	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 3 - Low Sills, Forebay = 259, Q = 44.0 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL (32 + 58 cfs) COEFFICIENTS**			0.8	0.81		Invert at exit =	250.5		
	Q =	44	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		6.00	Exit width =	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01	5.02	5.47	Trash Rack K =	2		1
	Cd_{sow} =	NA	**Forebay =**	**259.0**	Baffles =	23	0	0				0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.64	6.26	6.60	44	44.00	0.0002	0.34	NA	orifice	0.77
2	16.20	243.51	251.95	1.50	1.00	249.64	250.02	5.13	5.52	44	44.00	0.0007	0.38	NA	orifice	0.85
3	30.78	243.96	252.86	1.50	1.00	250.02	250.44	5.06	5.48	44	44.00	0.0001	0.42	NA	orifice	0.82
4	45.28	244.41	253.77	1.25	1.00	250.44	250.93	5.02	5.52	44	44.00	-0.0001	0.49	NA	orifice	0.87
5	59.78	244.87	254.68	1.25	1.00	250.93	251.38	5.06	5.52	44	44.00	0.0000	0.45	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	251.38	251.78	5.08	5.47	44	44.00	0.0001	0.39	NA	orifice	1.01
7	87.78	245.74	256.43	1.25	1.00	251.78	252.25	5.03	5.51	44	44.00	0.0000	0.47	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	252.25	252.79	5.09	5.62	44	44.00	-0.0002	0.54	NA	orifice	0.81
9	114.78	246.59	258.11	1.25	1.00	252.79	253.27	5.20	5.68	44	44.00	-0.0001	0.48	NA	orifice	0.86
10	128.11	247.00	258.95	1.25	1.00	253.27	253.73	5.27	5.73	44	44.00	0.0000	0.46	NA	orifice	0.88
11	141.61	247.43	259.79	1.25	1.00	253.73	254.19	5.30	5.77	44	44.00	-0.0001	0.46	NA	orifice	0.87
12	154.61	247.83	260.60	1.25	1.00	254.19	254.66	5.36	5.83	44	44.00	-0.0001	0.47	NA	orifice	0.86
13	167.61	248.24	261.42	1.25	1.00	254.66	255.10	5.42	5.86	44	44.00	0.0000	0.44	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	1.00	255.10	255.55	5.46	5.91	44	44.00	-0.0001	0.45	NA	orifice	0.86
15	193.11	249.03	263.01	1.25	1.00	255.55	255.96	5.52	5.92	44	44.00	0.0001	0.40	NA	orifice	0.92
16	205.61	249.43	263.79	1.25	1.00	255.96	256.41	5.53	5.99	44	44.00	-0.0001	0.46	NA	orifice	0.84
17	218.11	249.82	264.57	1.25	1.00	256.41	256.87	5.60	6.06	44	44.00	-0.0001	0.46	NA	orifice	0.83
18	230.61	250.21	265.35	**1.50**	1.00	256.87	257.28	5.67	6.07	44	44.00	0.0001	0.40	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	257.28	257.75	5.78	6.25	44	44.00	-0.0002	0.48	NA	orifice	0.65
20	254.70	250.50	266.86	**1.50**	1.00	257.75	258.06	6.25	6.56	44	44.00	0.0003	0.31	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	258.06	258.29	6.56	6.79	44	44.00	0.0000	0.23	NA	orifice	0.96
22	278.70	250.50	268.36	1.50	1.00	258.29	258.56	6.79	7.06	44	44.00	0.0001	0.27	NA	orifice	0.83
23	290.70	250.50	269.11	1.50	1.00	258.56	258.85	7.06	7.35	44	44.00	0.0008	0.29	NA	orifice	0.76
				19.17	2.27											
Exit Slot	303.849	250.50	tunnel	2.27	0.01	258.85	258.97	8.46	8.46	44		0.0000	0.12	846.19	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	258.97	258.98	8.47	8.47	44		0.0000	0.00	846.65	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 4 - Low Sills, Forebay = 260, Q = 50.5 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL (44 + 58 cfs) COEFFICIENTS**				0.8	0.84		Invert at exit =	250.5	
	Q =	50.5	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			6.71	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01		5.21	5.69	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**260.0**	Baffles =	23		0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.72	6.26	6.68	50.5	50.50	0.0001	0.42	NA	orifice	0.80
2	16.20	243.51	251.95	1.50	1.00	249.72	250.20	5.21	5.69	50.5	50.50	-0.0001	0.48	NA	orifice	0.85
3	30.78	243.96	252.86	1.50	1.00	250.20	250.70	5.24	5.74	50.5	50.50	-0.0001	0.51	NA	orifice	0.82
4	45.28	244.41	253.77	1.25	1.00	250.70	251.29	5.29	5.88	50.5	50.50	-0.0003	0.59	NA	orifice	0.87
5	59.78	244.87	254.68	1.25	1.00	251.29	251.82	5.42	5.95	50.5	50.50	-0.0002	0.53	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	251.82	252.27	5.52	5.97	50.5	50.50	0.0000	0.45	NA	orifice	1.01
7	87.78	245.74	256.43	1.25	1.00	252.27	252.81	5.53	6.07	50.5	50.50	-0.0003	0.54	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	1.00	252.81	253.41	5.64	6.25	50.5	50.50	-0.0003	0.60	NA	orifice	0.81
9	114.78	246.59	258.11	1.25	1.00	253.41	253.94	5.83	6.36	50.5	50.50	-0.0003	0.53	NA	orifice	0.86
10	128.11	247.00	258.95	1.25	1.00	253.94	254.45	5.94	6.44	50.5	50.50	-0.0003	0.50	NA	orifice	0.88
11	141.61	247.43	259.79	1.25	1.00	254.45	254.95	6.02	6.53	50.5	50.50	-0.0003	0.50	NA	orifice	0.87
12	154.61	247.83	260.60	1.25	1.00	254.95	255.45	6.12	6.62	50.5	50.50	-0.0003	0.50	NA	orifice	0.86
13	167.61	248.24	261.42	1.25	1.00	255.45	255.92	6.21	6.69	50.5	50.50	-0.0002	0.47	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	1.00	255.92	256.41	6.28	6.76	50.5	50.50	-0.0002	0.48	NA	orifice	0.86
15	193.11	249.03	263.01	1.25	1.00	256.41	256.83	6.37	6.80	50.5	50.50	0.0000	0.43	NA	orifice	0.92
16	205.61	249.43	263.79	1.25	1.00	256.83	257.31	6.41	6.89	50.5	50.50	-0.0003	0.48	NA	orifice	0.84
17	218.11	249.82	264.57	1.25	1.00	257.31	257.80	6.50	6.98	50.5	50.50	-0.0003	0.48	NA	orifice	0.83
18	230.61	250.21	265.35	**1.50**	1.00	257.80	258.22	6.59	7.01	50.5	50.50	0.0000	0.42	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	258.22	258.72	6.72	7.22	50.5	50.50	-0.0004	0.50	NA	orifice	0.65
20	254.70	250.50	266.86	**1.50**	1.00	258.72	259.05	7.22	7.55	50.5	50.50	0.0001	0.32	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	259.05	259.28	7.55	7.78	50.5	50.50	0.0001	0.24	NA	orifice	0.96
22	278.70	250.50	268.36	1.50	1.00	259.28	259.57	7.78	8.07	50.5	50.50	0.0001	0.28	NA	orifice	0.83
23	290.70	250.50	269.11	1.50	1.00	259.57	259.87	8.07	8.37	50.5	50.50	0.0003	0.31	NA	orifice	0.76
				21.22	2.24											
Exit Slot	303.849	250.50	tunnel	2.24	0.01	259.87	260.00	9.49	9.49	50.5		0.0000	0.12	948.57	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	260.00	260.00	9.49	9.49	50.5		0.0000	0.00	949.05	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 5 - Low Sills, Forebay = 261, Q = 57.8 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL (Ave 32- 85 cfs) COEFFICIENTS**				0.8	0.87		Invert at exit =	250.5	
	Q =	57.8	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			7.38	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01		5.30	5.88	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**261.00**	Baffles =	23		0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.81	6.26	6.77	57.8	57.80	-0.0002	0.51	NA	orifice	0.82
2	16.20	243.51	251.95	1.50	1.00	249.81	250.38	5.30	5.88	57.8	57.80	-0.0003	0.58	NA	orifice	0.87
3	30.78	243.96	252.86	1.50	1.00	250.38	250.99	5.42	6.03	57.8	57.80	-0.0003	0.61	NA	orifice	0.82
4	45.28	244.41	253.77	1.25	1.00	250.99	251.67	5.58	6.26	57.8	57.80	-0.0003	0.68	NA	orifice	0.88
5	59.78	244.87	254.68	1.25	1.00	251.67	252.29	5.81	6.42	57.8	57.80	-0.0004	0.61	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	252.29	252.77	5.98	6.46	57.8	57.80	-0.0002	0.48	NA	orifice	1.06
7	87.78	245.74	256.43	1.25	1.00	252.77	253.38	6.03	6.64	57.8	57.80	-0.0004	0.61	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	253.38	254.02	6.22	6.86	57.8	57.80	-0.0005	0.64	NA	orifice	0.84
9	114.78	246.59	258.11	1.25	1.00	254.02	254.60	6.44	7.01	57.8	57.80	-0.0005	0.57	NA	orifice	0.88
10	128.11	247.00	258.95	1.25	1.00	254.60	255.14	6.59	7.13	57.8	57.80	-0.0005	0.54	NA	orifice	0.90
11	141.61	247.43	259.79	1.25	1.00	255.14	255.63	6.71	7.21	57.8	57.80	-0.0004	0.50	NA	orifice	0.93
12	154.61	247.83	260.60	1.25	1.00	255.63	256.20	6.80	7.37	57.8	57.80	-0.0006	0.57	NA	orifice	0.84
13	167.61	248.24	261.42	1.25	1.00	256.20	256.71	6.97	7.48	57.8	57.80	-0.0005	0.51	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	1.00	256.71	257.20	7.07	7.56	57.8	57.80	-0.0004	0.49	NA	orifice	0.90
15	193.11	249.03	263.01	1.25	1.00	257.20	257.65	7.17	7.61	57.8	57.80	-0.0002	0.44	NA	orifice	0.95
16	205.61	249.43	263.79	1.25	1.00	257.65	258.15	7.22	7.73	57.8	57.80	-0.0005	0.50	NA	orifice	0.86
17	218.11	249.82	264.57	1.25	1.00	258.15	258.64	7.34	7.83	57.8	57.80	-0.0005	0.49	NA	orifice	0.87
18	230.61	250.21	265.35	**1.50**	1.00	258.64	259.10	7.44	7.89	57.8	57.80	-0.0003	0.46	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	259.10	259.62	7.60	8.12	57.8	57.80	-0.0007	0.52	NA	orifice	0.67
20	254.70	250.50	266.86	**1.50**	1.00	259.62	259.96	8.12	8.46	57.8	57.80	0.0002	0.35	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	259.96	260.23	8.46	8.73	57.8	57.80	0.0001	0.27	NA	orifice	0.92
22	278.70	250.50	268.36	1.50	1.00	260.23	260.53	8.73	9.03	57.8	57.80	0.0005	0.30	NA	orifice	0.84
23	290.70	250.50	269.11	1.50	1.00	260.53	260.86	9.03	9.36	57.8	57.80	0.0001	0.33	NA	orifice	0.77
				23.21	2.21											
Exit Slot	303.849	250.50	tunnel	2.21	0.01	260.86	260.99	10.48	10.48	57.8		0.0000	0.13	1047.82	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	260.99	260.99	10.48	10.48	57.8		0.0000	0.01	1048.33	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 6 - Low Sills, Forebay = 262, Q = 65 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL (CD(58) +2*CD(69) cfs)/3 COEFFICIENTS**				0.8	0.90		Invert at exit =	250.5	
	Q =	65	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			8.08	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01		5.39	6.07	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**262.00**	Baffles =	23		0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.90	6.26	6.86	65	65.00	-0.0004	0.60	NA	orifice	0.85
2	16.20	243.51	251.95	1.50	1.00	249.90	250.58	5.39	6.07	65	65.00	-0.0003	0.68	NA	orifice	0.88
3	30.78	243.96	252.86	1.50	1.00	250.58	251.29	5.62	6.32	65	65.00	-0.0003	0.71	NA	orifice	0.83
4	45.28	244.41	253.77	1.25	1.00	251.29	252.07	5.87	6.65	65	65.00	-0.0002	0.78	NA	orifice	0.89
5	59.78	244.87	254.68	1.25	1.00	252.07	252.76	6.20	6.89	65	65.00	-0.0004	0.69	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	252.76	253.28	6.45	6.97	65	65.00	-0.0004	0.52	NA	orifice	1.08
7	87.78	245.74	256.43	1.25	1.00	253.28	253.96	6.54	7.21	65	65.00	-0.0005	0.68	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	253.96	254.65	6.79	7.48	65	65.00	-0.0005	0.69	NA	orifice	0.85
9	114.78	246.59	258.11	1.25	1.00	254.65	255.27	7.06	7.68	65	65.00	-0.0007	0.62	NA	orifice	0.89
10	128.11	247.00	258.95	1.25	1.00	255.27	255.84	7.26	7.84	65	65.00	-0.0007	0.58	NA	orifice	0.90
11	141.61	247.43	259.79	1.25	1.00	255.84	256.36	7.42	7.93	65	65.00	-0.0006	0.52	NA	orifice	0.96
12	154.61	247.83	260.60	1.25	1.00	256.36	256.98	7.53	8.15	65	65.00	-0.0008	0.62	NA	orifice	0.84
13	167.61	248.24	261.42	1.25	1.00	256.98	257.52	7.74	8.28	65	65.00	-0.0008	0.54	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	1.00	257.52	258.03	7.88	8.38	65	65.00	-0.0007	0.50	NA	orifice	0.92
15	193.11	249.03	263.01	1.25	1.00	258.03	258.49	7.99	8.46	65	65.00	-0.0004	0.46	NA	orifice	0.95
16	205.61	249.43	263.79	1.25	1.00	258.49	259.02	8.07	8.59	65	65.00	-0.0009	0.53	NA	orifice	0.87
17	218.11	249.82	264.57	1.25	1.00	259.02	259.53	8.20	8.71	65	65.00	-0.0008	0.51	NA	orifice	0.88
18	230.61	250.21	265.35	**1.50**	1.00	259.53	260.01	8.32	8.80	65	65.00	-0.0007	0.48	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	260.01	260.55	8.51	9.05	65	65.00	0.0001	0.54	NA	orifice	0.68
20	254.70	250.50	266.86	**1.50**	1.00	260.55	260.91	9.05	9.41	65	65.00	0.0001	0.36	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	260.91	261.20	9.41	9.70	65	65.00	0.0010	0.29	NA	orifice	0.91
22	278.70	250.50	268.36	1.50	1.00	261.20	261.51	9.70	10.01	65	65.00	0.0002	0.31	NA	orifice	0.84
23	290.70	250.50	269.11	1.50	1.00	261.51	261.86	10.01	10.36	65	65.00	0.0002	0.35	NA	orifice	0.77
				25.21	2.20											
Exit Slot	303.849	250.50	tunnel	2.20	0.01	261.86	261.99	11.48	11.48	65		0.0000	0.13	1147.87	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	261.99	261.99	11.48	11.48	65		0.0000	0.01	1148.41	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 7 - Low Sills, Forebay = 262.5, Q = 68.8 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**1' SILL (Ave 50- 85 cfs) COEFFICIENTS**			0.80	0.91		Invert at exit =	250.5		
	Q =	68.8	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.36	Exit width =	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.18	5.96	Trash Rack K =	2		1
	Cd_{sow} =	NA	**Forebay =**	**262.50**	Baffles =	23	0	0				0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.69	5.96	6.65	68.8	68.80	-0.0003	0.69	NA	orifice	0.86
2	16.20	243.51	251.95	1.50	1.00	249.69	250.47	5.18	5.96	68.8	68.80	-0.0001	0.78	NA	orifice	0.88
3	30.78	243.96	252.86	1.50	1.00	250.47	251.26	5.51	6.30	68.8	68.80	-0.0001	0.80	NA	orifice	0.83
4	45.28	244.41	253.77	1.25	1.00	251.26	252.12	5.85	6.71	68.8	68.80	0.0000	0.86	NA	orifice	0.89
5	59.78	244.87	254.68	1.25	1.00	252.12	252.88	6.26	7.01	68.8	68.80	-0.0003	0.75	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	1.00	252.88	253.43	6.57	7.13	68.8	68.80	-0.0005	0.56	NA	orifice	1.09
7	87.78	245.74	256.43	1.25	1.00	253.43	254.16	6.69	7.42	68.8	68.80	-0.0004	0.73	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	254.16	254.89	6.99	7.72	68.8	68.80	-0.0005	0.73	NA	orifice	0.85
9	114.78	246.59	258.11	1.25	1.00	254.89	255.54	7.30	7.95	68.8	68.80	-0.0008	0.65	NA	orifice	0.89
10	128.11	247.00	258.95	1.25	1.00	255.54	256.14	7.53	8.14	68.8	68.80	-0.0009	0.60	NA	orifice	0.91
11	141.61	247.43	259.79	1.25	1.00	256.14	256.67	7.72	8.25	68.8	68.80	-0.0008	0.53	NA	orifice	0.97
12	154.61	247.83	260.60	1.25	1.00	256.67	257.32	7.84	8.49	68.8	68.80	0.0001	0.65	NA	orifice	0.83
13	167.61	248.24	261.42	1.25	1.00	257.32	257.89	8.08	8.65	68.8	68.80	0.0001	0.57	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	1.00	257.89	258.41	8.24	8.76	68.8	68.80	-0.0009	0.52	NA	orifice	0.92
15	193.11	249.03	263.01	1.25	1.00	258.41	258.88	8.37	8.85	68.8	68.80	-0.0006	0.48	NA	orifice	0.96
16	205.61	249.43	263.79	1.25	1.00	258.88	259.43	8.46	9.00	68.8	68.80	0.0001	0.54	NA	orifice	0.87
17	218.11	249.82	264.57	1.25	1.00	259.43	259.95	8.61	9.13	68.8	68.80	0.0001	0.52	NA	orifice	0.89
18	230.61	250.21	265.35	**1.50**	1.00	259.95	260.44	8.74	9.24	68.8	68.80	-0.0009	0.50	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	260.44	261.00	8.94	9.50	68.8	68.80	0.0001	0.55	NA	orifice	0.68
20	254.70	250.50	266.86	**1.50**	1.00	261.00	261.37	9.50	9.87	68.8	68.80	0.0001	0.37	NA	orifice	0.82
21	266.70	250.50	267.61	1.50	1.00	261.37	261.67	9.87	10.17	68.8	68.80	0.0005	0.30	NA	orifice	0.90
22	278.70	250.50	268.36	1.50	1.00	261.67	262.00	10.17	10.50	68.8	68.80	0.0001	0.32	NA	orifice	0.84
23	290.70	250.50	269.11	1.50	1.00	262.00	262.35	10.50	10.85	68.8	68.80	0.0001	0.36	NA	orifice	0.77
				26.19	2.19											
Exit Slot	303.849	250.50	tunnel	2.19	0.01	262.35	262.48	11.97	11.97	68.8		0.0000	0.13	1197.13	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	262.48	262.49	11.98	11.98	68.8		0.0000	0.01	1197.69	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 8 - Low Sills, Forebay = 263, Q = 72.8 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		1' SILL (CD(85) +2*CD(69) cfs)/3 COEFFICIENTS			0.8	0.93		Invert at exit =	250.5	
	Q =	72.8	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.77	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01	5.48	6.27	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**263.01**	Baffles =	23	0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.99	6.26	6.95	72.8	72.80	-0.0004	0.69	NA	orifice	0.88
2	16.20	243.51	251.95	1.50	1.00	249.99	250.78	5.48	6.27	72.8	72.80	-0.0001	0.79	NA	orifice	0.89
3	30.78	243.96	252.86	1.50	1.00	250.78	251.59	5.82	6.63	72.8	72.80	-0.0001	0.81	NA	orifice	0.83
4	45.28	244.41	253.77	1.25	1.00	251.59	252.47	6.18	7.06	72.8	72.80	0.0000	0.88	NA	orifice	0.89
5	59.78	244.87	254.68	1.25	1.00	252.47	253.24	6.60	7.37	72.8	72.80	-0.0003	0.77	NA	orifice	0.93
6	73.78	245.31	255.55	1.25	1.00	253.24	253.80	6.94	7.49	72.8	72.80	-0.0006	0.55	NA	orifice	1.11
7	87.78	245.74	256.43	1.25	1.00	253.80	254.55	7.05	7.80	72.8	72.80	-0.0004	0.75	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	254.55	255.28	7.38	8.11	72.8	72.80	-0.0006	0.73	NA	orifice	0.87
9	114.78	246.59	258.11	1.25	1.00	255.28	255.93	7.69	8.35	72.8	72.80	-0.0009	0.66	NA	orifice	0.90
10	128.11	247.00	258.95	1.25	1.00	255.93	256.54	7.93	8.54	72.8	72.80	0.0001	0.61	NA	orifice	0.92
11	141.61	247.43	259.79	1.25	1.00	256.54	257.06	8.12	8.64	72.8	72.80	-0.0008	0.52	NA	orifice	1.00
12	154.61	247.83	260.60	1.25	1.00	257.06	257.75	8.23	8.91	72.8	72.80	0.0001	0.68	NA	orifice	0.82
13	167.61	248.24	261.42	1.25	1.00	257.75	258.33	8.51	9.09	72.8	72.80	0.0001	0.58	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	1.00	258.33	258.84	8.68	9.20	72.8	72.80	0.0001	0.51	NA	orifice	0.94
15	193.11	249.03	263.01	1.25	1.00	258.84	259.32	8.81	9.29	72.8	72.80	-0.0008	0.48	NA	orifice	0.97
16	205.61	249.43	263.79	1.25	1.00	259.32	259.87	8.90	9.45	72.8	72.80	0.0001	0.55	NA	orifice	0.88
17	218.11	249.82	264.57	1.25	1.00	259.87	260.39	9.06	9.58	72.8	72.80	0.0001	0.52	NA	orifice	0.90
18	230.61	250.21	265.35	**1.50**	1.00	260.39	260.91	9.19	9.70	72.8	72.80	0.0001	0.51	NA	orifice	0.75
19	242.61	250.50	266.10	**1.50**	1.00	260.91	261.46	9.41	9.96	72.8	72.80	0.0001	0.55	NA	orifice	0.69
20	254.70	250.50	266.86	**1.50**	1.00	261.46	261.84	9.96	10.34	72.8	72.80	0.0000	0.38	NA	orifice	0.83
21	266.70	250.50	267.61	1.50	1.00	261.84	262.17	10.34	10.67	72.8	72.80	0.0001	0.32	NA	orifice	0.89
22	278.70	250.50	268.36	1.50	1.00	262.17	262.50	10.67	11.00	72.8	72.80	0.0001	0.33	NA	orifice	0.85
23	290.70	250.50	269.11	1.50	1.00	262.50	262.86	11.00	11.36	72.8	72.80	0.0001	0.37	NA	orifice	0.77
				27.21	2.18											
Exit Slot	303.849	250.50	tunnel	2.18	0.01	262.86	262.99	12.48	12.48	72.8		0.0000	0.13	1247.92	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	262.99	262.99	12.48	12.48	72.8		0.0000	0.01	1248.49	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 9 - Low Sills, Forebay = 264, Q = 81.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**85 cfs 1' sill COEFFICIENTS**			0.80	0.98		Invert at exit =	250.5	
	Q =	81.4	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		9.40	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.32	6.27	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**264.00**	Baffles =	23	0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.83	5.96	6.79	81.4	81.40	-0.0001	0.83	NA	orifice	0.92
2	16.20	243.51	251.95	1.50	1.00	249.83	250.78	5.32	6.27	81.4	81.40	0.0001	0.96	NA	orifice	0.91
3	30.78	243.96	252.86	1.50	1.00	250.78	251.75	5.82	6.79	81.4	81.40	0.0001	0.97	NA	orifice	0.84
4	45.28	244.41	253.77	1.25	1.00	251.75	252.76	6.33	7.34	81.4	81.40	0.0001	1.01	NA	orifice	0.90
5	59.78	244.87	254.68	1.25	1.00	252.76	253.64	6.89	7.77	81.4	81.40	0.0000	0.88	NA	orifice	0.93
6	73.78	245.31	255.55	1.25	1.00	253.64	254.22	7.33	7.92	81.4	81.40	-0.0009	0.59	NA	orifice	1.16
7	87.78	245.74	256.43	1.25	1.00	254.22	255.07	7.48	8.33	81.4	81.40	-0.0002	0.85	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	255.07	255.84	7.90	8.68	81.4	81.40	-0.0005	0.77	NA	orifice	0.90
9	114.78	246.59	258.11	1.25	1.00	255.84	256.54	8.25	8.96	81.4	81.40	0.0001	0.70	NA	orifice	0.92
10	128.11	247.00	258.95	1.25	1.00	256.54	257.19	8.54	9.19	81.4	81.40	0.0001	0.65	NA	orifice	0.94
11	141.61	247.43	259.79	1.25	1.00	257.19	257.70	8.77	9.28	81.4	81.40	0.0001	0.51	NA	orifice	1.07
12	154.61	247.83	260.60	1.25	1.00	257.70	258.48	8.87	9.64	81.4	81.40	-0.0007	0.77	NA	orifice	0.81
13	167.61	248.24	261.42	1.25	1.00	258.48	259.10	9.24	9.87	81.4	81.40	0.0001	0.63	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	1.00	259.10	259.62	9.46	9.98	81.4	81.40	0.0001	0.52	NA	orifice	0.99
15	193.11	249.03	263.01	1.25	1.00	259.62	260.12	9.59	10.09	81.4	81.40	0.0001	0.50	NA	orifice	0.99
16	205.61	249.43	263.79	1.25	1.00	260.12	260.70	9.70	10.27	81.4	81.40	0.0001	0.58	NA	orifice	0.90
17	218.11	249.82	264.57	1.25	1.00	260.70	261.22	9.88	10.40	81.4	81.40	0.0001	0.52	NA	orifice	0.94
18	230.61	250.21	265.35	**1.50**	1.00	261.22	261.78	10.01	10.57	81.4	81.40	0.0001	0.56	NA	orifice	0.74
19	242.61	250.50	266.10	**1.50**	1.00	261.78	262.35	10.28	10.85	81.4	81.40	0.0001	0.57	NA	orifice	0.72
20	254.70	250.50	266.86	**1.50**	1.00	262.35	262.76	10.85	11.26	81.4	81.40	-0.0003	0.41	NA	orifice	0.83
21	266.70	250.50	267.61	1.50	1.00	262.76	263.13	11.26	11.63	81.4	81.40	0.0000	0.37	NA	orifice	0.85
22	278.70	250.50	268.36	1.50	1.00	263.13	263.47	11.63	11.97	81.4	81.40	0.0008	0.35	NA	orifice	0.86
23	290.70	250.50	269.11	1.50	1.00	263.47	263.86	11.97	12.36	81.4	81.40	-0.0001	0.39	NA	orifice	0.78
				29.20	2.17											
Exit Slot	303.849	250.50	tunnel	2.17	0.01	263.86	263.99	13.48	13.48	81.4		0.0000	0.12	1347.67	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	263.99	263.99	13.48	13.48	81.4		0.0000	0.01	1348.29	orifice	

b – Insurance Test Simulations for Low Sills (cont.):

Simulation 10 - Low Sills, Forebay = 265, Q = 89 cfs, Total Ladder Q = 89 cfs

Forebay Calcs	**LAMPREY WEIRS**		**85 cfs 1' sill COEFFICIENTS**			0.80	0.98		Invert at exit =	250.5		
	Q =	89	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		10.10	Exit width =	12		
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.45	6.52	Trash Rack K =	2		1
	Cd_{sow} =	NA	**Forebay =**	**265.0**	Baffles =	23	0	0				0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.96	5.96	6.92	89	89.00	0.0001	0.96	NA	orifice	0.92
2	16.20	243.51	251.95	1.50	1.00	249.96	251.03	5.45	6.52	89	89.00	0.0001	1.07	NA	orifice	0.91
3	30.78	243.96	252.86	1.50	1.00	251.03	252.09	6.07	7.13	89	89.00	0.0001	1.07	NA	orifice	0.84
4	45.28	244.41	253.77	1.25	1.00	252.09	253.19	6.68	7.77	89	89.00	0.0001	1.10	NA	orifice	0.90
5	59.78	244.87	254.68	1.25	1.00	253.19	254.14	7.32	8.27	89	89.00	0.0001	0.95	NA	orifice	0.93
6	73.78	245.31	255.55	1.25	1.00	254.14	254.76	7.83	8.46	89	89.00	0.0001	0.63	NA	orifice	1.16
7	87.78	245.74	256.43	1.25	1.00	254.76	255.66	8.02	8.92	89	89.00	0.0000	0.90	NA	orifice	0.89
8	101.28	246.16	257.27	1.25	1.00	255.66	256.48	8.50	9.32	89	89.00	-0.0004	0.82	NA	orifice	0.90
9	114.78	246.59	258.11	1.25	1.00	256.48	257.22	8.89	9.63	89	89.00	0.0001	0.74	NA	orifice	0.92
10	128.11	247.00	258.95	1.25	1.00	257.22	257.90	9.22	9.90	89	89.00	0.0001	0.68	NA	orifice	0.94
11	141.61	247.43	259.79	1.25	1.00	257.90	258.44	9.48	10.01	89	89.00	0.0001	0.54	NA	orifice	1.07
12	154.61	247.83	260.60	1.25	1.00	258.44	259.25	9.61	10.42	89	89.00	-0.0006	0.81	NA	orifice	0.81
13	167.61	248.24	261.42	1.25	1.00	259.25	259.91	10.01	10.67	89	89.00	0.0001	0.66	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	1.00	259.91	260.44	10.26	10.80	89	89.00	0.0001	0.54	NA	orifice	0.99
15	193.11	249.03	263.01	1.25	1.00	260.44	260.96	10.41	10.93	89	89.00	0.0001	0.52	NA	orifice	0.99
16	205.61	249.43	263.79	1.25	1.00	260.96	261.56	10.54	11.14	89	89.00	0.0001	0.60	NA	orifice	0.90
17	218.11	249.82	264.57	1.25	1.00	261.56	262.10	10.75	11.29	89	89.00	0.0001	0.54	NA	orifice	0.94
18	230.61	250.21	265.35	**1.50**	1.00	262.10	262.68	10.90	11.47	89	89.00	0.0001	0.58	NA	orifice	0.74
19	242.61	250.50	266.10	**1.50**	1.00	262.68	263.27	11.18	11.77	89	89.00	0.0001	0.59	NA	orifice	0.72
20	254.70	250.50	266.86	**1.50**	1.00	263.27	263.70	11.77	12.20	89	89.00	-0.0007	0.43	NA	orifice	0.83
21	266.70	250.50	267.61	1.50	1.00	263.70	264.08	12.20	12.58	89	89.00	-0.0001	0.38	NA	orifice	0.85
22	278.70	250.50	268.36	1.50	1.00	264.08	264.44	12.58	12.94	89	89.00	0.0001	0.36	NA	orifice	0.86
23	290.70	250.50	269.11	1.50	1.00	264.44	264.84	12.94	13.34	89	89.00	-0.0005	0.41	NA	orifice	0.78
				31.18	2.16											
Exit Slot	303.849	250.50	tunnel	2.16	0.01	264.84	264.98	14.47	14.47	89		0.0000	0.13	1446.57	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	264.98	264.98	14.47	14.47	89		0.0000	0.01	1447.21	orifice	

c – Insurance Test Simulations for Low Sills:

Simulation 1 - No Sills, Forebay = 257, Q = 38.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**						0.8	0.70		Invert at exit =	250.5	
	Q =	38.4	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			5.56	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		4.83	5.22	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**257.0**	Baffles =	23		11	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.31	5.96	6.27	38.4	38.40	0.0005	0.31	NA	orifice	0.72
2	16.20	243.51	251.95	1.50	0.00	249.31	249.57	5.80	6.06	38.4	38.40	0.0001	0.26	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	0.00	249.57	249.84	5.60	5.88	38.4	38.40	0.0001	0.27	NA	orifice	0.84
4	45.28	244.41	253.77	1.25	0.00	249.84	250.15	5.42	5.73	38.4	38.40	0.0004	0.31	NA	orifice	0.95
5	59.78	244.87	254.68	1.25	0.00	250.15	250.52	5.28	5.65	38.4	38.40	0.0001	0.37	NA	orifice	0.86
6	73.78	245.31	255.55	1.25	0.00	250.52	250.82	5.21	5.51	38.4	38.40	0.0007	0.30	NA	orifice	1.01
7	87.78	245.74	256.43	1.25	0.00	250.82	251.18	5.07	5.44	38.4	38.40	0.0002	0.37	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	251.18	251.55	5.02	5.38	38.4	38.40	0.0002	0.37	NA	orifice	0.91
9	114.78	246.59	258.11	1.25	0.00	251.55	251.97	4.96	5.38	38.4	38.40	0.0001	0.42	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	251.97	252.29	4.97	5.28	38.4	38.40	0.0002	0.32	NA	orifice	1.01
11	141.61	247.43	259.79	1.25	0.00	252.29	252.70	4.86	5.28	38.4	38.40	0.0001	0.42	NA	orifice	0.85
12	154.61	247.83	260.60	1.25	0.00	252.70	253.12	4.87	5.29	38.4	38.40	0.0001	0.41	NA	orifice	0.85
13	167.61	248.24	261.42	1.25	0.00	253.12	253.50	4.88	5.26	38.4	38.40	0.0001	0.38	NA	orifice	0.90
14	180.61	248.64	262.23	1.25	0.00	253.50	253.97	4.86	5.33	38.4	38.40	-0.0001	0.47	NA	orifice	0.77
15	193.11	249.03	263.01	1.25	0.00	253.97	254.28	4.94	5.25	38.4	38.40	0.0003	0.31	NA	orifice	1.03
16	205.61	249.43	263.79	1.25	0.00	254.28	254.65	4.86	5.22	38.4	38.40	0.0002	0.37	NA	orifice	0.94
17	218.11	249.82	264.57	1.25	0.00	254.65	255.06	4.83	5.25	38.4	38.40	0.0001	0.41	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	255.06	255.43	4.86	5.22	38.4	38.40	0.0001	0.36	NA	orifice	0.79
19	242.61	250.50	266.10	**1.50**	0.00	255.43	255.82	4.93	5.32	38.4	38.40	0.0001	0.39	NA	orifice	0.73
20	254.70	250.50	266.86	**1.50**	0.00	255.82	256.13	5.32	5.63	38.4	38.40	0.0002	0.32	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	256.13	256.32	5.63	5.82	38.4	38.40	-0.0006	0.19	NA	orifice	1.05
22	278.70	250.50	268.36	1.50	0.00	256.32	256.58	5.82	6.08	38.4	38.40	0.0001	0.26	NA	orifice	0.84
23	290.70	250.50	269.11	1.50	0.00	256.58	256.79	6.08	6.29	38.4	38.40	-0.0001	0.21	NA	orifice	0.92
				15.21	2.35											
Exit Slot	303.849	250.50	tunnel	2.35	0.01	256.79	256.99	6.48	6.48	38.4		0.0000	0.20	647.97	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	256.99	257.00	6.49	6.49	38.4		0.0000	0.01	648.56	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 2 - No Sills, Forebay = 258, Q = 44.3 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**						0.8	0.69					
	Q =	44.3	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			6.32	Invert at exit =	250.5		
	Cd_{slot} =	NA	Weir 248 Elev. =	249.3	Exit Loss =	0.01		5.63	6.05	Exit width =	12		
	Cd_{sow} =	NA	**Forebay =**	**258.0**	Baffles =	23		0	0	Trash Rack K =	2	1	0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.30	249.66	6.26	6.62	44.3	44.30	0.0001	0.36	NA	orifice	0.75
2	16.20	243.51	251.95	1.50	0.00	249.66	249.97	6.15	6.46	44.3	44.30	0.0006	0.31	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	0.00	249.97	250.29	6.00	6.33	44.3	44.30	0.0003	0.32	NA	orifice	0.83
4	45.28	244.41	253.77	1.25	0.00	250.29	250.65	5.88	6.24	44.3	44.30	0.0005	0.36	NA	orifice	0.94
5	59.78	244.87	254.68	1.25	0.00	250.65	251.07	5.79	6.20	44.3	44.30	0.0001	0.42	NA	orifice	0.87
6	73.78	245.31	255.55	1.25	0.00	251.07	251.42	5.77	6.11	44.3	44.30	0.0001	0.35	NA	orifice	0.99
7	87.78	245.74	256.43	1.25	0.00	251.42	251.83	5.68	6.09	44.3	44.30	0.0001	0.41	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	251.83	252.24	5.66	6.07	44.3	44.30	0.0001	0.41	NA	orifice	0.90
9	114.78	246.59	258.11	1.25	0.00	252.24	252.70	5.65	6.11	44.3	44.30	-0.0001	0.46	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	252.70	253.05	5.70	6.05	44.3	44.30	0.0001	0.35	NA	orifice	1.00
11	141.61	247.43	259.79	1.25	0.00	253.05	253.50	5.63	6.08	44.3	44.30	0.0000	0.45	NA	orifice	0.84
12	154.61	247.83	260.60	1.25	0.00	253.50	253.94	5.67	6.11	44.3	44.30	0.0000	0.44	NA	orifice	0.86
13	167.61	248.24	261.42	1.25	0.00	253.94	254.35	5.70	6.11	44.3	44.30	0.0001	0.41	NA	orifice	0.89
14	180.61	248.64	262.23	1.25	0.00	254.35	254.85	5.71	6.20	44.3	44.30	-0.0002	0.49	NA	orifice	0.78
15	193.11	249.03	263.01	1.25	0.00	254.85	255.18	5.81	6.14	44.3	44.30	0.0001	0.33	NA	orifice	1.01
16	205.61	249.43	263.79	1.25	0.00	255.18	255.56	5.75	6.13	44.3	44.30	0.0001	0.38	NA	orifice	0.93
17	218.11	249.82	264.57	1.25	0.00	255.56	255.99	5.74	6.17	44.3	44.30	0.0000	0.43	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	255.99	256.36	5.78	6.15	44.3	44.30	0.0001	0.37	NA	orifice	0.79
19	242.61	250.50	266.10	**1.50**	0.00	256.36	256.76	5.86	6.26	44.3	44.30	0.0001	0.40	NA	orifice	0.74
20	254.70	250.50	266.86	**1.50**	0.00	256.76	257.09	6.26	6.59	44.3	44.30	0.0001	0.33	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	257.09	257.29	6.59	6.79	44.3	44.30	-0.0003	0.20	NA	orifice	1.02
22	278.70	250.50	268.36	1.50	0.00	257.29	257.55	6.79	7.05	44.3	44.30	0.0001	0.26	NA	orifice	0.85
23	290.70	250.50	269.11	1.50	0.00	257.55	257.77	7.05	7.27	44.3	44.30	0.0000	0.22	NA	orifice	0.91
				17.21	2.30											
Exit Slot	303.849	250.50	tunnel	2.30	0.01	257.77	257.99	7.48	7.48	44.3		0.0000	0.22	748.09	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	257.99	258.00	7.49	7.49	44.3		0.0000	0.01	748.68	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 3 - No Sills, Forebay = 259, Q = 50.8 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**					0.8	0.68		Invert at exit =	250.5	
	Q =	50.8	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		6.90	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.90	6.35	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**259.0**	Baffles =	23	0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.46	5.96	6.43	50.8	50.80	0.0000	0.46	NA	orifice	0.78
2	16.20	243.51	251.95	1.50	0.00	249.46	249.88	5.96	6.38	50.8	50.80	0.0001	0.42	NA	orifice	0.84
3	30.78	243.96	252.86	1.50	0.00	249.88	250.31	5.92	6.35	50.8	50.80	0.0000	0.43	NA	orifice	0.83
4	45.28	244.41	253.77	1.25	0.00	250.31	250.78	5.90	6.36	50.8	50.80	-0.0001	0.47	NA	orifice	0.94
5	59.78	244.87	254.68	1.25	0.00	250.78	251.29	5.91	6.42	50.8	50.80	-0.0002	0.51	NA	orifice	0.88
6	73.78	245.31	255.55	1.25	0.00	251.29	251.73	5.99	6.43	50.8	50.80	0.0000	0.44	NA	orifice	0.97
7	87.78	245.74	256.43	1.25	0.00	251.73	252.22	5.99	6.47	50.8	50.80	-0.0002	0.49	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	252.22	252.71	6.05	6.54	50.8	50.80	-0.0002	0.49	NA	orifice	0.89
9	114.78	246.59	258.11	1.25	0.00	252.71	253.24	6.12	6.65	50.8	50.80	-0.0003	0.53	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	253.24	253.64	6.23	6.64	50.8	50.80	0.0001	0.40	NA	orifice	0.98
11	141.61	247.43	259.79	1.25	0.00	253.64	254.16	6.22	6.73	50.8	50.80	-0.0003	0.52	NA	orifice	0.83
12	154.61	247.83	260.60	1.25	0.00	254.16	254.64	6.33	6.81	50.8	50.80	-0.0002	0.48	NA	orifice	0.86
13	167.61	248.24	261.42	1.25	0.00	254.64	255.09	6.40	6.86	50.8	50.80	-0.0001	0.46	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	0.00	255.09	255.63	6.45	6.98	50.8	50.80	-0.0004	0.53	NA	orifice	0.79
15	193.11	249.03	263.01	1.25	0.00	255.63	256.00	6.59	6.96	50.8	50.80	0.0011	0.37	NA	orifice	0.99
16	205.61	249.43	263.79	1.25	0.00	256.00	256.41	6.57	6.98	50.8	50.80	0.0000	0.41	NA	orifice	0.93
17	218.11	249.82	264.57	1.25	0.00	256.41	256.86	6.59	7.05	50.8	50.80	-0.0002	0.46	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	256.86	257.26	6.66	7.05	50.8	50.80	0.0001	0.39	NA	orifice	0.78
19	242.61	250.50	266.10	**1.50**	0.00	257.26	257.68	6.76	7.18	50.8	50.80	0.0000	0.42	NA	orifice	0.74
20	254.70	250.50	266.86	**1.50**	0.00	257.68	258.02	7.18	7.52	50.8	50.80	0.0008	0.34	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	258.02	258.25	7.52	7.75	50.8	50.80	0.0000	0.23	NA	orifice	0.99
22	278.70	250.50	268.36	1.50	0.00	258.25	258.51	7.75	8.01	50.8	50.80	0.0001	0.27	NA	orifice	0.87
23	290.70	250.50	269.11	1.50	0.00	258.51	258.75	8.01	8.25	50.8	50.80	0.0001	0.24	NA	orifice	0.90
				19.21	2.27											
Exit Slot	303.849	250.50	tunnel	2.28	0.01	258.75	258.99	8.48	8.48	50.8		0.0000	0.23	847.78	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	258.99	258.99	8.48	8.48	50.8		0.0000	0.01	848.38	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 4 - No Sills, Forebay = 260, Q = 57.2 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**(4 * CD(38) + 3 * CD(85)/7**				0.8	0.67		Invert at exit =	250.5	
	Q =	57.2	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			7.59	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		5.96	6.51	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**260.00**	Baffles =	23		0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.55	5.96	6.51	57.2	57.20	-0.0003	0.55	NA	orifice	0.80
2	16.20	243.51	251.95	1.50	0.00	249.55	250.06	6.04	6.55	57.2	57.20	-0.0002	0.51	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	0.00	250.06	250.57	6.09	6.61	57.2	57.20	-0.0002	0.52	NA	orifice	0.82
4	45.28	244.41	253.77	1.25	0.00	250.57	251.12	6.16	6.71	57.2	57.20	-0.0004	0.55	NA	orifice	0.93
5	59.78	244.87	254.68	1.25	0.00	251.12	251.70	6.25	6.83	57.2	57.20	-0.0004	0.58	NA	orifice	0.89
6	73.78	245.31	255.55	1.25	0.00	251.70	252.21	6.39	6.91	57.2	57.20	-0.0003	0.52	NA	orifice	0.94
7	87.78	245.74	256.43	1.25	0.00	252.21	252.76	6.47	7.01	57.2	57.20	-0.0004	0.54	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	252.76	253.31	6.59	7.14	57.2	57.20	-0.0005	0.55	NA	orifice	0.87
9	114.78	246.59	258.11	1.25	0.00	253.31	253.89	6.72	7.30	57.2	57.20	-0.0005	0.58	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	253.89	254.33	6.88	7.33	57.2	57.20	-0.0001	0.45	NA	orifice	0.97
11	141.61	247.43	259.79	1.25	0.00	254.33	254.90	6.91	7.47	57.2	57.20	-0.0006	0.57	NA	orifice	0.82
12	154.61	247.83	260.60	1.25	0.00	254.90	255.40	7.07	7.57	57.2	57.20	-0.0004	0.51	NA	orifice	0.87
13	167.61	248.24	261.42	1.25	0.00	255.40	255.89	7.17	7.66	57.2	57.20	-0.0004	0.49	NA	orifice	0.88
14	180.61	248.64	262.23	1.25	0.00	255.89	256.45	7.25	7.81	57.2	57.20	-0.0007	0.56	NA	orifice	0.79
15	193.11	249.03	263.01	1.25	0.00	256.45	256.85	7.42	7.82	57.2	57.20	0.0000	0.40	NA	orifice	0.97
16	205.61	249.43	263.79	1.25	0.00	256.85	257.29	7.43	7.86	57.2	57.20	-0.0001	0.43	NA	orifice	0.92
17	218.11	249.82	264.57	1.25	0.00	257.29	257.76	7.47	7.95	57.2	57.20	-0.0004	0.48	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	257.76	258.17	7.56	7.96	57.2	57.20	0.0000	0.41	NA	orifice	0.78
19	242.61	250.50	266.10	**1.50**	0.00	258.17	258.60	7.67	8.10	57.2	57.20	-0.0001	0.43	NA	orifice	0.75
20	254.70	250.50	266.86	**1.50**	0.00	258.60	258.96	8.10	8.46	57.2	57.20	0.0008	0.36	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	258.96	259.20	8.46	8.70	57.2	57.20	0.0001	0.25	NA	orifice	0.96
22	278.70	250.50	268.36	1.50	0.00	259.20	259.48	8.70	8.98	57.2	57.20	0.0001	0.27	NA	orifice	0.88
23	290.70	250.50	269.11	1.50	0.00	259.48	259.73	8.98	9.23	57.2	57.20	0.0001	0.25	NA	orifice	0.89
				21.20	2.24											
Exit Slot	303.849	250.50	tunnel	2.24	0.01	259.73	259.99	9.48	9.48	57.2		0.0000	0.25	947.54	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	259.99	259.99	9.48	9.48	57.2		0.0000	0.01	948.15	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 5 - No Sills, Forebay = 261, Q = 63.7 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**		**(3* CD(38) + 4 * CD(85)/7**			0.8	0.66		Invert at exit =	250.5	
	Q =	63.7	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.27	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.96	6.59	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**261.00**	Baffles =	23	0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.63	5.96	6.59	63.7	63.70	-0.0004	0.63	NA	orifice	0.83
2	16.20	243.51	251.95	1.50	0.00	249.63	250.24	6.12	6.73	63.7	63.70	-0.0004	0.61	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	0.00	250.24	250.84	6.27	6.88	63.7	63.70	-0.0005	0.61	NA	orifice	0.81
4	45.28	244.41	253.77	1.25	0.00	250.84	251.48	6.43	7.06	63.7	63.70	-0.0005	0.63	NA	orifice	0.93
5	59.78	244.87	254.68	1.25	0.00	251.48	252.12	6.61	7.25	63.7	63.70	-0.0005	0.64	NA	orifice	0.90
6	73.78	245.31	255.55	1.25	0.00	252.12	252.71	6.81	7.41	63.7	63.70	-0.0006	0.60	NA	orifice	0.92
7	87.78	245.74	256.43	1.25	0.00	252.71	253.30	6.97	7.56	63.7	63.70	-0.0006	0.59	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	253.30	253.91	7.14	7.75	63.7	63.70	-0.0007	0.61	NA	orifice	0.86
9	114.78	246.59	258.11	1.25	0.00	253.91	254.54	7.33	7.95	63.7	63.70	-0.0007	0.63	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	254.54	255.03	7.53	8.02	63.7	63.70	-0.0004	0.49	NA	orifice	0.95
11	141.61	247.43	259.79	1.25	0.00	255.03	255.64	7.60	8.21	63.7	63.70	-0.0008	0.61	NA	orifice	0.81
12	154.61	247.83	260.60	1.25	0.00	255.64	256.17	7.81	8.34	63.7	63.70	-0.0007	0.53	NA	orifice	0.87
13	167.61	248.24	261.42	1.25	0.00	256.17	256.69	7.93	8.46	63.7	63.70	-0.0007	0.52	NA	orifice	0.87
14	180.61	248.64	262.23	1.25	0.00	256.69	257.27	8.05	8.63	63.7	63.70	0.0001	0.58	NA	orifice	0.80
15	193.11	249.03	263.01	1.25	0.00	257.27	257.71	8.24	8.67	63.7	63.70	-0.0002	0.43	NA	orifice	0.95
16	205.61	249.43	263.79	1.25	0.00	257.71	258.16	8.28	8.74	63.7	63.70	-0.0004	0.45	NA	orifice	0.91
17	218.11	249.82	264.57	1.25	0.00	258.16	258.65	8.35	8.84	63.7	63.70	-0.0007	0.49	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	258.65	259.08	8.45	8.87	63.7	63.70	-0.0002	0.42	NA	orifice	0.78
19	242.61	250.50	266.10	**1.50**	0.00	259.08	259.52	8.58	9.02	63.7	63.70	-0.0003	0.44	NA	orifice	0.75
20	254.70	250.50	266.86	**1.50**	0.00	259.52	259.89	9.02	9.39	63.7	63.70	0.0001	0.37	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	259.89	260.16	9.39	9.66	63.7	63.70	0.0001	0.27	NA	orifice	0.93
22	278.70	250.50	268.36	1.50	0.00	260.16	260.44	9.66	9.94	63.7	63.70	0.0001	0.28	NA	orifice	0.89
23	290.70	250.50	269.11	1.50	0.00	260.44	260.71	9.94	10.21	63.7	63.70	0.0001	0.27	NA	orifice	0.88
				23.19	2.21											
Exit Slot	303.849	250.50	tunnel	2.21	0.01	260.71	260.98	10.47	10.47	63.7		0.0000	0.27	1046.76	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	260.98	260.98	10.47	10.47	63.7		0.0000	0.01	1047.38	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 7 - No Sills, Forebay = 262, Q = 70.4 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**					0.8	0.65		Invert at exit =	250.5	
	Q =	70.4	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		8.96	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.96	6.67	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**262.0**	Baffles =	23	0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.71	5.96	6.67	70.4	70.40	-0.0003	0.71	NA	orifice	0.86
2	16.20	243.51	251.95	1.50	0.00	249.71	250.43	6.21	6.92	70.4	70.40	-0.0003	0.71	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	0.00	250.43	251.13	6.46	7.16	70.4	70.40	-0.0004	0.70	NA	orifice	0.81
4	45.28	244.41	253.77	1.25	0.00	251.13	251.84	6.71	7.43	70.4	70.40	-0.0004	0.72	NA	orifice	0.92
5	59.78	244.87	254.68	1.25	0.00	251.84	252.54	6.98	7.68	70.4	70.40	-0.0005	0.70	NA	orifice	0.91
6	73.78	245.31	255.55	1.25	0.00	252.54	253.22	7.24	7.92	70.4	70.40	-0.0006	0.68	NA	orifice	0.89
7	87.78	245.74	256.43	1.25	0.00	253.22	253.87	7.48	8.12	70.4	70.40	-0.0008	0.64	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	253.87	254.53	7.70	8.37	70.4	70.40	-0.0008	0.67	NA	orifice	0.85
9	114.78	246.59	258.11	1.25	0.00	254.53	255.20	7.95	8.62	70.4	70.40	-0.0008	0.67	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	255.20	255.73	8.20	8.73	70.4	70.40	-0.0008	0.53	NA	orifice	0.94
11	141.61	247.43	259.79	1.25	0.00	255.73	256.39	8.31	8.97	70.4	70.40	0.0001	0.66	NA	orifice	0.80
12	154.61	247.83	260.60	1.25	0.00	256.39	256.95	8.56	9.11	70.4	70.40	0.0001	0.55	NA	orifice	0.88
13	167.61	248.24	261.42	1.25	0.00	256.95	257.50	8.71	9.27	70.4	70.40	0.0001	0.56	NA	orifice	0.86
14	180.61	248.64	262.23	1.25	0.00	257.50	258.10	8.86	9.46	70.4	70.40	0.0001	0.60	NA	orifice	0.80
15	193.11	249.03	263.01	1.25	0.00	258.10	258.57	9.07	9.54	70.4	70.40	-0.0006	0.47	NA	orifice	0.92
16	205.61	249.43	263.79	1.25	0.00	258.57	259.05	9.15	9.62	70.4	70.40	-0.0007	0.47	NA	orifice	0.91
17	218.11	249.82	264.57	1.25	0.00	259.05	259.56	9.23	9.74	70.4	70.40	0.0001	0.51	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	259.56	260.00	9.35	9.79	70.4	70.40	-0.0004	0.44	NA	orifice	0.78
19	242.61	250.50	266.10	**1.50**	0.00	260.00	260.45	9.50	9.95	70.4	70.40	-0.0006	0.45	NA	orifice	0.75
20	254.70	250.50	266.86	**1.50**	0.00	260.45	260.83	9.95	10.33	70.4	70.40	0.0000	0.39	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	260.83	261.13	10.33	10.63	70.4	70.40	0.0010	0.29	NA	orifice	0.90
22	278.70	250.50	268.36	1.50	0.00	261.13	261.41	10.63	10.91	70.4	70.40	0.0001	0.28	NA	orifice	0.90
23	290.70	250.50	269.11	1.50	0.00	261.41	261.69	10.91	11.19	70.4	70.40	0.0001	0.28	NA	orifice	0.87
				25.19	2.20											
Exit Slot	303.849	250.50	tunnel	2.20	0.01	261.69	261.98	11.47	11.47	70.4		0.0000	0.29	1146.78	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	261.98	261.98	11.47	11.47	70.4		0.0000	0.01	1147.41	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 7 - No Sills, Forebay = 262.5, Q = 73.8 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	LAMPREY WEIRS						0.8	0.64		Invert at exit =	250.5	
	Q =	73.8	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			9.31	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		5.96	6.72	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**262.50**	Baffles =	23		0	0			0.66

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.75	5.96	6.72	73.8	73.80	-0.0002	0.75	NA	orifice	0.87
2	16.20	243.51	251.95	1.50	0.00	249.75	250.52	6.25	7.02	73.8	73.80	-0.0002	0.77	NA	orifice	0.83
3	30.78	243.96	252.86	1.50	0.00	250.52	251.27	6.56	7.31	73.8	73.80	-0.0003	0.75	NA	orifice	0.81
4	45.28	244.41	253.77	1.25	0.00	251.27	252.03	6.86	7.62	73.8	73.80	-0.0003	0.76	NA	orifice	0.92
5	59.78	244.87	254.68	1.25	0.00	252.03	252.76	7.16	7.89	73.8	73.80	-0.0005	0.73	NA	orifice	0.91
6	73.78	245.31	255.55	1.25	0.00	252.76	253.48	7.45	8.18	73.8	73.80	-0.0006	0.72	NA	orifice	0.88
7	87.78	245.74	256.43	1.25	0.00	253.48	254.15	7.74	8.41	73.8	73.80	-0.0008	0.67	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	254.15	254.85	7.99	8.68	73.8	73.80	-0.0008	0.70	NA	orifice	0.85
9	114.78	246.59	258.11	1.25	0.00	254.85	255.54	8.26	8.95	73.8	73.80	-0.0009	0.69	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	255.54	256.09	8.54	9.09	73.8	73.80	0.0001	0.55	NA	orifice	0.93
11	141.61	247.43	259.79	1.25	0.00	256.09	256.77	8.66	9.35	73.8	73.80	0.0001	0.68	NA	orifice	0.80
12	154.61	247.83	260.60	1.25	0.00	256.77	257.34	8.94	9.50	73.8	73.80	0.0001	0.56	NA	orifice	0.88
13	167.61	248.24	261.42	1.25	0.00	257.34	257.91	9.10	9.67	73.8	73.80	0.0001	0.57	NA	orifice	0.85
14	180.61	248.64	262.23	1.25	0.00	257.91	258.52	9.27	9.88	73.8	73.80	0.0001	0.61	NA	orifice	0.81
15	193.11	249.03	263.01	1.25	0.00	258.52	259.01	9.49	9.97	73.8	73.80	-0.0009	0.49	NA	orifice	0.91
16	205.61	249.43	263.79	1.25	0.00	259.01	259.49	9.58	10.07	73.8	73.80	0.0001	0.49	NA	orifice	0.91
17	218.11	249.82	264.57	1.25	0.00	259.49	260.01	9.68	10.20	73.8	73.80	0.0001	0.52	NA	orifice	0.86
18	230.61	250.21	265.35	**1.50**	0.00	260.01	260.46	9.80	10.25	73.8	73.80	-0.0005	0.45	NA	orifice	0.78
19	242.61	250.50	266.10	**1.50**	0.00	260.46	260.91	9.96	10.41	73.8	73.80	-0.0007	0.46	NA	orifice	0.76
20	254.70	250.50	266.86	**1.50**	0.00	260.91	261.30	10.41	10.80	73.8	73.80	0.0000	0.39	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	261.30	261.61	10.80	11.11	73.8	73.80	0.0004	0.31	NA	orifice	0.89
22	278.70	250.50	268.36	1.50	0.00	261.61	261.89	11.11	11.39	73.8	73.80	0.0001	0.28	NA	orifice	0.91
23	290.70	250.50	269.11	1.50	0.00	261.89	262.18	11.39	11.68	73.8	73.80	0.0011	0.29	NA	orifice	0.87
				26.19	2.19											
Exit Slot	303.849	250.50	tunnel	2.19	0.01	262.18	262.48	11.97	11.97	73.8		0.0000	0.30	1197.07	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	262.48	262.49	11.98	11.98	73.8		0.0000	0.01	1197.71	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 8 - No Sills, Forebay = 263, Q = 77.2 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**					0.8	0.64		Invert at exit =	250.5	
	Q =	77.2	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80		9.66	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01	5.96	6.76	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**263.0**	Baffles =	23	0	0			1

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.80	5.96	6.76	77.2	77.20	-0.0001	0.80	NA	orifice	0.89
2	16.20	243.51	251.95	1.50	0.00	249.80	250.62	6.29	7.11	77.2	77.20	-0.0001	0.82	NA	orifice	0.82
3	30.78	243.96	252.86	1.50	0.00	250.62	251.42	6.66	7.46	77.2	77.20	-0.0002	0.80	NA	orifice	0.80
4	45.28	244.41	253.77	1.25	0.00	251.42	252.22	7.00	7.81	77.2	77.20	-0.0002	0.80	NA	orifice	0.92
5	59.78	244.87	254.68	1.25	0.00	252.22	252.98	7.35	8.11	77.2	77.20	-0.0005	0.75	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	0.00	252.98	253.75	7.67	8.44	77.2	77.20	-0.0004	0.77	NA	orifice	0.87
7	87.78	245.74	256.43	1.25	0.00	253.75	254.43	8.00	8.69	77.2	77.20	-0.0008	0.69	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	254.43	255.16	8.27	9.00	77.2	77.20	-0.0007	0.73	NA	orifice	0.84
9	114.78	246.59	258.11	1.25	0.00	255.16	255.87	8.58	9.29	77.2	77.20	-0.0009	0.71	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	255.87	256.44	8.87	9.44	77.2	77.20	0.0001	0.57	NA	orifice	0.93
11	141.61	247.43	259.79	1.25	0.00	256.44	257.15	9.02	9.73	77.2	77.20	0.0001	0.71	NA	orifice	0.79
12	154.61	247.83	260.60	1.25	0.00	257.15	257.72	9.32	9.89	77.2	77.20	0.0001	0.57	NA	orifice	0.88
13	167.61	248.24	261.42	1.25	0.00	257.72	258.31	9.49	10.08	77.2	77.20	0.0001	0.59	NA	orifice	0.85
14	180.61	248.64	262.23	1.25	0.00	258.31	258.93	9.67	10.29	77.2	77.20	0.0001	0.62	NA	orifice	0.81
15	193.11	249.03	263.01	1.25	0.00	258.93	259.44	9.90	10.41	77.2	77.20	0.0001	0.51	NA	orifice	0.90
16	205.61	249.43	263.79	1.25	0.00	259.44	259.94	10.01	10.51	77.2	77.20	0.0001	0.50	NA	orifice	0.90
17	218.11	249.82	264.57	1.25	0.00	259.94	260.46	10.12	10.65	77.2	77.20	0.0001	0.53	NA	orifice	0.86
18	230.61	250.21	265.35	1.50	0.00	260.46	260.91	10.25	10.71	77.2	77.20	-0.0007	0.45	NA	orifice	0.78
19	242.61	250.50	266.10	1.50	0.00	260.91	261.37	10.41	10.87	77.2	77.20	-0.0009	0.46	NA	orifice	0.76
20	254.70	250.50	266.86	1.50	0.00	261.37	261.77	10.87	11.27	77.2	77.20	-0.0001	0.40	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	261.77	262.09	11.27	11.59	77.2	77.20	0.0002	0.32	NA	orifice	0.87
22	278.70	250.50	268.36	1.50	0.00	262.09	262.38	11.59	11.88	77.2	77.20	0.0001	0.28	NA	orifice	0.91
23	290.70	250.50	269.11	1.50	0.00	262.38	262.67	11.88	12.17	77.2	77.20	0.0006	0.30	NA	orifice	0.86
				27.19	2.18											
Exit Slot	303.849	250.50	tunnel	2.18	0.01	262.67	262.98	12.47	12.47	77.2		0.0000	0.31	1247.05	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	262.98	262.99	12.48	12.48	77.2		-0.0005	0.01	1247.69	orifice	

c – Insurance Test Simulations for Low Sills (cont.):

Simulation 9 - No Sills, Forebay = 264, Q = 84.1 cfs, Total Ladder Q = 85 cfs

Forebay Calcs	**LAMPREY WEIRS**						0.8	0.63		Invert at exit =	250.5	
	Q =	84.1	Weir 248 Head =	1	$Cd_{orifice}$ =	0.80			10.36	Exit width =	12	
	Cd_{slot} =	NA	Weir 248 Elev. =	249	Exit Loss =	0.01		5.96	6.84	Trash Rack K =	2	1
	Cd_{sow} =	NA	**Forebay =**	**264.0**	Baffles =	23		0	0			1

Weir	CL Location	Invert Elev.	Wall Elev.	Slot Width	Sill Height	h_{down}	h_{up}	h_2	h_1	Solving for H1 LHS	RHS	Diff	Delta h	h_1/P	Equation	Discharge Coefficient
1	1.20	243.04	250.94	1.50	0.00	249.00	249.88	5.96	6.84	84.1	84.10	0.0000	0.88	NA	orifice	0.91
2	16.20	243.51	251.95	1.50	0.00	249.88	250.82	6.37	7.31	84.1	84.10	0.0001	0.94	NA	orifice	0.82
3	30.78	243.96	252.86	1.50	0.00	250.82	251.72	6.86	7.75	84.1	84.10	0.0000	0.90	NA	orifice	0.80
4	45.28	244.41	253.77	1.25	0.00	251.72	252.61	7.30	8.19	84.1	84.10	0.0000	0.89	NA	orifice	0.91
5	59.78	244.87	254.68	1.25	0.00	252.61	253.41	7.74	8.54	84.1	84.10	-0.0003	0.81	NA	orifice	0.92
6	73.78	245.31	255.55	1.25	0.00	253.41	254.28	8.11	8.97	84.1	84.10	-0.0001	0.87	NA	orifice	0.84
7	87.78	245.74	256.43	1.25	0.00	254.28	255.01	8.53	9.27	84.1	84.10	-0.0008	0.73	NA	orifice	0.90
8	101.28	246.16	257.27	1.25	0.00	255.01	255.80	8.84	9.63	84.1	84.10	-0.0006	0.79	NA	orifice	0.83
9	114.78	246.59	258.11	1.25	0.00	255.80	256.54	9.21	9.96	84.1	84.10	-0.0009	0.75	NA	orifice	0.83
10	128.11	247.00	258.95	1.25	0.00	256.54	257.16	9.54	10.16	84.1	84.10	0.0001	0.61	NA	orifice	0.91
11	141.61	247.43	259.79	1.25	0.00	257.16	257.91	9.73	10.49	84.1	84.10	0.0001	0.75	NA	orifice	0.78
12	154.61	247.83	260.60	1.25	0.00	257.91	258.50	10.08	10.67	84.1	84.10	0.0001	0.59	NA	orifice	0.89
13	167.61	248.24	261.42	1.25	0.00	258.50	259.13	10.26	10.89	84.1	84.10	0.0001	0.62	NA	orifice	0.84
14	180.61	248.64	262.23	1.25	0.00	259.13	259.76	10.48	11.12	84.1	84.10	0.0001	0.63	NA	orifice	0.82
15	193.11	249.03	263.01	1.25	0.00	259.76	260.31	10.73	11.27	84.1	84.10	0.0001	0.55	NA	orifice	0.88
16	205.61	249.43	263.79	1.25	0.00	260.31	260.82	10.88	11.40	84.1	84.10	0.0001	0.52	NA	orifice	0.90
17	218.11	249.82	264.57	1.25	0.00	260.82	261.37	11.01	11.55	84.1	84.10	0.0001	0.54	NA	orifice	0.86
18	230.61	250.21	265.35	1.50	0.00	261.37	261.83	11.16	11.63	84.1	84.10	0.0001	0.47	NA	orifice	0.78
19	242.61	250.50	266.10	1.50	0.00	261.83	262.30	11.33	11.80	84.1	84.10	0.0001	0.47	NA	orifice	0.76
20	254.70	250.50	266.86	1.50	0.00	262.30	262.71	11.80	12.21	84.1	84.10	-0.0004	0.41	NA	orifice	0.80
21	266.70	250.50	267.61	1.50	0.00	262.71	263.06	12.21	12.56	84.1	84.10	0.0001	0.35	NA	orifice	0.85
22	278.70	250.50	268.36	1.50	0.00	263.06	263.34	12.56	12.84	84.1	84.10	0.0001	0.28	NA	orifice	0.93
23	290.70	250.50	269.11	1.50	0.00	263.34	263.66	12.84	13.16	84.1	84.10	0.0002	0.31	NA	orifice	0.86
				29.20	2.17											
Exit Slot	303.849	250.50	tunnel	2.17	0.01	263.66	263.98	13.47	13.47	84.1		0.0000	0.32	1347.27	orifice	
Exit Slot	317.001	250.50	tunnel	12.00	0.01	263.98	263.99	13.48	13.48	84.1		-0.0002	0.01	1347.93	orifice	

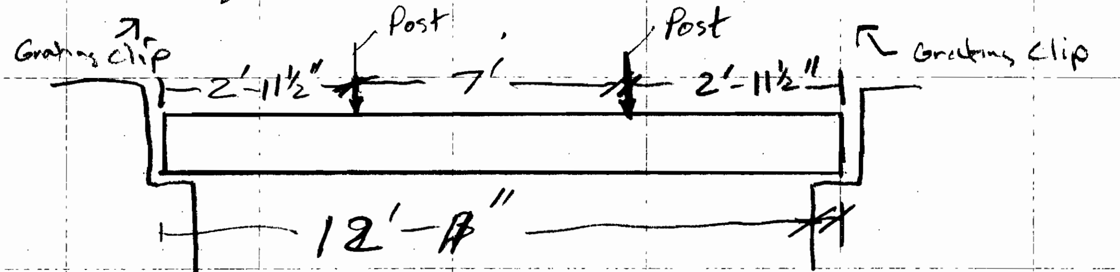
Appendix H – Structural

1. Diffuser 16 calculations
2. Slab moment calculation
3. Cracking moment
4. Slab Shear
5. Sliding Shear

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
John Day North Fish ladder	TMA	SHEET: 1 OF:
SUBJECT	CHECKED BY	
Diffuser 16 Structural Cap		PART:

- Existing Diffuser 16 Grating Will be Raised approximately 1' from its current elevation of 242.0
- In order to raise the grating, the existing Support Structure needs to be evaluated
- The details of the diffuser 16 supports are shown on Drawing JDF-1-5-2/9
- The existing diffuser grating is supported on Aluminum posts which Rest on 1'×1' reinforced concrete beams spaced on 6'-0" centers.
- The Existing Beams are loaded as follows



- The Beams are spaced @ 6' centers, so the Tributary Area for each Beam is 6'
- If 100 psf live load is applied to the grating, then each post will see

$$\underbrace{\left(\frac{7}{2}\right)+\left(\frac{2'-11\frac{1}{2}''}{2}\right)}_{4.98'} \times 6'-0'' = 29.875\ ft^2 \text{ of load}$$

- Each Clip Angle will See

$(3')(\cancel{13'})(\cancel{\ }) = 39\ ft^2$ of load

- Factored load Applied to each post is then $(100\,psf)\underbrace{(1.7\ \text{live load})}_{\text{to check Concrete Beam}}(29.875\,ft^2) = \underline{\underline{5.1}}$ kips

10 GRID

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
John Day North Fish ladder	TWA	SHEET: 2 OF:
SUBJECT	CHECKED BY	PART:
Diffuser 16 Structural Capacity		

- Factored Applied load to each edge clip angle is then $(100psf)(8.39 ft^2) = 3.9^k$ or $\frac{3.9^k}{13'} = 0.3^{k/ft}$ on clip

- Line load applied to Aluminum I 3x1.86 is

$$\frac{6' \times 13' \times 100psf}{13'} = 0.6^{k/ft}$$

- Center Span of I 3x1.86 AL Beam is $M_{max} = \frac{wl^2}{8} = \frac{\left(\frac{0.6^{k/ft}}{12''/in}\right)(7' \times 12'')^2}{8} = \cancel{44.1}^{in-k}$ factor

- Allowable Stress for 6061-T6 Alluminum w/ ... Span is 19^{ksi} w/out Welding Present

- Find S of I 3x1.86

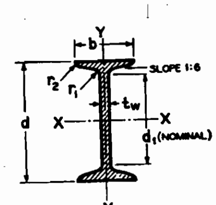


TABLE 14—I-BEAMS—AMERICAN STANDARD

The listed sizes are provided for the convenience of the designer; however, availability should be checked before making the final design selection. Additional sizes and shapes may be available from suppliers.

Designation I Depth × Wt in. lb/ft	With b in.	Web Thickness t_w in.	Area in.²	Avg Flange Thickness in.	r_1 in.	r_2 in.	d_1 in.	Axis x-x I_x in.⁴	Axis x-x S_x in.³	Axis x-x r_x in.	Axis y-y I_y in.⁴	Axis y-y S_y in.³	Axis y-y r_y in.
I 3 × 1.96	2.33	0.170	1.67	0.257	0.27	0.10	1.75	2.52	1.68	1.23	0.46	0.39	0.52
I 3 × 2.25	2.41	0.251	1.91	0.257	0.27	0.10	1.75	2.71	1.80	1.19	0.51	0.42	0.52
I 3 × 2.59	2.51	0.349	2.21	0.257	0.27	0.10	1.75	2.93	1.95	1.15	0.59	0.47	0.52

- Stress on Beam Simple Span is (~~ASD check by 1.7~~)

$\sigma = M/S = 44.1^{in-k} / 1.68 in^3 = \underline{26.3^{ksi}}$ **NG**

- Cantilever Stress is

$$m = \frac{wl^2}{2} = \frac{\left(\frac{0.6^{k/ft}}{12}\right)[1.35''-\text{in}]^2}{2} = 30.625^{in-k}$$

- $\sigma = M/S = \frac{30.625}{1.68 in^3} = \underline{18.2 ksi}$ **OK**

10 GRID

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
John Day North Fish Ladder	TMA	SHEET: 3 OF:
SUBJECT	CHECKED BY	
Diffuser 16 Structural Capacity		PART:

- Check Shear Capacity
  - $A_w = (0.170)(3") = \underline{5.1 in^2}$ $h/t_w = 3/0.17 = 17.6 < 36$ good
- Shear Stress $\sigma = V/A_w$
  - Center Span

$$V = \frac{w\ell}{2} = \frac{\left(\frac{0.6 K/ft}{12"}\right)(7' \times 12")}{2} = \underline{2.1^K}$$

$$\sigma_v = 2.\cancel{5}^K / 5 in^2 = \underline{0.4 ksi}$$ Shear OK

- for Cantilever Section

$$V = w \cdot \ell = \left(\frac{0.6 K/ft}{12}\right)(35") = \underline{1.75^k}$$ ok by inspection

- Conclussion - I 3 × 1.96 too Small!
- Find Minimum Section Modulus Required to Maintain 17 ksi Allowable
- for Simple span, tension Controlled

$$19^{ksi} = \frac{44.1^{in\text{-}K}}{S} \quad S_{req} = 44.1/19 = \underline{2.3 \ in^3}$$

- I 4 × 2.64 Has $S = 3.03 in^3$
- Check Existing I 3×1.96 Columns for Compression
- Each Post will See $(100 psf)(29.875 ft^2) = \underline{3}^K$ axial load
- Unbraced length of Post is 1'-1½" (JDF-1-5-2/9)
- Set $K = 1$, $L = 13.5"$, $r_x = 1.19$ $r_y = 0.52$
- $KL/r_x = 11.3$ $KL/r_y = 26$

10 GRID

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
JDNFL	TMA	SHEET: 4 OF:
SUBJECT	CHECKED BY	PART:
Diffuser 16 Capacity		

- So S between S_1 and S_2
- $F_n = 20.2 - 0.126(26) = 16.9^{ksi} < 19^{ksi}$

- Check b/t limits for flanges

$$b/t = \frac{2.33 - 0.170}{2 \times 0.257} = 4.2 < 5.2 \text{ so } 19^{ksi}$$

- Check b/t limits for Web

$$b/t = \frac{2.33 - 2(0.257)}{0.170} = 10.68 < 16 - 19^{ksi}$$

- 16.9 ksi Controls!
- $A = 1.67 in^2$
- So $\sigma_{comp} = P/A = 3^k / 1.67 in^2 = 1.8^{ksi} < 16.9^{ksi}$ OK

- Check the unbraced length 1' taller to raise the grating.

- $$KL/r_y = \frac{(1)(25.5'')}{0.52} = 49 < 66^{ksi} = S_2$$

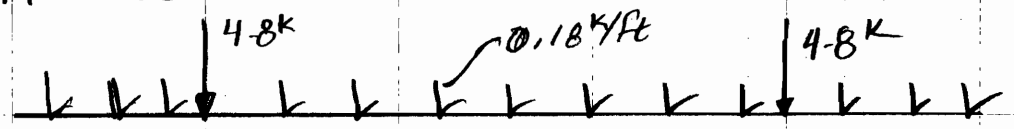
- So $F_n = 20.2 - 0.126(49) = \underline{\underline{14 ksi}}$
- $\sigma_{comp} = 1.8^{ksi} < 14^{ksi}$
- Existing Column Can be Raised 1' provided beams are incresed to I 4 × 2.64 or larger.

10 GRID

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY TMA	DATE:
SUBJECT	CHECKED BY	SHEET: 5 OF:
		PART:

- Check Support Beam (Concrete) Capacity
- Each Beam sees $3^K \times 1.6$ live load $= 4.8^K$ (No Hf) point loads plus dead weight.
- Beam Weight $= W = 0.15^{K/ft} \times 1.2 = 0.18^{K/ft}$ (No Hf)
- Load on $12'' \times 12''$ Concrete beam spanning $12'\,11''$ is



- Max Moment $= 17.803^{\prime\text{-}K}$ or $213.6^{\text{IN-K}}$
- Max Shear $= 6^{\text{kips}}$
- Beam is $1' \times 1'$ w/ 4 #6 bars w/ 1" clear cover and #3 ties
- So $d = 12'' - \frac{3}{8}'' - \frac{6/8}{2} - 1'' = \underline{\underline{10\ 1/4''}}$
- $A_s = 0.88\ \text{in}^2/\text{ft}$
- $a = \dfrac{A_s f_y}{0.85 f'_c b} = \dfrac{(0.88\text{in}^2)(40\text{ksi})}{(0.85)(3\text{ksi})(12'')} = 1.15''$
- $\phi M_n = (0.9)(0.88\text{in}^2)(40\text{ksi})\left(10.25 - \dfrac{1.15''}{2}\right)$

  $\phi M_n = 306\ \text{in-k} > 213.6\ \text{in-k}$ - $\underline{\underline{OK}}$
- Check Shear (Simple Shear)

  $\phi V_n = \phi V_c = \dfrac{(0.75)(2\sqrt{3000}(12'')(10.25''))}{1000} = \underline{\underline{5.05^K}}$ NG
- Check w/ 4500 psi Concrete

  $\phi V_c = 12.4^K$ - $\underline{\underline{OK}}$

10 GRID

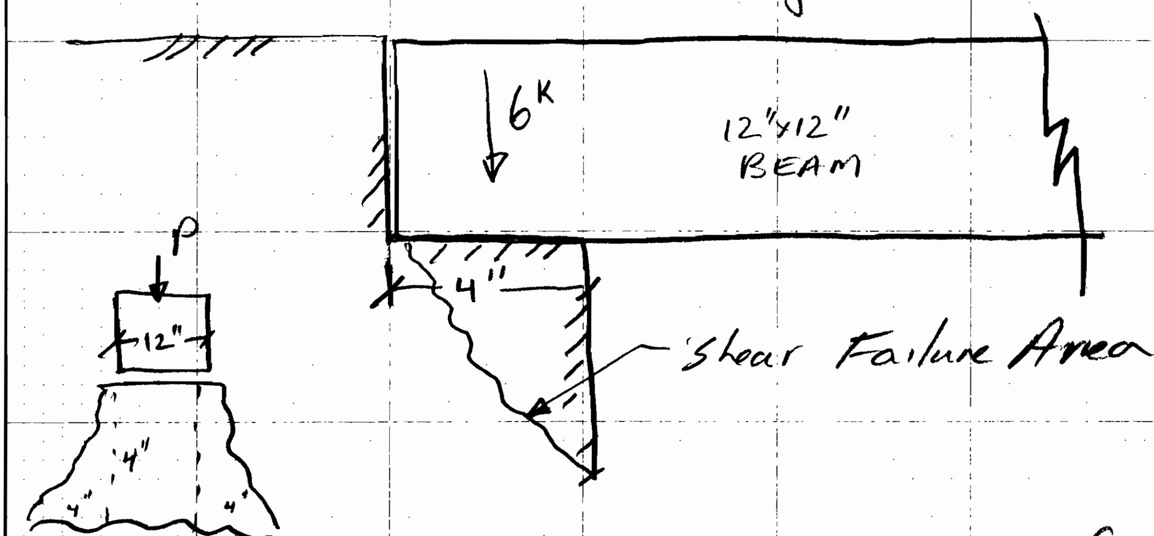
ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY TMA	DATE:
SUBJECT	CHECKED BY	SHEET: 6 OF:
		PART:

- Check 4" Corbel ledges where Support beams land.

- Check Beam Bearing
  - Bearing Area (Gross) = 12" x 4" = 48 in²
  - $\sigma_{Bearing} = P/A = 6^{kips} / 48 in^2 = 0.125$ ksi - OK

- Check Shear ON ledge



- Assume Shear Spread @ 45° down from the beam.

- Shear Area is (½)(4")(4") + (½)(4")(4") + (12")(4")
  = Shear Area = 64 in²

- Check area as unreinforced

$$\phi V_n = \frac{(0.55)(4/3)(64 in^2)\sqrt{3000}}{1000} = 2.6^K$$

- Check Reinforced

$$\phi V_n = (0.75)\, 2\sqrt{3000}\,(64 in^2) = 5.3^K$$

Close - 6.4^K w/ 4500 psi Concrete

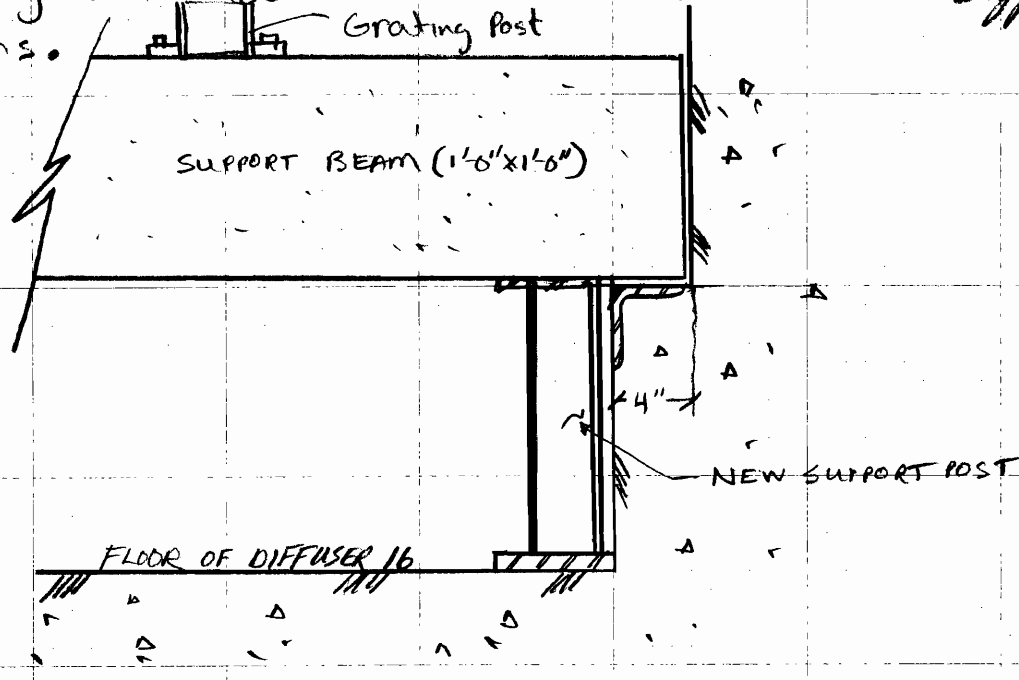
10 GRID

ENGINEERING DESIGN SHEET

OFFICE SYMBOL:

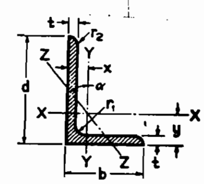
PROJECT	COMPUTED BY	DATE:
John Day NFL	TMA	SHEET: 7 OF:
SUBJECT	CHECKED BY	PART:

- Conclusion - Corbel May Crack. May Consider adding an additional Post beneath the Support beams.



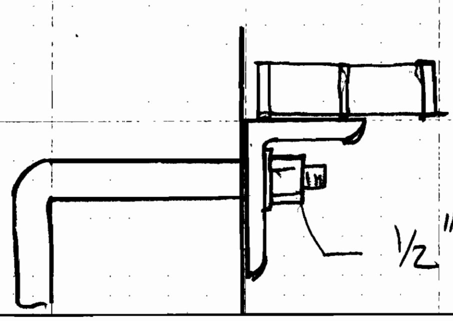
- CHECK Aluminum Support Angle
- JDF-1-2-5/9 shows a 2"x1½"x¼" ∠

TABLE 18—ANGLES—UNEQUAL LEGS



The listed sizes are provided for the convenience of the designer; however, availability should be checked before making the final design selection. Additional sizes and shapes may be available from suppliers.

Designation				Axis x-x				Axis y-y				Axis z-z		
L d × b × t in. in. in.	Weight lb/ft	Area in.²	r_1 in.	r_2 in.	I_x in.⁴	S_x in.³	r_x in.	y in.	I_y in.⁴	S_y in.³	r_y in.	x in.	α	I_z in.⁴	r_z in.
L 1.75 × 1.25 × 0.125	0.42	0.36	0.188	0.125	0.108	0.090	0.55	0.54	0.046	0.048	0.36	0.30	26°22′	0.026	0.27
L 1.75 × 1.25 × 0.25	0.81	0.69	0.188	0.12	0.199	0.172	0.54	0.60	0.083	0.092	0.35	0.35	25°47′	0.048	0.26
L 2 × 1.25 × 0.125	0.46	0.39	0.188	0.125	0.158	0.117	0.63	0.65	0.047	0.049	0.35	0.28	21°05′	0.028	0.27
L 2 × 1.25 × 0.25	0.88	0.75	0.188	0.125	0.291	0.224	0.62	0.70	0.086	0.093	0.34	0.33	20°31′	0.053	0.26
L 2 × 1.38 × 0.25	0.93	0.79	0.25	0.125	0.302	0.228	0.62	0.68	0.114	0.113	0.38	0.37	24°14′	0.067	0.29
L 2 × 1.5 × 0.125	0.50	0.42	0.188	0.125	0.17	0.12	0.63	0.60	0.08	0.07	0.44	0.36	28°44′	0.04	0.32
L 2 × 1.5 × 0.25	0.96	0.81	0.188	0.125	0.31	0.23	0.62	0.66	0.15	0.14	0.43	0.41	28°20′	0.08	0.32
L 2 × 1.5 × 0.375	1.38	1.17	0.188	0.125	0.43	0.33	0.60	0.70	0.20	0.19	0.41	0.45	27°37′	0.12	0.32



½" ∅ Galv Anchor @ 4'-0" Centers

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
JD NFL	TMA	SHEET: 8 OF:
SUBJECT	CHECKED BY	PART:
Clip Angle Capacity for Diff 16		

- Capacity of Galvanized Anchor in Shear
- If A307

  $\frac{1}{2}''$ A_{SE}

  - $V_{allow} \approx 12^{ksi} \times 0.14 in^2 = 1.68^k$ / Anchor Allow

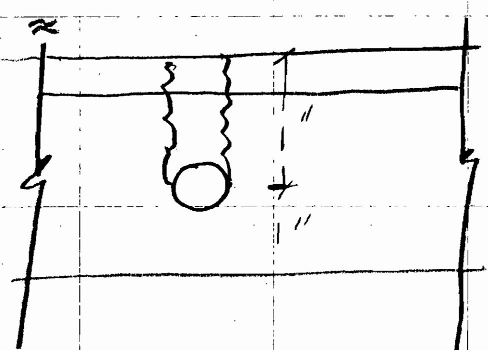
    ASD Allowable

- The Clip Angle Sees $39 ft^2$ of load (page 7)
  - $\frac{39 ft^2 \times 100 psf}{(1000)(13' \text{ length})} = \underline{\underline{0.3^{k/ft}}}$

- W/ Anchors @ 4' centers, each anchor sees
  $0.3^{k/ft} \times 4' = \underline{\underline{1.2^k}} < 1.68^k$ **OK**

- Check Block Shear of aluminum ∠ section

- Shear Area ≈



Area ≈ 1" × 2 sides × 1/4"

$A_v = \underline{\underline{0.5 in^2}}$

- $\sigma_v allow \approx 12^{ksi}$

- $P_{allow} = \sigma_v A_v = 12^{ksi} \times 0.5 in^2 = \underline{\underline{6^{kips}}}$

- Check Angle Spanning 4' between Bolts
  - $M = \frac{w\ell^2}{8} = \frac{\left(\frac{0.3^{k/ft}}{12''}\right)(4' \times 12'')^2}{8} = \underline{\underline{7.2^{in\text{-}k}}}$

$\sigma = M/S_{Angle} = \frac{7.2^{in\text{-}k}}{0.23 in^3} = \underline{\underline{31^{ksi}}}$ **NG**

- Angle Cannot Span between Anchors w/ 100 psf loading.

10 GRID

ENGINEERING DESIGN SHEET OFFICE SYMBOL:

PROJECT	COMPUTED BY	DATE:
JD NFL	TMA	SHEET: 9 OF:
SUBJECT	CHECKED BY	
Clip Angle Capacity diffuser 16		PART:

- Size New Angle for 4' Span w/ 0.3 k/ft of live load.
- Use 19 ksi Allowable
- $S = 7.2^{in\text{-}k} / 19^{ksi} = 0.38 in^3$
- L 2.5 x 2.5 x 1/4 or Space Bolts @ 2' to take Moment.

or
- $19^{ksi} \times 0.23 in^2 = 4.37^{in\text{-}k}$
- $4.37^{in\text{-}k} = \frac{(0.3/12)(\ell)^2}{8}$

$\ell_{max} = 37.4''$

- Conclussion

1. Posts OK @ 1' higher Elevation
2. Beams Need to be I 4 x 2.64 or add More Columns
3. Concrete Support beams Need Bracing for Shear Corbel failure
4. Clip Angle Needs to be L 2.5 x 2.5 x 1/4 or instal anchors @ 2'.

10 GRID

Table 2-21
Allowable Stresses for BUILDING and Similar Type Structures
6061–T6, –T651, –T6510, –T6511
Extrusions up thru 1 in., Sheet & Plate, Pipe, Standard Structural Shapes, Drawn Tube, Rolled Rod and Bar, 6351–T5 Extrusions

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Equations that straddle the shaded and unshaded areas apply to both.

*For tubes with circumferential welds, equations of Sections 3.4.10, 3.4.12, and 3.4.16.1 apply for $R/t \le 20$.

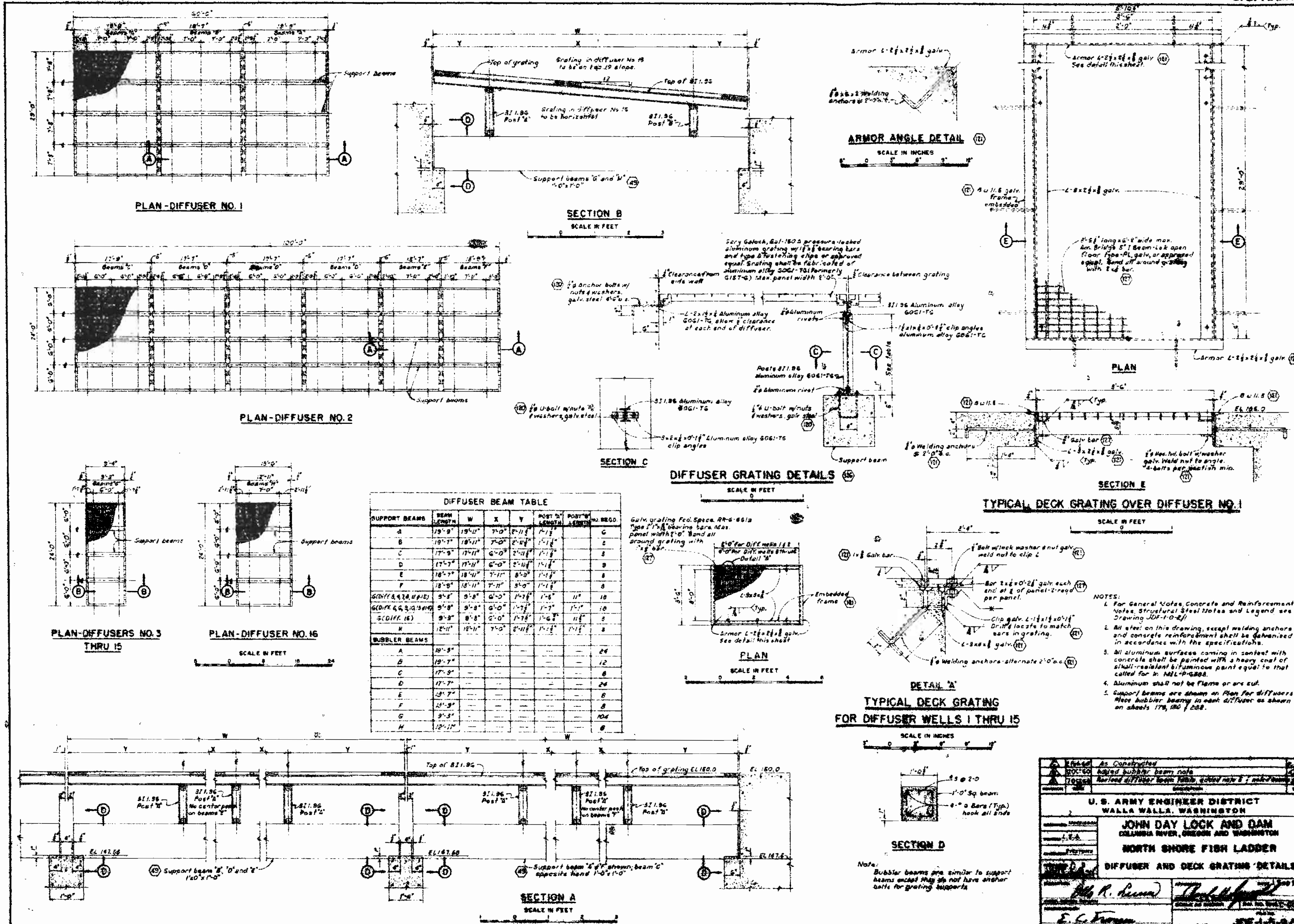
Type of Stress	Type of Member or Component	Spec. 3.4.	Allowable Stress (white bar)	Allowable Stress (shaded bar)
f_T **TENSION**, axial, net section	Any tension member	**1**	19	11†
f_{bT} **TENSION IN BEAMS,** extreme fiber, net section	Rectangular tubes, structural shapes bent around strong axis	**2**	19	11†
	Round or oval tubes	**3**	24	13.5†
	Shapes bent about weak axis, bars, plates	**4**	28	16†
f_{BRG} **BEARING**	On rivets and bolts	**5**	34	18†
	On flat surfaces and pins and on bolts in slotted holes	**6**	23	12†

F_{bT} 27

Type of Stress	Type of Member or Component	Spec. 3.4.	Allowable Stress Slenderness ≤ S_1	Slenderness Limit S_1	Allowable Stress Slenderness Between S_1 and S_2	Slenderness Limit S_2	Allowable Stress Slenderness ≥ S_2
f_c **COMPRESSION IN COLUMNS,** axial, gross section	All columns	**7**	19	$kL/r = 9.5$	$F_n = 20.2 - 0.126\,(kL/r)$ (in ksi)	$kL/r = 66$	$51{,}000/(kL/r)^2$
			12†	—	12†	$kL/r = 65$‡	$51{,}000/(kL/r)^2$
COMPRESSION IN COMPONENTS OF COLUMNS gross section	Flat plates supported along one edge - columns buckling about a symmetry axis	**8**	19	$b/t = 5.2$	$23.1 - 0.79\,(b/t)$	$b/t = 10$	$154/(b/t)$
			12†	—	12†	$b/t = 13$‡	$154/(b/t)$
	Flat plates supported along one edge - columns not buckling about a symmetry axis	**8.1**	19	$b/t = 5.2$	$23.1 - 0.79\,(b/t)$	$b/t = 12$	$1970/(b/t)^2$
			12†	—	12†	$b/t = 13$‡	$1970/(b/t)^2$
	Flat plates with both edges supported	**9**	19	$b/t = 16$	$23.1 - 0.25\,(b/t)$	$b/t = 33$	$490/(b/t)$
			12†	—	12†	$b/t = 41$‡	$490/(b/t)$
	Flat plates with one edge supported and other edge with stiffener	**9.1**	See Section 3.4.9.1 Rs I-A-31				
	Flat plates with both edges supported and with an intermediate stiffener	**9.2**	See Section 3.4.9.2				
	Curved plates supported on both edges, walls of round or oval tubes	**10***	19	$R/t = 16$	$22.2 - 0.80\sqrt{R/t}$	$R/t = 141$	$\dfrac{3200}{(R/t)(1 + \sqrt{R/t}/35)^2}$
			12†	$R/t = 9.0$	$13.5 - 0.50\sqrt{R/t}$	$R/t = 290$	

Type of Stress	Type of Member or Component	Spec. 3.4.	Allowable Stress Slenderness ≤ S_1	Slenderness Limit S_1	Allowable Stress Slenderness Between S_1 and S_2	Slenderness Limit S_2	Allowable Stress Slenderness ≥ S_2
f_{bc} COMPRESSION IN BEAMS, extreme fiber gross section f_{bc}	Single web beams bent about strong axis	11	21	$L_b/r_y = 23$	$23.9 - 0.124 L_b/r_y$	$L_b/r_y = 79$	$\frac{87{,}000}{(L_b/r_y)^2}$
			12†	—	12†	$L_b/r_y = 85$‡	
	Round or oval tubes	12*	25	$R_b/t = 28$	$39.3 - 2.70\sqrt{R_b/t}$	$R_b/t = 81$	Same as Section 3.4.10
			14†	$R_b/t = 51$	$23.9 - 1.39\sqrt{R_b/t}$	$R_b/t = 137$	
	Solid rectangular and round section beams	13	28	$d/t\sqrt{L_b/d} = 13$	$40.5 - 0.93\, d/t\sqrt{L_b/d}$	$d/t\sqrt{L_b/d} = 29$	$\frac{11{,}400}{(d/t)^2 (L_b/d)}$
			16†	$d/t\sqrt{L_b/d} = 26$	$40.5 - 0.93\, d/t\sqrt{L_b/d}$	$d/t\sqrt{L_b/d} = 29$	
	Rectangular tubes and box sections	14	21	$L_b S_c / .5\sqrt{I_y J} = 146$	$23.9 - 0.24\sqrt{L_b S_c / .5\sqrt{I_y J}}$	$L_b S_c / .5\sqrt{I_y J} = 1700$	$\frac{24{,}000}{(L_b S_c / .5\sqrt{I_y J})}$
			12†	—	12†	$L_b S_c / .5\sqrt{I_y J} = 2000$‡	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Flat plates supported on one edge	15	21	$b/t = 6.8$	$27.3 - 0.93\, b/t$	$b/t = 10$	$182/(b/t)$
			12†	—	12†	$b/t = 15$‡	$182/(b/t)$
	Flat plates with both edges supported	16	21	$b/t = 22$	$27.3 - 0.29\, b/t$	$b/t = 33$	$580/(b/t)$
			12†	—	12†	$b/t = 48$‡	$580/(b/t)$
	Curved plates supported on both edges	16.1*	25	$R_b/t = 1.6$	$26.2 - 0.94\sqrt{R_b/t}$	$R_b/t = 141$	$\frac{3800}{(R_b/t)(1 + \sqrt{R_b/t}/35)^2}$
			14†	$R_b/t = 2.5$	$14.7 - 0.44\sqrt{R_b/t}$	$R_b/t = 290$	
	Flat plates with one edge supported and the other edge with stiffener	16.2	See Section 3.4.16.2				
	Flat plates with both edges supported and with an intermediate stiffener	16.3	See Section 3.4.16.3				
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane) gross section	Flat plates with compression edge free, tension edge supported	17	28	$b/t = 8.9$	$40.5 - 1.41\, b/t$	$b/t = 19$	$4{,}900/(b/t)^2$
			16†	$b/t = 17$	$40.5 - 1.41\, b/t$	$b/t = 19$	$4{,}900/(b/t)^2$
	Flat plate with both edges supported	18	28	$h/t = 46$	$40.5 - 0.27\, h/t$	$h/t = 75$	$1520/(h/t)$
			16†	—	16†	$h/t = 95$‡	$1520/(h/t)$
	Flat plate with horizontal stiffener, both edges supported	19	28	$h/t = 107$	$40.5 - 0.117\, h/t$	$h/t = 173$	$3500/(h/t)$
			16†	—	16†	$h/t = 219$‡	$3500/(h/t)$
f_v SHEAR IN WEBS, gross section	Unstiffened flat webs	20	12	$h/t = 36$	$15.6 - 0.099\, h/t$	$h/t = 65$	$39{,}000/(h/t)^2$
			7.5†	—	7.5†	$h/t = 72$‡	$39{,}000/(h/t)^2$
	Stiffened flat webs $a_e = a_1/\sqrt{1 + 0.7(a_1/a_2)^2}$	21	12	—	12	$a_e/t = 66$	$53{,}000/(a_e/t)^2$
			7.5†	—	7.5†	$a_e/t = 84$‡	$53{,}000/(a_e/t)^2$

[redacted] use 4 welds also?



DIFFUSER BEAM TABLE

SUPPORT BEAMS	BEAM LENGTH	W	X	Y	POST "A" LENGTH	POST "B" LENGTH	NO. REQD.
A	19'-9"	19'-11"	7'-0"	2'-11 3/4"	1'-1 1/2"		6
B	19'-7"	19'-11"	7'-0"	2'-8 3/4"	1'-1 1/2"		2
C	17'-9"	17'-11"	6'-0"	2'-11 3/4"	1'-1 1/2"		8
D	17'-7"	17'-11"	6'-0"	2'-11 3/4"	1'-1 1/2"		8
E	18'-7"	18'-11"	7'-11"	8'-9"	1'-1 1/2"		8
F	18'-9"	18'-11"	7'-11"	9'-0"	1'-1 1/2"		8
G(DIFF 3, 4, 7, 8, 11 & 12)	9'-8"	9'-8"	6'-0"	1'-7 3/4"	1'-5"	11"	18
G(DIFF 5, 6, 9, 10, 13 & 14)	9'-8"	9'-8"	6'-0"	1'-7 3/4"	1'-7"	1'-1"	18
G(DIFF. 16)	9'-9"	8'-8"	2'-0"	1'-7 3/4"	1'-6 3/4"	11 3/4"	3
H	12'-11"	18'-11"	7'-0"	2'-11 3/4"	1'-1 1/2"	1'-1 1/2"	8
BUBBLER BEAMS							
A	18'-5"	—	—	—	—	—	24
B	19'-7"	—	—	—	—	—	12
C	17'-9"	—	—	—	—	—	8
D	17'-7"	—	—	—	—	—	24
E	13'-7"	—	—	—	—	—	8
F	13'-9"	—	—	—	—	—	8
G	9'-3"	—	—	—	—	—	104
H	12'-11"	—	—	—	—	—	8

NOTES:
1. For General Notes, Concrete and Reinforcement Notes, Structural Steel Notes and Legend see Drawing JDF-1-0-2/1
2. All steel on this drawing, except welding anchors and concrete reinforcement shall be galvanized in accordance with the specifications.
3. All aluminum surfaces coming in contact with concrete shall be painted with a heavy coat of alkali-resistant bituminous paint equal to that called for in MIL-P-6883.
4. Aluminum shall not be flame or arc cut.
5. Support beams are shown on Plan for diffusers. Place bubbler beams in each diffuser as shown on sheets 179, 180 & 232.

		As Constructed
	20 Oct 60	Added bubbler beam note
	7 Oct 60	Revised diffuser beam table, added note 5

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

JOHN DAY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON

NORTH SHORE FISH LADDER

DIFFUSER AND DECK GRATING DETAILS

JDF-1-5-2/3

John Day Dam - North Fish Ladder

Fixed moment - One Way Slab Analysis

cover =	2	in
f'c =	3000	psi
fy =	40000	psi
b =	12	
FLF	1.7	
Hf =	1.3	
phi =	0.9	

pool at 264 - Normal Depth

Section	t	bar	db	s	d	Span	depth	Mu	Ab	As	p	a	phiMn
9	18	9	1.128	6.00	15.44	24.0	6.0	63.58	1.00	2.00	0.011	2.61	84.73
9	18	8	1	6.00	15.50	24.0	6.0	63.58	0.79	1.57	0.008	2.05	68.21
9	18	9	1.128	6.00	15.44	24.0	6.0	63.58	1.00	2.00	0.011	2.61	84.73
10	18	9	1.128	6.00	15.44	24.0	6.5	66.89	1.00	2.00	0.011	2.61	84.73
10	18	8	1	6.00	15.50	24.0	6.5	66.89	0.79	1.57	0.008	2.05	68.21
10	19	9	1.128	6.00	16.44	24.0	6.5	68.22	1.00	2.00	0.010	2.61	90.73
11	19	9	1.128	6.00	16.44	24.0	6.0	64.91	1.00	2.00	0.010	2.61	90.73
11	19	8	1	6.00	16.50	24.0	6.0	64.91	0.79	1.57	0.008	2.05	72.93
11	20	9	1.128	6.00	17.44	24.0	6.0	66.24	1.00	2.00	0.010	2.61	96.72
12	20	9	1.128	6.00	17.44	24.0	6.3	67.89	1.00	2.00	0.010	2.61	96.72
12	20	9	1.128	6.00	17.44	24.0	6.3	67.89	1.00	2.00	0.010	2.61	96.72
12	21	10	1.27	6.00	18.37	24.0	6.3	69.22	1.27	2.53	0.011	3.31	127.01
13	21	8	1	6.00	17.50	22.6	6.0	67.56	0.79	1.57	0.007	2.05	77.64
13	16	8	1	6.00	12.50	22.6	7.0	67.55	0.79	1.57	0.010	2.05	54.07
13	16	8	1	6.00	12.50	22.6	7.3	69.27	0.79	1.57	0.010	2.05	54.07

Slab reinforcing nearest surface spans transverse direction Sections 9 - 12.
Note reinforcing change with respect to section 13.

Original computations used 17.5' at weir 267 and 14.5 at weir 264. Assumed two way action for Section 13.

Project: John Day NFL
Office: NWP-EC-DS
Date: 2/26/2008

Mcr Cracking Moment

f'c= 4500 psi
fr = 503 psi
fy= 40000 psi

Section	P (k)	h (in)	b (in)	A	S	Mcr (k')	Mn	Mn/Mcr	Mn/Mcr lower limit	Ie/Ig
9	550	48	60	2880	23040	1333	2220	1.67	1.2	0.35
10	625	48	60	2880	23040	1383	2220	1.61	1.2	0.35
11	700	48	60	2880	23040	1433	2220	1.55	1.2	0.35
12	750	48	60	2880	23040	1466	2220	1.51	1.2	0.35
13	415	48	48	2304	18432	1049	1775	1.69	1.2	0.35

Note:

Ie/Ig shall not exceed 0.8.

Ie/Ig > 0.35 for fy = 40 ksi.

John Day Dam

Allowable

cover =	2	in	
f'c =	3000	psi	
v =	90	psi	ACI 318-56 allowable
b =	12		pool at 268
j =	0.875		

Section	t	bar	db	s	d	V	Span	depth	Demand
9	18	9	1.128	6.00	15.44	14.59	24.0	6.7	7.7
9	18	8	1	6.00	15.50	14.65	24.0	7.1	8.0
9	18	9	1.128	6.00	15.44	14.59	24.0	8.0	8.7
10	18	9	1.128	6.00	15.44	14.59	24.0	8.3	8.9
10	18	8	1	6.00	15.50	14.65	24.0	9.0	9.4
10	19	9	1.128	6.00	16.44	15.53	24.0	10.0	10.3
11	19	9	1.128	6.00	16.44	15.53	24.0	10.3	10.6
11	19	8	1	6.00	16.50	15.59	24.0	11.0	11.1
11	20	9	1.128	6.00	17.44	16.48	24.0	11.2	11.4
12	20	9	1.128	6.00	17.44	16.48	24.0	11.8	11.8
12	20	9	1.128	6.00	17.44	16.48	24.0	12.5	12.4
12	21	10	1.27	6.00	18.37	17.35	24.0	13.6	13.3
13	21	8	1	6.00	17.50	16.54	22.6	14.5	13.2
13	16	8	1	6.00	12.50	11.81	22.6	16.0	13.5
13	16	8	1	6.00	12.50	11.81	22.6	17.5	14.6

Slab reinforcing nearest surface spans transverse direction Sections 9 - 12.
Note reinforcing change with respect to section 13.

Original computations used 17.5' at weir 267 and 14.5 at weir 264. Assumed two way action for Section 13.

John Day North Fish Ladder

Tranverse EQ Direction EQ: 1000 yr

Reference: Seismic Evaluation Procedures for Existing CW Powerhouses, FEMA 356.

Acceptance Criteria: Sliding Shear

fy=	40	ksi	columns
μ_{sf} =	1		

Section	Element	Axial (k)	As	V_G	V_E	V_{UD}	V_{SF}	DCR
9	Column	540	31.2	10	200	210	852	0.25
10	Column	620	31.2	10	200	210	932	0.23
11	Column	710	31.2	10	200	210	1022	0.21
12	Column	745	31.2	10	200	210	1057	0.20
13	Column	415	24.96	10	200	210	665	0.32

Note

1. DCR < 1 is acceptable

Appendix I –Mechanical

Appendix J – Electrical