US Army Corps
of Engineers ®
Portland District

Design Documentation Report No. 1

John Day Lock and Dam
North Fish Ladder Exit Section and Count Station Improvements

Columbia River, Oregon-Washington

May 2008

60% Review

EXECUTIVE SUMMARY (60% Report)

This Design Documentation Report (DDR) covers the design, construction, operation, and maintenance of proposed improvements to the exit section and count station of John Day North Fish Ladder (JDAN). This report describes the project background, outlines technical aspects of the design, and describes operations, maintenance, and construction concerns. Records of coordination with the U.S. Army Corps of Engineers, Portland District and regional agencies are also included.

The John Day Dam has the longest mean upstream passage time for adult salmon on the lower Columbia River. Telemetry research data for migration rates (recorded 1996-2001) indicated John Day median passage times were longest for the lower four dams for all species (from about 1 to 1.5 days), and that John Day Dam had the highest percentage of fish that took longer than 5 days to pass (about 9% to 14%; see Section 3 for more details). In addition to the salmon passage issues, upstream passage rates of adult lamprey have plunged in recent years to disturbing levels at both Bonneville and John Day projects. At the JDAN, passage and delay problems have been attributed to two physically separate and hydraulically independent locations:

1. Upper fish ladder section—exit section, diffuser 16, and count station.
2. Lower fishway section—entrance, auxiliary water supply pumps, diffusers 1-15, transition pool, and lower overflow ladder weir section.

The middle portion of the fish ladder (that separates upper and lower fish ladder sections) is comprised of standard Ice Harbor overflow weirs and orifices (weirs 172-248) where passage access for both salmon and lamprey is generally favorable. The chief area of salmon delay is found in the relatively slack water of the transition pool of the lower fish ladder section, where large numbers of fish routinely turn back to tailrace after entering the fish ladder system. There are also significant problems for salmon in upper fish ladder section, such as delay, jumping and chronic incidents of turn-around. Lamprey have difficulty passing through the entrance and going up the exit section.

The Portland District has been tasked with the redesign of JDAN to improvement both adult salmon and lamprey passage in both upper (exit and count station) and lower (entrance and lower fish ladder) sections of the ladder. The conceptual stage of design development is much farther along in the upper fish ladder section compared to lower fish ladder section. In the upper section, the design configuration is largely derived from the highly successful 2003 reconstruction of the John Day South Fish Ladder (JDAS) exit section. The conceptual stage for the lower fish ladder is still in feasibility and alternative analysis stage; thus, the design study effort for the lower fish ladder section has been separated into an Alternative Study report (after completion of the Alternative Study report, a DDR supplement will be completed for the lower fish ladder section and added to this DDR). Given the two different stages of design development and potential scale of combined costs, the construction schedule is divided between fiscal year (FY) 2010 in the upper section and FY 2011 in the lower fish ladder section. The current focus of this DDR is the upper fish ladder section including the exit channel section, ladder flow control system, and count station.

Specific adult passage issues in the upper ladder system are commonly attributed to confounding shape configurations, undesirable hydraulic conditions, and frequent geometry changes that challenge or confuse upward migrating fish. The existing serpentine weir configuration of the exit section force salmon to turn towards the downstream direction in order to go continue upstream, confusing them enough to fallback, jump or turn around. At the count station, there exists an abrupt 23-inch-high raised floor which causes undesirable hydraulic conditions at both ends of the counting slot. A third geometry problem is found at weir 249, which separates the count station and serpentine weirs. Weir 249 is an unorthodox wall with five orifices (often referred to as the 'holey wall') where salmon have been frequently observed to turn around and swim back downstream through the count station. The chronic behavior of fish turning around or fallback hinders the job of fish counting. The sharp corners of the serpentine weirs and holey wall impede lamprey passage in the exit section. At the upstream end of the exit section, modulating and permanent vertical sills prevent lamprey from using means of floor attachment to move up the exit section.

The criteria for salmon and lamprey passage are quite different. Lamprey are much weaker swimmers and use wall or floor attachment to move through moderate to high velocity zones (>2 feet/second), whereas salmon routinely burst through portals with velocities from 8-14 feet/second. In order to accommodate both, lamprey-improved features were added to the design of the exit section and count station, such as seamless floor connections (via floor orifices) through in all new weirs and the count station, and rounding all outer corners of the new weirs to 4-inch minimum radius. While the new design of the exit section weirs will be essentially based on the vertical slot and orifice design of the revised JDAS exit section, the new lamprey features presented significant changes in geometry and required physical modeling to assure that the hydraulic conditions would be acceptable for both salmon and lamprey. Another key difference is that the JDAN count station is located immediately downstream of the exit section, whereas the JDAS count station is located in the lower fish ladder. The level of hydraulic and biological complexity would be higher at the JDAN, where the potentially robust vertical slot flow from the exit section discharges into the sensitive count station area. At JDAS, the exit section weir discharges into a standard ladder weir pool.

An original design concept was formulated from the JDAS configuration, adapted for lamprey passage with rounded corners. The new lamprey-improved exit section and count station were evaluated and incrementally modified in a 1:5 scale physical model at the Environmental Services Corporation (ENSR) hydraulic laboratory (see ENSR's *John Day North Ladder Physical Hydraulic Model Study Final Report* located in Appendix G). There were five lab site visits; two were with agency representatives during which the final configuration design was established.

The proposed changes to the upper ladder section are summarized below (starting from upstream):

- Remove 1st (upstream) vertical slot and sill baffle in forebay transition section.
- Modify 2nd baffle (remove 2.5-foot sill and add orifice) in forebay transition.
- Remove all 18 serpentine weirs and holey wall and replace with 23 lamprey-improved, JDAS-type weirs with 15- to 18-inch vertical slots and 18- by 18-inch orifices.
- Add electrically powered sill actuators and support structure for 22 new weirs.
- Raise top of sidewalls in exit section by 3 feet (possibly fiberglass).
- Raise Count Station floor 1 foot to match invert at new weir 1 (holey wall site).
- Add 12-inch-wide metal strip over left (south) side of floor diffuser 16.
- Remove 23-inch ramp through count slot and lower viewing window.
- Replace/upgrade crowder (new transition farings, horizontal vanes and backboard) and lighting.

The purpose of the DDR study is to provide the technical basis for plans and specifications, and to document the final design for and during construction of the JDAN adult fish passage improvements. The focus of this DDR stage is for improvements to the upper ladder section (exit section and count station). After the Alternative Study is completed for the lower ladder section, a DDR supplement will be developed and added to this report. Costs are not presented at this time. Plates of the proposed project and reference drawings of the existing system are located at the end of the report.

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JOHN DAY LOCK AND DAM
PERTINENT DATA

GENERAL

River Mile	215.6
Drainage Area, square miles	226,000
Length at Crest, feet	5,900
Discharges in cubic feet per second (cfs):	
Minimum of record	30,500
Mean annual	194,700
Maximum of record	1,240,000
Adopted standard project flood:	
Used for design at dam site	1,060,000
Used for design through lake area	1,050,000
Revised: (1968 derivation)	
Unregulated	1,516,000
Regulated by existing storage	820,000
Spillway design flood	2,250,000
Probable maximum flood (1968 derivation)	2,050,000
Project in operational status	April 1968

LAKE

Elevations:	
Maximum	276
Normal operating range	257-268
Flood Storage (between backwater profiles for 800,000 cfs), acre-feet	500,000
Length, miles	76.4
Area at elevation 268 (flat), acres	55,000
Length of shoreline, miles	200

PERTINENT DATA (continued)

SPILLWAY

Overall length, feet	1,252
Crest elevation	210
Control Gates:	
Type	Tainter
Number	20
Size, width by height above crest	50 x 58.5
Deck elevation	281
Crane capacity, tons	50
Maximum design capacity, cfs	2,250,000

POWERHOUSE

Length, overall, feet	1,975
Width, overall, transverse section, feet	243.25
Intake deck elevation	281
Draft tube deck elevation	235
Maximum ht, draft tube invert to intake deck, feet	235
Spacing, main units, feet	90
Turbines:	
Type	Kaplan 6-blade
Runner diameter, inches	312
Revolutions per minute	90
Rating, horsepower	212,400
Generator rating, nameplate, kilowatts	135,000
Units installed complete initially	16
Skeleton units provided initially	4
Total number of units definitely provided for	20
Initial plant capacity, rated, kilowatts	2,160,000
Ultimate plant capacity, rated, kilowatts	2,700,000
Crane capacities, tons:	
Intake gantry	525
Bridge, each of 2	375
Draft tube gantry	50
First power on line	July 1968
Unit 16 on line	4 Nov 1971

PERTINENT DATA (continued)

NAVIGATION LOCK

Type	Single lift
Net clear length, feet	369
Net clear width, feet	86
Minimum water depth over sills, feet	15
Maximum upper water surface elevation in chamber	268
Top of lock walls, elevation	273
Minimum water surface elevation in chamber	155
Upstream sill block elevation	242
Downstream sill block elevation	140
Upstream gate	86’ x 27’ submersible lift
Downstream gate	86’ x 113’ lift
Maximum lift, feet	113
Average lift, feet	105
Minimum lift, feet	97
Length of guard walls, feet:	
Upstream	642
Downstream	700
Opened to navigation	April 1968

NAVIGATION DOWNSTREAM CHANNEL

Width, feet	250
Bottom elevation	139

NORTH SHORE ABUTMENT EMBANKMENT

Crest elevation	286
Crest width, feet	30
Material	Rockfill with impervious core
Slopes:	
Upstream	1 on 2
Downstream	1 on 2

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
A-E	Architect-Engineer
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	auxiliary water supply
BiOp	Biological Opinion
CENWD	Corps of Engineers Northwestern Division (U.S. Army)
CENWP	Corps of Engineers Portland District (U.S. Army)
CENWW	Corps of Engineers Walla Walla District (U.S. Army)
CERL	Construction Engineering Research Laboratory
CFD	Computational Fluid Dynamics
cfs	cubic feet per second
CL	centerline
cm	centimeter(s)
COV	coefficients of variation
CRES	corrosion-resisting steel
CRLTW	Columbia River Basin Lamprey Technical Workgroup
CRSI	Concrete Reinforcing Steel Institute
CS	count station
DEQAS-R	Design Earthquake Analysis System
DDR	Design Documentation Report
DM	Design Memorandum
DOF	degrees of freedom
EM	Engineer Manual
ENSR	Environmental Services Corporation
ER	Engineering Regulations
ERDC	Engineer Research and Development Center (WES)
ETL	Engineering Technical Letter
FCRPS	Federal Columbia River Power System
FEM	finite element method
FEMA	Federal Emergency Management Agency
FFDRWG	Fish Facility Design Review Work Groups
FFU	Fisheries Field Unit
FPE	fish passage efficiency
ft	foot or feet
ft/s	foot or feet per second
FY	fiscal year (October 1 through September 30)
HELCRABS	Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems
HQUSACE	Headquarters U.S. Army Corps of Engineers
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
IWW	in-water work

ACRONYMS AND ABBREVIATIONS (continued)

JDA	John Day Lock and Dam
JDAN	John Day North Fish Ladder
JDAS	John Day South Fish Ladder
LPS	lamprey passage system
MCACES	Micro Computer Cost Estimating System
MCE	maximum credible earthquake
MDE	maximum design earthquake
MIP	minimum irrigation pool = 262.5 feet MSL
MOP	minimum operating pool = 257.0 feet MSL
MSL	mean sea level
NEC	National Electrical Code
NEHRP	National Earthquake Hazards Reduction Program
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NHC	Northwest Hydraulic Consultants
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
OBE	operational basis earthquake
O.D.	outside diameter
OSHA	Occupational Safety and Health Administration
PDT	Project Development Team
PGA	Peak Ground Acceleration
PIT	passive integrated transponder
PLC	programmable logic control
pcf	pounds per cubic feet
psf	pounds per square feet
psi	pounds per square inch
PUD	Public Utilities District
rpm	revolutions per minute
SD	standard deviation
SMTS	specified minimum tensile strength
TM	Technical Manual
UBC	Uniform Building Code
UCS	unconfined compressive strength
UL	Underwriters Laboratories
USACE	U.S. Army Corps of Engineers

1. INTRODUCTION

1.1. Scope and Purpose

1.1.1. General

This Design Documentation Report (DDR) presents the technical details of the main features of the proposed improvements to the exit section and count station in the upper fish ladder section of the John Day North Fish Ladder (JDAN).

1.1.2. Main Features

The main feature of proposed improvements to the upper fish ladder section is the replacement of 18 existing serpentine weirs and weir 249 (holey wall) by 23 lamprey-improved vertical slot and orifice weirs similar in design configuration to the John Day South Fish Ladder (JDAS) exit section installed in 2003. In addition, significant changes will be made in the forebay transition (through non-overflow dam) and count station.

1.1.3. Purpose

The purpose of the proposed project is to improve the adult salmon and lamprey passage through the count station and exit section of the JDAN. The passage issues associated with this system are described the Executive Summary and documented in greater detail in Section 3, *Biological Design/Considerations/Criteria.*

1.2. Authorization

1.2.1. General Information

Construction of John Day Dam was originally authorized by the Flood Control Act of 17 May 1950, and generally conforms to plans contained in a review report on the Columbia River and tributaries published in House Document 531, 81st Congress, 2nd Session. That document provided for a dam, power plant, navigation lock, fish passage facilities, and a slack water lake extending to McNary Lock and Dam. A subsequent restudy of the flood control storage resulted in a reauthorized project to reduce flood control storage to 500,000 acre-feet. Reauthorization was recommended and the revision adopted by the Public Works Committee of the Senate and House by letters dated 22 April 1957 and 12 December 1957, respectively. Construction began in July 1958 and was completed in 1968-71-73.

1.2.2. Fish Passage

The 1934 Fish and Wildlife Coordination Act, as amended, has traditionally been the most important legal authority for ensuring protection or compensation for salmon and steelhead affected by federal water projects. The Mitchell Act of 1938, as amended, recognized the impossibility of identifying and requiring compensation for salmon and steelhead losses resulting from a wide array of land and water resource activities. It authorized appropriation of federal tax revenues to restore and enhance the salmon and steelhead runs of the Columbia Basin.

Authority to modify and update the fish passage facilities is contained in the Fish and Wildlife Coordination Act of August 1958 (Public Law 85-625), as amended in 16 U.S.C. 661 *et seq*. and in the original project authorization. In a letter dated 18 May 1979, the District Engineer was directed by the Division Engineer to prepare a design memorandum which would address the correction of the deficient downstream passage of juvenile fish at John Day Dam.

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

1.2.3. Objectives

The Updated Proposed Action of the Remanded National Marine Fisheries Service's (NMFS) Biological Opinion (BiOp) for Operation of the Columbia River Power System states that through 2007, the USACE will focus on actions that were initiated under the 2000 BiOp (NMFS 2007). Plans are underway to guide specific actions at each of the Lower Snake and Columbia River projects and to determine the optimal combination of adult and juvenile passage actions to meet the system performance standards.

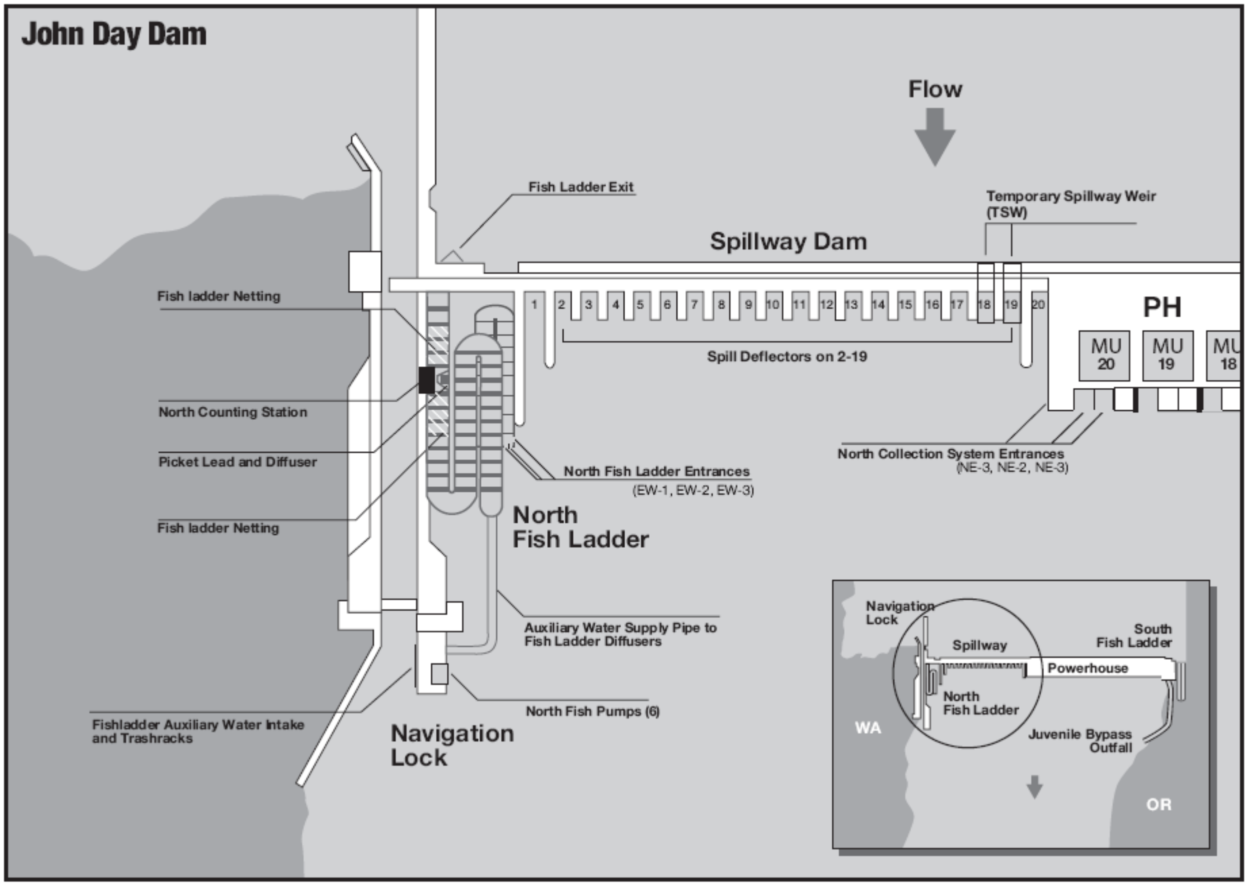
1.3. General Project Description

John Day Lock and Dam (JDA) is located on the Columbia River, 215.6 river miles from its mouth and approximately 112 miles east of Portland, Oregon. It is the third dam on the Columbia River upstream of the confluence with the Pacific Ocean. The dam is a concrete gravity structure with a total length of 5,900 feet. Structures include the south shore fish ladder, a powerhouse with 16 generating units plus four skeleton bays, a 20-bay spillway, a single lift navigation lock, a rockfill embankment on the north shore, and the north shore fish ladder.

General project construction was started on the spillway, lock, and JDAN in May 1959 within the first-step cofferdam against the north riverbank, and the south portion of the river open for navigation and fish passage. During this period, the navigation lock was mostly completed. In May 1962, the first-step cofferdam was removed and the second-step cofferdam was constructed to enclose the construction of the powerhouse and JDAS. During this period, river diversion was through the low spillway bays and navigation was over a low upper sill in the navigation lock. The second-step cofferdam was removed in April 1967, and the spillway was again isolated by construction of a third-step cofferdam to permit the raising of the low spillway bays. This construction was completed during a single low-water season, during which time the river flow passed through ten skeleton power units. Upon completion of this work, the reservoir was filled during the spring flood runoff of 1968.

The JDAN is located on the north shore the Columbia River between spillbay 1 to the south and the navigation lock to the north (Figure 1-1). The JDAN tailrace entrance and exit to forebay are also located between spillbay 1 and the navigation lock. There are three main sections of the ladder: upper ladder (exit section and count station), middle ladder (overflow weirs 172-248), and lower ladder section including overflow weirs with diffusers, transition pools, entrance, and auxiliary water supply (AWS) system. The discharge from the forebay, 80 to 120 cubic feet per second (cfs), is controlled and sent down the middle ladder section from the upper ladder section. In the lower ladder section, AWS flow is added to the ladder system incrementally through floor diffusers to produce a typical total discharge of 700 to 900 cfs at the entrance in order to attract fish from the tailrace.

Figure 1-1. Plan Schematic of John Day North Fish Ladder, Spillway, and Navigation Lock



The components of the JDAN system include the following:

a. Upper Ladder Section
   i. Exit Section
      1. Forebay transition tunnel
      2. Serpentine weirs with sill actuators
      3. Weir 249 (holey wall)
   ii. Count Station
      1. Diffuser 16 with piping and control valve for flow augmentation
      2. Counting Slot with viewing window and Crowder
      3. Trashrack and picket lead
      4. Slide gate to control through picket lead
      5. Weir 248 (where ladder head is monitored)

b. Middle Ladder Section
   i. Overflow ladder section with no diffusers–weirs 172-248
   ii. Two tiers and three legs with 180 degree bends

c. Lower Ladder Section
   i. Lower overflow ladder with floor diffusers #3 to #15 (between weirs 155-171)
   ii. Transportation channel or transition pool with large floor diffusers #1 and #2
   iii. Entrance weirs (two 12-foot long telescoping weirs)
      1. Entrance weir 1 and 2 operational
      2. Entrance weir 3 (side weir to spillbay 1) permanently closed
   iv. Auxiliary Water Supply
      1. Six pump intakes with trashracks from navigation locks
      2. Six 158 horse power, 73-inch diameter pumps
      3. 17.5-foot wide pump discharge channel with movable crane
      4. AWS conduit to diffuser outlets

A general plan view of the general ladder system is shown in reference drawing JDF-1-5-2/12 (all reference drawings are located at the end of this report). A general elevation view is shown in drawing JDF-1-4-2/58. The focus of this DDR is the modifications to the upper ladder section.

1.4. Coordination with Others

Coordination on this project has taken place with a number of Regional stakeholder groups; including, state, federal, and tribal entities on topics relevant salmon and lamprey passage. Fish passage improvement coordination with the agencies and tribes has occurred and will continue through the Fish Facility Design Review Work Groups (FFDRWG).

All agency representatives were invited to participate in two agency site visits to the 1:5 JDAN physical model at the Environmental Services Corporation (ENSR) laboratory to assess and provide technical assistance in the design of the proposed design configuration. A biologist and hydraulic engineer from NMFS participated in both agency site visits. The trip report from NMFS staff for the final model site visit is included in Appendix D.

This project lies entirely within the limits of the John Day Project, which is owned by the Federal Government; therefore, there are no real estate concerns.

1.5. Project-Specific References

1.5.1. Previous Reports and Studies

Northwest Hydraulic Consultants (NHC). August 2002. John Day Dam South Fish Ladder Control Section, Hydraulic Model Study.

U.S. Army Corps of Engineers. 1959. Design Memorandum No. 16 – Spillway, Navigation Lock, Right Abutment Embankment and North Shore Fish Facilities, Supplement No. 1 Included. Walla Walla District.

U.S. Army Corps of Engineers. 1970. Design Memorandum No. 22, Supplement No. 1– Modifications to Fish Ladder Flow Control and Exit Sections. Walla Walla District.

U.S. Army Corps of Engineers. 1984. Modification of Fish Ladders at John Day Dam Columbia River, Oregon and Washington Technical Report No. 103-2 Hydraulic Model Investigation. Northwest Division, Bonneville Hydraulic Laboratory.

U.S. Army Corps of Engineers and Cook Consulting. October 2002. The John Day North Fish Ladder and Auxiliary Water Supply Pumps Evaluation Study Report, with Recommendations for Compliance with Fisheries Requirements. Portland District.

U.S. Army Corps of Engineers. November 2002. John Day South Fish Ladder Control Section Modification Letter Report. Portland District.

U.S. Army Corps of Engineers. 2003. Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems (HELCRABS) John Day North Fish Ladder Hydraulic/Operational Evaluation. Portland District.

1.5.2. Reports and Studies for the Design Documentation Memorandum

Environmental Services Corporation (ENSR). February 2008. The John Day North Fish Ladder Physical Model Study Report (located in Appendix G of this report).

National Marine Fisheries Service (NMFS). 2007. Operation of the Federal Columbia River Power System (FCRPS) including 19 Bureau of Reclamation Projects in the Columbia Basin (draft) [revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)].

U.S. Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. April 2007. Biological Assessment for Effects of Federal Columbia River Power System and Mainstem Effects of Other Tributary Actions on Anadromous Salmonid Species Listed Under the Endangered Species Act.

2. BACKGROUND AND FINAL DESIGN CONFIGURATION

2.1. BACKGROUND

2.1.1. Temporary Fish Ladder

The John Day North Fish Ladder (JDAN) came on-line in 1968 when the spring runoff initially filled the pool. During construction and prior to the attaining normal pool, there was a temporary fish ladder on the north side. The temporary fish ladder was built from piles driven into excavated rock through the north shore non-overflow dam to provide adult fish passage for water levels of a largely unimpeded river. The vertical slot ladder was approximately 230-feet long and 12-feet wide. The vertical slot openings were 2 feet, 10 inches. The invert elevation varied from 153.59 feet on the forebay side to 150.0 feet on the tailrace side, but most of the channel was level at elevation 152.9 feet [all elevations at mean sea level (MSL)]. The top of the support piles and baffles in the passageway were at elevation 182 feet. This channel was closed off after construction and presumably filled with concrete. This channel is being investigated as a possible conduit route for a forebay source of auxiliary water supply (AWS) water to the lower ladder system and entrance area.

2.1.2. Exit Section and Count Station

The originally constructed exit section consisted of 19 non-overflow weirs with three to five orifices. There were two lower orifices, located 3 feet centerline (CL) from each sidewall. The orifices were 18-inches wide and 3-feet, 4-inches high. The bottom orifices were flush with the invert in the lower half of the system but not the upstream weirs. A third 18-inch-wide orifice was located higher and in the middle of each weir. The orifices had different heights and the elevation of orifice invert above the floor varied between 4 feet at the bottom to 10.5 feet at the top of the exit section. The opening areas of the weirs totaled from 13.8 to 15.3 square feet with the larger area downstream. Weir 249 was an entirely separate entity with five orifices (the ‘holey wall’ from the beginning), four on the sides (two raised) and one raised in the middle; summing to a total cross-sectional opening area of about 20 square feet. The original exit weirs passed 50% to 90% of the flow (depending on forebay) required for the main overflow ladder section downstream of the count station, with remaining flow augmented by diffuser 16. The system experienced problems from the outset because shallow-swimming fish species, mainly shad, were reluctant to pass through the exit section. The elevated middle orifices were enlarged in the second year of operation to create free surface flow.

The original forebay transition had the same basic outer dimensions (12-feet wide and 19.5-feet high) than what currently exists. The forebay transition had two baffles in the tunnel (spaced more evenly than currently exists). Both baffles blocked the middle of the channel and allowed for flow between the edges and sidewalls. The side slot openings extended to the invert.

The original counting station was similar in configuration to existing station except it did not have the existing 45 degree transition in the upstream sidewall approach to the count slot on the north side. The whole viewing window/count slot setup was also positioned 8 feet upstream of the existing location. Instead of a ramp, 2-feet high system screens and louvers ramp in the count slot. Visibility was difficult for fish counting and the fish typically stalled in pools on both sides of the count slot.

Major modifications were completed in 1972 to install the existing serpentine weir system in the exit section (Design Memorandum 22, Supplement 1, CENWW 1970). In the original exit weir system, the shad did not pass effectively, sometimes causing numbers to accumulate to levels where the ladder might become essentially blocked. The design was based on a 1:10 physical model study at the Division Hydraulic Laboratory at Bonneville Dam (Technical Report 103-2, Hydraulic Model Investigation, CENWD 1984). The means of flow transfer from pool-to-pool was shifted entirely from orifices to vertical slot. The intent was to provide more access for the shallow swimmers without hindering the deeper swimmers. Due to the difficulty of acquiring consistent or reliable water level data in the model tests, the slot sizes were based on slot velocities [design maximum 5.7 feet per second (ft/s)] rather than head drop (design maximum 6 inches) between pools. When the satisfactory slot velocities were could not be obtained for the full range of forebay elevations (257 to 268 feet), actuated sills were designed for the upper half of the system.

In the forebay transition, the original baffles were replaced by the two existing baffles, where flow now passes a single and alternative side of each baffle. Concrete sills 2.5-feet high were placed in each 2-foot-wide side slot openings for both baffles. The existing 8-inch-thick, 12-inch-long stubwalls were also installed as flow deflectors in 1972. The purpose of these changes was to create a more distinct attraction flow through the forebay transition.

During the 1972 modifications, all of the three upper orifices were replaced at weir 249 (holey wall). The two outer orifices were covered and replaced by orifices cut adjacent and flush to the sidewalls at invert elevation 248 feet. The middle orifice was covered and replaced by a higher orifice with orifice invert raised to elevation 248 feet. The new middle orifice was 25-inches wide by 2-feet high. With all the changes, the total opening area at weir 249 was reduced from approximately 20 to 18.5 square feet.

During the 1972 modifications, the viewing window/count slot setup in the counting station was shifted 8 feet downstream to the current location. This made room for the existing 45 degree sidewall transition on the upstream, north side of the slot. A 17-inch-high ramp was installed through the count slot. The upstream end was blunt edged and the downstream end was transitioned at 45 degrees to the invert. The steepness of the downstream transition was dictated by presence of the barrier screen guide—used in the past to temporarily block fish passage when counters needed to take breaks (the practice of closing barrier screen guide closure has since been terminated and the count estimates are adjusted statistically for the periods when the counters are away from the window). The 1972 modifications did provide a more streamlined transition and passage route though the count station.

The final ramp configuration was developed sometime later, probably by the John Day Project. The height of the ramp was raised to 23 inches and a gradual transition was added to the upstream end. The downstream transition currently has a multiple slope.

The grating on diffuser 16 was changed from 1-inch openings to 0.75-inch openings in 2006 to prevent lamprey from infiltrating and become trapped behind the screens. The upstream trashrack for the diffuser piping was also changed from 0.75 inch to 5/8 inch so that debris would not enter the system and plug the back side of the diffuser. Project biologists report that this change has effectively kept lamprey out of the diffuser.

2.2. DESCRIPTION OF EXISTING UPPER LADDER SECTION

A plan and elevation view of the upper ladder section is shown in reference drawing JDF-1-5-2/19 (located at the end of this report). The total length of the exit section and count station is 411.33 feet from forebay intake to weir 248 (downstream of the count station). Most of the exit section is 24-feet wide (same as the remainder of the fish ladder down the overflow ladder section to the lower transition pool), but the upper 112 feet is narrower at 12-feet wide in the 54-foot-long upstream forebay transition tunnel and 22 feet, 7 inches wide in the remaining 58 feet. The invert is level at elevation 250.5 feet in the upstream 112 feet, and is sloped at 1:32 over the next 240 feet down to elevation 243.0 feet at weir 249. The count station pool invert is level at invert elevation 242.0 feet. The overflow ladder section assumes a 1:10 slope downstream of weir 248. Back in the exit section, the top of the sidewalls is sloped at 1:16, descending from elevation 270.0 feet at the exit to the forebay transition tunnel to elevation 254.0 feet at weir 252 in the serpentine weir section. The top remains level at elevation 254 feet most of the way through the count station.

2.2.1. Forebay Transition

The forebay transition is the connection between the forebay and exit section weirs. The transition is a tunnel is through the non-overflow dam and is 12-feet wide by 19.5-feet high. The invert elevation is constant at 250.5 feet. On the upstream end there is a trashrack. On the downstream end (as flow exits the tunnel) there is a transition to width 22 feet, 7 inches[1] with both sidewalls flared outwardly at 45 degrees. There are two baffle walls in the tunnel. The walls block all but 2 feet of the 12-foot width, leaving a single opening on one side of the tunnel for each baffle, with the openings on alternate sides of the channel. The opening for the upstream baffle is on the south side and on the north side for the second baffle, creating a zigzagging flow pattern for migrating fish. The 12-inch projecting stubwalls divert the slot jets away from the sidewall. Each opening has a 2.5-foot-high permanent concrete sill.

2.2.2. Serpentine Weirs

There are 18 serpentine weirs from weirs 250-267 (see reference drawing JDF-1-5-2/19). The serpentine section is 294 feet long with a typical spacing of 16 feet between weirs. In the upstream 58 feet, the invert is constant at elevation 250.5 feet, and slopes at a rate of 1/32 for the remainder of the way to weir 249 (holey wall). Between each weir, there are two pools separated by vertical slots. One pool is on the north side of the channel and the second pool is on the south. At the weir location, a vertical slot directs flow in a northwestwardly direction (generally downstream direction) into the north pool. The discharge from the north to south pool is through the second slot that directs the jet in a southeastwardly direction (generally upstream direction). Upward migrating fish must move in a lateral S pattern from one side to the other before progressing upstream to the next pair of pools. There are 35 vertical slots and 34 pools between weirs 250-267.

In the upper half of the system, there are actuated sills in 17 of the slots. The sill heights range from 0.3 feet at weir 259 to 6.5 feet at weirs 266-267. The sills are closed (in the slot) during normal and upper forebay levels to control flow and head drop between pools (6 inches design maximum). The sills are opened (out of slot) when the forebay drops below elevation 261 feet so that there will be adequate flow distributed head down the serpentine channel. When the forebay is rising, the sills are closed when the level rises above elevation 263.0 feet. There is a 2-foot forebay dead-band between

[1] There is a second transition (located 58 feet below the exit section) to the nominal 24-foot width that exists for the remainder of the ladder.

sill operations. At normal sill operation, the discharge rates in the exit section ranges from 21.4 cfs at forebay 261 to 70.2 cfs at maximum forebay 268. At no sill operation, the discharge rates range from 20 cfs at minimum operating pool (MOP elevation 257.0 feet) up to 58.5 cfs at forebay 263.

2.2.3. Weir 249 (Holey Wall)

A cross-sectional view of weir 249 (holey wall) is shown in the upper left of reference drawing JDF-1-5-2/17. The holey wall is the separating point between the serpentine weir system on the upstream side and the count station on the downstream side. The holey wall is a remnant of the original exit section weirs and has five orifices. The three upper orifices were repositioned in the 1972 modifications. All three upper orifices have an invert of elevation 248 feet (5 feet above floor) and are 2-feet high. The two outer ones were cut adjacent to the sidewalls and are 1.5-feet wide. The upper middle orifice is centered in the holey wall and is 2-feet, 1-inch wide. The two bottom orifices are located 3 feet CL from each sidewall and are 1.5-feet wide by 3.5-feet tall.

The holey wall has been identified as a location where fish halt or turn back presumably because it represents a unique geometry with no zone of dominate discharge. It may also present a confusing array of five weaker discharge points from which salmon must choose. When salmon move past the holey wall, they are then confronted by yet another change in geometry and hydraulics (serpentine weirs), and project biologists have observed salmon fall back there.

2.2.4. Diffuser 16

Diffuser 16 is located in the upstream pool of the count station and downstream of weir 249. The diffuser footprint is 14.5-feet long by 24-feet wide. The opening spacing in the grating is 0.75-inch, recently changed to prevent lamprey entrapment. The invert of the grating is at elevation 242 feet, an abrupt 1-foot drop from the invert at the holey wall. This represents a barrier to lamprey passage. The diffuser is supplied by a 36-inch outside diameter (O.D.) pipeline from the forebay (see reference drawing JDN-1-3-20/1). The intake is on the upstream side of the non-overflow dam, outside (south of the dividing wall) of the upstream lock approach channel. The length of the pipe is approximately 400 feet and the invert for the pipe is a constant elevation at 230.5 feet. A slide gate is located at the upstream end to regulate diffuser flow and modulates to maintain a constant ladder head (1.0 feet for salmon, 1.3 for shad, ± 0.1 feet).

2.2.5. Count Station

The count station area consists of two pools separated by a count slot with viewing window (see reference drawings JDF-1-5-2/25 for plan and JDF-1-5-2/27 for profile views). The length of the count station area is 48-feet long, the distance between weirs 248 and 249. Flow enters the count station through weir 249 and diffuser 16. Make-up water issues upwards through the floor grating of diffuser 16 in the upstream pool. Downstream of the diffuser and upstream of the count slot, the sidewalls converge at a 45 degree angle to narrow the channel from 24 feet to 4 feet in width through the count slot. The walls flare out again to 24 feet in width downstream of the count slot and upstream of weir 248.

On the north side of the count station, the sidewalls are solid. The building, counting office, and viewing window are located on the north side of the count slot. The existing viewing window could be lowered an additional 11.5 inches to provide better viewing capability.

On the south side, the sidewalls are porous with a trashrack on the upstream side and a picket lead on the downstream side (see reference drawing JDF-1-5-2/31). The purpose of the picket lead is to guide approaching fish into the count slot. The opening spacing between bars for both trashrack and picket lead is 1 inch. The picket lead consists of 5-inch by 0.25-inch members that are oriented 45 degrees so that the bars are aligned with the general direction of flow. Salmon cannot pass through the picket lead but lamprey can (which is an acceptable passage route). The trashrack consists of 3-inch by 0.25-inch members that are oriented in the standard direction, perpendicular to the main frame, and consequently 45 degrees with respect to the general flow direction. The outer frames of both trashrack and picket lead are 6-feet, 8.25-inches long and 11-feet, 11.5-inches tall. There are two panels of each which form the porous sidewalls on both sides.

Between the trashrack and picket lead, there is a manual slide gate (see 'bulkhead' in reference drawing JDF-1-5-2/31; the bulkhead was either modified or replaced later by a slide gate) with dimensions of 9-feet, 10-inches wide by 7-feet high (water depth in count station is 6.0 to 6.3 feet). The gate is used to regulate the proportion of the total count station inflow (80-120 cfs) that goes through the trashrack and picket lead. By deduction, the gate determines the flow and velocities through the count slot. The normal range of flow rate through the picket lead will be between about 40 to 80 cfs (depending on salmon or adult ladder head operation), with gross average velocities of 0.6 to 1.4 ft/s. The position of the slide gate is rarely if ever changed. A 40-inch gate opening was measured during a prototype site visit with CENWP and Environmental Services Corporation (ENSR) staff.

The count slot is 4-feet wide. On the south side of the slot, there is a crowder (or 'counting board,' see reference drawing JDF-1-5-2/30). The crowder is 4.5-feet long by 5-feet, 11.75-inches tall by 4-feet, 2-inches deep. The crowder's position can be adjusted by the counter to change the gap opening between the crowder and counting window. The gap openings range from 18-36 inches. The counters narrow the gap when they need visibility due to water turbidity; the wider gap is meant to be used when there is high fish volume. The gap in a normal crowder position is 24 inches and is reportedly almost never made wider. Velocities[2] through the gap and slot can range from 2 to 4 feet per second (ft/s).

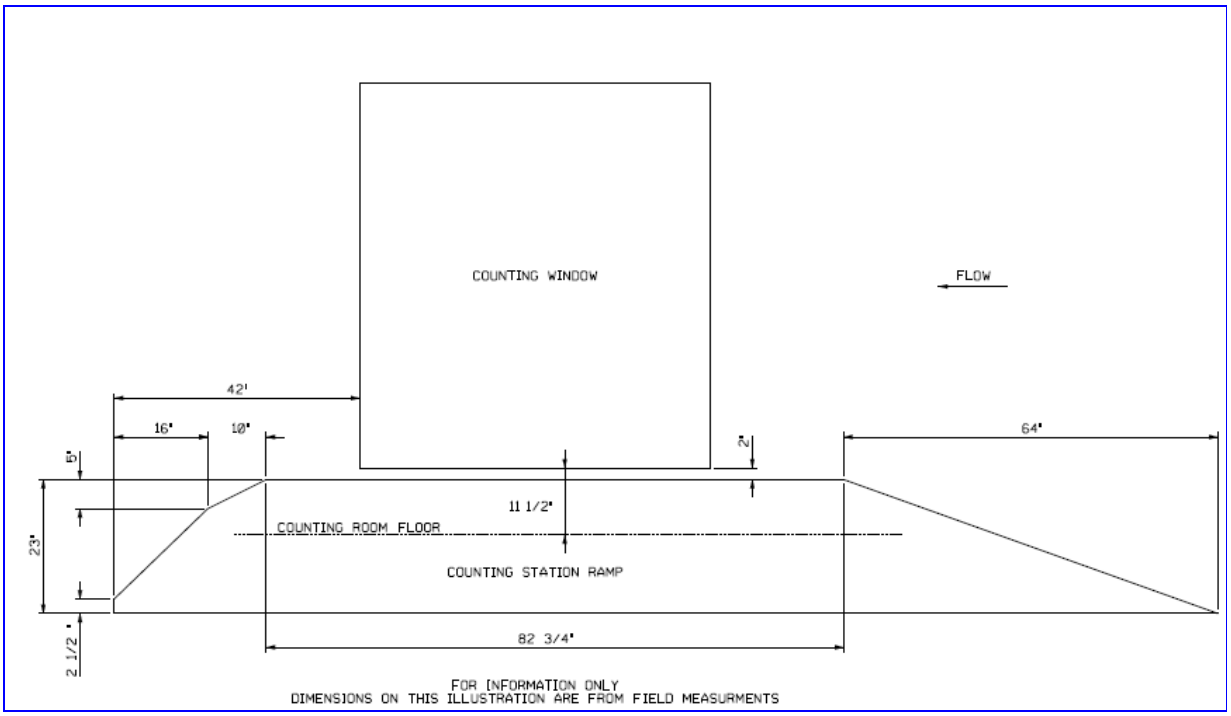
The barrier gate (reference drawing JDF-1-5-2/31) is located at the downstream end of the count slot and is 3-feet, 10-inches wide by 6-feet, 11.75-inches high. The location of the gate is at the 2.5-inch lip at the downstream end of the count station ramp. The barrier gate frame is covered with grating instead of skin plate to allow flow to pass through it. The purpose of the gate was to suspend fish passage without disrupting flow operations while counters could take breaks. This practice has been stopped and statistical means are now used to fill in the time gaps. Consequently, the barrier gate is obsolete.

The 23-inch high ramp through the count slot is shown in reference drawing JDF-1-5-2/27. However, the existing ramp is about 6 inches higher and has a gradual transition on the upstream end. The downstream transition now has a broken-back slope and is constrained by the location of the (now obsolete) barrier gate. The actual (field measured) profile of the ramp is shown in Figure 2-1 (all dimensions in inches). The figure also shows the relative position of the window with respect to the ramp and original invert at elevation 242.0 feet.

[2] Velocities through the gap have not been measured at JDAN, but they have been measured during the HELCRABS studies at about 2.1 ft/s at JDAS, 3.2 ft/s at The Dalles North Fish Ladder, and 4.2 ft/s at Bonneville A Branch Fish Ladder; it is not clear whether the measurements were taken in the narrow gap between crowder and window, or at one end of the slot where the width is wider.

Weir 248 represents the downstream end of the count station area (see lower left of reference drawing JDF-1-4-2/52; the center orifice has been blocked since the 1970s). Water level data is automatically monitored in the pool between the count slot and weir 248 to regulate ladder head. Weir 248 is a standard overflow ladder weir with two 6-feet long overflow weirs and two orifices flush with the channel invert. However, the orifices in weir 248 are larger than the standard 18-inch by 18-inch orifices found down the remainder of the overflow ladder section. Weir 248 orifices are instead 22-inches wide by 20.75-inches high. The reason for the enlarged orifices in weir 248 is that the approach flow energy is different than for the rest of the overflow weirs. In a normal overflow weir, the weir crests and orifices are in direct line between weirs and residual energy from the upstream flow carries to the next weir to contribute to the flow efficiency and total discharge rate for a given head difference. At Weir 248, the majority of the upstream energy issues through the count slot in the middle of the pool and is not in line with either weir crests or orifices but instead impinges against the center baffle of the non-overflow weir. In order produce 1-foot of ladder head at both weir 248 and in the rest of the overflow ladder section, the orifices must be sized larger at weir 248.

Figure 2-1 Existing Ramp through Count Slot at Count Station (looking north towards counting window)



2.3. PROPOSED MODIFICATIONS TO UPPER LADDER SECTION

Modifications are proposed for all parts of the upper ladder section. The intent of the modifications is to improve both salmon and lamprey passage. The proposed configuration modifications were developed in the 1:5 physical hydraulic model at the ENSR hydraulic laboratory (see *John Day North Ladder Physical Hydraulic Model Study Final Report* located in Appendix G).

2.3.1. Forebay Exit Transition

a. Remove existing baffle (east-most) with 2-foot opening slot and 2.5-foot sill (this baffle is the most upstream with slot opening on south side).
b. Modify remaining existing baffle with 2-foot slot (downstream baffle).
   i. Cut out 2.5-foot sill to match invert (elevation 250.5 feet).
   ii. Move existing 8-inch wide by 12-inch long vertical stubwall upstream by 4.5 feet; the distance of the stubwall 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).

2.3.2. New Lamprey-Improved Weirs with Vertical Slot and Orifice

a. Replace all 18 serpentine weirs and holey wall (weir 249) with 23 new lamprey-improved weirs (new weir numbers start with 1 at the downstream end in the place of existing holey wall).
b. Each new weir will contain a vertical slot (15- to 18-inch width) and orifice (18- by 18-inch).
c. The new JDAN weirs will be similar in configuration to the 2003 JDAS weirs except for the following differences:
   i. All outside corners (particularly through slot and orifice) will be rounded to a minimum 4-inch radius.
   ii. Vertical slot flow orientation will be directed towards northwest instead of southwest.
   iii. Weir walls will be 10-inches thick.
   iv. Fin added to downstream baffle to augment flow stability.
   v. Variable spacing between new weirs with 15 feet maximum between weirs 1 and 2 at the downstream end and 12 feet (minimum) between weirs 18-23.
d. Same as the JDAS design, the location of each new JDAN weir was positioned so that no weir walls will span any existing construction joints[3].
e. Sill heights are revised to handle higher efficiency weirs:
   i. 1-foot sill actuators for weirs 2-23.
   ii. Higher second tier sill actuators for Weirs 9-23 (combined sill heights will range from 1.75 feet at weir 9 height to 6 feet at weir 23).
   iii. Higher second tier sills will be L-shaped with vertical stem to block 3 inches of slot width for 18-inch-wide slots in weirs 18-23.
   iv. Construct platforms to support all sill actuators from above.
f. Raise top of sidewalls 3 feet above existing (to discourage fish jumping); alternative material can be used to avoid overweighting exit section. (Top of new weirs will match top of existing sidewalls.)

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[3] There will be longitudinally projecting stubwalls that will cross certain joints; where a projecting section extends across a joint (from the main weir baffle wall), it will not be tied into the floor on the other side of the joint from the main baffle wall.

2.3.3. Count Station

a. Remove existing 23-inch high ramp and barrier screen gate.
b. Lower counting window 11.5 inches.
c. Raise count station floor by 1 foot to match invert (elevation 243.0 feet) at new weir 1 (former holey wall location).
    i. Horizontal grade will extend 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 (~ elevation 242 feet) at existing ladder weir 248.
d. Add 12-inch-wide strip (metal plate) for lamprey passage over diffuser 16 grating along south sidewall to guide lamprey to orifice in weir 1.
e. Insert 1-inch shims under picket lead & trashrack to augment lamprey passage behind count slot.
f. Replace or upgrade antiquated crowder, automated window cleaner, backboard and lighting. PDT will also investigate video counting and coordinate the design of all improvements with Fish Field Unit (FFU) and fish counters.
g. Add transition fairings to transition flow into upstream and out of down stream ends of crowder.
    i. Upstream end will have 3-inch radius corner, downstream 6-inch radius corner.
    ii. Farings will have adjustable lengths in straight section for crowder motion.
h. Horizontal vanes (spaced 18 inches apart) added to upstream fairing to prevent vertical circulation at count slot intake.

3. BIOLOGICAL DESIGN/CONSIDERATIONS/CRITERIA

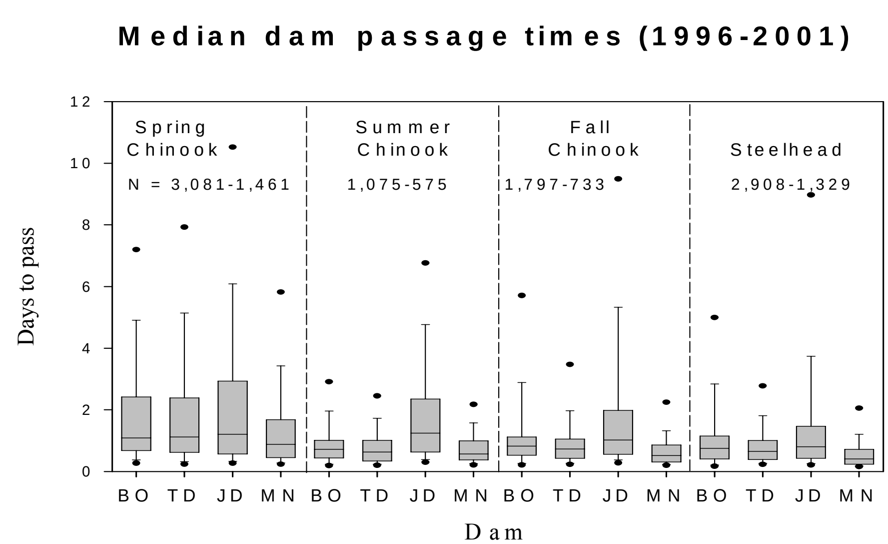
3.1. ADULT SALMON AND STEELHEAD PASSAGE

3.1.1. General

The John Day Lock and Dam (JDA) is uniquely positioned with the John Day River just upstream creating different mixes of water at each ladder; the Deschutes River is not far downstream into which fish stray and return after falling back over the dam and where many fish slow migration in relationship to river temperatures. In ladder temperature differentials, long passage time, fish jumping, and difficulties with counting fish have been of concern at JDA for many years.

Historically, mean adult passage times at JDA (first tailrace line detection to ladder exit; see reports for exact detection locations) have been among the longest of anywhere on the river. University of Idaho telemetry data summarizing migration rates from 1996-2001 indicated that JDA median passage times were longest for the lower four dams for all species (from about 1 to 1.5 days; Figure 3-1) and that JDA had the highest percentage of fish that took greater than 5 days to pass, about 9% to 14%. The National Marine Fisheries Service (NMFS) analyses of data from 1998-2001 showed JDA tailrace passage times being longer than the other lower Columbia River dams, and that the transition pool may be the main area of concern. Low-water velocities in the transition portion of the lower ladder are likely contributing to fish stalling or dropping back downstream.

Figure 3-1. Median Passage Times by Species and Dam, 1996-2001



Fish jumping, which can lead to stranding and mortality, has been a persistent problem in ladders at JDA since it was built. Installation of slot and orifice weirs in the south ladder control section in the winter of 2002-2003 basically eliminated jumping in the ladder and improved passage times.

Adult salmonids, primarily steelhead (*Oncorhynchus mykiss*), have been jumping in the fishways of JDA since initial construction in 1968. This has led to mortality from both stranding on catwalks and netting, and exiting the ladder to the ground below. Hard strikes against metal and concrete as well as possible depletion of energy reserves have been additional concerns.

The flow-control sections at JDA were designed to create a serpentine flow pattern, forcing upstream migrants to swim in a continuous series of arcs, alternating between clockwise and counter-clockwise turns. Observers noted that jumping occurred most frequently on the south side of the ladder. The Fisheries Field Unit (FFU) proposed using a surface slot or a submerged orifice to provide salmonids a direct route into the upstream pools. In 2000, the FFU tested both a surface slot and a submerged orifice in the south ladder; a significant reduction in jumping was observed with each treatment (slot $P < 0.05$, orifice $P < 0.05$). In 2001, the slot and orifice were tried in combination; a significant reduction in jumping was also observed with this treatment ($P \leq 0.001$).

Based on these findings, the Portland District developed a design for the south ladder derived from the slot and orifice configuration at Ice Harbor Dam and The Dalles Dam's north ladder. This design included a full depth vertical slot near the center of the fishway directing flow toward the south fishway wall. It also included an 18-inch by 18-inch submerged orifice on the floor of the fishway near the north fishway wall. During the 2002-2003 winter maintenance season, contractors removed the old style serpentine weirs and replaced them with the vertical slot style of weirs. In the fall 2003, the FFU conducted a post-construction evaluation of the redesigned flow-control section. No jumping was observed in the flow-control section during 214 hours of observation in September and October 2003. Adult salmonids took less time to pass through the re-designed flow-control section than they did through the same section in 1993. Steelhead that exited the flow-control section on the same day they entered it took an average of 24 minutes to swim through the section in 2003 as compared to 51 minutes in 1993. Passage times for steelhead in all passage categories (day, night, next day, etc) were less in 2003 than in 1993.

John Day count stations, especially at north ladder, have led to discrepancies in counts when compared to enumerations at The Dalles and McNary dams. These counts are used to help evaluate hydrosystem passage and set harvest regulations. The primary problem is the large number of fish that spend time moving up and down in the counting window area, making accurate enumeration difficult. On the average, the same fish is counted 7 to 8 times before its final passage through the count window. Hydraulic conditions in and just above the counting station slot are likely contributing to this phenomenon.

A 1997-1998 study of passage in relation to differential ladder temperatures found ladder exits increased as temperature rose but that passage problems were more related to river temperature and other factors than to differences in temperature within the ladder. Mean and maximum ladder temperatures at JDA were much more strongly correlated with exit rates than were differences between forebay and ladder temperatures. There was little compelling evidence that steep gradients between forebay and fishway temperatures were an important independent cause of fishway exits or delay: the temperature gradient between the cooler lower-ladder water (downstream from diffusers) and water in the upper ladder may exacerbate exit behavior by adult fish because it occurs in the transition pool area, a location where adult fish delays have been identified at many dams. High rates of fishway and transition pool exit behavior under a wide range of temperature conditions, however, suggest that factors other than temperature alone were responsible for relatively slow passage at JDA.

3.1.2. Passage Times

One of the primary objectives of the adult passage studies was to identify sources of slowed adult passage at dams. In the report, *Adult Salmon and Steelhead Passage Through Fishways and Transition Pools at John Day Dam, 1997-2001* (Keefer et al., in review; Tables 3-1 to 3-3), University of Idaho researchers summarized passage behaviors, including passage times, through tailrace, fishway, transition pool, and full-project passage segments at JDA. Median full-dam passage times during the study years (1997, 1998, 2000, 2001) were longest for radio-tagged spring–summer Chinook salmon (26-36 hours), intermediate for steelhead (17-20 hours) and shortest for sockeye salmon (13 hours). Overall, passage times at JDA were among the longest recorded at any of the eight lower Columbia and lower Snake River dams (Keefer et al., 2004a). These long passage times were attributable, at least in part, to high fishway and transition pool exit rates at JDA. During the study years, adult fish from all runs were far more likely to exit into the tailrace at JDA than were the same fish at The Dalles (Keefer et al., 2003b; Keefer et al., in review); exit rates from JDA fishways were higher than those recorded in 1996 at Bonneville, McNary, Ice Harbor, and Lower Granite dams (Keefer et al., 2003a).

As in other adult passage time studies, mean times at JDA were longer than medians for all species/years, because some fish delayed for days or weeks and/or moved downstream temporarily. As a result, all passage time distributions were right-skewed. It is likely that salmonid migration times under pre-dam conditions were also skewed with some fish migrating slower than the bulk of the run, particularly in areas with natural constrictions like falls and rapids (Jensen et al., 1989; Gilhousen 1990; Rand and Hinch 1998).

To best determine where fish slowed, passage was partitioned by radio-tagged fish at JDA into five primary components: (1) first tailrace entry to first fishway approach; (2) first fishway approach to first fishway entry; (3) first fishway entry to first transition pool entry; (4) first transition pool entry to exit a pool into a ladder; and (5) ladder ascension. These passage segments capture the major fish passage environments at the dam, with segment endpoints marking transitions between environments. Some segments, such as transition pools, have been previously identified as sources of confusion or delay for adult migrants at other hydrosystem dams (Bjornn et al., 1998b; Keefer et al., 2003a). Defining 'delay' through any passage segment was an arbitrary decision, because fish may have temporarily stopped upstream migration or moved downstream for a variety of reasons, including nightfall (Naughton et al., 2005), route-searching behavior, response to environmental change, the number of fish passing a site, or difficult passage conditions at the dam. By way of summary, one measure of delay that was useful for classifying and comparing groups of fish was a time gap of greater than 24 hours through any of the five passage segments listed above.

In all years, the segment with the largest numbers of spring–summer Chinook salmon with passage times greater than 24 hours was from first transition pool entry to exit a pool into a ladder. Between 26% and 29% of the Chinook salmon took longer than 24 hours between transition pool entry and eventual exit into a ladder (see Table 3-1 through Table 3-3). Salmon were generally not inside the transition pools for most of the elapsed time, but instead were in the tailrace or entering and exiting the fishways. The longest transition pool passage times almost always included an exit from a pool into the tailrace. The transition pool segment also had the greatest numbers of steelhead and sockeye salmon with passage times longer than 24 hours, and the circumstances of transition pool 'delay' were similar for these runs. The passage segment from first fishway approach to first fishway entry also included a number of passage times longer than 24 hours, particularly for Chinook salmon in 1997, the year when flow and spill were highest. Ascending ladders, passing from fishway entry to transition pool entry, and even from tailrace entry to first fishway approach were generally efficient for all runs, with less than 10% taking longer than 24 hours to pass these segments in any run-year.

Table 3-1. Median Times (hours) for Radio-tagged Fish to Approach, Enter, and Pass through Fishways and Transition Pools, and to Pass JDA, 1997-1998

John Day Dam	Spring-Summer Chinook		Steelhead	Fall Chinook	
	1997	1998	1997	1997	1998
First tailrace to pass dam	35.8	31.2	16.9	22.9	13.3
Fishway entrance to pass dam	11.1	20.5	10.5	21.5	10.3
Tailrace to fishway approach	2.6	2.0	2.3	1.6	1.6
Fishway approach to fishway entry	2.4	2.6	0.3	0.5	0.0
Fishway entry to transition pool	0.4	0.6	0.2	1.2	0.0
First to last transition pool	1.4	6.5	2.0	9.0	1.8
Last transition pool to pass dam	2.9	2.7	2.9	2.8	2.9

Note: Includes all fish with records at each end of the passage segment.

Table 3-2. Median Times (hours) for Radio-tagged Fish from First-recorded Detection at Tailrace Receivers to First-recorded Fishway Entry at JDA, 1996-2002

Run	Year	Dam	*n*	Time from tailrace to first fishway entry (hours)				
				5%	25%	50%	75%	95%
Spring-Summer Chinook	1997	John Day	414	1.8	3.9	8.6	29.7	209.4
	1998	John Day	440	1.3	2.9	6.1	16.6	84.1
	2000	John Day	414	1.2	2.5	4.7	9.6	58.0
	2001	John Day	598	1.2	2.4	4.8	10.4	48.4
	2002	John Day	648	1.6	3.5	7.0	13.7	59.7
Steelhead	1997	John Day	351	1.3	2.0	3.4	7.7	22.4
	2000	John Day	442	1.1	1.9	3.8	9.9	25.9
	2001	John Day	438	1.2	1.7	2.8	6.0	17.1
	2002	John Day	641	1.3	2.0	3.7	9.6	33.4
Fall Chinook	1998	John Day	238	0.9	1.5	2.6	6.3	15.0
	2000	John Day	221	1.2	1.8	3.2	7.2	17.7
	2001	John Day	205	0.8	1.4	2.4	5.4	10.4
	2002	John Day	333	0.9	1.5	2.4	5.5	11.6
Sockeye	1997	John Day	309	0.9	1.2	1.9	3.3	11.4

Note: Telemetry coverage of fishway entrances varied between dams and between years.

Table 3-3. Number of Adult Radio-tagged Spring-Summer Chinook Salmon and Median Times to Pass from First Tailrace Record to First Fishway Approach, to First Fishway Entrance, and to Pass JDA Based on Month Fish were First Detected in the Tailrace

	Chinook Salmon							
	1997		1998		2000		2001	
First tailrace to first approach	N	**Med.**	N	**Med.**	N	**Med.**	N	**Med.**
April	62	**3.6**	116	**2.0**	111	**2.3**	222	**1.9**
May	276	**2.8**	245	**2.2**	169	**1.5**	274	**1.6**
June	73	**2.5**	80	**1.9**	137	**1.3**	111	**1.3**
July	128	**2.0**	100	**1.4**	96	**1.2**	85	**1.2**
First tailrace to first entry								
April	43	**21.1**	98	**9.0**	68	**9.6**	201	**7.1**
May	189	**14.8**	194	**8.7**	130	**5.2**	235	**4.7**
June	65	**7.3**	66	**5.2**	126	**3.7**	91	**3.4**
July	117	**4.9**	82	**3.0**	86	**2.8**	70	**2.8**
First tailrace to pass dam								
April	58	**144.9**	104	**44.2**	116	**27.6**	215	**31.0**
May	275	**33.1**	226	**32.9**	167	**19.1**	276	**20.9**
June	70	**29.9**	74	**28.8**	126	**33.1**	112	**27.0**
July	124	**25.8**	101	**22.2**	78	**33.0**	83	**32.7**
First approach to first entry								
April	43	**17.1**	98	**3.9**	68	**2.7**	201	**2.9**
May	189	**4.5**	194	**4.2**	130	**2.3**	235	**1.9**
June	65	**2.2**	66	**1.9**	126	**1.9**	91	**1.1**
July	117	**1.3**	82	**0.9**	86	**1.1**	70	**0.6**

From Keefer et al., in review.

Spring-summer Chinook passage times at JDA tended to decrease as water temperatures warmed each year. This behavior was consistent with dam passage at other dams and migration times through longer hydrosystem reaches (Bjornn et al., 2000a; Keefer et al., 2004a; Keefer et al., in review). Increasing passage rates were likely due to increased metabolic activity at warmer temperatures (Erkinaro 1999; Økland 2001), but may also have been related to increased proportions of fish destined for upriver spawning areas (e.g., Snake and mid-Columbia River tributaries) as migrations processed. Keefer and others (2004b) also reported increasing passage rates by Chinook salmon as temperatures warmed in unimpounded reaches and tributaries.

Fish of all species that dropped back down the ladder into the tailrace had longer dam passage times than fish that did not in almost all months of all years. Increases in passage time associated with exiting a fishway were 13 hours to longer than 30 hours for spring-summer Chinook, 10 to 16 hours for steelhead, and 7 to 13 hours for sockeye salmon in most individual months. Similar delays were observed for fish that exited transition pools into the tailrace; the overlap between fish that exited fishways and those that exited transition pools to the tailrace was extensive because many fish migrated upstream in fishways to transition pool areas before turning around and exiting fishways.

Behavior in transition pools and fishway exit behavior were very good predictors of overall dam passage times for all runs. Fish that exited transition pools into the tailrace had dam passage times that were significantly longer than times for fish that moved through transition pools without exiting. Similarly, fish that exited fishways took significantly longer than fish that did not exit. Non-uniform flows, lack of sufficient attractive flow, temperature changes, locations of floor diffusers, fishway configuration, or a combination of these or other variables may have contributed to the behaviors we observed in transition pools. Fishway exits not related to transition pools may also have been related to some of the variables described above. These results are consistent with previous studies that showed fishway and transition pool exits were sources of delay for adult migrants (Bjornn et al., 1998a, 1998b; Keefer et al., 2003a).

Water temperatures in the fishways and ladders were implicated in adult exit behavior in a more detailed study of temperature effects at JDA that used the 1997 and 1998 data (Keefer et al., 2003b). In that study, fishway exit rates at JDA were strongly positively correlated with mean and maximum water temperatures in the ladders (Keefer et al., 2003b). In this study, the likelihood of fish exiting a transition pool into the tailrace was generally higher for fish that first entered the WA-shore pool, for Chinook salmon later in the migration when water temperatures were elevated, and for some steelhead migrating during the warm summer months.

It was also noted that some variability in passage times and behaviors like fishway and transition pool exits can be attributed to diel cycles. Adult salmon and steelhead are unlikely to pass dams at night (Keefer et al., 2004a; Naughton et al., 2005). As a result, fish that enter fishways and tailraces late in the day tend to pass the following day resulting in longer passage times.

The multivariate analyses of complete passage times at JDA indicated that an exit from a transition pool into the tailrace was the most influential predictor of passage time for all four years of spring–summer Chinook salmon, for sockeye salmon, and for 2 of 3 years for steelhead. Time of day was secondary in 2 years for Chinook salmon, while water temperature and/or date also provided good predictive capabilities for several run years. Fishway exits were also important (in addition to transition pool exits) in some cases. Collectively, these results suggest that how adult fish behaved after entering JDA fishways was the most important determinant of how long fish took to pass the dam. Seasonal and diel effects were also important, reflecting a general aversion to passing dams at night and increasing migration speeds during warmer periods or as spawning times approached.

The results suggest that the best opportunities for improving adult passage efficiency at JDA include reducing fallout from fishways and transition pools. The overwhelming majority of 'efficient' (i.e., fast) dam passages by all three species were by fish that did not exit. Modifications to transition pool weirs, including increasing hydraulic head at lower weirs and raising velocities through orifices, may increase the proportions of fish that pass directly through transition pool areas. Experimental results at Lower Granite Dam (Naughton and Peery 2003) indicate that these types of transition pool weir modifications can reduce transition pool fallout and lower dam passage times.

3.1.3. John Day Salmon Research Report References

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3.2. Adult Lamprey Passage

3.2.1. General

Restoring migration corridors for anadromous Pacific lamprey (*Lampetra tridentate*) has been identified as one of the most important needs for recovery of declining populations in the Columbia and Snake Rivers (CRLTW 2005). Adult lamprey must negotiate four mainstem hydropower dams to reach the confluence of the Columbia and Snake Rivers, and to attain spawning areas in headwater streams, they must pass up to five additional dams. Radio-telemetry studies have determined that adult lamprey passage at lower Columbia River dams is poor relative to that of salmonids, and have identified particular fishway structures that are obstacles to lamprey passage (Bjornn et al., 2000b, 2002a; Moser et al., 2002a,b, 2005c).

At the Bonneville and John Day dams, adult lamprey are obstructed or delayed at fishway entrances, collection/transition areas at the bottom of the fishways, and count-station areas at the top of the fishways. In contrast, lamprey exhibit relatively rapid and successful passage through the pool and weir sections of the fishways, where they are exposed to rapid currents. When lamprey encounter obstacles they often fall back downstream and exit the fishways (Moser et al., 2002a). Consequently, lamprey passage at Bonneville Dam requires 4 to 5 days on average. Lamprey exhibit relatively higher passage efficiency and are delayed less at The Dalles than at Bonneville or John Day dams (Moser et al., 2002b, 2005).

Radio-telemetry work in 1997-2002 showed that adult Pacific lamprey passage efficiency (the percentage of lamprey that successfully passed over the dam of those that approached the dam base) at Bonneville Dam was less than 50% in all years (Moser et al., 2002b, 2005b). This occurred in spite of the fact that approximately 90% of the lamprey tagged in all study years returned to the base of the dam after release downstream, indicating migrational motivation and low tagging effects (Moser et al., 2002a). Passage efficiency for lamprey that approached The Dalles was consistently higher than at Bonneville, while passage efficiency at JDA was usually lower than at Bonneville Dam. These data indicated that lamprey passage is restricted by the dams, particularly Bonneville and JDA, and that these projects may be contributing to declines in basin-wide lamprey abundance.

Models of lamprey passage rates at Bonneville and The Dalles dams further support the observation that lamprey pass more easily at The Dalles than at Bonneville (Moser et al., 2005c). Delay of lamprey below Bonneville Dam may subject them to increased predation pressure from sea lions and sturgeon (R. Stansell, U.S. Army Corps of Engineers, personal communication). Models of lamprey passage rates at both Bonneville and The Dalles indicated that lamprey delay decreased with time of year (Moser et al., 2005c). That is, during the course of the summer, lamprey passage rates at these dams increased. These data suggest that lamprey are most delayed during the early part of the season (May-June) when water temperatures are low and sea lion abundance at the base of Bonneville Dam is highest. Also project discharge rates and tailwater velocities are higher in spring.

Construction differs between Bonneville/JDA and The Dalles in the flow-control section at the top of the fishways. At Bonneville and the JDAN, this part of the fishway has serpentine weirs, whereas at The Dalles there are overflow weirs at the top of fishways. At the top of Bonneville and JDA fishways, adult Pacific lamprey are routinely delayed and/or obstructed by the serpentine weirs located immediately upstream from the count stations at both the Bradford Island (Washington shore) and JDA north fishways (Moser et al., 2002c, 2003b, 2005a). In contrast, at The Dalles Dam from 1997-2002, 99% of radio-tagged lamprey that approached the top of fishways passed successfully over the dam (Moser et al., 2005a).

3.2.2. Gratings

At hydropower projects in the lower Columbia River Basin, migrating adult lamprey routinely pass through picket leads and diffuser gratings into areas where they can be delayed, injured, or killed. In 2006 and 2007, studies were undertaken to determine the gap sizes needed to exclude adult lamprey. The ability of adult lamprey to pass through vertical gaps of 2.5, 2.2, 1.9, 1.6, or 1.3 centimeters (cm) in height was evaluated. Vertical gaps were produced by placing a perforated divider in a large (1.8 × 0.9 × 0.6 meter) flow-through tank and then raising the divider from the tank floor by placing appropriately sized spacers under its bottom edge. Mean length of the 242 lamprey used in these evaluations was 67.5 cm [standard deviation (SD) = 4.2 cm, range 53.0-79.0 cm], mean weight was 494 grams (SD = 85 grams, range 282-800 grams), and mean girth was 11.3 cm (SD = 0.8 cm, range 9.2-13.7 cm). All lamprey were able to volitionally pass through a 2.5 cm vertical gap, 47% passed through a 2.2 cm gap, and no lamprey passed through gap sizes of 1.9 cm or less.

Dewatering simulations using 50 additional lamprey also were conducted. For these tests, a diffuser grating partition was positioned horizontally in the tank at a depth of 15 cm, completely separating the tank into upper and lower compartments. Ten lamprey were released in the upper part of the tank and the water was then lowered 30 cm in 3 minutes, stranding the lamprey on the grating and inducing them to pass through into the lower compartment. The groups of lamprey were tested with two grating sizes: 2.5 and 1.9 cm. The lamprey used in these experiments was comparable in size to those used in the vertical gap experiments: mean length was 67.5 cm (SD = 4.7 cm, range 56.0-77.0 cm), mean weight 481 grams (SD = 88 grams, range 284-684 grams), and mean girth 11.0 cm (SD = 0.9 cm, range 8.9-12.9 cm). No lamprey passed through diffuser grating with 1.9-cm bar spacing, while 86% were able to pass through grating with 2.5-cm bar spacing.

Based on these results and on comparisons to size ranges of lamprey collected after a year of freshwater residence, it was concluded that a gap or bar spacing of 1.9 cm (0.75 inch) is needed to exclude most adult lamprey in the Columbia River drainage. Using this information, the USACE conducted a field test of the 1.9-cm grating at JDA. No lamprey passed through an installed 1.9-cm grating, confirming the findings. A new 1.9-cm fishway grating and corresponding intake screen gap criteria was established based on these studies. Hydraulic and structural evaluations are being undertaken to establish a new grating design to replace existing gratings and intake screens.

3.2.3. Rounding of Corners

University of Idaho laboratory evaluations of the effectiveness of rounding corners indicated a significant relationship between rounding bulkheads and an increase in night time passage rates in the test flume from 32.5% to 50.8% and a reduction in passage times from a mean of 3 minutes to 1.4 minutes (Daigle et al., 2005, *Evaluation of Adult Pacific Lamprey Passage and Behavior in an Experimental Fishway at Bonneville Dam*, Table 9 and Figure 17, page 33). However, these improvements were small when compared to those that occurred when they reduced head and velocity. After the installation of rounding modifications to the Bonneville spillway entrance bulkheads in 2000, there was a corresponding small increase (44%-57% to 60%-65%) in passage efficiencies at those entrances for several years (2000 -2002; Moser et al., 2002, *Migration Behavior of Adult Pacific Lamprey in the lower Columbia River*, Table 2, page 28). The passage efficiency for the collection section of the ladders just above the entrances increased even more for those same years (54%-60% to 89%-96%) and may indicate other factors influenced entrance improvements beside the bulkhead shape modifications. Confounding factors such as differences in river conditions, changes to spill patterns, small sample sizes, and reductions in nighttime flows as a part of another test, may also have influenced the results.

Both of these evaluations focused on shape changes at entrances where rejection is high at Bonneville dam and the researchers emphasized that the entrances should be the location to attempt to round structures; that efforts elsewhere may not be needed. Their data shows that other areas of the fishways with high velocities and unrounded surfaces, such as the main ladder portion of Washington Shore and Bradford Island fishways have good passage times and passage efficiencies of around 90% or better. The serpentine weirs may also benefit from some rounding and the installation of the adult passive integrated transponder (PIT) readers in the top of the ladders included rounding of all corners as a required feature.

One factor that may be important in determining where rounding may be most useful is the added presence of confusing or alternative flows where high velocities exacerbate the problem. The major locations of passage difficulties at most dams are entrances, transition pools, serpentine weirs, and AWS; all are areas with confusing flows (circular flows in serpentine weirs, optional flows from diffusers or to the sides of entrances that may be enticing when confronted with high velocity for major upstream movement). Lamprey are attracted to high flows as is shown by their passage distribution relative to flows at Bonneville, but may be searching for the complex structures of a normal river environment to find holdfasts and low-flow pockets to work their way over difficult high-flow passage areas such as rapids, falls, or dams. Dams do not offer this complexity of passage options and those that are present, such as moving into lower flow diffuser gratings, are problematic.

Another issue is the level of priority that rounding should be given. Much of the above mentioned evidence, especially the flume evaluations, points to potentially greater benefits in passage metrics related to decreased velocities, that might be especially important during the 1100-1500 time period when upstream movements peaks in and into ladders. Evaluations of the effects on lamprey passage by reducing flows at entrances were conducted in the 2000-2003 time period, but there were problems with consistency of test velocities, samples were small, and a different location may be a more appropriate test site. Ironically during the height of lamprey passage, head and velocities at entrances are increased to assist with shad passage, sometimes up to 2 feet of head and 12+ feet per second velocities.

The judicious use of rounding, especially where it can be done at entrances or in exit sections facing upgrade, may be beneficial and conversations have begun among researchers and engineers about how to accomplish this at powerhouse entrances (first focus will be Bonneville Washington shore downstream north entrance) with multiple slots and floating weirs. At other sites, consideration is needed as to whether cost and effort should be prioritized over other efforts to improve passage such as a Washington shore ladder, AWS lamprey passage system (LPS), or installation of smaller opening gratings. For instance, passage efficiency is high in the main ladder sections above the transition areas at Bonneville with good passage times, despite no rounding. Lamprey-improved features will continue to be incorporated into all modification or repairs in ladders, including rounding of corners, establishing a smaller size grating opening criteria, and improving smoothness of concrete; most recently in the serpentine weir sections where the adult PIT reader were installed.

3.2.4. Adult Lamprey Passage Research Report References

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4. HYDRAULIC DESIGN

4.1. GENERAL

This section describes the hydraulic design of the modifications to the John Day North Fish Ladder (JDAN) exit section and count station. The design of the exit section is largely derived from the configuration from the John Day South Fish Ladder (JDAS), which was built in 2003, where salmon jumping was solved and passage times were improved. Same as the JDAS system, the modified JDAN exit section will contain 23 new weirs, each with a vertical slot and one orifice. The footprint and profile for the JDAN and JDAS exit sections will be almost identical. However, there are certain key differences between JDAS and JDAN:

(1) *The width of the forebay transition (tunnel through the non-overflow dam) is 12 feet in JDAN versus 6 feet in JDAS.*

This width difference did not have ultimate design implications with JDAN, but there were early design considerations to narrow the channel to attain higher velocities.

(2) *There is only one exit baffle in the JDAS forebay transition versus two in the JDAN transition, and the JDAN baffle has 2.5-foot sills while the JDAS has none.*

At JDAS the single baffle (without sill) would not create significant headloss that would restrict inflow from the upstream end. Conversely, the two exit JDAN baffles (each with 2.5-foot sills) created significant headloss and restricted inflows at low forebay operations for JDAN. This inflow restriction created difficulties meeting the 5-foot minimum depth criteria in the more hydraulic efficient exit weirs. Considerable design effort was required to modify the exit baffles at JDAN. One baffle will be removed entirely and the 2.5-foot sill will be removed from the remaining exit baffle.

(3) *The JDAN count station is located immediately downstream of the exit section, separated by weir 249 (holey wall), whereas the JDAS count station is located in lower down in the fish ladder between weirs 193 and 194 (physically separated from the exit section by 55 overflow ladder weirs).*

At JDAS, the downstream end of the flow control weirs would interface with a standard ladder weir (with pool diffuser), weir 248. The standard ladder receiving pool for the most downstream JDAS flow control weir (weir 1) vertical slot jet is relatively robust, and not as hydraulically and biologically sensitive as the corresponding receiving pool at JDAN: the count station. Considerable design effort was required to integrate the hydraulics between the JDAN weir 1 and the count station to assure acceptable fish passage conditions.

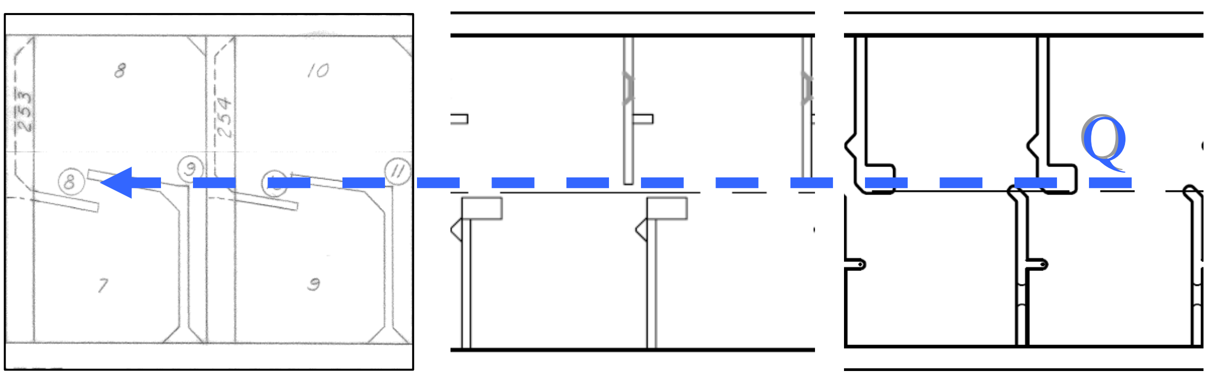
The holey wall is recognized as a problem for salmon passage and will be replaced by weir 1 of the new vertical slot/orifice design. The vertical slot jet from weir 1 will issue more concentrated flow energy into the count station pool. Consequently, the general orientation of the weirs (the direction of vertical slot discharge) was horizontally flipped so the vertical slot jets would be directed to the north-west instead of south-west as in JDAS. This way the weir 1 slot jet will impinge upon solid wall on the north side of the pool instead discharging into the trashrack on the south side.

The center-to-center spacing for the JDAS weirs were designed to be a uniform 13.1 feet, but the final construction rendered the actual spacing more arbitrary—resulting in somewhat random variation between about 12.1 to 14.1 feet (reasons are unclear). During the JDAS physical model study in 2001, the designers encountered high instability and seiching[4] in the pools when the initial configuration (based on The Dalles north fish ladder) was tested. The stability problems were ultimately corrected by modifications to the shape of the vertical slot intake. The cause of seiching was attributed to insufficient energy dissipation between pools, which would accumulate in the downstream direction. The JDAS designers recognized a precursor to the instability when vertical slot jets tended to 'short-circuit'[5] between slot openings, rather impinge in the downstream corner of weir pools so that the energy could be more effectively dissipated. They also noted that adequate energy dissipation was more difficult to attain in the lower weir pools, where energy tended to accumulate and lower pool depths provided the less pool volume to absorb the energy. Based on the observations from the JDAS study, the JDAN spacing was made variable so that the longest pool lengths would be located in the lower pools to increase volume there. The JDAN spacing will range from 12 feet at the upstream end to 15 feet at the downstream end.

A final and key deviation from the JDAS design is the JDAN design objective to provide modified geometry that augments lamprey passage performance. The key criterion is the 4-inch rounding of all corners around all high velocity openings that are indented (not adjacent to and flush with a sidewall or floor). This deviation from the JDAS design would increase hydraulic efficiency and alter flow patterns in the weir pools. Consequently, the hydraulic design and biological evaluation of the proposed project required hydraulic modeling. The final design configuration and proposed operation were developed in a 1:5 scale physical model at the Environmental Services Corporation (ENSR) laboratory.

The evolution of weir configurations (plan) are shown in Figure 4-1 starting at left with existing JDAN serpentine weirs (not modeled), to JDAS weirs, to proposed JDAN lamprey improved weirs on right (the comparative configurations are oriented so that the top faces north and general flow goes west).

Figure 4-1. Comparative Plan Views of Weir Configurations (a) Existing JDAN Serpentine Weirs, (b) JDAS Weirs, and (c) Proposed JDAN Lamprey-Improved Weirs



(a) (b) (c)

[4] Seiching is the tendency for water levels to oscillate in large amplitude cycles.
[5] Short circuiting is the tendency for the vertical slot jet to curve prematurely towards the next slot opening downstream without effectively utilizing the pool volume (i.e., corner facing upstream towards the slot opening) for energy dissipation. See Figure 4-2 (right figure) and discussion on previous page for additional description of 'short circuiting'.

Significant modifications are also proposed forebay transition and the count station. In the forebay transition (tunnel through non-overflow dam), there were modifications to the existing two baffles. One baffle will be removed entirely and the other will be modified by removing the 2.5-foot concrete sill and inserting an orifice in the bottom corner of the south wall. The 8-inch projecting stubwall will be moved upstream, closer to the remaining baffle with the vertical slot.

In the count station, the existing 23-inch ramp through the count slot will be removed and the window will be extended down at least 11 inches for better viewing. The entire floor of the count station will be raised 1-foot so that the existing diffuser 16 grating will be flush with the invert at the new weir 1. Downstream of the count slot, the concrete floor will be sloped to match the invert at the downstream existing weir 248. The existing crowder will be replaced and fairings will be attached to both ends of the new crowder to reduce flow separation in both transitions. Horizontal vanes will be attached to the upstream fairing to prevent undesirable vertical circulation. On the south side of the diffuser, a 12-wide metal plate will be placed over the length of the diffuser to create a ‘lamprey sidewalk’ to the orifice in weir 1. Unlike all the other new weirs, the orifice will be located in the south sidewall at weir 1.

4.2. REFERENCES

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4.3. EXIT SECTION AND COUNT STATION CRITERIA

The hydraulic and geometric criteria are distinctly different between salmon and lamprey. Lamprey fish are much weaker swimmers and must rely on surface attachment capabilities in order to pass through higher velocity zones [>2 feet per second (ft/s)]. Conversely, salmon can easily swim burst through portals with velocities up to 14 ft/s and can perform sustained swimming in velocities up to 4 ft/s. As there is limited data on lamprey swimming and passage capabilities, the primary criteria focuses on geometry conducive to attachment or leverage, and provision of low velocity zones within high volume, high velocities passage openings such as fishway entrances. In addition to salmon and lamprey passage concerns, there are shad passage concerns which must be addressed to avoid blockage of the fishways during certain months of the fish passage season. This requires an adjustment in the ladder operation.

Overall adult salmon criteria are mandatory. The shad criterion intervenes in the operation of the ladder during certain periods in the fish passage season, when shad become so numerous that the ladder is in danger of becoming blocked. Under shad criteria, salmon can still pass effectively, but the conditions are less ideal. Most importantly, the salmon will pass a ladder operating under shad criteria quicker than a ladder operating under salmon criteria that is blocked by shad. The lamprey criteria are intended to improve access and passage capability to the ladder system without compromise to adult salmon passage.

4.3.1. 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 minimum forebay conditions).
- Minimum pool depth is 5 feet. The depth is computed by the difference in elevation between the water surface and the invert at the center of the pool.
- Ladder head should be 1.0 foot (± 0.1 ft). The ladder head criterion does not apply in the weirs of the flow control section upstream of diffuser 16 (there the heads are passively dependent on the inflow rates based on forebay elevation and given sill setting). The shad and adult ladder head criterion does apply to the standard ladder weirs downstream of diffuser 16 and the count station, where make-up water is added in to adjust the ladder head at weir 249, located downstream of the count station.
- If the shad fish numbers exceed 5,000 fish per day at the North Fishway Counting Station, then the ladder head should be raised to 1.3 feet (± 0.1 ft)[6]. As noted in previous bullet, this criterion only applies to the standard ladder weirs downstream of the count station and does not alloy to the weirs in the flow control section upstream of the count station.
- Channel velocities should be between 1.5 to 4 ft/s); 2 ft/s is optimum.
- Diffuser efflux velocities ≤ 0.5 ft/s.
- Minimum orifice size for Columbia mainstem projects: 18-inches wide x 18-inches high.
- Minimum vertical slot width for Columbia mainstem projects: 15 inches.

- Minimum Pool Volume Size = $\dfrac{\gamma QiHo}{4\, ft - lbs/s - ft^3}$

  where
  γ = Unit weight of water = 62.4 lbs/ft^3
  Qi = Total inflow to pool [cubic feet per second (cfs)]
  Ho = Head drop between pools (ft)
  Pool Volume = Depth x width x length (ft^3). See second bullet for definition of depth.

- Design range of velocities through counting slot: 2 to 6 ft/s; normal is 3 ft/s.
- Design range of opening width in counting slot between window and crowder: 18 to 30 inches.

[6] 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.

4.3.2. Lamprey Criteria

- Four inches minimum radius rounding on all outside corners (>180 degree in change in bearing in any surface) of indented 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 to assure lamprey passage.
- Diffuser gratings with maximum 0.75-inch openings to prevent lamprey infiltration.
- At least one seamless floor connection without steps or abrupt corners between weir pools (usually orifice) and through counting slot and picket leads in count station.

4.3.3. Design Ranges for Criteria Compliance

- Range of Forebay Elevations:
    - Minimum Operating Pool (MOP) = 257 feet
    - Minimum Irrigation Pool (MIP) = 262.5 feet
    - Maximum Operating Pool = 268 feet

- Range of Discharge Rates:
    - Maximum discharge in flow control weirs = 85 cfs (based on discharge rate that produces 1.0-foot ladder head at the downstream ladder control weir 248).
    - Minimum discharge rate in flow control weir section is based on the combination of weir flow and available diffuser flow (for given forebay level) that must sum to the required downstream ladder flow rate that is discharged down the ladder at the given operating downstream ladder control head setting:
        - Downstream ladder flow rate at 1.0-foot ladder control head = 85 cfs.
        - Downstream ladder flow rate at 1.0-foot ladder control head = 113 cfs.

4.4. Hydraulic Design Methods

Physical modeling was chosen as the primary tool to perform the hydraulic design and develop the design configuration. Physical modeling was selected to provide biologists and engineers a venue and means to evaluate a large range of flow conditions within a narrow time schedule, and assure that the question of ladder stability could be verified over the full length of the exit section and count station, and over the complete range of forebay[7] and flow conditions. Computational fluid dynamics (CFD) was considered initially, but there were concerns about obtaining adequate resolution over the full length of the flow control section with rounded weirs (the full length was required, as explained above).

The one-dimensional numerical model was previously developed by CENWP-EC-HD for the JDAS design. This model was modified for the JDAN system and was used in conjunction with the physical modeling to speed the design and modeling process. By incorporating data from the physical model, the numerical model could be applied to better predict flow rates required in the model to match intended test forebay elevations prior to and during site visits. More importantly, the model was used to design sill settings that could be later tested or confirmed in the physical model.

[7] 257 feet (MOP) to 268 feet (maximum operating pool).

4.4.1. Physical Model

The physical hydraulic model was built and operated by ENSR, who first performed a model similitude analysis (Froude, Euler, Reynolds and Weber numbers) to determine the theoretically minimum sized model (1:10 scale) that could be applied without incurring scale distortions. The actual model scale of 1:5 was selected based on CENWP's request, minimization of impacts from model construction tolerances, and to provide better viewing capability for visitors and evaluators.

The *John Day North Ladder Physical Hydraulic Model Study Final Report* is located in Appendix G. The report contains thorough documentation of the all alternatives viewed, provides test data results, and presents the model drawings for the configuration (see from modification tests, documentation tests and insurance tests. The modification tests were completed after changes were made to the model weirs to determine water level data and weir coefficients. In an iterative process of data exchange, CENWP would use the latest ENSR water level data and weir coefficients for application in their one-dimensional numerical model to revise sill settings or vertical slot widths, and assist ENSR with flow rate prediction in future model tests. The ENSR documentation tests were run after the final design configuration was determined; the tests included water level data, velocity vectors in select weir pools and count station (CS), and video of dye tests. The insurance tests were the last series of tests and were run to check hydraulic stability in the ladder over the full range of possible forebay/flow conditions for all three sill settings. These tests were run at 1-foot forebay increments. In addition to water level data, pool depth data were collected over time to record amounts of sloshing or possible seiching. The insurance tests verified the system will be stable over the full range of operations for all three sill settings; there were no case of instability from seiching or transients, and all pool depth oscillations were within 0.5-feet prototype.

Five model site visits were completed to the ENSR physical hydraulic model, three by the Project Development Team (PDT) and two agency trips, as shown below:

Site Visit Date	Visitors	Purpose
July 5-6, 2007	PDT	Model initiation (Configuration 1).
August 13-15, 2007	Agency & PDT	View baseline (Configuration 1 & 2) and new JDAN lamprey-improved weirs (Configuration 3 or Design 1).
October 23-24, 2007	PDT	View revisions in inlet transition, orifice relocation in weirs, and CS modifications (Configuration 4).
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 (Configuration 5).

Four detailed trip reports are located in Appendix G (the November 7-8 trip is incorporated into the trip report for November 19-20, 2007). A synopsis of each trip is provided below. The ENSR Corporation administered dye as means of educing and clarifying the patterns of jets, currents and eddies in the pools, slots, and orifices for the visitors.

A true baseline for of the complete existing JDAN exit section was not constructed. The hydraulic conditions within the existing serpentine section were understood (thoroughly documented from the previous JDAN model study by CENWD) and were known to cause biological issues at JDA. The hydraulic conditions in the existing holey wall and count station were not so well understood and needed to be viewed to help understand the nature of the problem in this area. The JDAS weirs were attached to the existing holey wall and count station to gain insight as to how the JDAS style weirs would interact with upstream and downstream ends of the JDAN exit system. This also expedited schedule and provided the technical team insight into hydraulic/biologic success of the JDAS exit section weirs. The JDAS modified baseline (with holey wall or without it) was not intended to represent a design alternative; however, it represented a possible fallback position if the PDT and region decided the lamprey improved design could not be made to work for salmon.

July 5-6 PDT Site Visit. During this first trip, the PDT and one NMFS engineer viewed Configuration 1[8]. This included the existing JDAN count station and weir 249 (holey wall), coupled with JDAS weirs 2-23 inserted in the place of the actual existing serpentine weirs and existing JDAN forebay transition possessing the two baffle walls with 2.5-feet high sills. One model geometry correction and adjustment was identified for the upcoming agency trip in August.

Configuration	**ENSR Report Label**	**Forebay Transition**	**Exit Weirs**	**Weir 249**	**Count Station**
Configuration 1	JDAS modified baseline with holey wall	JDAN existing	JDAS modified	Holey wall	Existing JDAN
Configuration 2	JDAS modified baseline	JDAN existing	JDAS modified	JDAS Weir 1	Lowered ramp
Configuration 3 (Design 1)	Alt. 1-modified weir design with lamprey-improved features	JDAN existing	JDAN lamprey improved with sidewall orifices	Same as above	Lowered ramp
Configuration 4 (Design 2)	Alt. 2-same as Alt. 1 except orifice moved to JDAS location	Narrowed, elliptical channel without baffles	JDAN lamprey improved with orifices at JDAS location	Same as above	1' raised floor, lamprey sidewalk
Configuration 11 (Design 3)	Alt. 5-final configuration	Modified exit baffles	Same as above	Same as above	Same as above with vanes

See Table 4-1 of the ENSR model report for more details.

August 13-15 Agency Site Visit. Two representatives from the NMFS attended on behalf of the agencies. During this trip, the visitors viewed the Configuration 1 (same as in the July 5-6 trip), Configuration 2[9] (same as Configuration 1 except holey wall was replaced by JDAS weir 1 and the ramp was lowered 1 foot in the count station), and Configuration 3[10] (the proposed lamprey-improved system, replacing the JDAN holey wall with lamprey-improved weir 1, and lowered ramp in the count station):

- Lamprey-improved weirs were based on JDAS design with rounded corners (4-inch radius) and orifice in sidewall.
- Count station with lowered ramps and weir 249 (holey wall) were replaced by lamprey-improved weir 1.

The lamprey-improved weirs showed promise but needed refinements. Most particularly, the orifice location would need to be moved from the sidewall back four feet inward to the original location used in the JDAS configuration. Flow through the sidewall orifice was very fast with little jet

[8] Referred to in the ENSR model report as the 'JDAS modified baseline model with holey wall'.
[9] Referred to in ENSR report as 'JDAS modified baseline' in the 3rd row of Table 4-1.
[10] Referred to in ENSR report as 'Alternative 1- modified weir design with lamprey friendly features'.

dissipation between pools. Based on the sight of unaltered dye traces streaking down several pools, there was a concern that energy through the orifices could be accumulating in the downstream direction. The biologists also reasoned that the fish approach the orifice from both sides in the hydraulic shelter behind the wall, and a high velocity trained along the sidewall would actually restrict access from that side. While the sidewall orifices were attempted on behalf of the lamprey, it was also deemed that lamprey would fare better in the original JDAS locations, since they also would approach from both sides. The edges of the orifices would remain rounded to improve lamprey access.

A significant proposal was to raise the floor in the count station by 1 foot to provide a more seamless invert surface through counting slot up to the invert on weir 249 (or the new weir 1). This would be achieve the same purpose as lowering the count slot ramp 1 foot (as originally intended), only in a more seamless manner. A fixed width (24-inch) opening through the count slot was discussed. Assuming this proposition would be too controversial, ENSR was tasked with developing fairings to add to the both ends of the crowder to better transition the flow through the count slot. Corrections to the existing geometry were also identified by JDA Project staff for the count station to properly position the location of the crowder in the count slot.

In the forebay transition (tunnel through the non-overflow dam), there was another proposal to make it more streamlined and remove the existing two vertical slot baffles with 2.5-foot sills. The intent was to reduce the width to the forebay tunnel to increase the normal channel velocity from 0.8 ft/s to 2 ft/s and the reduce head loss upstream of weir 23 at low forebay levels.

October 23-24 PDT Site Visit. At this trip, most changes showed the intended hydraulic/biological improvements. The repositioning of the orifices to the original JDAS location resulted in more effective energy dissipation between orifices (no more dye streaks extending several pools). The changes in the count station showed improved flow patterns. However, in the narrowed streamlined transition to the forebay, chronic vortex problems appeared upstream of weir 23. After several unsatisfactory attempts to eliminate the vortexing problem, the PDT decided to return in November 7-8 to correct the problem.

November 7-8 PDT Site Visit. During this trip the PDT refined the narrow channel forebay transition configuration to eliminate the vortexing. However, the solution required some unorthodox geometry (fish moving through the orifice would exit into a short tunnel), leaving an uncertainty about how fish (or 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 one of the two baffles (upstream one), and adding an orifice in the remaining baffle (downstream one). The primary vortex problem was eliminated by moving the stubwall 4.5 feet upstream and closer to the existing 2-foot slot opening. 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. It should be noted that nearly all vortices encountered did not draw from the surface, but were instead underwater coils at almost horizontal axes extending between the vertical slot opening and the edge of the transition side wall. Thus, the higher surface tension of the model was not a factor in suppressing vortices in comparison to prototype. Other factors[11] indicate model was acceptable for vortex evaluation.

[11] From page 82 of ASCE (2002), model design must meet the following criteria to evaluate vortexing in sump pump systems: Length ratio (Lr) <10 (ENSR model Lr <5); RE> $1.5x10^4$ (ENSR model RE> 10^5).

At the close of the trip, the PDT had two feasible forebay transitions, and decided to show the agencies the less radical alteration first (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 trip, if needed.

The PDT also experimented with the location of the triangles on the downstream 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 northwest 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.

November 19-20 Agency Site Visit. Two representatives of NMFS attended in representation of the agencies for the final site visit. During the initial tests, the visitors concentrated on the count station, the weir pools, and the forebay transition. The following observations set the agenda for the remainder of the trip:

1. At the intake of the count slot, there was a condition of vertical swirl. The agency representatives were concerned this might be a location where salmon might hold. There is a tendency for salmon to hold at both ends of the count slots at other projects.
2. For the weir pools, 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 any sills. For salmon progressing up the exit channel, the distinct change in hydraulic conditions between the pools represented a potential cause of passage delay similar to a change in geometry.
3. The Agency representatives saw no issues with the forebay transition.

<u>Resolution of Problem 1 – Vertical Swirl in Count Station Intake</u>

The swirl condition at the count slot intakes was generated by a standing wave, or stagnation point, against the upstream faring on the crowder. 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. A significant percentage will wrap around the upstream fairing into trashrack area.

An attempt to correct the flow conditions was done by adjusting the slide gate opening (behind the crowder). The slide gate controls the flow through the picket lead and trashrack and by doing this, establishes the residual discharge through count slot. The existing setting (measured in the field at JDAN) was 8-inch model scale (40-inch prototype). The group tried varying the opening 4 inches in each direction:

- 8-inch slide gate opening (40-inch prototype) results in about 3.5 ft/s in count slot (at 85 cfs ladder flow).
- 4-inch slide gate opening (20-inch prototype) results in about 6 ft/s in count slot (at 85 cfs ladder flow).
- 12-inch slide gate opening (60-inch prototype) results in about 2 ft/s in count slot (at 85 cfs ladder flow).

The 8-inch gate opening seemed to create the worst conditions of swirl. The 4-inch gate opening, while increasing slot velocity, seemed to improve the swirl but creates a tighter, smaller coil. The 12-inch setting reduced the swirl and slot velocity, and was probably the best setting. The Fisheries Field Unit (FFU) will explore optimum gate openings in field after construction.

The ultimate solution to the vertical circulation at the count slot intake was a series of horizontal vanes. The vanes would be attached to the new upstream faring planned to go the crowder. During the visit, a preliminary shape was fabricated by ENSR. The vertical swirl was eliminated. After the trip, ENSR developed a final design based on criteria provided by the visitors.

<u>Resolution to Problem 2 – Difference in Pool Hydraulics</u>

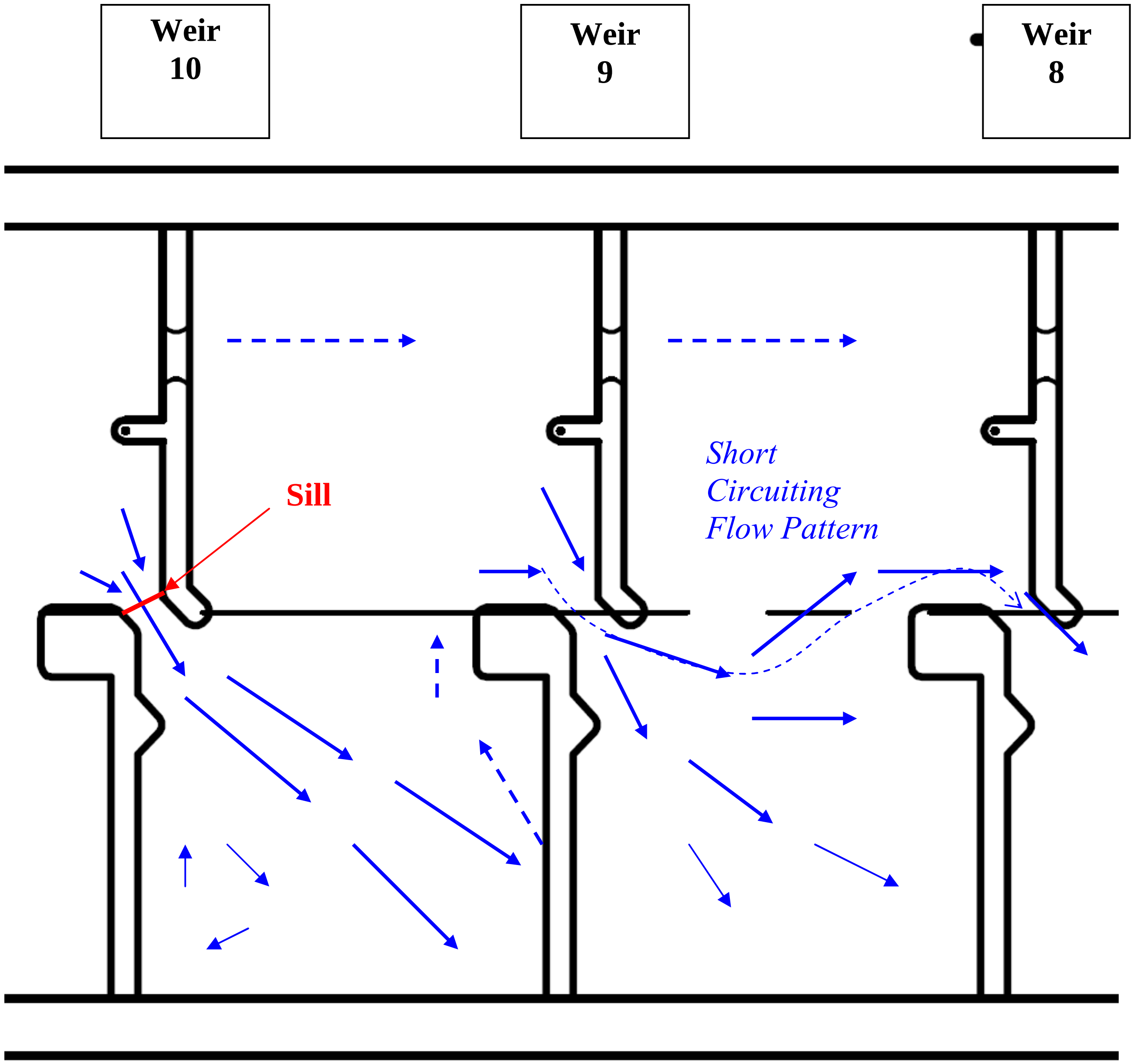
For the pools with sills, the flow patterns were more structured such that the vertical slot jet was consistently directed toward the northwest corner (see left pool between weirs 9 and 10 in Figure 4-2). The presence of the bottom sill helps concentrate the flow to pass directly over (or normal to the axis of) the weir. This usually results in a more concentrated and consistent jet pattern that is more 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 and 9 in Figure 4-2), and more diffusive jets.

Short-circuiting is an issue inherited from the previous JDAS model study conducted at the Northwest Hydraulic Consultants' (NHC) laboratory in 2001, where instability was associated with the pattern. However with the lamprey weir study, there were numerous cases of short-circuiting but no evidence of ladder instability. One likely reason that short-circuiting is not a problem in the lamprey improved weirs is 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 and the jet spreads with radial distance from the slot. Short-circuiting may not be biological problem as long as the system does not become unstable. However, the change in conditions between pools with and without sills could cause fish delay or turn-around

To address the issue of different pool hydraulics, a solution was proposed to include low sills (12-inches high) for the remainder of the weirs that did not have sills (weirs 1-9). This generally assured a consistent pattern between pools at low to high sill operations.

Post November 20 Trip Changes. At the end of the trip, there were four possible sill settings (no sill, 1-foot sills, medium sills, and high sills) or three sill leaves for all weirs upstream of weir 9. This would create difficulties in the sill actuator design. Staff from CENWP and ENSR worked jointly to reduce the number of settings to three (no sills, 1-foot sills, and high sills) with two sill leaves for weirs upstream of weir 9, and were verified with tests in the ENSR model. After the trip, the sill was removed from weir 1. The differences in count station pool hydraulics were subtle and insignificant when viewed with and without sill. However, the ENSR data proved that the head drop would be excessive (1.2 to 1.4 feet) with a sill. When the sill was removed, the head drop at weir 1 fell back within criteria (<1 foot).

Figure 4-2. Comparison of Pool Flow Patterns Without Sill and Sill in Upstream Weir



ENSR Tests for Final Design Configuration. The lists of documentation tests and Insurance tests (both described earlier) are shown in Table 4-1 and Table 4-2.

Table 4-1. ENSR Documentation Tests for Velocities, Flow Patterns, and Video Data

ENSR DOCUMENTATION TESTS – DEC 2007			
Forebay	Ladder Head	Sill Setting	Estimated Flow Rates
257.0	1.3	No sills	38.2
262.5	1.0	No sills	72.2
262.5	1.0	1-foot sills	68.1
262.5	1.0	High sills	45.8
262.5	1.3	High sills	45.7
268.0	1.0	High sills	85.0

Table 4-2. ENSR Documentation Tests for Velocities, Flow Patterns, and Video Data

ENSR INSURANCE TESTS – JAN/FEB 2008					
No Sills		1-foot Sills		High Sills	
Forebay (ft)	Flow Rates (cfs)	Forebay (ft)	Flow Rates (cfs)	Forebay	Est. Flow Rates
257.0	38.4	257.0	31.8		
258.0	44.3	258.0	37.7		
259.0	50.8	259.0	44.0		
260.0	57.2	260.0	50.5		
261.0	63.7	261.0	57.8	261.0	33.4
262.0	70.4	262.0	65.0	262.0	39.6
262.5	73.8	262.5	68.8	262.5	42.9
263.0	77.2	263.0	72.8	263.0	46.2
264.0	84.1	264.0	81.4	264.0	53.1
		265.0	89.0	265.0	60.4
				266.0	68.0
				267.0	76.0
				268.0	85.0
Ladder head = 1 foot in all tests					

4.4.2. One-Dimensional Numeric Hydraulic Model

A one-dimensional hydraulic numerical model was used by CENWP to design the sill settings and test for compliance with pool depth and head drop criteria. This model was developed in-house during the JDAS design and adapted for the JDAN design effort. The model applies the following series of equations to determine head drop across a weir for an assumed exit section flow rate:

Qt = Discharge in Exit Section in cubic feet per second (cfs) = Qs + Qo

Vertical Slot Flow

$$Qs = Cd * H_1 * \sqrt{2g * Hw}$$

where
Qs = Vertical slot discharge (cfs)
Cd = Vertical slot discharge coefficient
H_1 = Upstream pool depth above invert or top of sill in vertical slot (ft)
H_1 = upstream water elevation – invert elevation – sill height
g = gravitational constant = 32.2 ft/s2
Hw = Head difference between upstream and downstream pool = (H1 – H2)
H_2 = Downstream pool depth above invert or top of sill in vertical slot (ft)
H_2 = Downstream water elevation – invert elevation – sill height

The orifice discharge rate was computed of the orifice dimensions and assumed orifice discharge coefficient:

Orifice Flow

$$Qo = Co * Ao * \sqrt{2g * Hw}$$

where
Qo = Orifice flow through the weir in cfs
Co = orifice discharge coefficient (assumed to be constant 0.80)
Ao = orifice area = (18 inches x 18 inches/144 = 2.25 ft^2)

With the orifice coefficient assumed constant at 0.80, the vertical slot discharge coefficients varied with pool depth and sill height. The average discharge coefficients for different sill settings and forebay level with consequent exit section flow rates are shown in Table 4-3. The JDAN discharge coefficients of the lamprey improved weirs are comparably higher (JDAS weirs were 0.66-0.69). The table also shows the general effect of depth and sill height on the values.

Table 4-3. Average Discharge Coefficients (Cd) versus Sill Setting and Forebay Elevation and Exit Section Discharge Rate

No Sills			1-foot Sills			High Sills		
Forebay (ft)	**Flow Rate (cfs)**	**Cd**	**Forebay (ft)**	**Flow Rate (cfs)**	**Cd**	**Forebay (ft)**	**Flow Rate (cfs)**	**Cd**
257	38.4	0.88	257	31.8	0.83			
261	63.7	0.86	261	57.8	0.87	261	33.4	0.79
264	84.1	0.85	264	81.4	0.90	264	53.1	0.82
						268	85.0	0.87

4.5. PROJECT FEATURES

The proposed new features are shown (in inches at 1:5 model scale) in Plates 4-35 through 4-39 of Volume 2 of ENSR's physical hydraulic model report located in Appendix G. The overall plan and profile view is in Plate 4-39 of the ENSR report.

4.5.1. Exit Section

Forebay Transition. The description of the proposed changes are described in Section 2.3.1 and shown in plate 4-35 of the ENSR report. With the increased hydraulic efficiency of the new lamprey-improved weirs, the existing baffles will create too much head loss to permit the new system to operate in criteria. Consequently, one baffle (upstream) was removed. The sill in the remaining (downstream) baffle was also removed for the same purpose, plus to augment lamprey passage. The orifice on the south wall was placed to provide a more direct route for salmon and lamprey that navigate through the orifices in the weirs. The repositioning of the 8-inch stubwall will help prevent the formation vortices around the vertical slot intake at the new weir 23. The rounded triangle is also added to prevent vortices.

Exit Channel Weirs. The description of the proposed changes are described in Section 2.3.2 and shown in detail in Plates 4-36 and 4-37 of the ENSR report (see Appendix G).

Vertical Slots. The openings through the vertical slots are rounded instead of chamfered or sharp cornered at JDAS. The flow patterns will be less contracted and concentrated in JDAN as compared to JDAS. With sills in place the vertical slot jets tend to project predictably towards the northwest corner, with some impingement against the 26-inch wide hammer-head shaped baffle that extends upstream 26 inches from the north side of the slot. The purpose of the hammer head baffle is to hinder the tendency for flow to short circuit between weir slots and to house the sill actuator leaves. Flow from the upstream slot jet will flow around the baffle to elongate streamlines to the next slot. With no sills or low sills in deep flows, the slot jet is not as structured and part of the flow will short circuit between slots. However, the jets are generally diffusive and energy is adequately dissipated within the pools so the instability does not occur. The vertical slot widths will be either 15 inches or 18 inches:

- 18-inch slot with in weirs 1 to 3.
- 15-inch slot with in weirs 4 to 17.
- 18-inch slot with in weirs 18 to 23 (at high sill settings slots will be closed to 15 inch).

Weirs 1-3 have 18-inch slots to prevent the head drop from exceeding criteria at maximum flow rates. The flow depths through the slots are lowest at these weirs and extra width is required to compensate. Weirs 18-23 are also wide at 18 inches. The purpose is to minimize head drop and maintain head through the horizontal invert section in minimum forebay operations. These wider widths are required to assure minimum depth criteria in the pools between weirs 11-18 where the channel invert is sloped. At high sill settings, the slots in weirs 18-23 are narrowed (extension of upper sill leaf) to 15 inches to provide more even head drop through the system and more headloss at the upstream end to prevent excessive head buildup from occurring at the downstream weirs.

Orifices. Orifices will be 18-inch square and the inside edges will be rounded to 4-inch radius. The discharge through the rounded orifices will be more hydraulically efficient than standard sharp cornered ladder orifices. The orifice jet will also be less contracted and less concentrated. The diffusive nature of the jets allows adequate energy dissipation between weirs and there was no appreciable energy accumulation observed moving downstream between pools. The use of the same location as in JDAS (4 feet from side wall) contributed to effective energy dissipation and stability.

Sills. There will be three sill settings: high, low and no sills. The sill settings and slot widths for all weirs are shown in Table 4-4. The low sills are uniformly 1 foot between weirs 2 to 23. The high sills go as high as 6 feet in weir 23.

Table 4-4. Design Sill Settings and Slot Widths for JDAN

Weir	No Sills (FB <264 ft)		Low Sills (1-foot) (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							

4.5.2. Count Station

The description of the proposed changes to the count station are described in Section 2.3.3 and shown in Plate 4-38 of the ENSR report (see Appendix G).

Diffuser 16. The grating has already been replaced to restrict lamprey infiltration through the bars. The grating will need to be raised by 1 foot in the new design to match invert elevation 243 at weir 1. The 12-inch lamprey sidewalk will cover the edge against the south sidewall and reduce the open area through the grating by about 4%. The increased discharge capacity of the exit section (20% to 90%) higher than existing will more than buffer the reductions in diffuser flow capacity imposed by the lamprey screen and the 12-inch plate. The diffuser velocities will not exceed 0.5 ft/s velocity criteria at any time. Diffuser 16 rating curves were estimated by assuming full control gate opening and from the following series of equations:

$$Qd = Ap * \sqrt{\frac{2g*(FB - Zcs)}{\sum Ki}}$$

where

Qd = Diffuser 16 flow in cfs

Ap = Inside area of 36-inch OD pipeline (= 6.92 ft^2)

g = gravity

FB = Forebay elevation (ft)

Zcs = Water surface elevation in count station pool (249.3 feet assumed)

ΣKi = Summation of all head loss coefficients corrected to flow area *Ap*

$$Ki1 = \frac{K1 * Ap^2}{A1^2}$$

*where K*1 is the loss coefficient for area *A*1 and *Ki*1 is the loss coefficient for *Ap*.

A list of head loss coefficients from intake to grating is included in Table 4-5. The *K* value for reference location is the coefficient for the specific location assuming the flow area at the reference location. The *Ki* values are the adjusted loss coefficients to the pipe area *Ap*, computed from the above equation.

Table 4-5. Head Loss Coefficients Used in Diffuser 16 Flow Computations

Feature	*K* for Reference Location	Reference Flow Area (ft^2)	*Ki* Adjusted to *Ap*
Intake	0.50	6.92	0.50
Open Valve	0.20	6.92	0.20
Pipe Friction (fL/D)	0.05	6.92	0.05
u/s Bend	0.15	6.92	0.15
d/s Bend	1.10	6.92	1.10
Orifice Expansion	1.00	26.40	0.07
Orifice Exp	0.01	26.40	0.001
Manifold	0.04	26.40	0.003
Grating	0.70	303.60	0.0004
		SUM	2.08

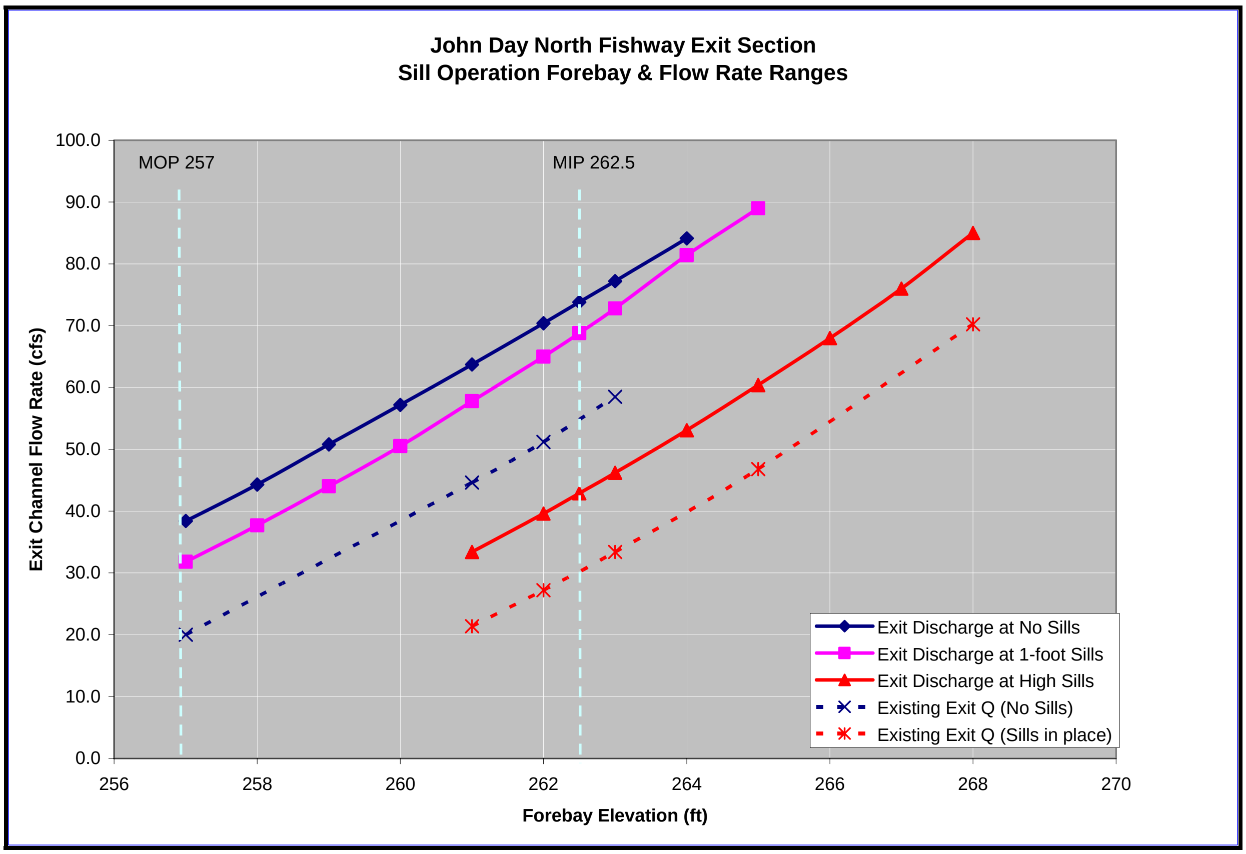
Crowder and Counting Slot. With the new fairings attached to the crower the range of operation will be reduced from the original 1.5 to 3.0 feet gap opening. It is anticipated that the maximum gap opening will be about 2.5 feet (however, Project personnel and counters cannot recall an occasion when the gap was opened as wide as 3 feet.) With the existing ramp removed, there will be an additional one foot of depth through the slot, which will make up for the loss in maximum width capacity.

Slide Gate. The slide gate may be adjusted by Project biologists or members of the FFU to readjust the velocities in the deeper count slot, and if needed, to tweak conditions to facilitate salmon passage through the count slot.

4.5.3. Ladder Flow Control

The new exit section discharge rates will be uniformly higher than the existing system by about 10 to 20 cfs. At minimum operating pool (MOP) 257, the no sill discharge will be over 90% higher than no sill discharge rates for the existing system. At a medium forebay (263) operation with high sills, the new JDAN discharge rate will be 25% to 38% higher than existing. At maximum forebay 268, the JDAN discharge rate will be 20% higher. This extra discharge reduces the frequency of conditions where there is a shad flow deficit. The rating curves for exit channel discharge rates versus forebay elevation for each sill setting are shown in Figure 4-3. In the figure, the curves for the proposed system are solid and the curves for the existing system are dashed.

Figure 4-3. Exit Section Discharge Rate versus Forebay Elevation for Each Sill Operation



The sill setting arrangement provides three different setting choices at minimum irrigation pool (MIP) 262.5, and two choices at MOP 257. If shad flow (ladder head = 1.3 feet, ladder flow = 123 cfs) occurs at low forebay, then the no sill operation may be best to handle low forebay conditions.

The maximum and minimum forebay and discharge rate for each sill setting is lasted in Table 4-6. 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 4-3). 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 4-6. Sill Operation Ranges and Ladder Performance at Minimum Operation for Each Sill Setting

Sill Operation Ranges					Ladder Performance at Minimum Forebay for Setting	
Sill Setting	**Minimum Forebay (ft)**	**Minimum Exit Discharge (cfs)**	**Maximum Forebay (ft)**	**Maximum Exit Discharge (cfs)**	**Maximum Ladder Head (ft)**	**Shad Flow Deficit (cfs)**
No Sills	257	38.2	264.1	85	1.2	9.9
1-foot Sills	257	31.8	264.5	85	1.13	16.5
High Sills	261	33.4	268	85	1.3	0

The estimated available flow from diffuser 16 (yellow curve) is shown in context with the exit section flow in Figure 4-4. The shad flow deficit is shown in the lower left corner of the figure for no sill and low sill settings.

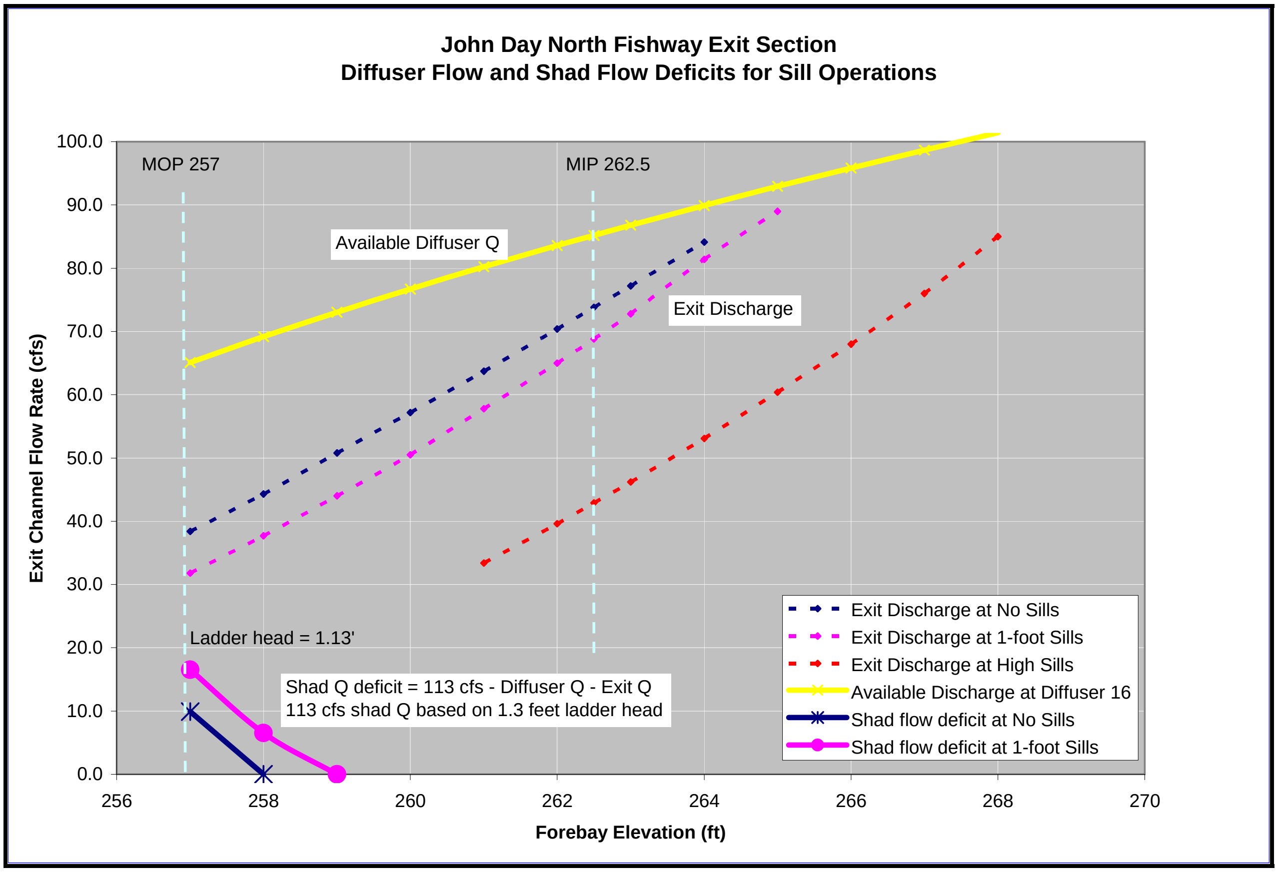
The sill settings will be activated and controlled by programmable logic control (PLC) as a function of forebay level and current trend (rising or falling). The anticipated range of operations between forebay elevations operation with 2-feet deadband are shown in Table 4-7.

Table 4-7. Recommended Sill Operation with Respect to Forebay Elevations and Trend

Sill Setting	Minimum Forebay Dropping	Maximum Forebay Rising	Deadband Width
High Sills	261	268	2 feet
Low Sills	259	263	2 feet
No Sills	257	261	--

There is a lot of redundancy between no sill and low sill operations. If the Project biologists or FFU personnel find a clear biological preference for one of these operations over the other, then operational ranges can be later readjusted in the programmable logic control (PLC).

Figure 4-4. Estimated Available Diffuser Flow and Shad Ladder Flow Deficit by Sill Setting



5. STRUCTURAL DESIGN

5.1. GENERAL

The John Day North Fish Ladder (JDAN) currently does not conform to hydraulic or biological criteria. The failure of the system to operate within the recommended criteria has resulted in fish passage delays, fish jumping, and an overall lack of passage efficiency. Also, the current ladder configuration does not adequately accommodate the passage of lamprey. In order to ensure that the ladder performs to hydraulic and biological criteria, new lamprey-friendly weirs will be installed.

5.2. REFERENCES

American Concrete Institute (ACI) 318-56, Building Code Requirements for Reinforced Concrete.

ACI 318-05, Building Code Requirements for Reinforced Concrete.

ACI 437, Strength Evaluation of Existing Concrete Buildings.

American Institute of Steel Construction (AISC) Manual of Steel Construction, Allowable Stress Design, 9th Edition.

Aluminum Design Manual, 2005.

ASCE 7-05, Minimum Design Loads for Buildings and Other Structures.

Design Memorandum (DM) 16, Spillway, Navigation Lock, Right Abutment Embankment, and North Shore Fish Facilities, John Day Lock and Dam.

DM 22, South Shore Permanent Fish Facilities.

Engineer Manual (EM) 1110-2-6053, Earthquake Design and Evaluation of Concrete Hydraulic Structures.

EM 1110-2-2104, Strength Design for Reinforced-Concrete Hydraulic Structures.

Federal Emergency Management Agency (FEMA) 356, Prestandard and Commentary for the Seismic Rehabilitation of Buildings.

International Building Code, IBC 2003.

Report on Concrete Operations and Tests July 1, 1969.

5.3. DESIGN OF NEW WEIRS

Twenty-three new weirs will be constructed (replacing existing weirs 249 to 267) in sections 9 to 13 of the existing ladder, and new lamprey-improved vertical slot and orifice weirs will be installed (Plate 1). All new weirs, except weir 1, have been designed with adjustable actuated gates to allow for the control of flow. New weirs have been designed and detailed based on model results performed at Environmental Services Corporation's (ENSR) laboratory.

5.3.1. Weir Design Loading

Weirs in the control section will be designed for a minimum of 1 foot of differential hydrostatic pressure on each portion of the weir. The operational criterion for the exit weirs is 0.5 to 1.0 feet.

This flow is exceeded slightly (1.1 to 1.2 feet)[12] at maximum flow (85 cfs) and under 0.5 feet at minimum operating pool (MOP) for most pools.

In addition to the hydrostatic head described above, each control section weir will be designed for operator loading and misoperation of the adjustable sill gates. The possibility of stall torque from the operator motor being transferred through the operator shaft, into the adjustable sill, and into the concrete weir will also be evaluated. Depending on the stiffness of the adjustable sill plate, the severity of this load will be evaluated.

The dead load due to dead weight of the weirs alone if they are manufactured using reinforced concrete increases the load with respect to the existing weirs. The original as constructed weirs (see reference drawing JDF-1-4-2/52 located at the end of this report) weighed approximately 800 pounds per foot of ladder width. The new ladder weirs weigh approximately 1,200 pounds per foot. In order to facilitate construction of the new weirs, alternate materials may be selected. Possible materials include reinforced concrete, fiberglass, and stainless steel. The respective unit weights of each of these materials in a dry condition will be used to determine gravity loads due to weir construction.

5.3.2. Weir Anchorage

New weirs will be anchored into the fish ladder as was done for the south ladder modification. Each of the new weirs will be supported on two sides. New reinforcing with be grouted such that full development is achieved.

An evaluation of the existing ladder structure is described in the following sections. The existing ladder structure was designed with weirs that were anchored on four sides. The previous modification generally anchored weirs along two edges.

Anchorage will consist of either reinforcing dowels that are embedded into the new weir sections. The anchorage connection between the new weirs and the access platforms must be designed to take this vertical gravity load, as well as a portion of the horizontal hydrostatic loading described above.

Weir anchorage will consist of dowels drilled and installed in the floor and walls of the existing ladder. Dowels will be designed to transfer moment and shear loads. If precast concrete weirs are installed, then receiving pockets will be cast in the precast weirs to receive the reinforcing dowels that have been drilled and grouted into the existing ladder structure. Receiving pockets will then be grouted back to secure the precast weir to the existing structure.

5.3.3. Materials Selection and Construction Techniques

Control weirs may be fabricated from reinforced concrete, stainless steel, or fiberglass depending on capacity calculations of both the new weirs and the existing ladder structure. Reinforced concrete may either be precast or cast in place. The benefits of reinforced concrete include availability, ability to form, and durability. Precast concrete sections would provide a smoother concrete finish and would eliminate the need to pump concrete to the elevated ladder structure at a height of approximately 70 feet.

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[12] The 1.3 feet criteria for shad does not apply in the weirs of the flow control section where heads are dependent on forebay elevation at a given sill setting, The shad criteria does apply to the standard ladder weirs downstream of diffuser 16, where make-up water is added in to adjust the ladder head at weir 249.

Weirs have been arranged so that the main section of the weir wall does not cross an existing expansion joint. The weir wing sections and stub outs at some locations will cantilever across the expansion joints to permit movement of the ladder as a result of thermal deflection and settlement.

5.4. ACCESS CATWALKS

5.4.1. Access Catwalks – Purpose

Access walkways provide access to actuators and will support actuator electrical conduits. Access catwalks allow Project personnel access the operating equipment used to manipulate the adjustable sills as shown in the mechanical plates. The new access walkway will be similar to that used for the south fish ladder. The new access platform will be designed to span longitudinally along the centerline of the fish ladder. Access catwalks will also allow Project personnel to access the operating equipment used to manipulate the adjustable sills as shown in the mechanical plates.

5.4.2. Access Catwalks Design Loading

Access catwalks will be designed for the following loading:

- Dead load from the gravity weight of materials including handrail components, adjustable sill operator components including electrical cabinets, and necessary construction materials for maintenance and repair of operators.
- The assumed unit weights for materials are as follows:

Material	Unit Weight (psf)	Use
Reinforced Concrete	150	Walkway Main Structure
Steel	490	Guardrail/Operators
Fiberglass Structural Shapes	120	Guardrail/Fish Barrier
Aluminum	165	Miscellaneous Structures

- Live load from project crew access at a value of 100 pounds per square feet (psf) or a concentrated load of 1,000 pounds.
- Live load from stall torque on the adjustable sill operators at a value of 280% of the rated torque for the chosen adjustable sill operator as transferred through the sill operator anchorage and into the catwalk.

5.4.3. Access Catwalks Anchorage

Access catwalks will be supported from the tops of the new weirs. Access catwalks will be designed simple span between the existing ladder weirs for vertical gravity loading.

5.4.4. Access Catwalks Material Selection and Construction

The access catwalks will be constructed of structural steel using a design similar to that used at the south ladder. Since the new weirs at the north ladder will not be raised 3 feet as was done at the south ladder, the support structure will be anchored to the top of concrete weirs rather than the weir sidewalls. Supporting beams for the access catwalk will be placed 1 foot above the top of the fish ladder. Access catwalks will need to be individually detailed in areas where they align with the location of the existing ladder struts as shown on reference drawing JDF-1-5-2/19. The capacity of the existing strut will be accounted for in the fabrication of access catwalks and support structures.

5.5. DEMOLITION OF WEIRS

5.5.1. Demolition of Existing Weirs

The existing weirs (ladder sections 9 to 13) will be saw cut and removed from the existing ladder structure. The existing weirs were modified in the 1970s as shown in reference drawings JDF-1-5-2/19 through JDF-1-5-2/23. The existing weirs will be saw cut flush with the existing ladder floor. Where new weirs will be aligned with the existing demolished weir, the existing ladder floor will be roughened to a minimum 0.25-inch amplitude. Where new weirs do not line up with existing weirs, the existing vertical reinforcing dowels will be burned back a minimum of 2 inches below the ladder invert. The existing surface will be bush hammered or cut with a water jet and patched back with a suitable non-shrink grout or epoxy patching material that is trowel finished to provide an adequate ladder floor finish for fish and lamprey passage.

In all cases, the existing fish ladder struts will not be modified. In addition, the existing walkway structure shown on reference drawing JDF-1-5-2/22 will be demolished, as the existing weirs that support this structure will no longer be present. Existing weir concrete will be broken into manageable pieces and loaded in a skiff for crane removal. More than one large crane with a 150-foot boom will likely be required to remove the existing weirs.

5.5.2. Demolition of Holey Wall (Existing Weir 249)

Demolition of the holey wall will require many of the same details as described above for the demolition of the existing weirs.

5.5.3. Demolition of Existing Exit Section Weirs

Demolition of the existing exit section weirs will be similar to that described above. Access to the exit sections weirs is not readily available from a crane as the exit sections weirs are beneath the intake deck. As a result, these weirs will need to be saw cut into manageable pieces that can be handled by laborers for loading into a skiff box. In addition, the lack of crane support in this area will require the contractor to erect support for the weir during demolition to prevent collapse of the weir and to provide for worker safety.

5.6. DIFFUSER GRATING MODIFICATIONS

5.6.1. Diffuser Grating Modifications for Lamprey Passage

As described in Section 3, *Biological Design/Considerations/Criteria*, the existing diffuser gratings in the control and exit section will be modified for lamprey passage. In order to modify the existing grating sections, new grating with 0.75-inch clear opening between the bars will be provided. In addition to the change in porosity for the grating, alternate materials will be investigated. Galvanized steel grating will not be used in the diffusers in order to prevent the leaching of zinc into the ladder system. The leaching of zinc from galvanized steel has been shown to be detrimental to salmon passage. The use of fiberglass or aluminum grating will be investigated for the replacement of diffuser grating at diffuser 16.

The existing diffuser grating in diffuser 16 was recently modified for lamprey criteria. However, as described below for count station modifications, the existing grating will be raised approximately 1 foot in elevation. Adjusting the height of the diffuser provides the opportunity to investigate more fish-friendly grating alternative materials and will require the installation of new grating support posts. In addition to raising the elevation of the diffuser grating, a section of the grating will be covered for Lamprey passage. As shown in Figure 3-19 of ENSR's *John Day North Ladder Physical Hydraulic Model Study Final Report* (see Appendix G), a solid section of grating or grating cover will be installed to on the south side of diffuser 16 to promote lamprey passage. The solid section or "sidewalk" will be installed to align with orifice in weir 249. The solid sidewalk allows lamprey to traverse across diffuser 16 providing a solid surface for attachment by lamprey. The sidewalk will likely be fabricated from fiberglass or stainless steel that is anchored to the new grating section installed in diffuser 16. The use of a cover plate allows the plate to be modified or replaced based on lamprey response or damage without replacing the entire diffuser grating.

5.6.2. Grating Design Loading

Diffuser gratings are designed for a live load of 100 psf or a concentrated load of 250 pounds. The existing diffuser grating supports this design loading. The new grating will be designed to support this loading while minimizing live load deflection. In order to minimize the deflection and withstand this design loading with a more friendly material such as aluminum or fiberglass, additional grating supports will be required.

5.6.3. Grating Support Modifications

As described above, the use of a light weight and fish friendly grating section in diffuser 16 will require additional supports to minimize the deflection due to the required design loading. New grating support beams and posts to minimize the grating support span will be required to support the new grating both due to loading requirements and as a method of raising the existing diffuser grating by approximately 1 foot.

Raising the existing diffuser grating will require the existing aluminum grating support posts and beams as shown on reference drawing JDF-1-5-2/9 will need to be replaced. The current diffuser gratings are designed for the above loading conditions, but the substructure (posts and beams) were not designed for this loading. The existing support structure has been detailed to support a live load on the order of 40 psf. The existing support beams will be modified to ensure a continuity of load path for the required 100 psf.

Based on an analysis of the existing grating substructure presented in Appendix H, the following modifications need to be made:

1. The existing aluminum I 3 x 1.96 posts can be increased in height by 1 foot.
2. The existing I 3 x 1.96 support beams need to be replaced with I 4 x 2.64 beams in order to support the 100 psf loading. Alternative, additional I 3 x 1.96 posts can be installed to decrease the span of the existing I 3 x 1.96 beams.
3. The 1-foot x 1-foot concrete support beams require additional support posts to increase the area of concrete supporting the ends of the beams. The existing beams rest on a 4-inch-wide concrete ledge as shown on reference drawing JDF-1-2-5/9. This ledge cannot support the required shear load for the 100 psf loading. Additional support (aluminum or concrete posts) should be placed beneath the existing concrete beam to prevent shear failure (see Appendix H calculations).
4. The existing L 2- x 1.5- x 0.25-inch aluminum support angle cannot support the 100 psf loading. The beam needs to either be replaced with an L 2.5- x 2.5- x 0.25-inch aluminum angle or have additional 0.5-inch or larger anchors installed on 2-foot centers to support the required load.

Replacement of some or all existing diffuser grating on the Columbia River is currently being investigated by a separate Project Development Team (PDT). The PDT may choose to replace some or all existing grating and support structures with stainless steel. If this product moves forward, then the above aluminum support changes should be also replaced with stainless steel. This would require replacement of the existing galvanized steel anchorages as well.

Required porosity and velocity criteria will be considered with respect to any structural changes to the grating support system.

5.7. COUNT STATION MODIFICATIONS

5.7.1. Existing Count Station Conditions

The existing count station is shown on reference drawings JDF 1-5-2/25 through JDF 1-5-2/31. The existing count station is being modified to improve fish passage. The existing count station was fabricated such that there was a 2-foot section of ladder beneath the count station window that was not visible from through the count window. In order to prevent the potential of fish passing below the existing count window and not being counted, the existing count station floor was ramped up as shown on reference drawing JDF-1-5-2/27 section J/17. The steel ramp section raised the floor elevation abruptly from elevation 242.0 to elevation 243.42. The steel platform and grating was installed as shown and then became difficult to clean as the grating filled with debris. In order to combat this, the existing grating section shown in the referenced drawing was filled with concrete.

5.7.2. Count Station Modifications – Raising the Floor Elevation

The existing floor elevation varies from elevation 242.0 to 243.42 feet at the top of the added ramp as described above. As shown in the ENSR hydraulic model report (see Appendix G), the existing floor between at diffuser 16 to the downstream edge of the existing count station window. A transition of constant slope between the downstream edge of the count station window and the invert of weir 248 will be maintained.

In order to raise the floor in this area without overloading the existing ladder structure, a hollow section will be installed in place of a solid concrete overlay. The hollow section will likely be fabricated from stainless steel or fiberglass framing elements. The hollow sections will be anchored to the existing ladder floor with post-installed concrete anchors.

Installing transitions fabricated from stainless steel or fiberglass will eliminate the need to cast concrete at elevation in the ladder and will eliminate the need to feather concrete. Feathering concrete in these areas to maintain smooth transitions for fish passage would likely lead to the spalling of concrete over time. In addition, reinforcing thin concrete sections is difficult to achieve will maintaining minimum concrete cover requirements.

5.7.3. Count Station Modifications - Demolition of Existing Ramp

In order to improve fish passage in this section, the existing concrete and steel ramp will be demolished. Demolition of this existing ramp will permit the complete raising of the ladder floor to an elevation acceptable to eliminate possible counting errors and to improve salmon passage.

5.8. LADDER SYSTEM STRUCTURAL CAPACITY ANALYSIS

Concerns have been expressed with respect to the existing capacity of the fish ladder and the capacity with respect to modified loads. Also, the recognized earthquake hazard at JDA has increased significantly since the time of construction. Some level of seismic evaluation of the north fish ladder has been conducted.

5.8.1. Material Properties

Concrete Strength. The following values were used for the evaluation:

γ = 150 pcf
ν = 0.15 - 0.20
f'c = 3000 (original design value)
f'c = 4500 psi (expected compressive strength[13])
f'c = 4000 psi (new construction)
E = 3,823,676 psi = 550,610 ksf

where
Ec = Modulus of Elasticity = 57,000 $(f'c)^{1/2}$ ACI 318-02, 8.5
γ = unit weight of concrete
ν = Poisson's (ratio concrete)
f'c = compressive strength of concrete

Compressive Strength Test Data. The Report on Concrete Operations and Tests (July 1, 1969) presents test data for the JDAN. Figure 5-1 presents the following summary information:

All mix designs exceeded 3000 psi @ 28 days
All mix designs exceeded 4500 psi @ 6 months
All mix designs exceeded 5500 psi @ one year

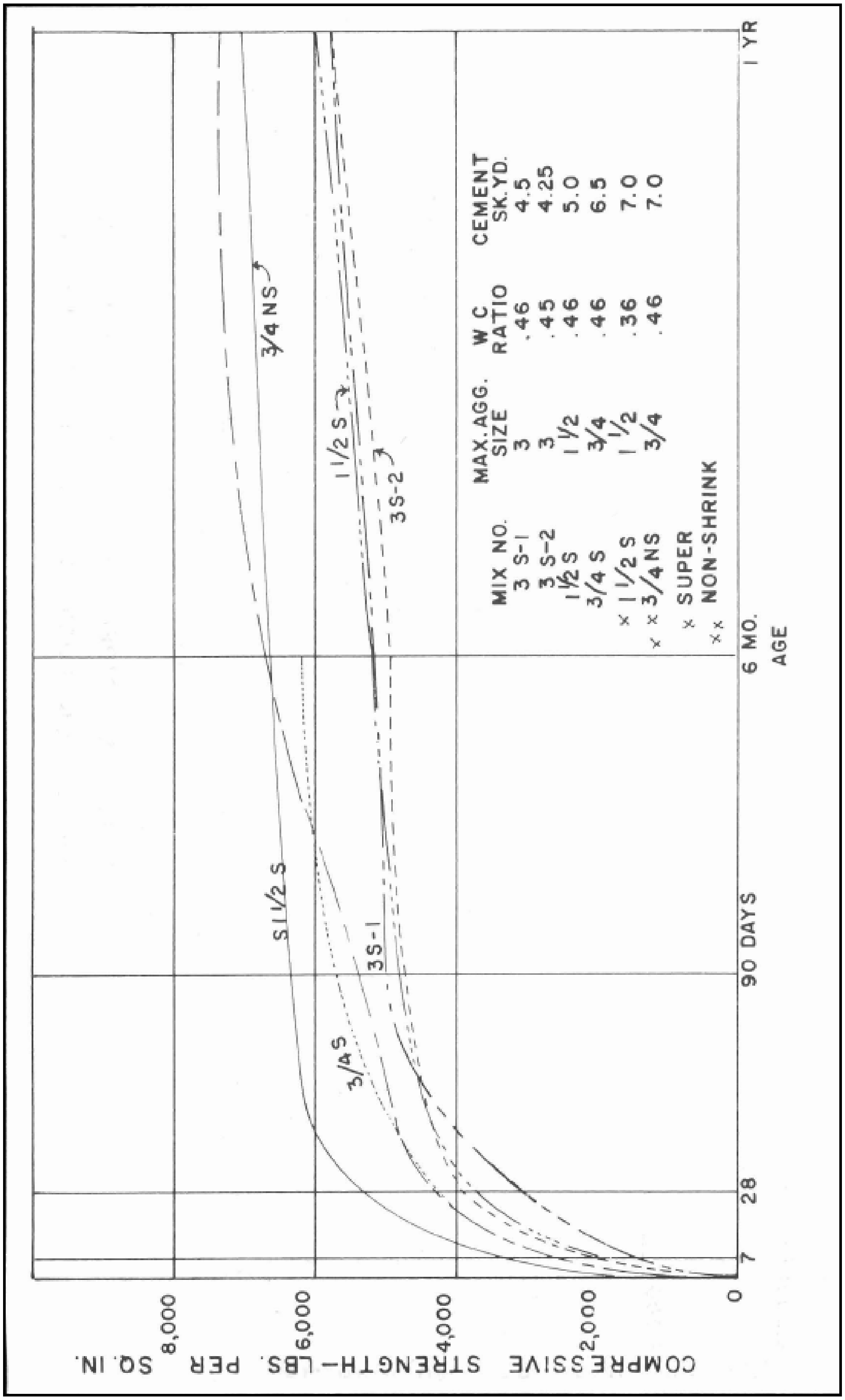
Based on available concrete test data, the expected concrete compressive strength will be used for evaluation.

Reinforcing. Information with respect to reinforcing steel can be found in the original design memorandum.[14] Reinforcing steel used with respect to the north fish ladder was billet steel, intermediate grade as noted in Section 306 of ACI 318-56.[15] The specified minimum yield strength of structural, intermediate and hard grades is 33,000 psi, 40,000 psi and 50,000 psi, respectively.[16]

Minimum yield = 40,000 psi.
Minimum tensile = 70,000 psi

[13] Actual f'c value likely higher, assumed an expected strength factor = 1.5; see Table 6-4, FEMA 356.
[14] DM No. 15.4, Powerhouse Structural Design, John Day Lock and Dam, March 1962.
[15] DM 22, page 3-3.
[16] Concrete Reinforcing Steel Institute (CRSI) Engineering Data Report No. 48, Evaluation of Reinforcing Bars in Old Reinforced Concrete Structures.

Figure 5-1. Compressive Strength of Structural Concrete, Spillway, and North Fish Ladder



Allowable Stress

Tension: fs = 20,000 psi.
Compression, vertical column reinforcement.[17]: fs = 16,000 psi.
Computations will use fy = 40 ksi.

Expected Strength Material Properties. See data below for expected strength factors used to translate lower bound material properties to expected strength material properties.[18]

Material Property	Factor
Concrete compressive strength	1.50
Reinforcing steel tensile strength	1.25
Reinforcing steel yield strength	1.25

5.8.2. Reinforcing Detailing

Development length = $24d_b$

where
d_b = reinforcing bar diameter, in.

Cover. Minimum cover for main reinforcing[19] is shown below.

Element	Cover
Columns	3"
Beams	2"
Walls	2"
Slab	2"

5.8.3. Loads

Original Water Loads. It is assumed that the original normal depth of flow was 7 feet. Design Memorandum 22 indicates that in general depth of flow was approximately 7 feet except at the ends due to variations in forebay and tailwater, "An average depth of 7 feet is used throughout the main portion of the fish ladder with greater depths at the upper and lower ends because of variations in forebay and tailwater elevations."[20]

The original design sections 9-12 used depths with approximately 1 foot of freeboard at section midspan. See below for the average depths used to analyze the middle channel slab. These depths are assumed to represent maximum depth.

Section	Depth	Wall Height
9	9.06	10.06
10	9.75	10.75
11	11.63	12.63
12	13.50	14.50

[17] ACI 318-56, Section 306, Part c.
[18] See Tables 5-3 and 6-4, FEMA 356.
[19] See drawing JDF-1-0-2/1 and DM 22.
[20] DM 22, page 3-5.

At the exit (section 13), the following depths were used:

Weir 264 – 14.5 feet
Weir 267 – 17.5 feet

It appears that an average depth of 16 feet was used for longitudinal analysis (John Day Lock and Dam, North Shore Fish Ladder section 13, page 20, 7/11/59).

Modified Water Loads. Original water loads are assumed have been approximately equal to anticipated loads after the 1970s modification.[21]

Proposed Water Loads. Proposed water loading is based on information provided by hydraulics section. Weirs are assumed subject to 0.5 to 1.0-foot differential. See data below for normal depths.

Weir	Location (feet)	Depth (feet)
1	1.20	6.39
2	16.20	5.49
3	30.78	5.67
4	45.28	5.86
5	59.78	6.00
6	73.78	6.17
7	87.78	6.30
8	101.28	6.44
9	114.78	5.95
10	128.11	5.80
11	141.61	5.87
12	154.61	5.93
13	167.61	5.99
14	180.61	6.06
15	193.11	6.10
16	205.61	6.11
17	218.11	6.13
18	230.61	6.34
19	242.61	6.31
20	254.70	6.53
21	266.70	6.81
22	278.70	7.11
23	290.70	7.26

5.8.4. Load Factors

The following load factors will be used with respect to evaluation of existing concrete.

Hf = 1
FL = 1.4
DL = 1.4

[21] DM 22, Supplement.

The Hf factor is a service ability factor used in lieu of serviceability checks (EM 1110-2-2104). The use of Hf = 1.3 is assumed conservative with respect to a strength evaluation of the modified structure. The ACI fluid load factor is 1.4, the use of 1.7 in this case is considered to be conservative with respect to this evaluation. A hydraulic load factor (Hf) of 1.7 will be used with respect to normal depth computations.

New design will use the following load factor values.

Hf = 1.3
FL = 1.7
DL = 1.4

5.8.5. Load Combinations

Evaluation.

1.4(D+F)

New Design.

H_f (1.4D + 1.7FL)

5.8.6. Weir Configurations

Original. Weirs 252 to 267 were originally anchored on four sides. Weirs 249 to 251 were cantilevered. The north fish ladder has undergone previous modification since the original construction. Design Memorandum 22 indicated minimal load increase at that that time.

Modified. Upper ladder weirs have been modified[22]. The modified (1970s) weirs in sections 9 to 13 generally appear to be anchored on two sides. The exception occurred where a portion of the original wall was reused to form part of the modified weir system. In these cases, the wall was also anchored to the strut above this portion of the wall. Below weir 252, the weirs were cantilevered from the ladder floor.

Proposed. The proposed configuration will be similar to the south shore modification[23].

5.8.7. Criteria

Original. The original design criteria was based on EM 1110-2-2101, Working Stresses for Structural Design and ACI 318-56. Provisions of ACI 318-56 code governed the original design.

[22] See drawings JDF-1-5-2/19 through JDF-1-5-2/23.
[23] See drawings JDF-0-13/1 and JDF-2-18/1 through JDF-2-18/30.

<u>Basic data</u>:

f'c = 3000 psi
fc = .35f'c = 1050 psi
fa = 20,000 psi tension

<u>Compression, vertical column reinforcement</u>: fs = 16,000 psi.

The shear strength of beams without web reinforcement considered concrete strength to be the only variable. The maximum allowable shear stress to be equal to 0.03 times the specified compressive strength (f' c) but not greater than 90 psi.

vc = 90 psi

Shear stress was computed as follows: v = V/bjd.

Current Evaluation. Criteria for the current modification will be based on:

- ACI 318-05, Building Code Requirements for Structural Concrete.
- ACI 437, Strength Evaluation of Existing Concrete Buildings.
- EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures.

Current Modification. Criteria for the current modification will be based on:

- ACI 318-05, Building Code Requirements for Structural Concrete.
- EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures.

5.8.8. Structural Analysis

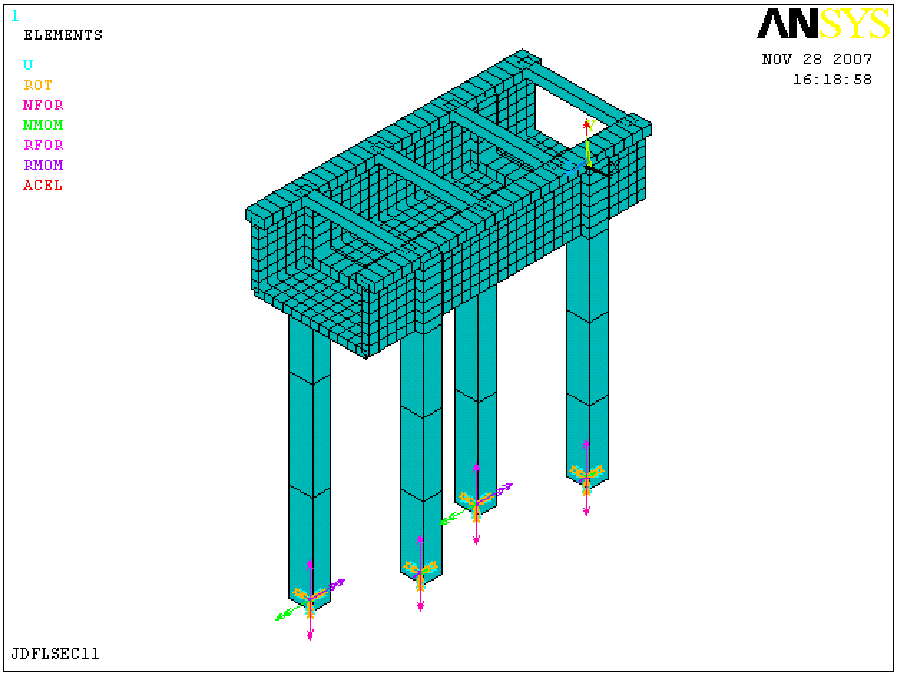
Structural analysis was conducted to determine structural demand versus reinforced concrete capacity at selected locations. EM 1110-2-3001 (1960), EM 1110-2-2101 (1958),[24] and ACI 318-56 were likely used, with modification, as the basis for the original design.

Structural Assumptions. The fish ladder functions as a rigid frame supported by columns founded on sound rock (Figure 5-2). Columns are keyed into the rock foundation and assumed to be fixed.[25] Columns are anchored into concrete with generally 20 #11 bars (except for section 13 which uses 16 #11). Reinforcing is embedded 4 feet.

Slab Model. One way slab analysis was initially conducted to evaluate existing and proposed conditions.[26] The analysis was refined to take advantage of two way action using finite element method (FEM) analysis.

[24] DM 22, page 3-3.
[25] DM 22, page 3-6.
[26] See Appendix H for typical worksheets.

Figure 5-2. Typical Ladder Section



Finite Element Method Model. Version 10.0 of the ANSYS program was used to conduct the FEM analysis of the JDAN (sections 9 to 13). Finite elements used are:

SHELL43 is well suited to model linear, warped, moderately-thick shell structures. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. This element is able to capture out of plane shear force.

SHELL181 is suitable for analyzing thin to moderately-thick shell structures. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. This element is able to capture out of plane shear force.

BEAM4 is a uniaxial element with tension, compression, torsion, and bending capabilities. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes.

Model assumptions:

1. Element size is 1 foot.
2. Walls and slabs were loaded with hydrostatic pressure.
3. Slab width = 24 feet (approximate).
4. Wall height = variable
5. Columns fixed

5.8.9. Capacity Computations

Slab

<u>Shear Capacity</u>

Vc = 2 (f'c) ½ b d
Vn = ϕ Vc
ϕ = 0.75 (alternatively ϕ = 0.85 of ACI 318, Appendix C was considered).

<u>Moment Capacity</u>

The following equation was using to compute the flexural capacity of slabs.

Mn = As(fy)(d-a/2)

where
As = area of tension reinforcement, $in.^2$
fy = yield strength of reinforcing, psi
d = distance from extreme compression fiber to the centroid of tension reinforcement, in.
a = depth of equivalent rectangular stress block, in.

Columns

<u>Shear Capacity</u>

Basic equations:

ϕVn > = Vu
ϕVn =ϕ(Vc+Vs)

See Section 5.9 for additional details.

<u>Moment Capacity</u>. Moment capacity (lateral direction) was computed using the program PCA Column. Expected strength concrete properties were used to column capacity.

Expected strength capacity (Sections 9 - 12): M = 2200 k-ft @ P = 0
Expected strength capacity (Section 13): M = 1775 k-ft @ P = 0

where
f'c = expected concrete compressive = 4500 psi
fy = 40 ksi.
ϕ = 0.9

Transverse Beams

<u>Midspan</u>
ϕMn = 4000 k'

<u>Support</u>
ϕMn = 1250 k'

5.8.10. Structural Demand

5.8.11. Demand Capacity Evaluation

Demand. Results of analysis are available as listed forces or graphically presented displacements, stresses and forces.

Demand/Capacity Evaluation. A demand capacity evaluation was conducted with respect to slab, transverse beams and columns.

5.8.12. Conclusions

1. Computed slab shear stress generally is within the allowable values used for original design. While simple beam (one-way action) model analysis and the assumptions noted would indicate overstress at some locations, the fish ladder is assumed to be adequate as the fish ladder slab is generally, except for ends, subject to two-way action. Loads are carried to four edges rather than two.

2. One-way slab analysis indicates the ladder slab generally has adequate capacity. Forces only exceed allowable at the upstream end of section 13 where fixed boundary conditions preclude the use of a one-way mode in this area.

3. North fish ladder sections 9 to 12 meet the current ACI 318 code requirements with demand computed using conservation one-way action, maximum depth and f'c = 3000 psi.

4. North fish ladder sections 9 to 12 meets the current ACI 318 and EM 1110-2-2104 requirements with demand computed using conservation one way action, normal depth and f'c = 3000 psi.

5. Slab moment may be computed at face of support. Flexural capacity appears adequate with respect to the current code and EM 1110-2-2104.

6. Columns and transverse beams have adequate capacity with respect to static loads.

5.9. SEISMIC EVALUATION

5.9.1. Original Seismic Design

An earthquake force equivalent to 0.05 gravity due to horizontal acceleration was assumed to act at the center of gravity.[27]

[27] DM 22, page 3-5.

5.9.2. Current Seismic Design

The following is an evaluation of the JDAN with respect to the maximum design earthquake (MDE) demand. A seismic analysis was conducted using the response spectra method. Response spectrum analysis was used to determine peak force demands. The following earthquake level was considered for this evaluation: maximum design earthquake (MDE) = 975 years.

A 3D finite element method (FEM) model was used with respect to this evaluation.
General structural modeling assumptions are:

1. Columns fixed at top of footings and extend to the centerline of the fish ladder slab.
2. Post yield stiffness is appropriate when performing seismic design or evaluation for the MDE.[28] Effective stiffness values will be used with respect to the MDE.
3. IBC Site Class B assumed.
4. The center-to-center column spacing was somewhat simplified.
5. Fluid mass was applied to the nodes of areas with fluid contact making up the fish ladder.

Material Properties for Dynamic Analysis.

Design Concrete Compressive Strength:

f'c = 3000 psi

Expected Concrete Compressive Strength:

f'ce = 4500 psi
E = 3,823,676 psi = 550,610 ksf

where
Ec = Modulus of Elasticity = 57,000 $(f'c)^{1/2}$ ACI 318-02, 8.5
fy = 40,000 psi

Effective Stiffness. The effective moment of inertia, I_E, of reinforced concrete structures at or near yield conditions can be significantly less than represented by the gross section moment of inertia, I_G. The reduced moment of inertia is designated as the effective moment of inertia and is a function of the ratio of the nominal moment capacity Mn to cracking moment Mcr.

$Ie/Ig = 0.8 - 0.9(Mn/Mcr-1) < 0.8$
$Ie/Ig > 0.35$ for grade 40 steel.

[28] EM 1110-2-2400, Section 4-6.

where
Mcr = (fr + P/A) Sb
fr = modulus of rupture
P = axial load
A = area
Sb = section modulus
Ig = gross moment of inertia
Ieff = effective moment of inertia
Ie/Ig = 0.35 was used for this current analysis.

Seismic Data

Earthquake Demand:

MDE – 1000-year event
Latitude = 45.7167
Longitude = -120.685

Return	EPGA	Pga
144	0.0451	0.0518
475	0.0844	0.0923
950	0.1184	0.1272
2475	0.1838	0.1953
5000	0.2500	0.2640

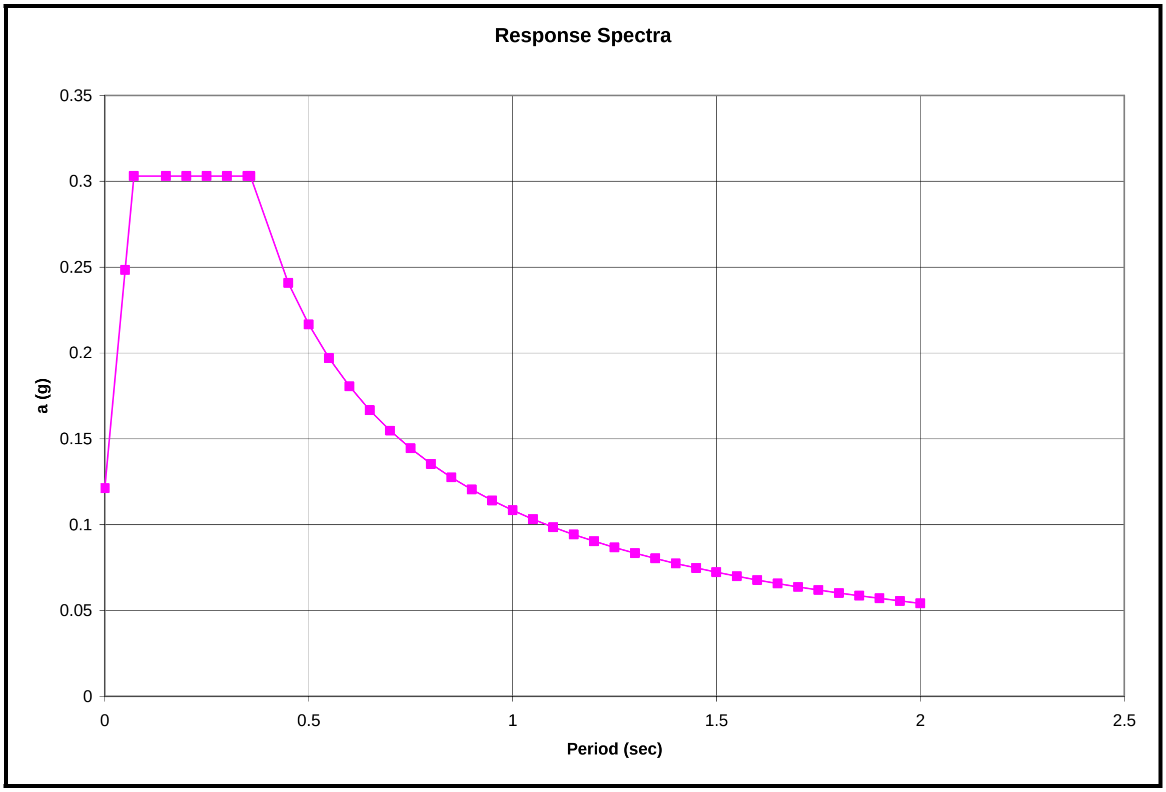
Determine the seismic coefficient using U.S. Geological Survey mapping:

Ss = 0.4536 2% in 50 yr
pga = .1926 2% in 50 yr
Site Class B

The following response spectra data was generated using USACE's Design Earthquake Analysis System (DEQAS) program.[29]

T	f	a
0.0010	1000.000	0.12122
0.0715	13.986	0.30305
0.3575	2.797	0.30305
0.5000	2.000	0.21668
0.8000	1.250	0.13543
0.9000	1.111	0.12038
1.0000	1.000	0.10834
1.5000	0.667	0.07223
2.0000	0.500	0.05417

[29] DEQAS uses current U.S. Geological Survey seismic data.



Loads

Selfweight Concrete

Selfweight is computed both within the FEM program and outside the program.

Fluid Weight

The added mass due to water was applied to appropriate nodes. The depth of flow within the ladder was assumed to be due to normal pool. Total water mass for each section was computed as follows.

Average Depth Maximum Pool

Section	Depth (feet)	Width	Length	Weight (k)	Mass
9	7.5	24	56	628.99	19.53
10	9	24	60	808.70	25.12
11	11	24	60	988.42	30.70
12	13	24	60	1168.13	36.28
13	16	21	58	1307.54	40.61

Average Depth Normal Pool

Section	Depth (feet)	Width	Length	Weight (k)	Mass
9	6	24	56	503.19	15.63
10	6.5	24	60	584.06	18.14
11	6	24	60	539.14	16.74
12	6.5	24	60	584.06	18.14
13	7.25	21	58	592.48	18.40

Assumptions. The MDE load is considered an extreme load case due to the very low probability (potentially high magnitude) of occurrence and should be combined with usual loads, normally expected loads and pool levels.[30]

Load Factors and Combinations. Site-specific response spectrum can be developed using the USACE program DEQAS[31] using site specific location data and the definition of the MDE.

$U_E = 1.0(D+L) + 1.0E$ Equation 3-15

Reference: EM 1110-2-2104, page 3-6.
Note that EM 1110-2-2104 would allow the use of the following:

$U = 0.75[Hf(1.0(D+L)+1.0E)]$ Equation 3-16

5.9.3. Brittle Mode of Failure Checks

In order to meet performance requirements all brittle modes of failure (all failure modes other than flexure) must be suppressed.

General. The following brittle modes of failure were subject to investigation.

- Shear
- Sliding shear failure
- Rebar splice failure
- Rebar anchorage failure
- Fracture of tensile reinforcement

Shear Failure. The shear capacity of columns was computed as per Chapter 5 of EM 1110-2-6053.

f'ca = 4500 psi.

The concrete component of shear strength is given by: Vc = 2(k+P/2000Ag)(f'ca)^0.5(Ae)

Basic equations:

[30] EM 1110-2-2104, page 3-4.
[31] The DEQAS program uses current USGS seismic data.

$\phi Vn >= Vu$
$\phi Vn = \phi(Vc+Vs)$

where
f'ca = Actual concrete compressive strength, psi
A_g = Gross concrete area, in^2
b = beam width, in.
P = Axial load on section
Vn = nominal shear strength, lb
Vu = factored shear force at section, lb
Vs = nominal shear strength provided by shear reinforcement, lb
Vs = Av(fy)d/s
Av = area of shear reinforcement within a distance s, $in.^2$

The following values were used with respect to the shear strength computation.

fy = 40000 psi
f'c = 3500 psi
ϕ = 1 as per FEMA 356, Section 6.4.2.3

See the worksheet titled "ShearCapColumns" for a summary of results with respect to this computation.

Sliding Shear Failure. Shear friction may be checked with the following equation.

$Vsf = \mu_{SF} (P + 0.25Asfy)$

where
Vsf = sliding shear capacity or shear friction capacity, lb
μ_{SF} = shear friction coefficient, as per ACI 318 = 1.0
P = axial load on section, lb
As = area of the longitudinal reinforcing across the potential failure plain, in2.
fy = yield strength of reinforcing steel, psi

For the purpose of this computation the lower-bound yield strength was used:

fy = 40,000 psi

Acceptability criteria:

$Vsf => V_{UD}$

where
V_{UD} = Shear demand due to gravity and earthquake (US/DS direction).

Rebar Splice Failure

ls =AbFy/(11.31*sqrt(f'ca)(c+db)

where
Ab = Area of reinforcing bars.
f'ca = actual concrete compressive strength.
c = the lesser of the clear cover over reinforcing bars, or half the clear spacing between adjacent bars.
db = reinforcing bar diameter, in.

Rebar Anchorage Failure. The reinforcing steel is spliced at the base of the downstream columns. The potential for splice failure exists as damage accumulates in this potential plastic hinge region.

EM 1110-2-6053 was used to check splice length requirements.

ls = Abfy/(11.31(f'ca)^1/2(c+db))

where
fy = expected yield strength, psi
db = reinforcing bar diameter, in

Compressive Spalling Failure. Columns can be shown to be adequate with respect to this performance requirement if displacement demands are low enough to keep concrete strains below the specified performance limits.

In most civil works structures, spalling will not occur and that the disastrous consequences of spalling is unlikely, such as the loss of concrete cover, the loss of confinement reinforcement, and the buckling of reinforcing steel.

When this check is required, a displaced-based analysis could be conducted.

Fracture of Tensile Reinforcement. Fracture of reinforcing steel can be prevented if Mn > 1.2 Mcr. Columns were found to meet this criteria.

f'c = 4500 psi

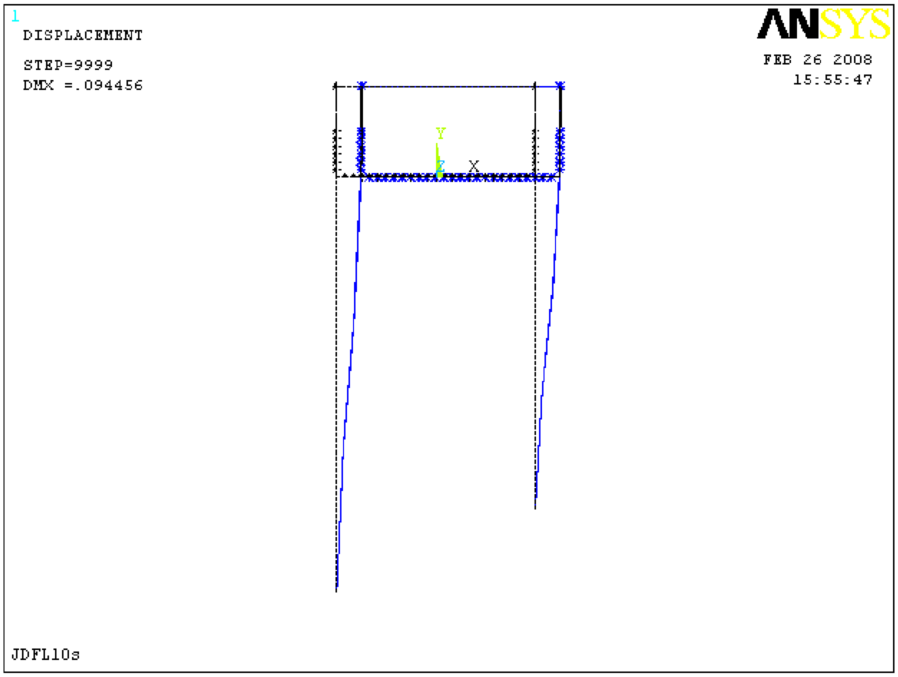
See the worksheet titled "McrCompWSJD" for a summary of results with respect to this computation.

5.9.4. Results of Dynamic Analysis

A summary of Section 10 results:

First mode period = 1.0 sec (Section 10 EI = 0.35EIg).
Displacement = 0.094456'

Displacement Plot (feet)



5.9.5. Demand Capacity Analysis of Columns for 1000-year Seismic Event

5.9.6. Conclusion

The existing fish ladder has the capacity to resist a 100-year earthquake event acting in the transverse direction. Additionally, the fish ladder met all brittle mode of failure checks noted.

5.10. SIDEWALL EXTENSION

The side wall of the upper ladder (sections 9 to 13) will be raised 3 feet such the potential for fish jumping is accommodated. A short 8-inch by 3-foot reinforced concrete wall is proposed. This wall will be offset from the edge of the fish ladder such that doweled reinforcing does not conflict with existing reinforcing.

Note that an apparently effective fish barrier is already in place at this location (see drawing JDF-1-5-2/10).

6. MECHANICAL DESIGN

6.1. GENERAL

This section describes all of the mechanical portions of the John Day North Fish Ladder (JDAN) improvements. This design includes the modification or replacement of all auxiliary water supply (AWS) pumps, modification of count station, and automation of the modified weir's sill gates.

6.2. REFERENCES

Philadelphia Mixing Solutions. November 22, 2006. John Day North Fish Ladder Auxiliary Water Supply Pump Shaft and Propeller Assembly Design Review for Two Load Cases.

Environmental Services Corporation (ENSR) drawings dated January 25, 2008.

6.3. MECHANICAL FEATURES

6.3.1. Attraction Water Supply

Use text from Alternative Letter Report when completed.

6.3.2. Count Station

Count Station Modifications

Through studies done at ENSR, it was discovered that there is a stall pattern near to the downstream side of the counting station. At this point, the fish at John Day often turn around or avoid the area. To correct this, horizontal flow vanes will be installed at the downstream corner of the counting station. When similar horizontal flow vanes were installed in the ENSR model, the stall pattern was corrected and a turbulent flow resulted.

Light Box

Diffuser Modifications

The diffuser section will be raised to be flush with the floor of weir 1, see model drawings. Along the south side of the ladder in weir 1, lamprey passage plating will be placed to allow lampreys to pass over diffuser safely.

Trash Rack and Picket Leads Modification

The existing trash rack and picket leads will be removed and replaced new.

Window Cleaner, Automatic

Window cleaner will clean to the bottom of the window to be able to clearly see and count all of the passing lamprey and fish.

Shade Improvement

6.3.3. Weirs with Adjustable Sill Gates

Sill Gate Actuators and Gearbox

Existing XX hydraulic actuators and sill gates located in the flow control section will be removed.

Weir 1 will not have any sill gates (see ENSR drawings). Weirs 2-8 will have one adjustable sill gate and weirs 9-23 will have two adjustable sill gates. Each sill gate will be able to swing open and close by means of an actuator. The sill gate will rotate on a shaft and the shaft will be operated by the actuator. The weirs with two sill gates will have two independent shafts and actuators. For the weirs with two sill gates, the gates will operate independently and there will be limit switches to ensure that the upper sill gate stops directly over the lower sill gate. Actuators will be product of the same manufacturer that is used for the John Day South Shore Fish Ladder (JDAS) but of a different model. JDAS used Limitorque L120 and the JDAN will use the MX Limitorque actuator. The L120 was the best option for single-phase power but with the ability for 3-phase power supply on the north shore, the MX is a better option with easier setup and less maintenance.

The shaft, gate, and associated parts, will be constructed of stainless steel 304L for corrosion reasons.

Bearings and Shafts

A 2-inch shaft will be inside of an 8-inch stainless steel tube and held in place using stub shafting. The 2-inch shaft will be the only portion that extends the entire length to the actuator. There may be up to four bearings on each shaft connected by struts to the weir. A window will be cut out of the 8-inch tubing to allow for the struts and support at each bearing. Two bearings will be used for each shaft, one at the top and one at the bottom. The bearing material will be a self-lubricating material and captive in a housing made of stainless steel 304L. Each bearing housing will be welded to struts that attach to the outer rotating shaft. At the bottom of each shaft will be a thrust bearing. A means for silt, water, and clams to drain out of the bottom of each shaft will be included in the design.

7. ELECTRICAL DESIGN

7.1. GENERAL

The John Day North Fish Ladder (JDAN) electrical features will be designed as described in this section. The major features covered in this section are the counting station and flow control section weirs.

7.2. REFERENCES

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations
EM 1110-2-3006, Hydroelectric Power Plant Electrical Design, June 1994

7.3. FEATURES

7.3.1. Count Station

Crowder

The purpose of the crowder is to force fish into the counting station slot. Demolition of the crowder electrical components will consist of removal of the motor, motor starter, control station, limit switches, and associated conduit and cable. Conduit will be removed back to the conduit bodies located nearest to where the conduit exits the count house and the visitor building under the EL. 254 walkway.

The 480V power sources for the existing crowder will be re-used. A new combination starter will be installed in FQ2 compartment 2D/E (see Plate 19).

The crowder will be controlled by a new National Electrical Manufacturers Association (NEMA) 4 control station located in the count house. The control station will utilize 120V AC to open and close the crowder.

Light Box

The light box is located on the south side of the counting station slot; opposite the fish counting window. The purpose of the light box is to back light the counting station slot to increase visibility for fish counting. Demolition of the crowder lights will consist of removal of the light box, ballast, ballast enclosure, switch and associated conduit and cable.

The existing 120V power source will be reused. Panelboard FR2 circuit r4 will be reused to provide power to the crowder lights.

The light box will be operated manually by an industrial switch located in the count house. A new NEMA 4X enclosure will replace the existing ballast box.

Window Cleaner, Automatic

The purpose of the window brush is to automate the task of cleaning the count house viewing window.

120V power for the new window brush will be supplied by FR2.

Control for the window brush will be located in the count house.

Regulating Bulkhead

The purpose of the regulating bulkhead is to adjust the amount of water allowed to bypass the counting station slot. Demolition of the regulating bulkhead electrical components will consist of removal of the motor, motor starter, limit switches and associated conduit and cable. Conduit will be removed back to the conduit bodies located nearest to where the conduit exits the count house and the visitor building under the EL. 254 walkway.

The power sources for the existing regulating bulkhead will be reused; 480V AC will be supplied to a new starter from FQ2 compartment 1AR

A new NEMA 4X combination starter will be used to control the new regulating bulkhead motor. The new combination starter will be located to the left of the EL. 254 entrance to the fish viewing room.

7.3.2. Flow Control Section

Currently water in the upper fish ladder is regulated by hydraulically adjustable weirs. Demolition of the adjustable weirs electrical components will consist of removal of the existing hydraulic pump power, control station and associated conduit and cable. The hydraulic pump is located in the DSQ1 substation on EL. 262 of the north non-overflow dam. Power is supplied to the pump from LR4 circuit 34.

Sill Gate Actuators

The sill gates regulate the amount of water in the upper fish ladder based on forebay water level. New electric Limitorque MX series actuators will be used to adjust the sill gates. The initial request from project personnel was to duplicate the south fish ladder installation. Due to the challenges face with the installation of 37 actuators over 300 feet, the north fish ladder power and controls will be different than the south fish ladder.

To overcome the voltage drop created by the 300 foot run to the furthest actuator, the north fish ladder actuators will be powered by 480V. Power for the adjustable sill actuators will be supplied by a new 3R Square-D I-Line panelboard. The panelboard will be housed in a new NEMA 4X enclosure located on the east side of the stairwell and elevator building at the north non-overflow dam (see Plate 17). The new 480V panelboard will be supplied from DSQ1 located on EL. 262 of the north non-overflow dam. The maximum number of 3-poles breakers that can be installed in an I-Line panelboard is limited to 22. For this reason, six actuators will be powered from a single breaker (see Plate 18).

Control will be provided by a new PLC located in the exit weir control panel (see below). The actuators can also be controlled locally from integrated controls located on the actuator or manually by hand-wheel operation. One of the challenges faced is the number of cables and conduits required for a direct-wired control and indication installation. To reduce the number of conduits and cables, a DeviceNet network will be used to communicate with each of the 37 actuators. The use of the DeviceNet protocol will allow each actuator to be individually addressed and controlled by the PLC. This reduced the number of conduit and cables to one 0.75-inch conduit and one twisted pair cable that is daisy-chained from actuator to actuator.

Control Panel

A new NEMA 12 exit weir control panel will be installed in the EL. 254 fish viewing room of the visitor building. The exit weir control panel will house the PLC and a new color touch screen. The operators will utilize the touch screen to monitor and control the 37 actuators. From the touch screen the operator will have the ability to:

- Input the current forebay level (low, normal or high).
- Control each actuator individually.
- View the position of each actuator.
- View error and alarms generated by the actuators.

Training will be provided to project personnel on the operation and maintained of the PLC and touch screen. The touch screen programming will be performed with the input of the operators.

8. CONSTRUCTION

9. OPERATIONS AND MAINTENANCE

9.1. GENERAL

9.2. FEATURES

9.2.1. Exit Section

9.2.2. Count Station

9.2.3. General Maintenance

10. COST ESTIMATES

10.1. Project Description

a. General Description: This cost estimate is for construction of ...

1. Exit Section
2. Count station.

b. Construction Methodology

10.2. Basis of Design and Estimate:

a. Basis of Design:

b. Basis of Estimate. The estimate for this project was developed using information provided by the designers, including sketches and quantities. ...

10.3. Construction Schedule:

a. Duration
b. Overtime
c. Construction Windows.

10.4. Project Construction.

a. Acquisition Plan
b. Subcontracting Plan.
c. Site Access.
d. Quantities.
e. Unusual Conditions (Soil, Water, Weather).
f. Unique Construction Techniques .
g. Equipment/Labor Availability and Distance Traveled.
h. Overhead, Profit and Bond.

10.5. Environmental Concerns.

10.6. Contingencies

10.7. Effective Dates for Labor, Equipment, Material Pricing. October 2008.

10.8. Functional Costs:

a. 01 Account - Lands and Damages: The construction site is on Government Property, therefore there are no separate real estate costs expected.

b. 18 Account - Cultural Resources: All work is remodeling of existing construction project features with do not require Cultural preservation, so there are no 18 account costs.

c. 30 Account - Planning, Engineering and Design:

d. 31 Account - Construction Management: This account covers construction management of the proposed modifications.

e. 33 Account - Hazardous, Toxic, and Radioactive Waste, HTRW: No HTRW material is assumed in the work areas, so there are no 33 Account costs.

See Table 10.1 and 10.2 for total project costs.

10.9. Escalation: Mid-point of construction is assumed to be January 2011.

10.10. Lost Power Revenue.

10.11. Operation and Maintenance Costs.

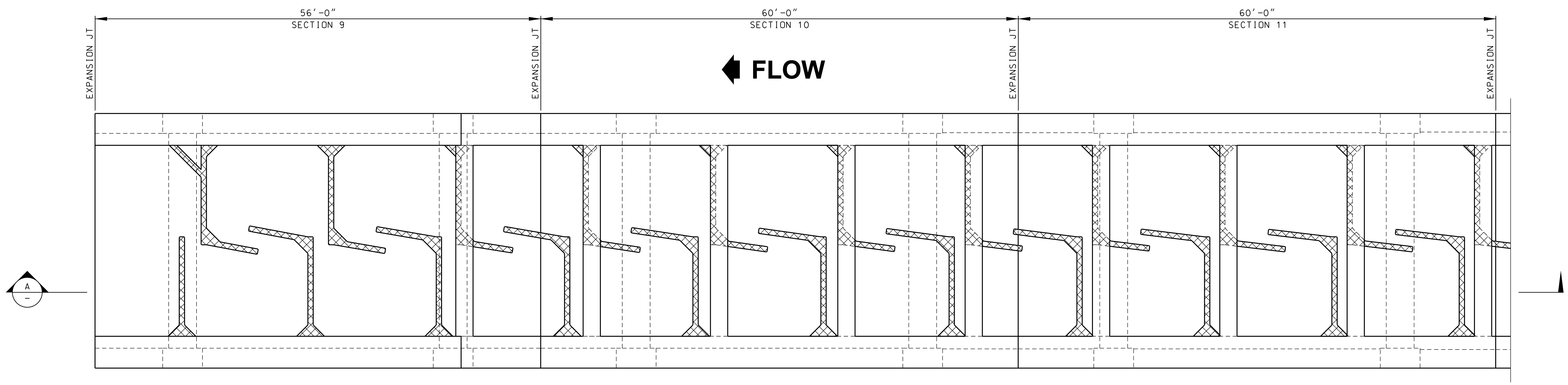
10.12. Working Project Estimate.

a. Exit Section
b. Count station.

11. CONCLUSIONS AND RECOMMENDATIONS

LIST OF PLATES

NORTH AND SOUTH FISH LADDER REFERENCE DRAWINGS (located at end of plates)



PLAN
1/8" = 1'-0"

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CKD BY: CHK BY
SUBMITTED BY: SUBMITTER'S NAME
PLOT SCALE: 1:1
PLOT DATE: 5/22/2008
SIZE: ANSI-D
FILE NAME: PLATE_02.dgn
DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

EXISTING PLAN AND SECTION
W/DEMOLITION 1

SHEET IDENTIFICATION
2
SHEET SNO OF NOS

DESIGN FILE: Z:\COLUMBIA\JOHNDAY\NORTH_FISH_LADDER\ADULT_PASSAGE_IMPROVEMENTS\DESIGN_DOCUMENTATION_REPORT\DESIGN_FILES\DRAWINGS\02-STRUCTURAL\PLATE_02.DGN

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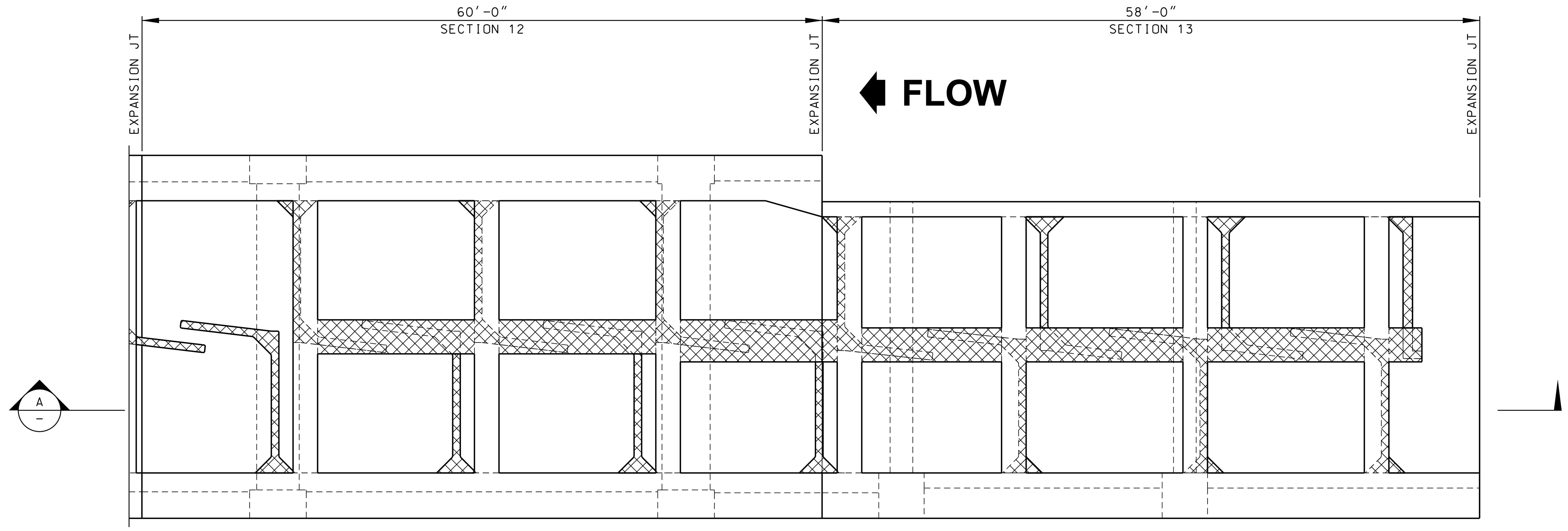

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PLOT DATE: 5/22/2008
SIZE: ANSI-D
FILE NAME: PLATE_03.dgn
DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

EXISTING PLAN AND SECTION
W/DEMOLITION 2

SHEET IDENTIFICATION
3
SHEET SNO OF NOS

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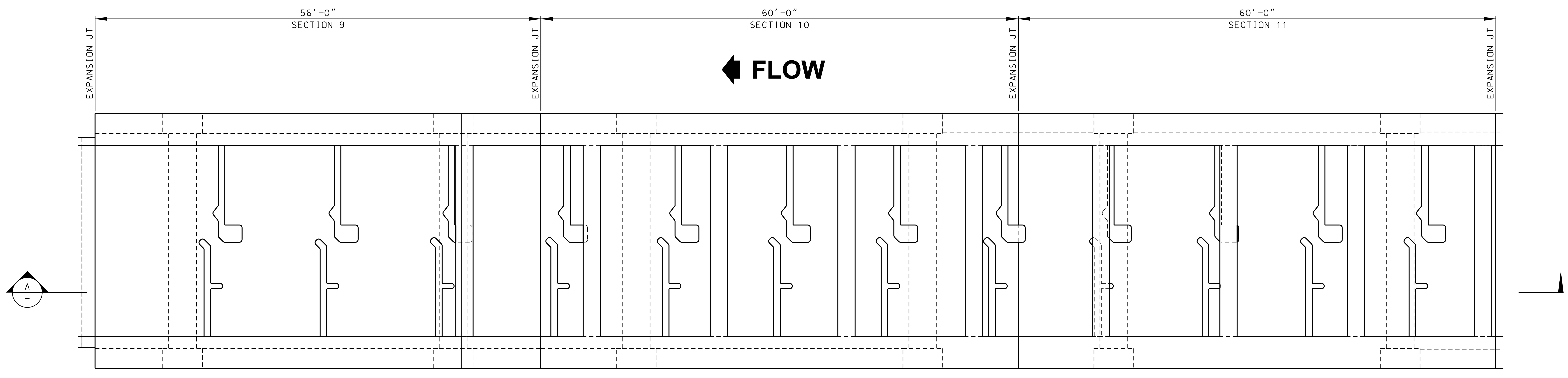

PLAN

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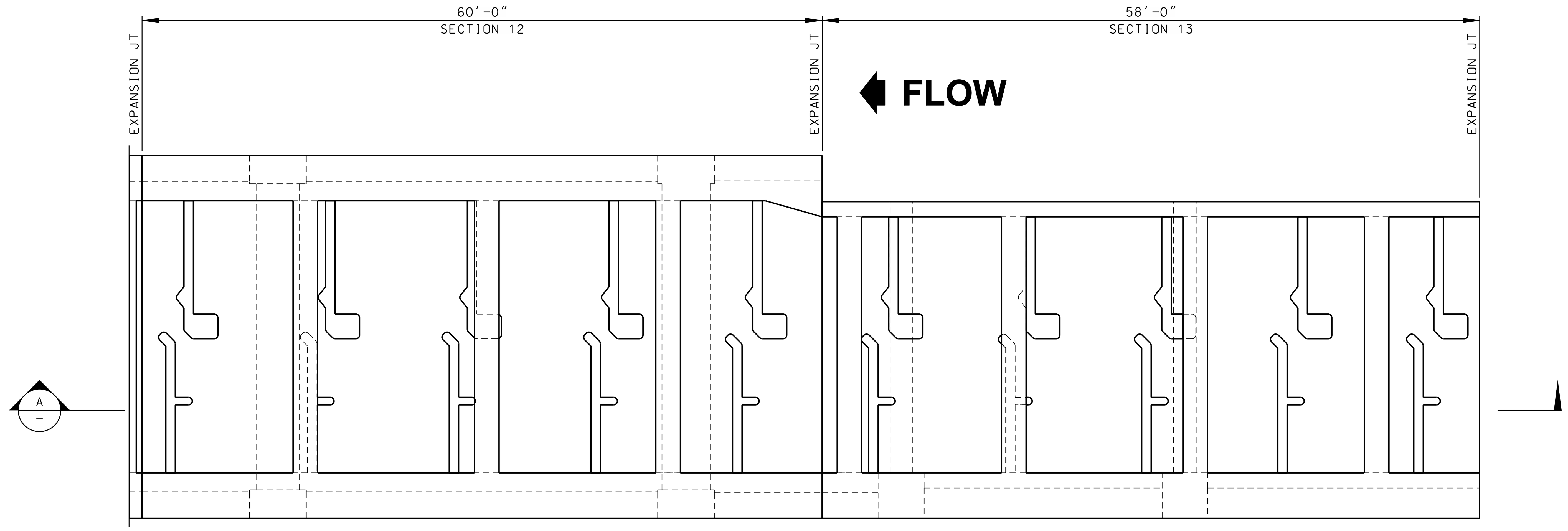
PLOT SCALE: 1:1	PLOT DATE: 5/22/2008	DRAWING NUMBER:
SIZE: ANSI-D	FILE NAME: PLATE_04.dgn	

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

NEW PLAN AND SECTION 1
WITH NEW RADII

SHEET IDENTIFICATION
4
SHEET SNO OF NOS



PLAN
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SIZE: ANSI-D
FILE NAME: PLATE_05.dgn
DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

NEW PLAN AND SECTION 2

SHEET IDENTIFICATION
5
SHEET SNO OF NOS

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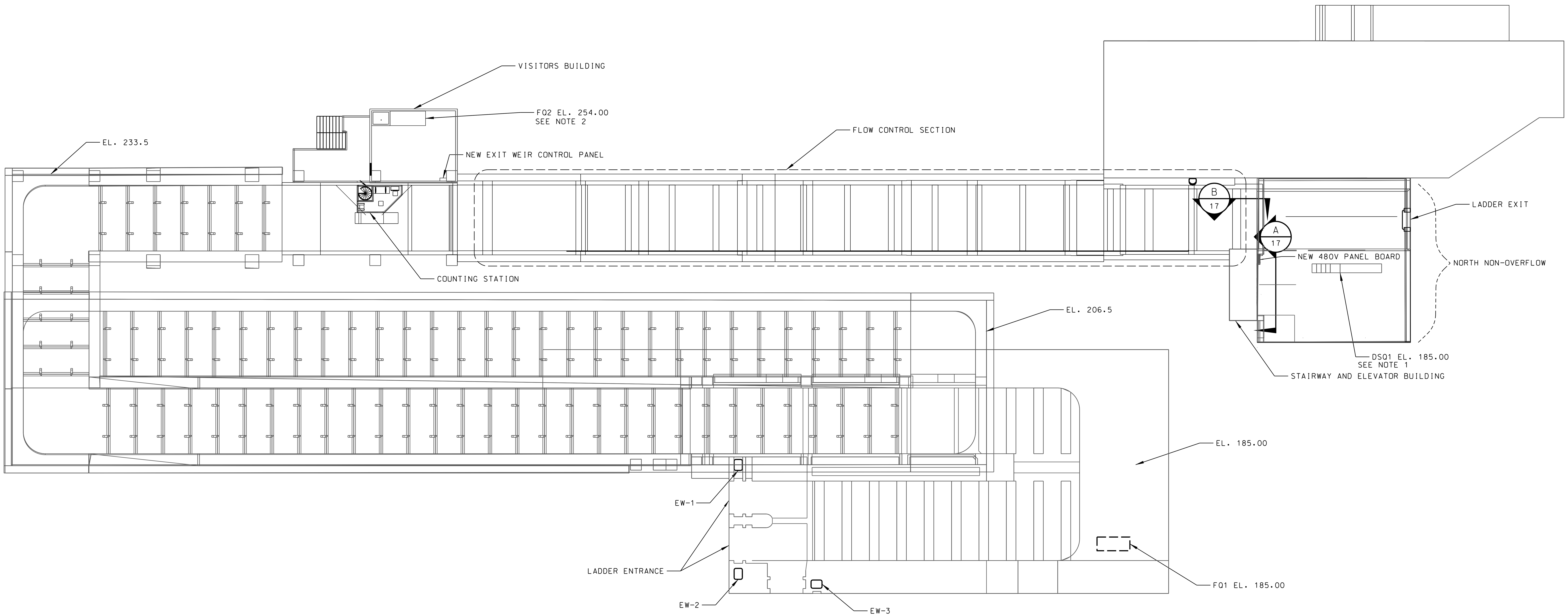

NORTH FISH LADDER ELECTRICAL PLAN VIEW

SCALE: 1"= 20'
20' 0 20'

REFERENCE DRAWINGS

NOTES:

1. DS01 IS LOCATED ON EL. 262 OF THE NORTH NON-OVERFLOW: IN THE DS01 SUBSTATION.
2. F02 IS LOCATED EL. 254 OF THE VISITORS BUILDING: IN THE ELECTRICAL & MECHANICAL EQUIPMENT ROOM. SEE PLATE 18 FOR FRONT DETAILS.
3. WEIR HOIST MOTORS EW-1. EW-2 & EW-3 SHALL BE SURPLUSED TO THE GOVERNMENT.

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DATE: ISSUE DATE
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CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER: FILE NUMBER

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4
NORTH FISH LADDER
ELECTRICAL
PLAN VIEW

SHEET IDENTIFICATION
16

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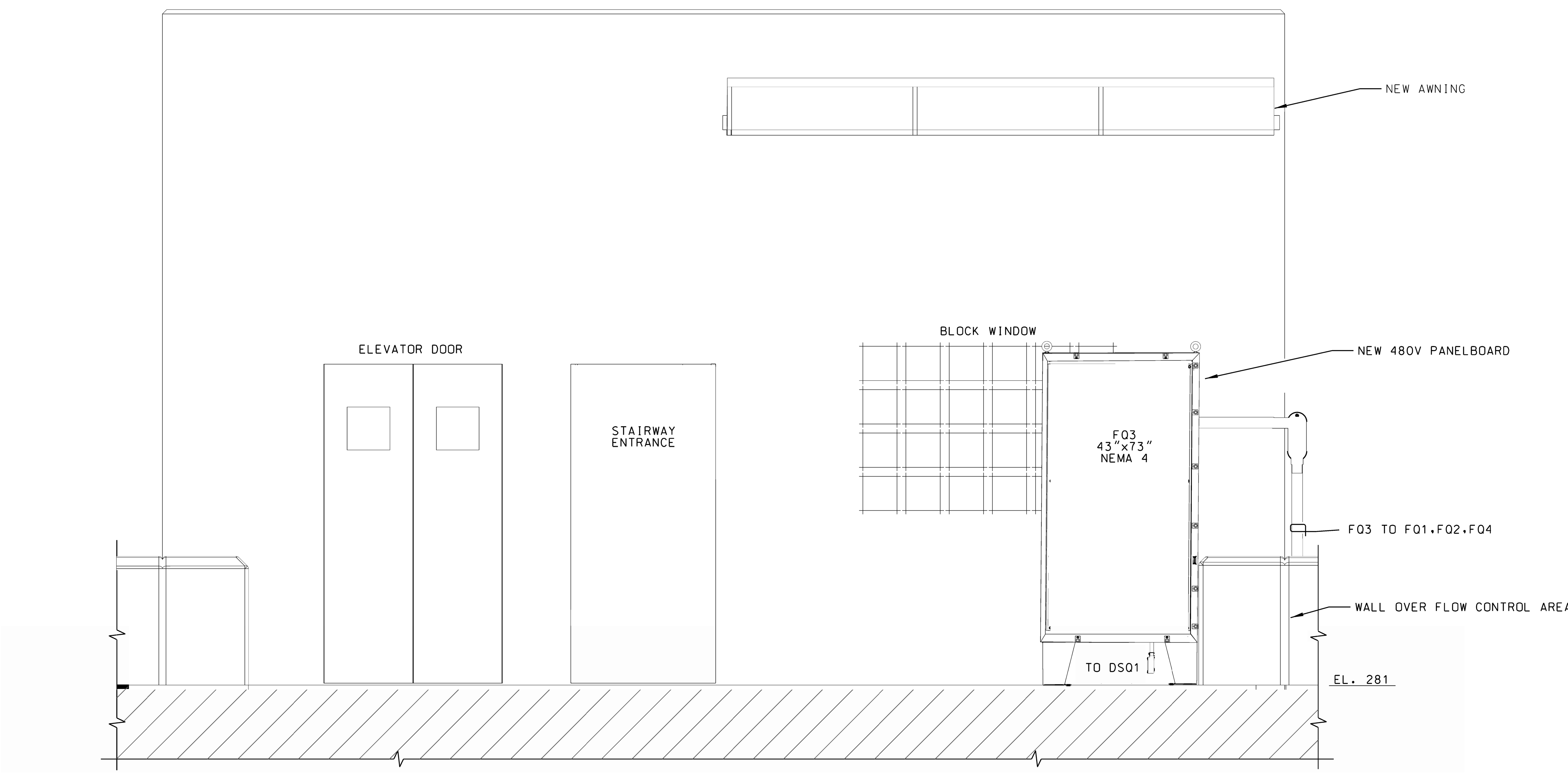
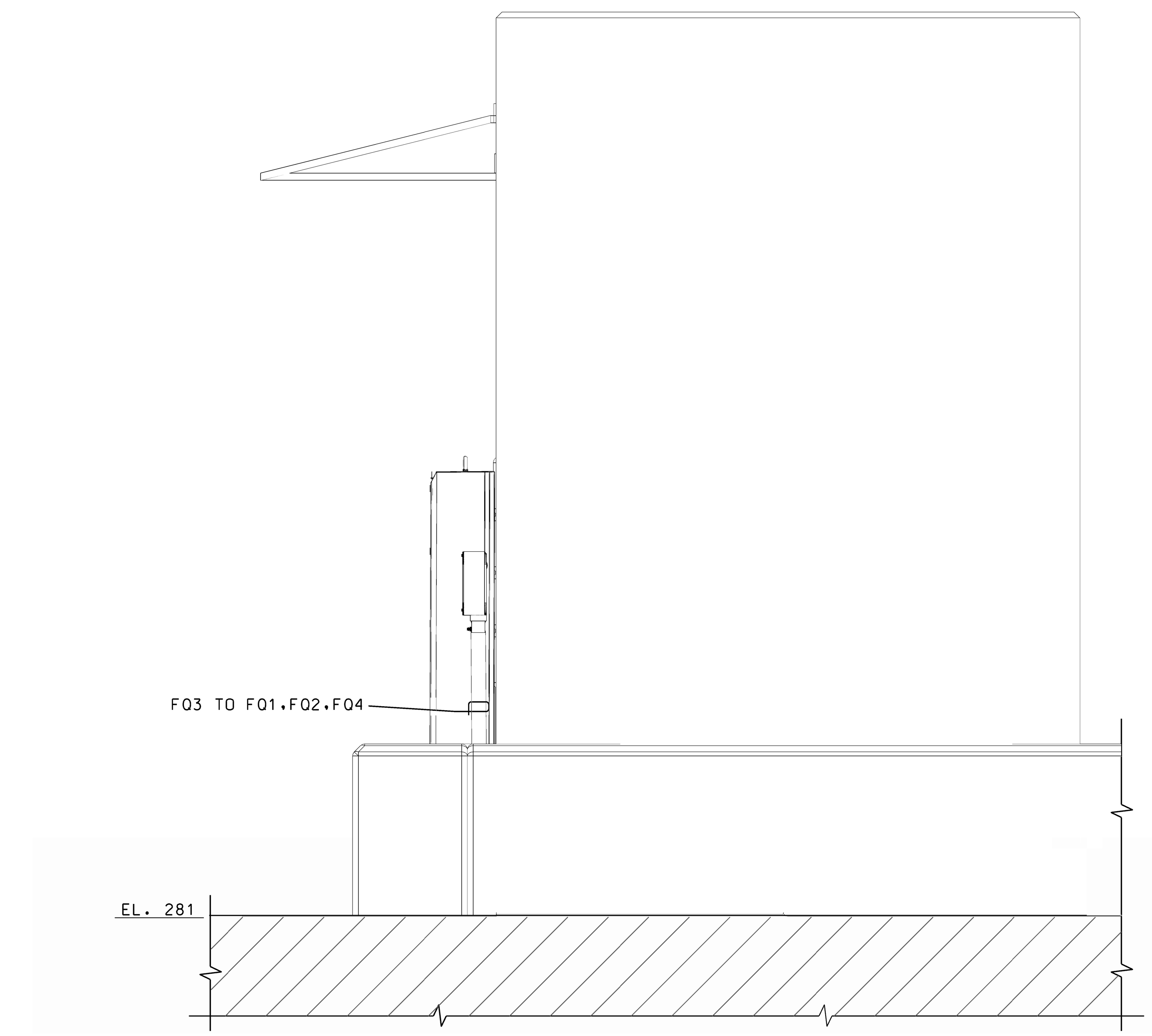
DATE AND TIME PLOTTED: 5/22/2008 10:22:31 AM | BY USERNAME: G2ECDTRS (BATCH PLOT JOB) | SHEET NAME: PLATE 16



WEST VIEW

SECTION A / 16



SOUTH VIEW

SECTION B / 16

REFERENCE DRAWINGS

NORTH NON-OVERFLOW
STAIRWAY & ELEVATOR BLDG.

SCALE: 1/2"= 1'-0"
12" 0 1' 2' 3' 4'

NOTES:

1. NEW 480V PANELBOARD SHALL BE INSTALLED IN A NEMA 4X ENCLOSURE.

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PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

NORTH NON-OVERFLOW
STAIRWAY & ELEVATOR BLDG.

SHEET IDENTIFICATION
17
SHEET 2 OF 4

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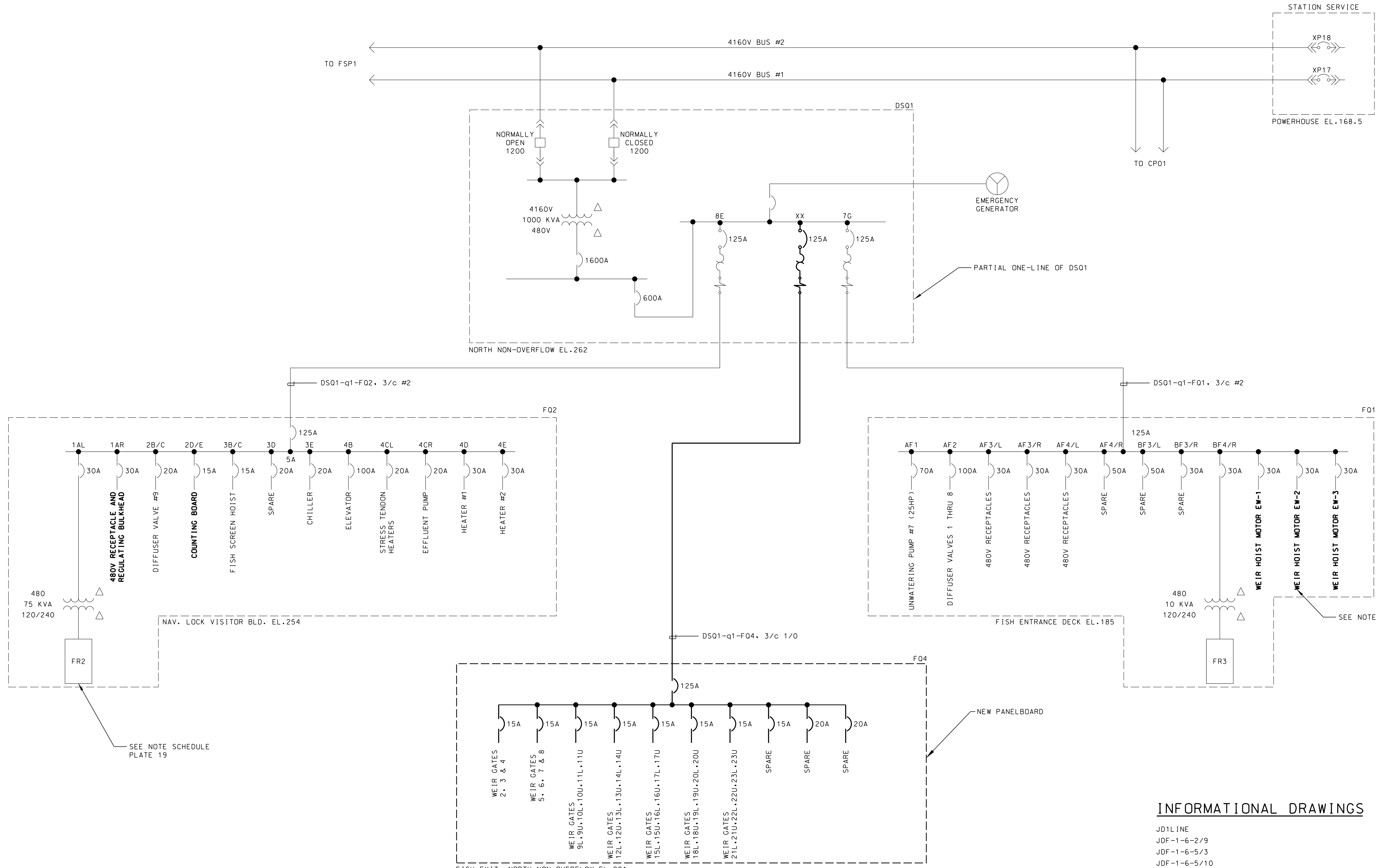

NORTH FISH LADDER
REVISED 480V ONE-LINE DIAGRAM

INFORMATIONAL DRAWINGS

JD1LINE
JDF-1-6-2/9
JDF-1-6-5/3
JDF-1-6-5/10
JDN-1-6-14/5
JDN-1-6-14/5.1
JDN-1-6-14/7

NOTES:

1. BOLD LINES INDICATED NEW OR MODIFICATIONS TO EXISTING.
2. REMOVE CONDUCTORS TO WEIR HOIST MOTORS.
3. RELABEL BREAKERS AS SPARE.

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PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4
NORTH FISH LADDER
REVISED 480V ONE-LINE DIAGRAM

SHEET IDENTIFICATION
18
SHEET 4 OF 3

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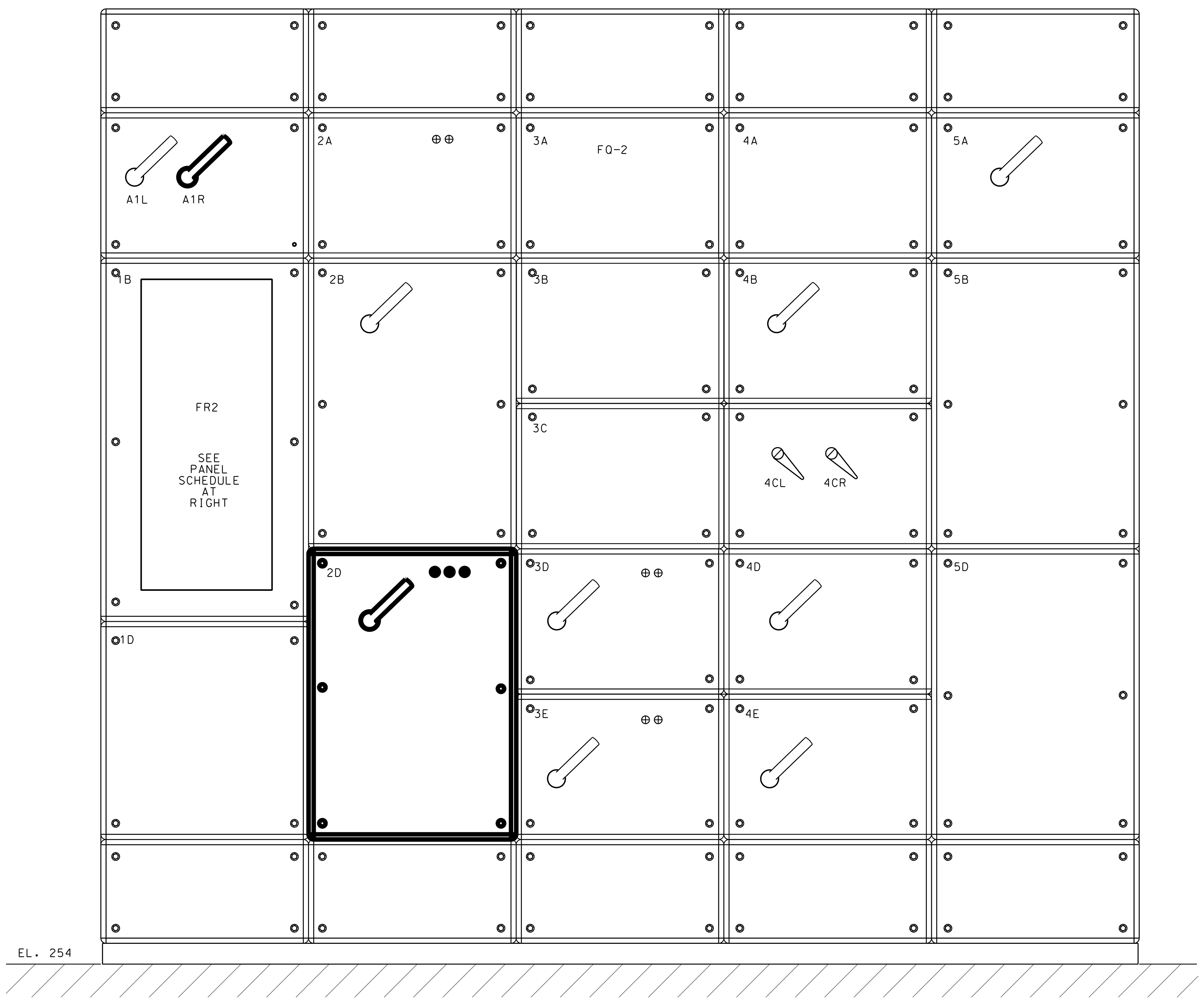
DATE AND TIME PLOTTED: 5/22/2008 10:33:20 AM | BY USERNAME: G2ECDTRS (BATCH PLOT JOB) | SHEET NAME: PLATE 18



FQ2 FRONT DETAIL

SCALE: 1½" = 1'-0"
12" 9" 6" 3" 0 1'

LIGHTING PANEL FR2		LOCATION: NORTH FISH LADDER					ENCLOSURE TYPE (NEMA 250):		AIC:	
BUS	VOLTS: 240	PHASE: 2		☐ MAIN CB:			☐ ISO GND		☐ SURF MTD	
	AMPS: 180	WIRES: 3		■ MAIN LUGS			☐ FEED THRU		■ FLUSH MTD	
CKT NO	DESCRIPTION	LOAD VA A	LOAD VA B	CB A/P	CB A/P	LOAD VA A	LOAD VA B	DESCRIPTION	CKT NO	
1*	CIRCULATING PUMP			20 / 3	20 / 3			AIR CONDITIONING CONTROL	2*	
3	FLOAT WELL METER			20 / 1	20 / 1			COUNTING BOARD & PASSAGE LIGHTS	4	
5	FLOAT WELL HEATER & TIMER			20 / 1	20 / 1			UNIT HEATER	6	
7	DECK RECEPTACLE			20 / 1	20 / 1			VENT FANS	8	
9	COMPRESSOR			20 / 1	20 / 1			1st FLOOR & TOP FLOOR LIGHTS	10	
11	2nd FLOOR & STAIRWELL LIGHTS			20 / 1	20 / 1			SPARE	12	
13	2nd FLOOR RECPT & HALLWAY LIGHTS			20 / 1	20 / 1			AUTO DOOR & CLOCK TIMER	14	
15	MEN'S HAND DRYER			20 / 1	20 / 1			1st FLOOR RECEPTACLES	16	
17	WOMEN'S HAND DRYER			20 / 1	20 / 1			GALLERY ACCESS STAIRWAY LIGHTS	18	
19	3rd FLOOR E.WALL RECEPTACLES			20 / 1	20 / 1			ELEVATOR LIGHTS	20	
21	RECEPTACLES			20 / 1	20 / 1			COUNTIING HOUSE A/C	22	
23, 25	HOT WATER HEATER			20 / 2	20 / 2			COUNTING HOUSE HEATER	24, 26	
	CONNECTED VA	0	0			0	0	CONNECTED VA		
	TOTAL CONNECTED VA	0	0			0	0	TOTAL DEMANDED VA		

* F FRAME BREAKER

FR2 PANEL SCHEDULE

REFERENCE DRAWINGS

JDF-10.0-6-2/13
JDN-1-6-14/5
JDN-1-6-14/5.1
JDN-1-6-14/7

NOTES:

1. AREA TO BE MODIFIED IS IN BOLD

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CKD BY: J.BRACKIN
SUBMITTED BY: DUNCAN KWONG, P.E.
PLOT SCALE: 1:1
PLOT DATE: 5/22/2008
SIZE: ANSI-D
FILE NAME: PLATE_19.dgn
DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4
FQ2 CONTROL CENTER LAYOUT

SHEET IDENTIFICATION
19
SHEET 4 OF 4

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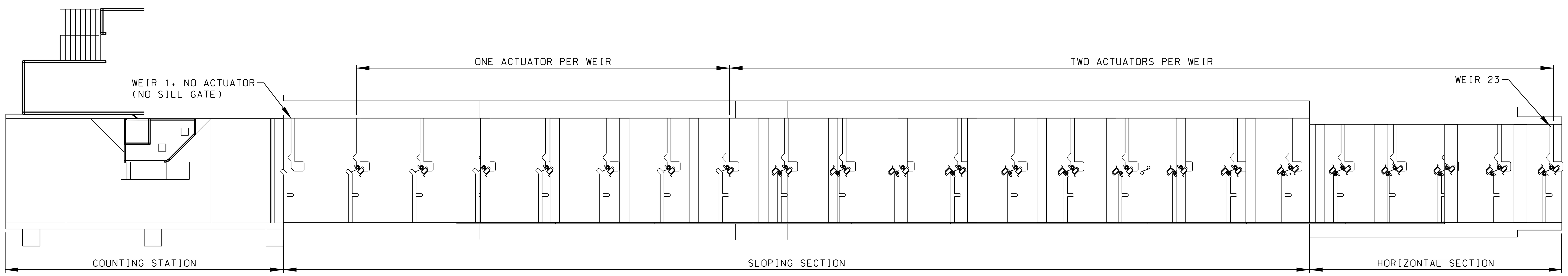
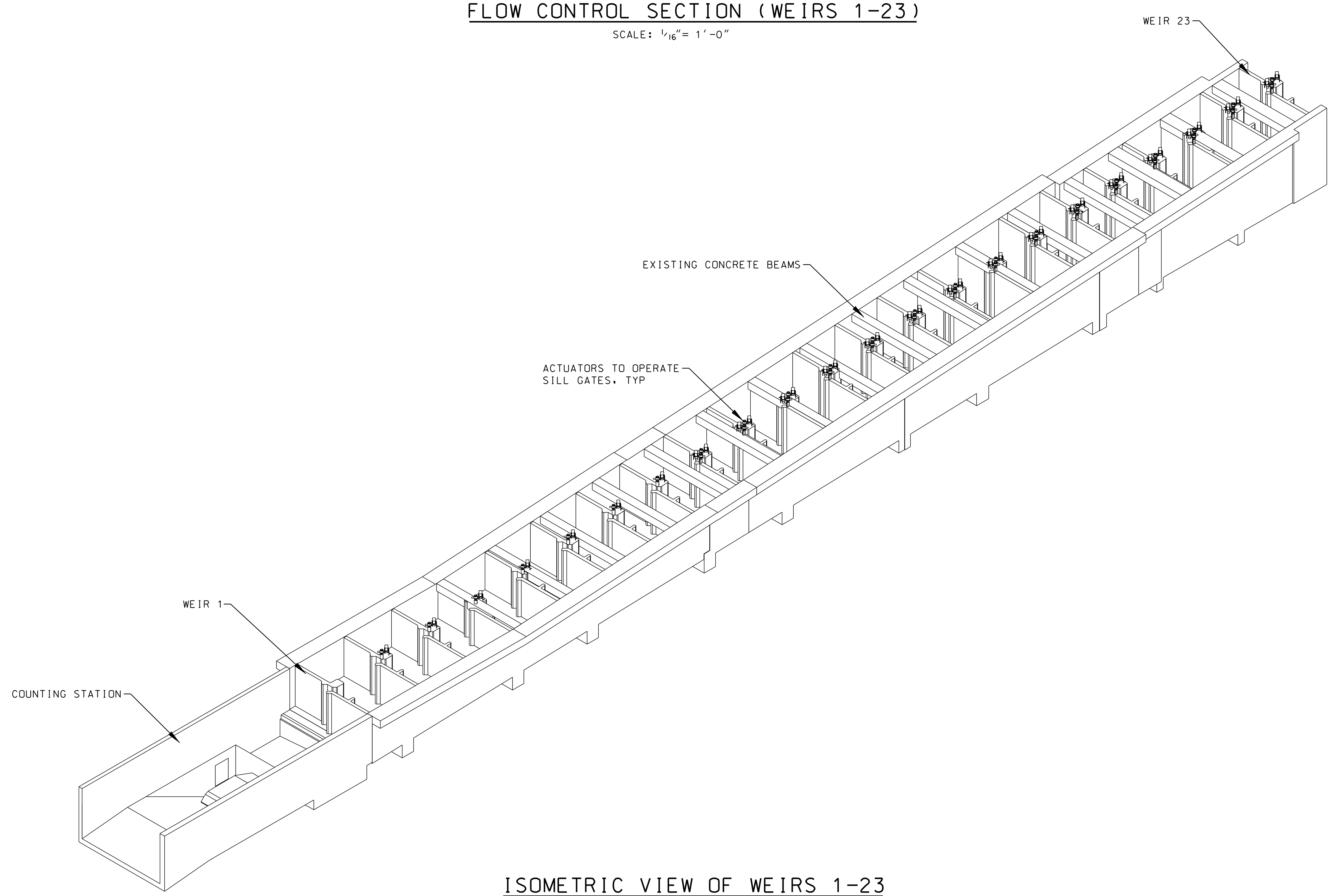


FLOW CONTROL SECTION (WEIRS 1-23)

SCALE: 1/16" = 1'-0"



ISOMETRIC VIEW OF WEIRS 1-23

SCALE: 1/16" = 1'-0"
5' 0 10' 20' 30'

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DWN BY: DWN BY | CKD BY: CHK BY
SUBMITTED BY: SUBMITTER'S NAME
PLOT SCALE: 1:1 | PLOT DATE: 5/22/2008
SIZE: ANSI-D | FILE NAME: Plate 21.dgn

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AE / CONTRACTOR (CITY, STATE)
AE / CONTRACTOR ID

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

SHEET TITLE LINE 1
SHEET TITLE LINE 2
SHEET TITLE LINE 3

SHEET IDENTIFICATION
21
SHEET SNO OF NOS

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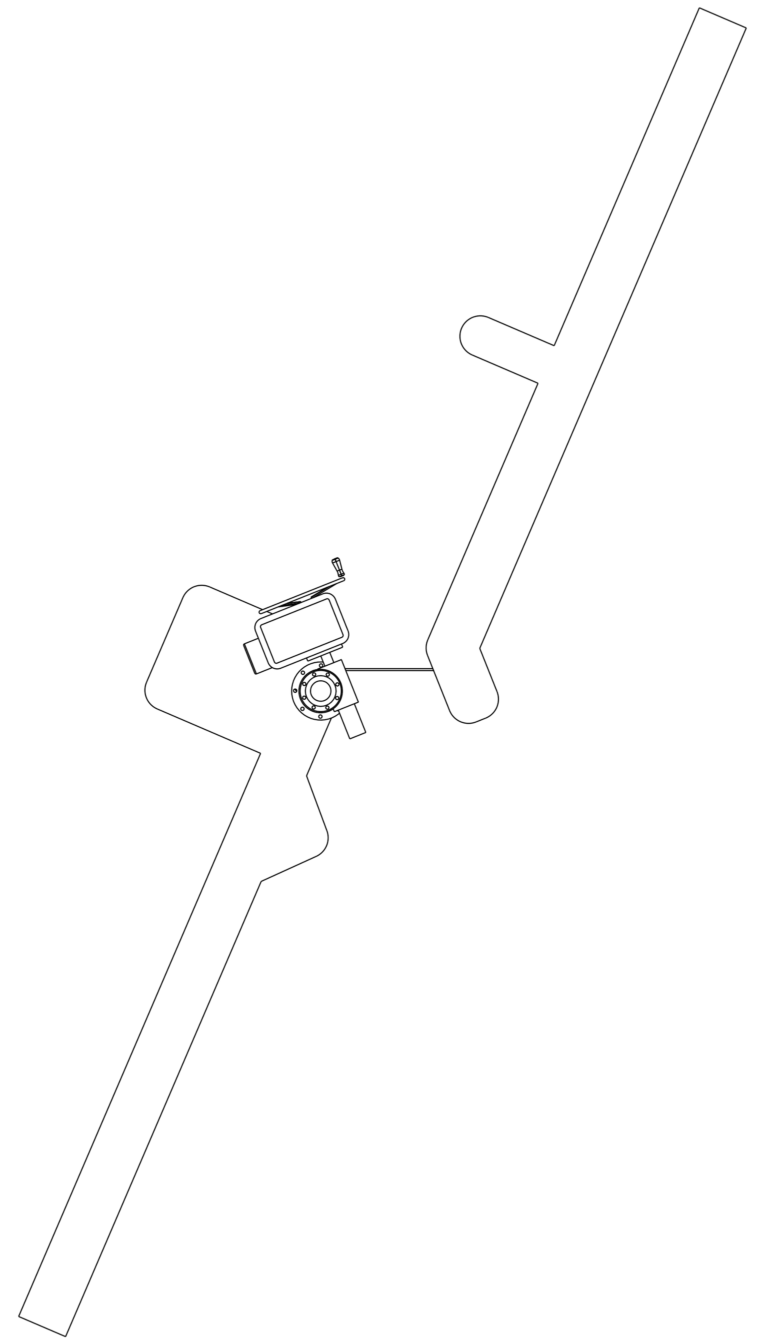
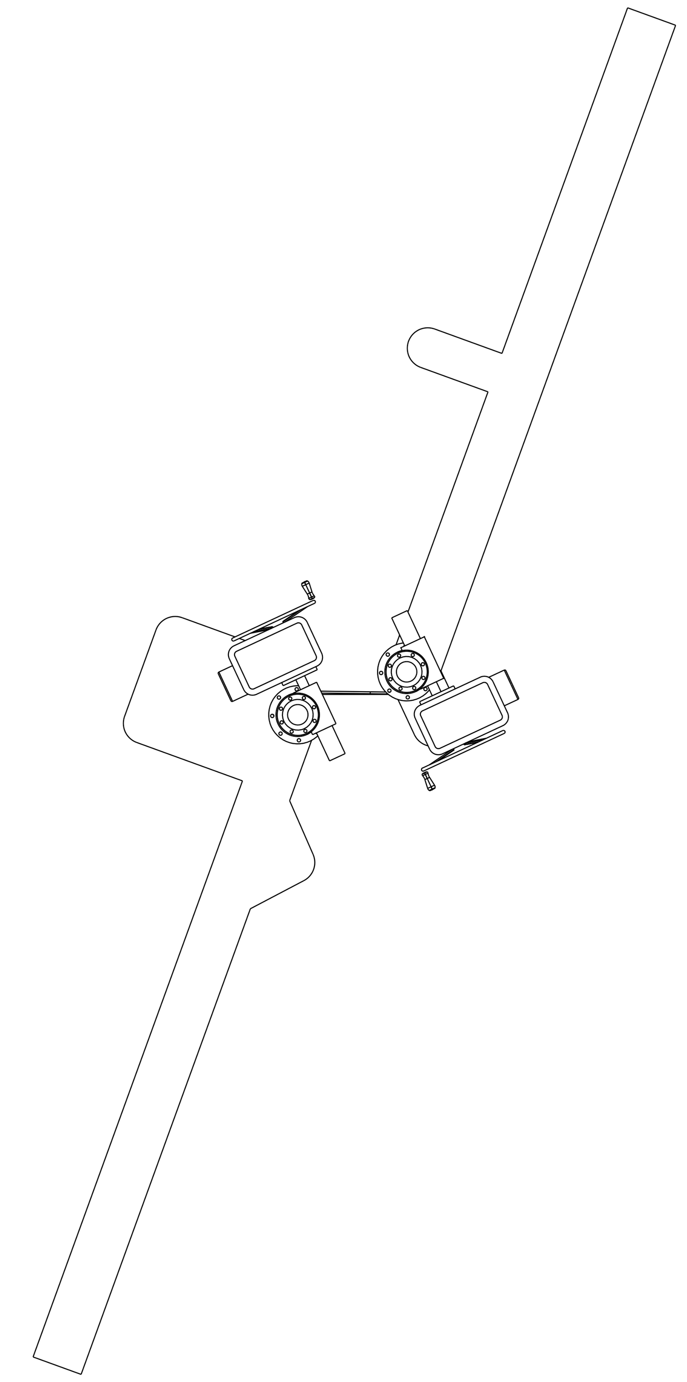
DATE AND TIME PLOTTED: 5/22/2008 10:33:38 AM | BY USERNAME: G2ECDTRS (BATCH PLOT JOB) | SHEET NAME: STANDARD_SHEET

Weir	Lower Sill Gate		Upper Sill Gate			
	Gate Width (ft)	Gate Height (ft)	Gate Width (ft)	Gate Height (ft)	Stem width (ft)	Number of Controls
1	Weir 1 has no Sill Gate - 1.50 ft wide slot					none
2	1.50	1.00	---	---	---	one
3	1.50	1.00	---	---	---	one
4	1.25	1.00	---	---	---	one
5	1.25	1.00	---	---	---	one
6	1.25	1.00	---	---	---	one
7	1.25	1.00	---	---	---	one
8	1.25	1.00	---	---	---	one
9	1.25	1.00	1.25	1.75	---	two
10	1.25	1.00	1.25	2.25	---	two
11	1.25	1.00	1.25	2.50	---	two
12	1.25	1.00	1.25	2.75	---	two
13	1.25	1.00	1.25	3.00	---	two
14	1.25	1.00	1.25	3.25	---	two
15	1.25	1.00	1.25	3.50	---	two
16	1.25	1.00	1.25	3.75	---	two
17	1.25	1.00	1.25	4.00	---	two



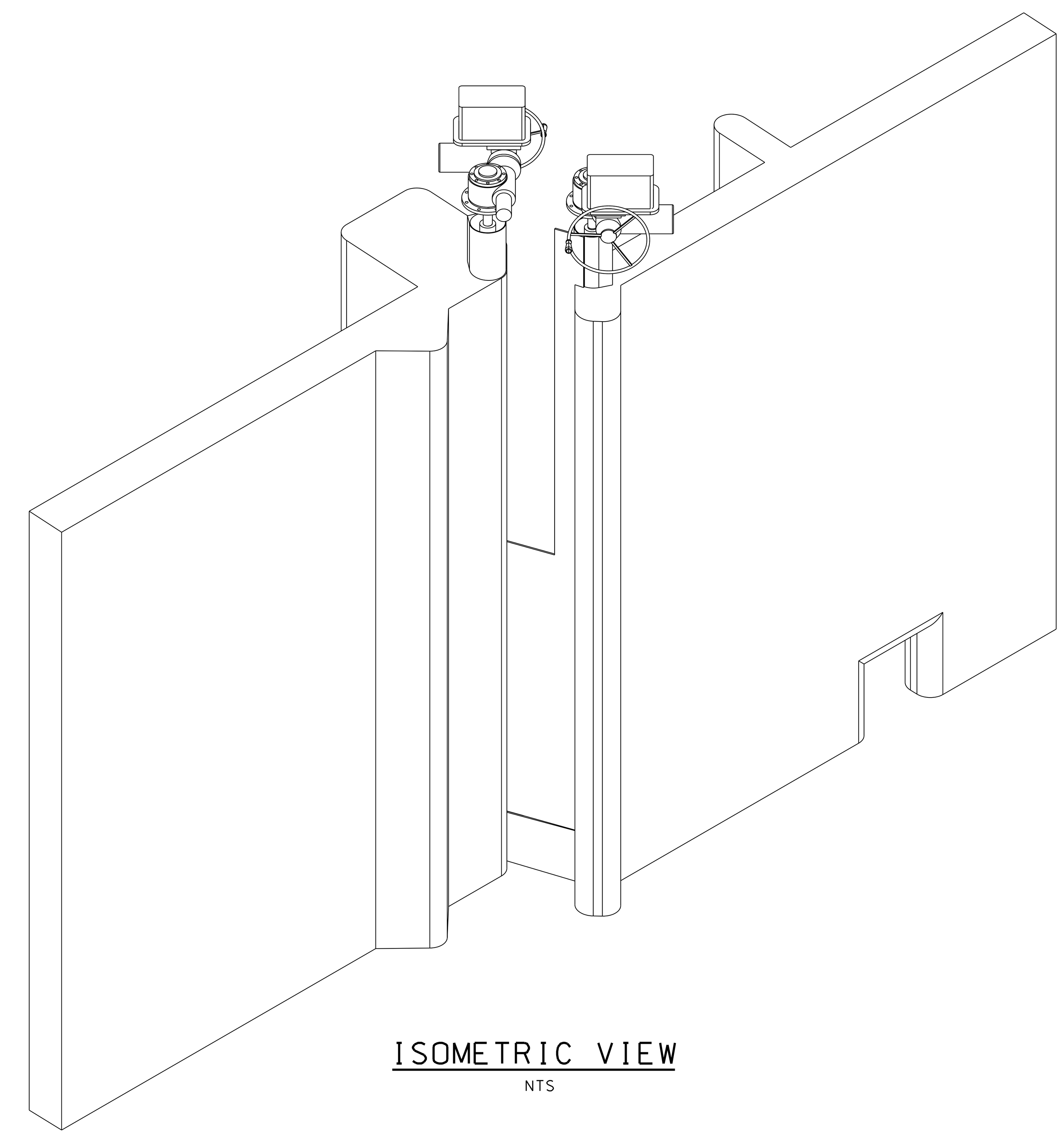
FLOW CONTROL SECTION WEIRS 1-8

SCALE: 3/8" = 1'-0"



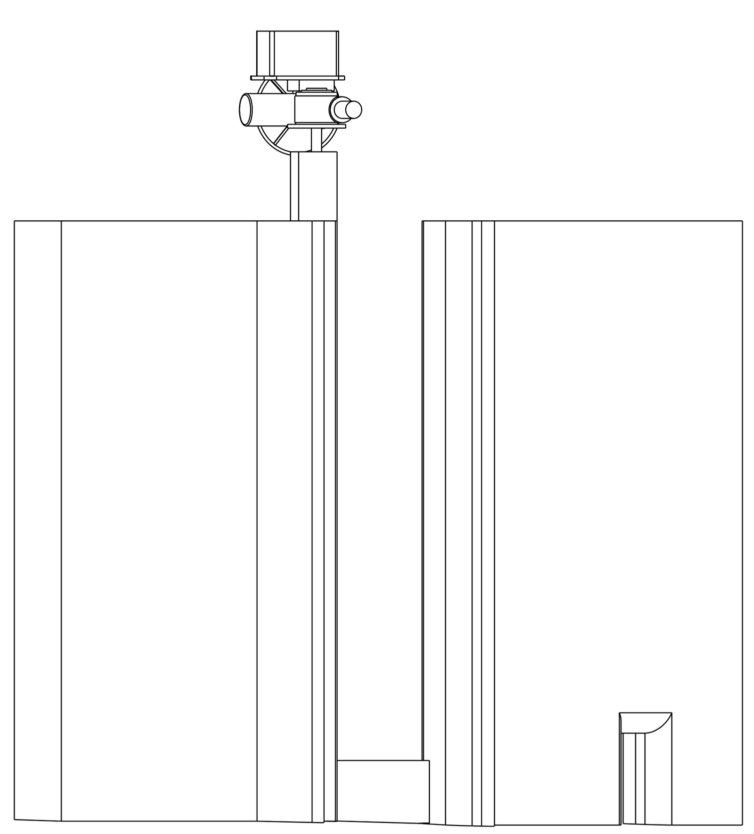
FLOW CONTROL SECTION WEIRS 9-17

SCALE: 3/8" = 1'-0"



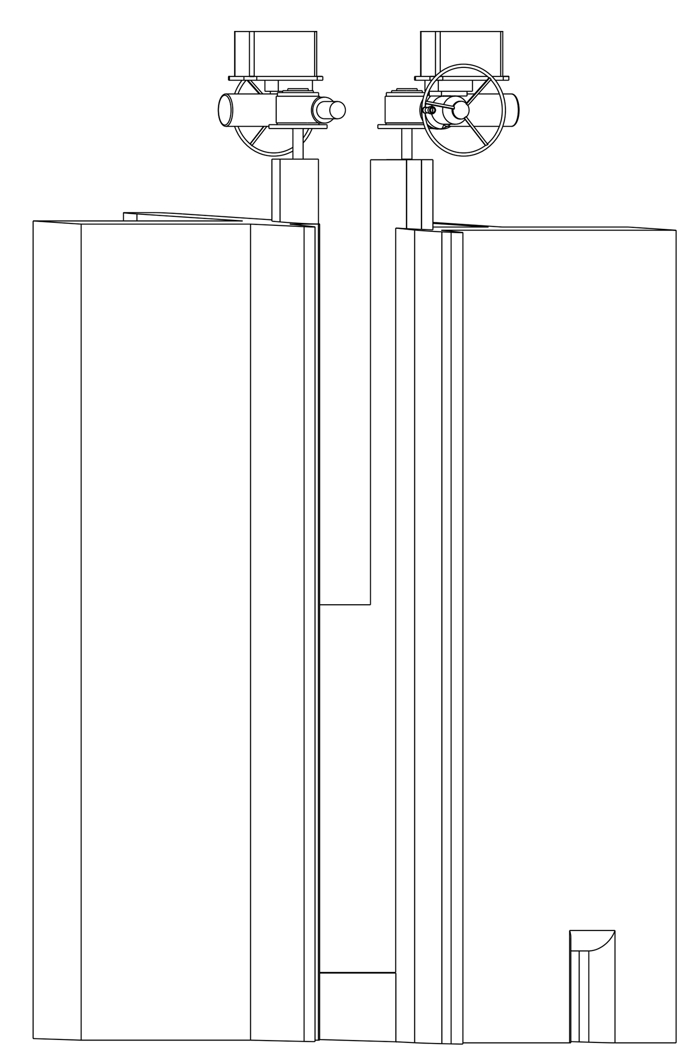
ISOMETRIC VIEW

NTS



FLOW CONTROL SECTION WEIRS 1-8

SCALE: 3/8" = 1'-0"



FLOW CONTROL SECTION WEIRS 9-17

SCALE: 3/8" = 1'-0"

SCALE: 3/8" = 1'-0"
12" 0 2' 4' 6'

NOTES:

1. NOTES: SEE TABLE 1 FOR ACTUAL DIMENSIONS OF EACH SILL GATE. VIEWS SHOWN HAVE BEEN ROTATED TO VIEW THE SILL GATES.

2. ALL JOINTS, WELDS, EDGES, ETC. THAT FISH MAY COME INTO CONTACT WITH SHALL BE GROUND FLUSH AND SMOOTH.

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DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

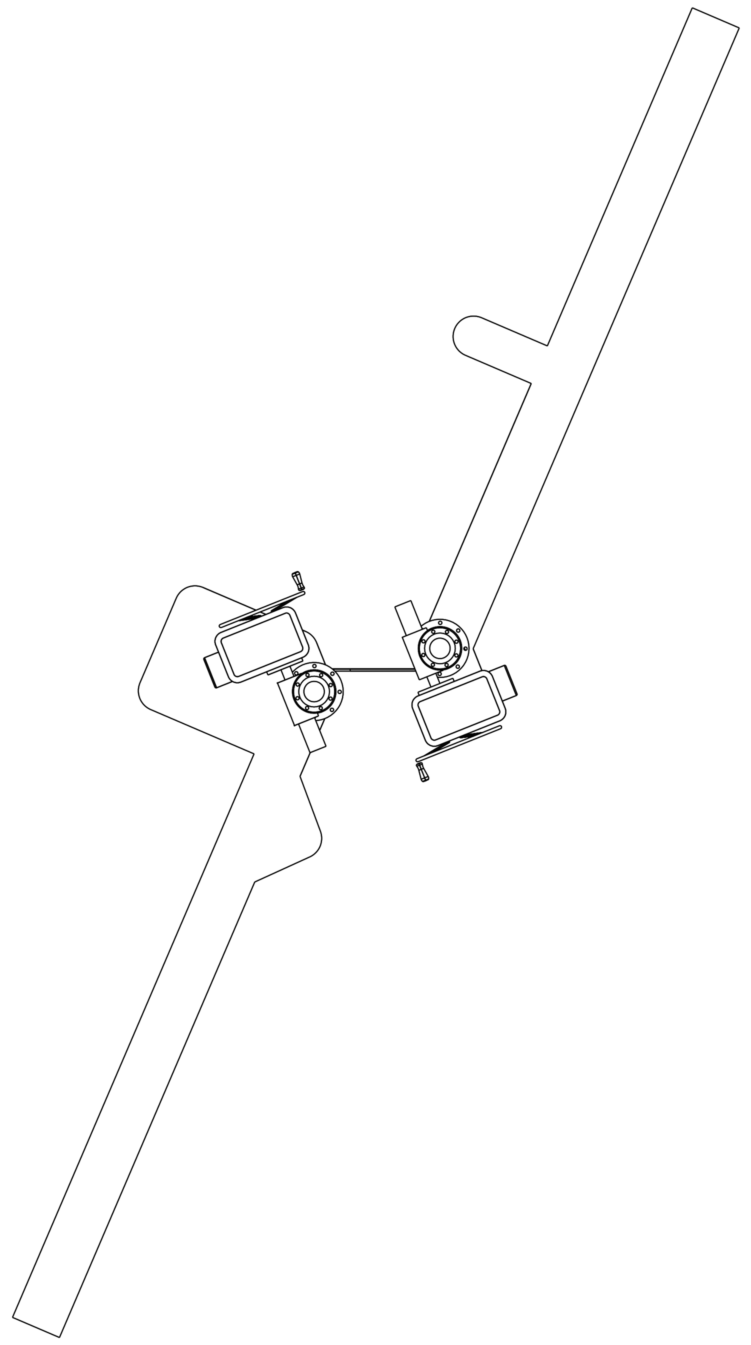
PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

SHEET IDENTIFICATION
22
SHEET OF

DESIGN FILE: Z:\COLUMBIA\JOHNDAY\NORTH_FISH_LADDER\ADULT_PASSAGE_IMPROVEMENTS\DESIGN_DOCUMENTATION_REPORT\DESIGN_FILES\DRAWINGS\03-MECHANICAL\PLATE 22.DGN

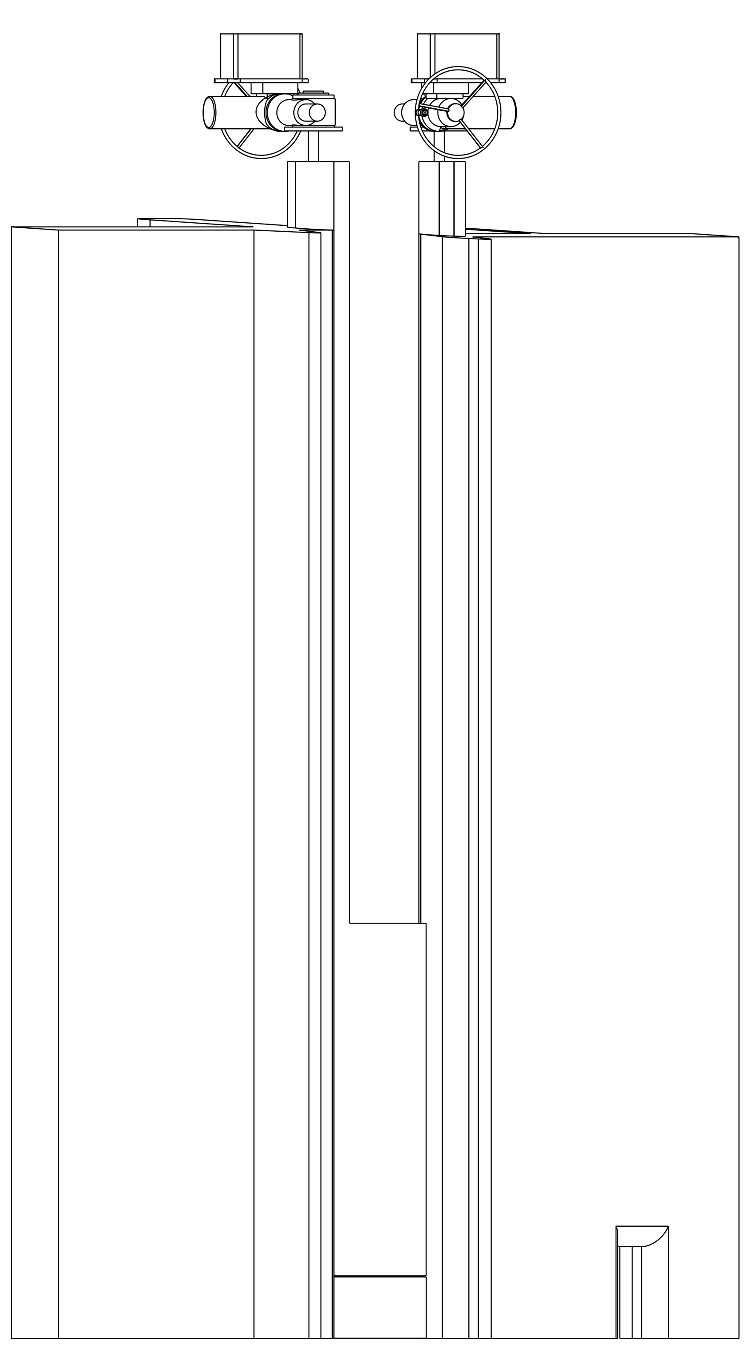
DATE AND TIME PLOTTED: 5/22/2008 10:33:47 AM | BY USERNAME: G2ECDTRS (BATCH PLOT JOB) | SHEET NAME: WEIR SHEET

Weir	Lower Sill Gate		Upper Sill Gate			
	Gate Width (ft)	Gate Height (ft)	Gate Width (ft)	Gate Height (ft)	Stem width (ft)	Number of Controls
18	1.50	1.00	1.25	4.25	0.25	two
19	1.50	1.00	1.25	4.75	0.25	two
20	1.50	1.00	1.25	5.25	0.25	two
21	1.50	1.00	1.25	5.50	0.25	two
22	1.50	1.00	1.25	5.75	0.25	two
23	1.50	1.00	1.25	6.00	0.25	two



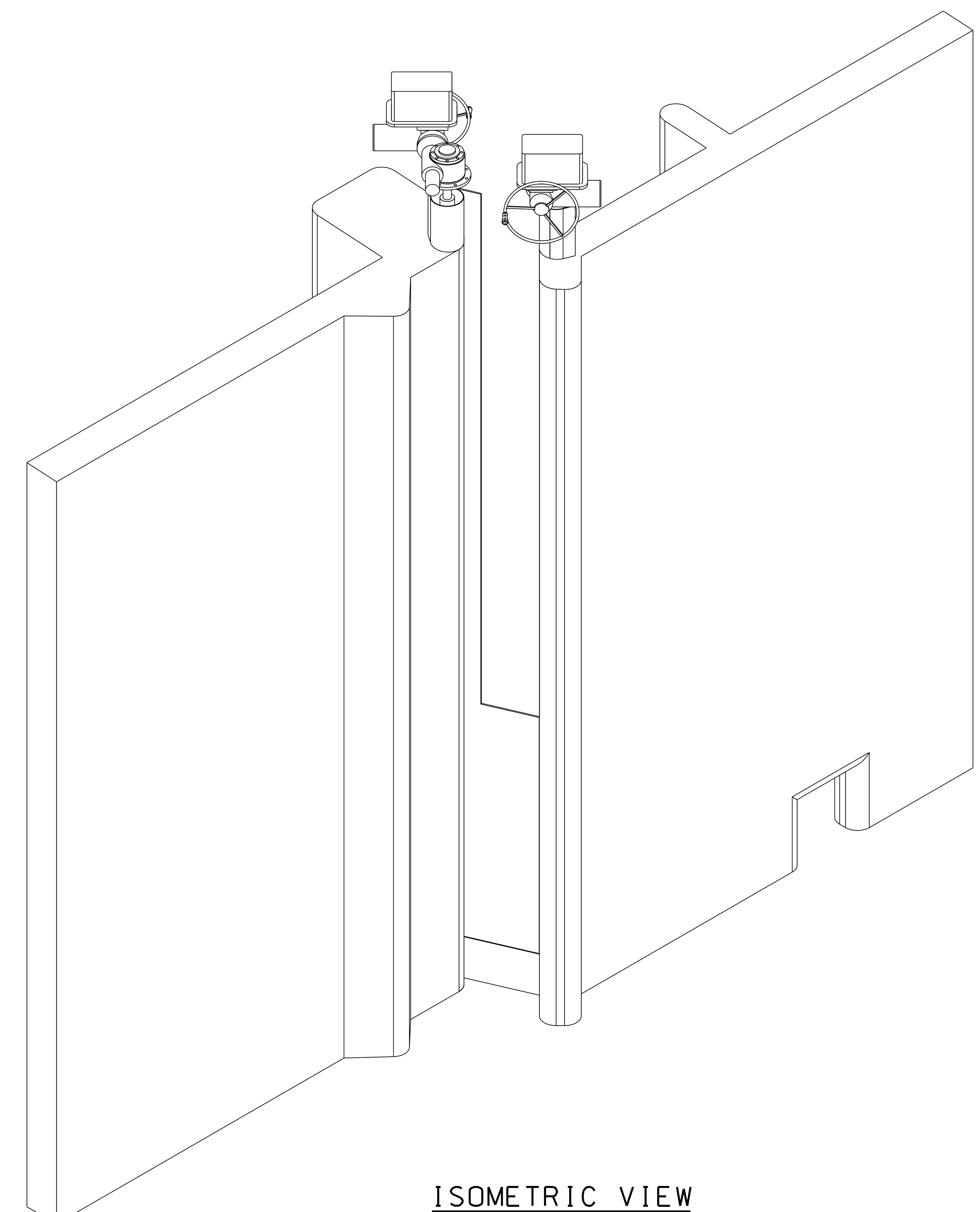
FLOW CONTROL SECTION WEIRS 18-23

SCALE: 3/8"= 1'-0"



FLOW CONTROL SECTION WEIRS 18-23

SCALE: 3/8"= 1'-0"



ISOMETRIC VIEW

NTS

SCALE: 3/8"= 1'-0"

12" 0 2' 4' 6'

NOTES:

1. NOTES: SEE TABLE 1 FOR ACTUAL DIMENSIONS OF EACH SILL GATE. VIEWS SHOWN HAVE BEEN ROTATED TO VIEW THE SILL GATES.

2. ALL JOINTS, WELDS, EDGES, ETC. THAT FISH MAY COME INTO CONTACT WITH SHALL BE GROUND FLUSH AND SMOOTH.

US Army Corps of Engineers® Portland District

60% DDR

MARK | DESCRIPTION | DATE | APPR.

U. S. ARMY CORPS OF ENGINEERS
PORTLAND DISTRICT
PORTLAND, OREGON

DESIGNED BY:
DWN BY: CKD BY:
SUBMITTED BY:
PLOT SCALE: 1:1 PLOT DATE: 5/22/2008
SIZE: ANSI-D FILE NAME: Plate 23.dgn

DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

SHEET IDENTIFICATION
23
SHEET OF

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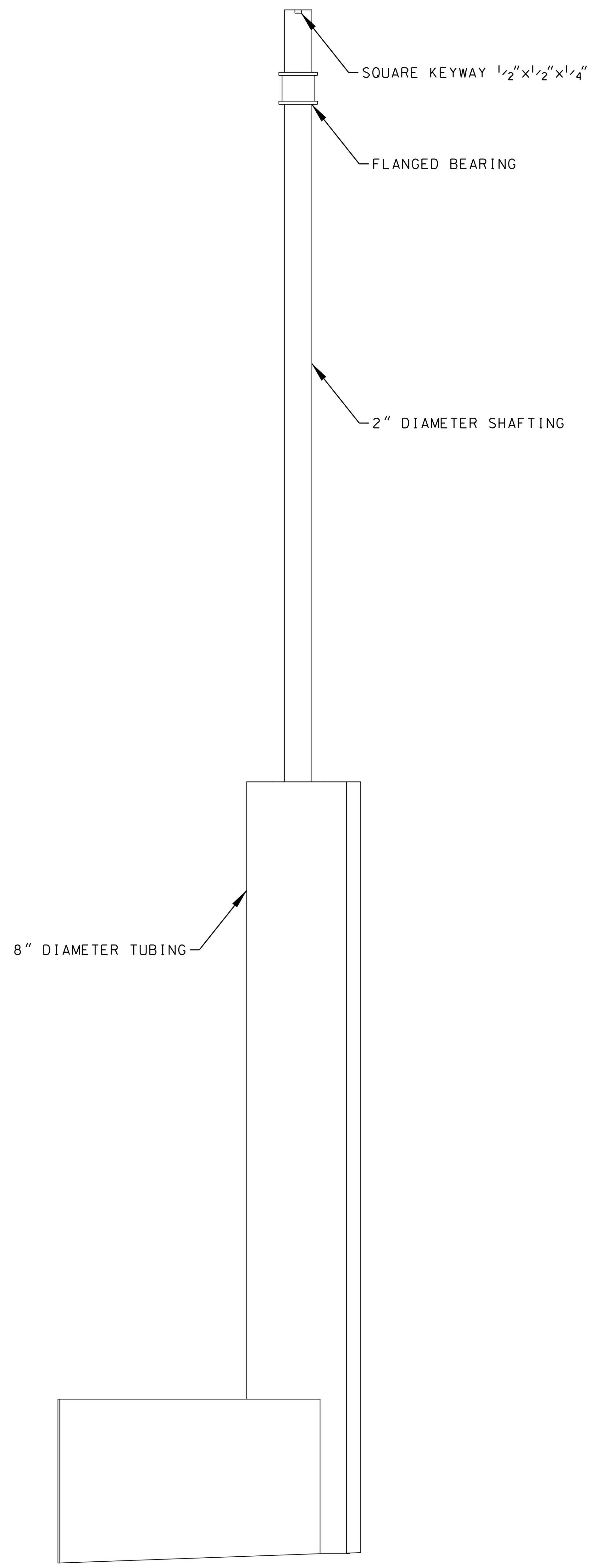
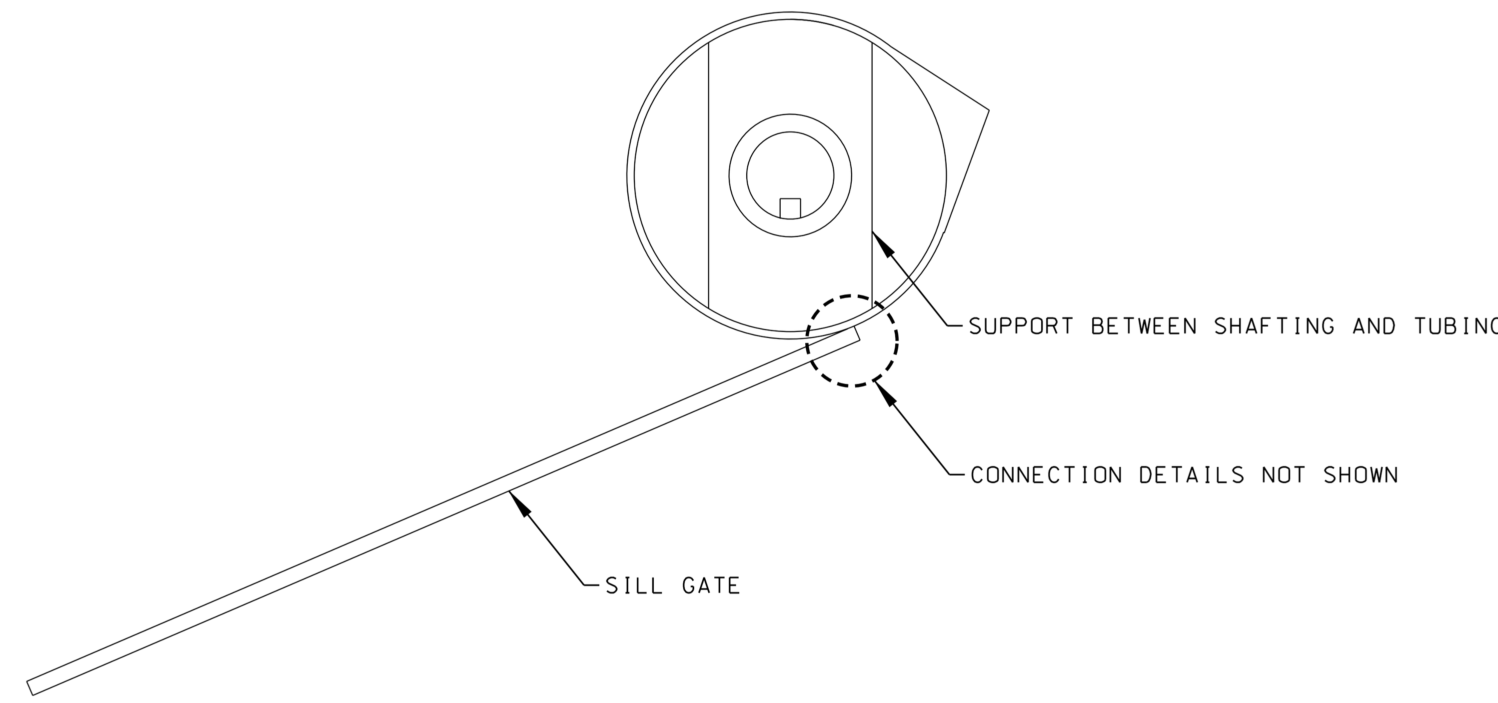
DATE AND TIME PLOTTED: 5/22/2008 10:33:56 AM | BY USERNAME: G2ECDTRS (BATCH PLOT JOB) | SHEET NAME: WEIR SHEET



SILL GATE SHAFT

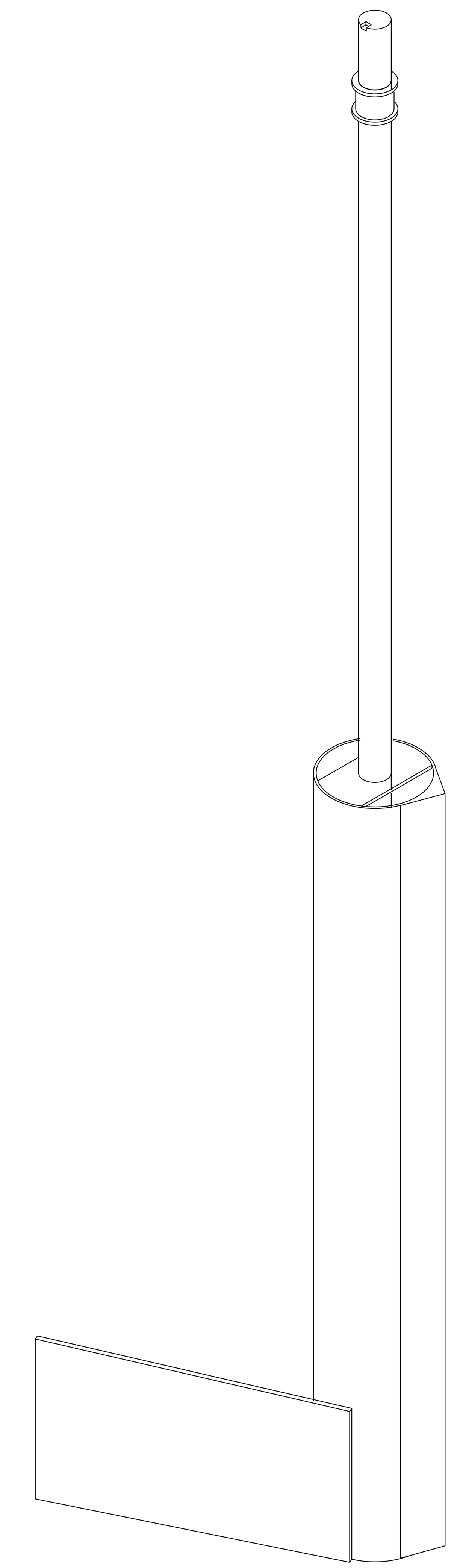
SCALE: 1 1/2"= 1'-0"

NOTE: SEE TABLE 2 FOR HEIGHT OF SHAFTING AND TUBING



TOP VIEW OF SILL GATE SHAFT

SCALE: 3"= 1'-0"



ISOMETRIC VIEW

NTS

NOTES:

1. NOTES: SEE TABLE 1 FOR ACTUAL DIMENSIONS OF EACH SILL GATE. VIEWS SHOWN HAVE BEEN ROTATED TO VIEW THE SILL GATES.

2. ALL JOINTS, WELDS, EDGES, ETC. THAT FISH MAY COME INTO CONTACT WITH SHALL BE GROUND FLUSH AND SMOOTH.

SCALE: 1 1/2"= 1'-0"

12" 9" 6" 3" 0 1'

SCALE: 3"= 1'-0"

0 3" 6" 12"

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Portland District

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MARK	DESCRIPTION	DATE	APPR.

U. S. ARMY CORPS OF ENGINEERS
PORTLAND DISTRICT
PORTLAND, OREGON

DESIGNED BY:
DWN BY:
CKD BY:
SUBMITTED BY:
PLOT SCALE: 1:1
PLOT DATE: 5/22/2008
SIZE: ANSI-D
FILE NAME: Plate 24.dgn
DATE: ISSUE DATE
SOLICITATION NO.: W9127N-07-B-####
CONTRACT NO.: CONTRACT NUMBER
DRAWING NUMBER:

PROJECT TITLE LINE1
PROJECT TITLE LINE 2
PROJECT TITLE LINE 3
PROJECT TITLE LINE 4

SHEET IDENTIFICATION
24
SHEET OF

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DATE AND TIME PLOTTED: 5/22/2008 10:34:04 AM

BY USERNAME: G2ECDTRS (BATCH PLOT JOB)

SHEET NAME: WEIR SHEET