US Army Corps
of Engineers
Portland District

DESIGN DOCUMENTATION REPORT NO. 24

COUGAR DAM DOWNSTREAM FISH PASSAGE
WILLAMETTE RIVER BASIN
SOUTH FORK MCKENZIE RIVER, OREGON

COUGAR DAM DOWNSTREAM FISH PASSAGE

31 October 2018 **90% DRAFT**

EXECUTIVE SUMMARY

1. INTRODUCTION

This Design Documentation Report (DDR) presents the features for the proposed downstream fish passage project on the South Fork of the McKenzie River at Cougar Dam Reservoir (Cougar). The main feature of the Cougar downstream fish passage project is a floating screen structure (FSS) designed to collect, hold, and transport juvenile fish, specifically spring Chinook salmon, downstream of the dam.

2. PURPOSE

The purpose of the Cougar downstream fish passage facility is to collect juvenile spring Chinook from the forebay of Cougar Reservoir. The 2008 Willamette Project Biological Opinion Reasonable and Prudent Alternative (RPA) requires the design, construction, and operation of a downstream fish passage system.

The purpose of this DDR is to provide the technical basis for plans and specifications, determine the estimated cost of the project, and document the final design for construction of the Cougar downstream juvenile fish passage facility.

3. LOCATION

The Cougar downstream juvenile fish passage facility is located in the cul-de-sac of the Cougar Reservoir forebay, adjacent to the water temperature control tower.

4. DESCRIPTION OF FACILITY

The fish passage facility has the following major features, which are described in general in Section 1 and in detail in other sections:

- Floating screen structure to collect and hold fish.
- Modifications to the water temperature control tower.
- Mooring structures and connections.
- Downstream fish transport system.
- Retaining wall and excavation.
- Crew access.
- Debris management.

5. CONSTRUCTION ACCESS

The dam is accessible via NF-410 off Highway 126. Assembly of the FSS is to take place at Slide Creek Campground and boat ramp, located on the south end of Cougar Reservoir (Note: The Product Development Team is also evaluating the North Sunnyside site for assembly). Assembly will likely occur on a level pad located at an elevation allowing the FSS to float when the reservoir refills in the spring.

6. CONSTRUCTION SCHEDULE

The construction duration is approximately 30 months. Construction is scheduled to begin in July of 2020 and be completed in December of 2022. A deep drawdown at Cougar Reservoir is scheduled for the entire calendar year of 2021. One construction contract will be used for the construction of the Cougar downstream fish passage project.

7. COST

The estimated cost of this project is $150 million for design and construction. The construction contract is estimated to cost $120 million.

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PERTINENT DATA FOR COUGAR PROJECT

Date Completed	1963
River Mile/Stream	4.4 on South Fork McKenzie River
Drainage Area (square miles)	208
Dam Height (feet)	452
Dam Crest El. (feet**)	1,705.0
Maximum/Full Pool El. for maximum flood control operations (storage)	1,699.0 feet (200,000 acre-feet)
Maximum Conservation Pool El. (storage)	1,690.0 feet (189,000 acre-feet)
Spillway Crest El. (storage)	1,656.8 feet (151,200 acre-feet)
Minimum Forebay El. for WTCT Operation	1571.0 feet***
Minimum Conservation Pool El. (storage)	1,532.0 feet (52,200 acre-feet)
Minimum Power Pool El. (storage)	1,516.0 feet (43,500 acre-feet)
Standard Project Flood Tailwater El.	1270.5 feet (includes full use of spillway for Standard Project Flood)
Normal Maximum Tailwater El.	1258.0 feet (for normal maximum discharge through powerhouse and regulating outlet of 6,500 cfs)
Minimum Tailwater El.	1252.4 feet (at minimum powerhouse outflow)
Turbines	Two 12.5 MW Francis (650-1,100 cfs combined hydraulic capacity)*
Spillway	Two radial Tainter gates (76,140 cfs combined hydraulic capacity)
Regulating Outlets (RO)	Two (12,050 cfs combined hydraulic capacity. See table below)

	Min Q (cfs)	Max Q (cfs)	Min Q (cfs)	Max Q (cfs)
Reservoir El. (ft)	1532	1532	1690	1690
Single unit Operation				
1 x Turbine	335	550	325	450
Single RO Gate Operation				
1 x RO at minimum gate opening (1.25 ft)	320		710	
1 x RO at maximum gate opening (12.5 ft)		3000		5800
Double Unit Operation				
2 x Turbine	670	1100	650	900
Double RO Gate Operation				
2 x RO at minimum gate opening (1.25 ft)	640		1420	
2 x RO at maximum gate opening (12.5 ft)				11800

* Flow rates depend on the height of the pool

** All elevations in this report are in feet Mean Sea Level NGVD29

*** This is a conservative elevation. In recent years the Cougar WTC weirs have been operated when the reservoir was as low as elevation 1,564 feet.

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ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ABS	American Bureau of Shipping
A-E	Architect-Engineer
AFD	adult fish and debris (collection tank)
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASTM	American Society for Testing Materials
AV	amphibious vehicle
AWS	American Welding Society
AWWA	American Water Works Association
BiOp	Biological Opinion
C	Celsius (degrees)
CAD	computer-aided drafting
CFD	computational fluid dynamics
cfs	cubic feet per second
fps	feet per second
DC	direct current
DDR	Design Documentation Report
ODEQ	Oregon State Department of Environmental Quality
DM	Design Memorandum
DSAC	Dam Safety Action Classification
EC	Engineering Circular
EIS	Environmental Impact Statement
EM	Engineering Manual
EPA	Environmental Protection Agency
ER	Engineering Regulation
ESA	Endangered Species Act
ETL	Engineering Technical Letter
FBG	floating bulkhead gate
FCE	fish collection efficiency
fps	feet per second
FSS	Floating Screen Structure
FY	Fiscal Year (October 1 through September 30)
GBR	Geotechnical Baseline Report (2005)
GHS	General Hydrostatics (model)
gp	poorly-graded gravel
gpm	gallons per minute
HEC	Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center River Analysis System
HGMP	Hatchery Genetic Management Plan
HMI	human-machine interface
hp	horsepower
HVAC	heating, ventilation, and air conditioning
IES	Issues Evaluation Study
IMAC	integrated monitoring, alarm and control system
IRRM	Interim Risk Reduction Measure

kip	1000 pounds-force
ksf	kips per square foot
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt hour
lb	pound
LED	light-emitting diode
MDE	maximum design earthquake
mm	millimeter
mph	miles per hour
MW	megawatt
Mwh	megawatt hour
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NGVD29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OBE	operating basis earthquake
ODFW	Oregon Department of Fish and Wildlife
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
PDT	Product Development Team
PFMA	Potential Failure Mode Analysis
PGA	peak ground acceleration
PLC	programmable logic controller
psf	pounds per square foot
psi	pounds per square inch
RFI	Request for Information
RO	regulating outlet
RMC	USACE Risk Management Center
RQD	rock quality designation
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
UHRS	uniform hazard response spectra
UPS	uninterrupted power supply
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWILD	Underwater Inspection in Lieu of Drydocking
V	volt
WTCT	water temperature control tower

SECTION 1 - PURPOSE AND INTRODUCTION

1.1 SCOPE AND PURPOSE

This Design Documentation Report (DDR) presents the technical details of the main features of the proposed downstream fish passage project at Cougar Dam and Reservoir (Cougar) on the South Fork of the McKenzie River in the Willamette River Basin of Oregon, in Portland District, U.S. Army Corps of Engineers (USACE). The main feature of the project is the floating screen structure (FSS).

The main elements of the proposed project at Cougar Dam are the following:

- An FSS to safely collect and hold fish from Cougar Reservoir.
- Modifications to the water temperature control tower (WTCT).
- A mooring plan for securing the FSS.
- A system to transport collected fish from Cougar Reservoir to the South Fork of the McKenzie River downstream of Cougar Dam.
- A retaining wall and excavation to allow the FSS to operate at low pool elevations.
- A crew access plan.
- A debris management plan.

The purpose of the proposed project is to provide a fish passage facility that meets National Marine Fisheries Service (NMFS) criteria for downstream passage of Endangered Species Act (ESA) listed fish. The 2008 Willamette Project Biological Opinion Reasonable and Prudent Alternative (RPA) 4.12.1 requires the design, construction, and operation of a downstream fish passage system. The parameters used to establish the design criteria for the FSS and system to transport collected fish pertain specifically to juvenile spring Chinook salmon. However, the facility will be designed to allow other fish species to enter, be safely held, and be transported. This DDR describes proposed construction work at Cougar Dam for the FSS projected for calendar years 2020, 2021, and 2022.

1.2 AUTHORIZATION

The Willamette Valley Project, of which Cougar Dam is a part, was authorized principally by three separate successive Flood Control Acts: 1938, 1950, and 1960. House Document 531, authorized by the Flood Control Act of May 17, 1950 (81st Congress, 2nd Session) remains the overall guiding legislation pertaining to operation and maintenance of the project. The Willamette Valley Project was authorized with the full recognition that it would cut off extensive areas of upstream habitat. To compensate, fish hatcheries and other measures were authorized. The Cougar Dam downstream fish passage project is being constructed in order to compensate for the loss of volitional fish passage caused by the construction of Cougar Dam.

1.3 GENERAL PROJECT DESCRIPTION

The Willamette River Basin is located in northwestern Oregon, and is approximately 150 miles long and 75 miles wide. It covers 12 percent of the state, contains extensive, rich agricultural land and forests, and is home to approximately 70 percent of the state's residents. The Willamette basin itself is composed of 11 sub-basins. The Willamette River, as it flows north to the Columbia, is an important tributary, and produces the Upper Willamette River Chinook salmon, one of six lower Columbia River salmon species that have been listed as Threatened by the NMFS under the ESA. Salmon runs in the Columbia and Willamette basins have enormous historical, economic, and cultural significance. Figure 1-1 is a vicinity map depicting the McKenzie Sub-Basin and the location of Cougar Dam within the McKenzie Sub-Basin. During the last 50 years, 13 USACE reservoirs have been constructed in the basin for a variety of purposes, including flood damage reduction, power generation, and supply of water for irrigation and recreation. Cougar Dam was placed into operation primarily for flood risk management as a unit of the Willamette Valley system of reservoirs (Willamette Valley Project). Besides flood damage reduction, its purposes include power generation, water supply for irrigation and municipal and industrial use, navigation, fish and wildlife, water quality, and recreation. The project controls runoff from a drainage area of 210 square miles of mountainous and timbered land.

The main features at the project include an embankment dam, concrete gated spillway, water temperature control tower (WTCT), regulating outlet works, hydropower facilities, and diversion tunnel. The WTCT, which is integral to the design of the FSS, is described in the two paragraphs below.

The 302-foot-high WTCT was constructed adjoining the original intake tower and began operation in May 2005. The WTCT is capable of selectively withdrawing water from different reservoir elevations to meet target outflow water temperatures, providing more natural conditions for salmonids in the South Fork and mainstem McKenzie rivers. The original intake tower includes a dry well (with operating equipment, stairs, and elevator), dual regulating outlet (RO) conduits, debris collection structure (trashrack), and access bridge. The original intake tower was modified for water temperature control through addition of a wet well with nine adjustable weir gates for selective withdrawal and lower RO and penstock bypass gates. The WTCT wet well serves both the power generating facilities and the RO works.

The selective withdrawal gates for temperature control consist of nine 9-foot-wide by 47-foot-tall independently telescoping weirs. Six are located upstream of the ROs and three are located upstream of the penstock. The RO bypass gates consist of two 9-foot-wide by 27-foot-high gated openings at centerline elevation 1,488.5 feet that pass water into the lower portion of the WTCT tower wet well. The penstock bypass gate is a 9-foot-wide by 19-foot-high gated opening that passes water into the lower portion of the WTCT wet well.

Cougar Dam has a current Dam Safety Action Classification (DSAC) of 2, which means there is high urgency for action. The DSAC system is described in ER 1110-2-1156, Safety of Dams – Policy and Procedures. A Phase 2 Issue Evaluation Study is underway to refine understandings of risk-driving potential failure modes. Section 10.4.c of this DDR includes a description of the dam safety issues.

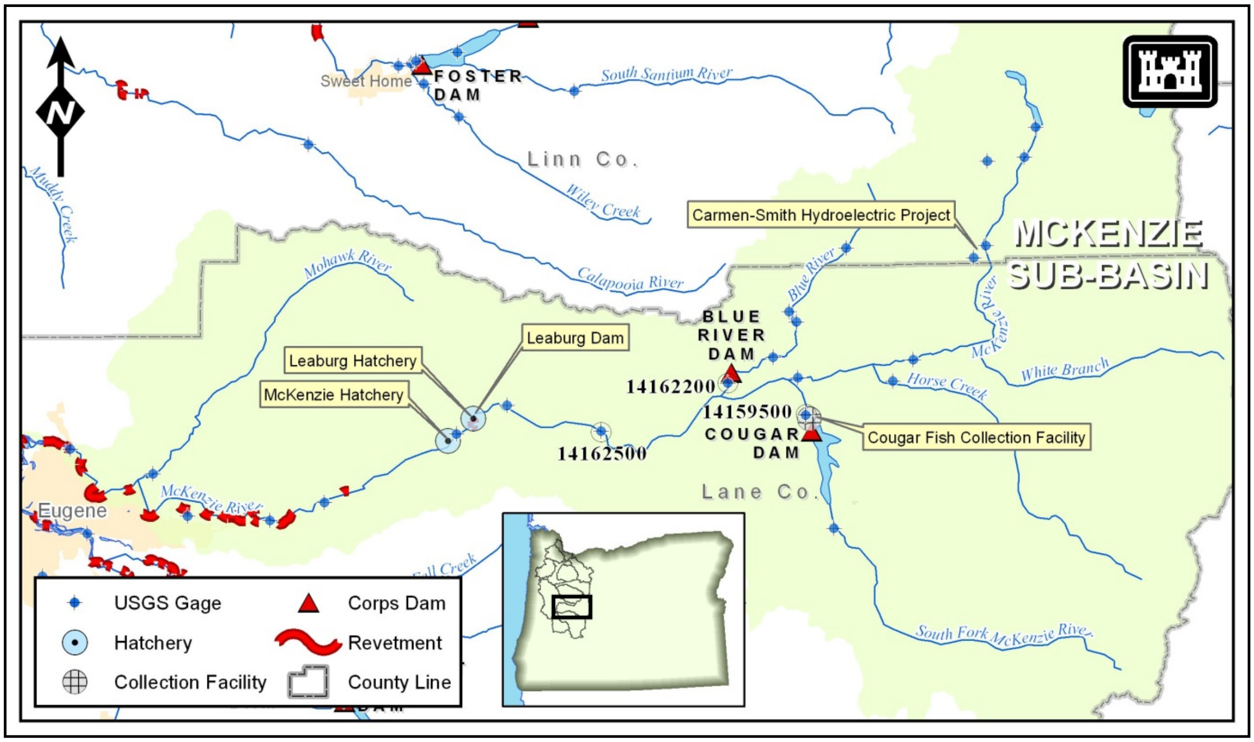

Figure 1-1. Vicinity Map

The proposed FSS, which will be described more below, is located in the cul-de-sac of the reservoir at the WTCT. The downstream release site is co-located with the Adult Fish Collection Facility, downstream of Cougar Dam. Construction of the FSS is at Slide Creek Campground, located on the southern end of Cougar Reservoir. Figure 1-2 is a location map providing an overview of the site. The red line on the location map is the main access road.

All elevations in this report are in National Geodetic Vertical Datum of 1929 (NGVD29), unless otherwise stated. This is the datum used for the Cougar Dam project.

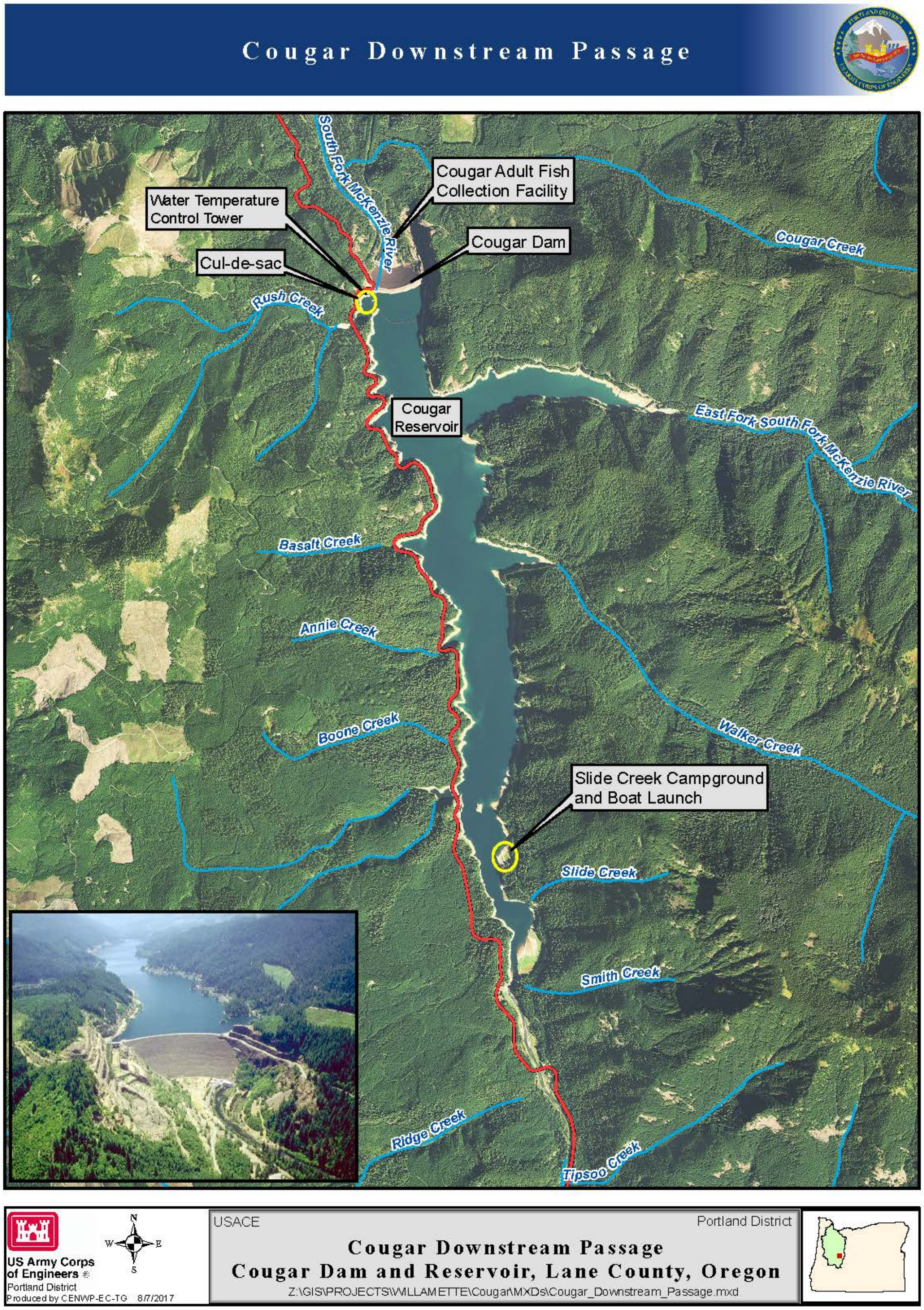

Figure 1-2. Site Map History

1.4 COORDINATION WITH OTHERS

Design and construction activities are being fully coordinated with Bonneville Power Administration (BPA), NMFS, Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), U.S Forest Service (USFS), Oregon Department of Environmental Quality (ODEQ), the Oregon State Historic Preservation Office, and will be coordinated with other agencies as appropriate in the future. Government to government consultation and coordination has also been initiated with the Confederated Tribes of Grand Ronde, the Confederated Tribes of Siletz Indians, and the Confederated Tribes of Warm Springs.

1.5 DOWNSTREAM FISH PASSAGE DESIGN

An Engineering Documentation Report (EDR) concluded that passage of fish downstream of Cougar Dam would be best accomplished through the use of a floating screen structure (FSS) and truck transport. In the EDR phase, a multi-discipline Product Development Team (PDT) evaluated six structural alternatives and five operational alternatives. The following advantages were identified for the gravity-fed FSS:

- Maintains current operational flows.
- Maintains temperature operations and conditions in the forebay (cul-de-sac).
- Minimizes extent of mechanical/powered equipment required and associated operations and maintenance (O&M).
- Maximizes flexibility for future improvements if needed, including transport options.
- Position at the dam allows for ease of access,
- Minimizes risks for false attraction (pump discharge and competing flows),

The DDR PDT has the task of determining how best to design the FSS within the following high-level criteria and constraints:

- Use NMFS criteria and achieve Chinook salmon population replacement.
- Do not negatively impact the dam project's flood risk reduction and hydropower missions.
- Do not increase dam safety risk.
- Meet the dam project's water temperature control targets.
- The FSS must operate over the normal pool elevation range, from minimum flood control pool (1,532 feet) to maximum conservation pool (1,690 feet). To accommodate pool fluctuations around minimum flood control pool, the minimum operating elevation will be 1,528 feet. The FSS must survive over the full pool elevation range, from minimum power pool (1,516 feet) to maximum pool (1,699 feet).

In addition to these high-level criteria and constraints, Chapter 3 of the EDR and subsequent chapters in this DDR provide further biological, water quality, hydraulic, structural, mechanical, electrical, civil, geotechnical, environmental, cultural, construction, real estate, and operations and maintenance criteria and constraints.

As listed in paragraph 1.1, the main elements of the downstream fish passage project are the FSS, modifications to the WTCT, mooring configuration, fish transport system, retaining wall and excavation, crew access, and debris management. The following paragraphs discuss options considered and key decisions related to these elements. The selected design includes an FSS with two entrances, located as close to the WTCT as possible, and moored to a truss tower positioned to the east of the WTCT. Fish transport will occur using amphibious vehicles.

a. Floating Screen Structure

A key factor for the FSS is its configuration. The PDT evaluated three main configurations, labelled A1, A2, and A3. The differences among these configurations involve the number of FSS entrances and the location of the entrances within the cul-de-sac.

Configuration A1 is the Single Entrance Inline FSS, which is in line with slot three of the WTCT. The entrance to the FSS is located in the middle of the cul-de-sac. Figure 1-3 depicts configuration A1 hydraulically connected to slot three of the WTCT, showing the cul-de-sac topography.

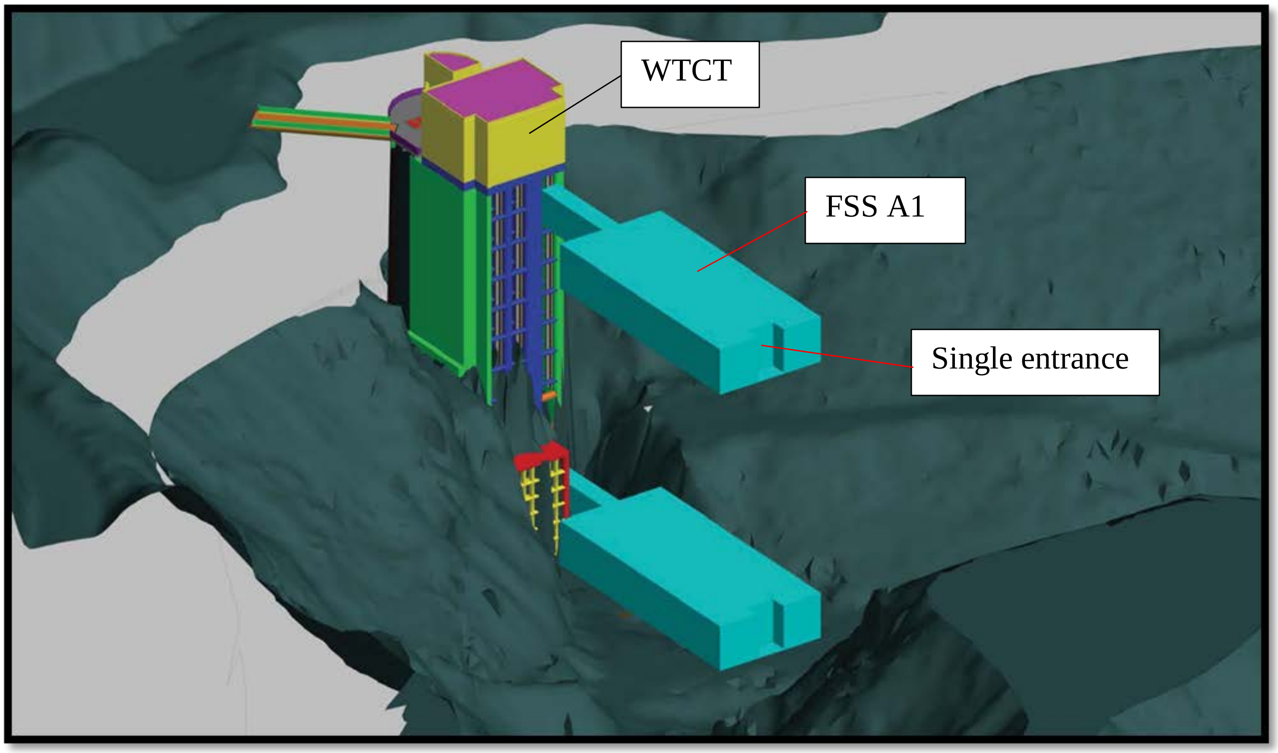

Figure 1-3. Single Entrance In-line Floating Screen Structure

Configuration A2 is the Dual Entrance Angled FSS, which is on the east side of the WTCT. There are two entrances on the Dual Entrance Angled FSS, with the starboard collection channel sized to pass 400 cubic feet per second (cfs) and the port collection channel sized to pass 600 cfs. The entrances to the Dual Entrance Angled FSS are located adjacent to the front of the WTCT. Figure 1-4 depicts configuration A2 hydraulically connected to slot three of the WTCT, showing the cul-de-sac topography.

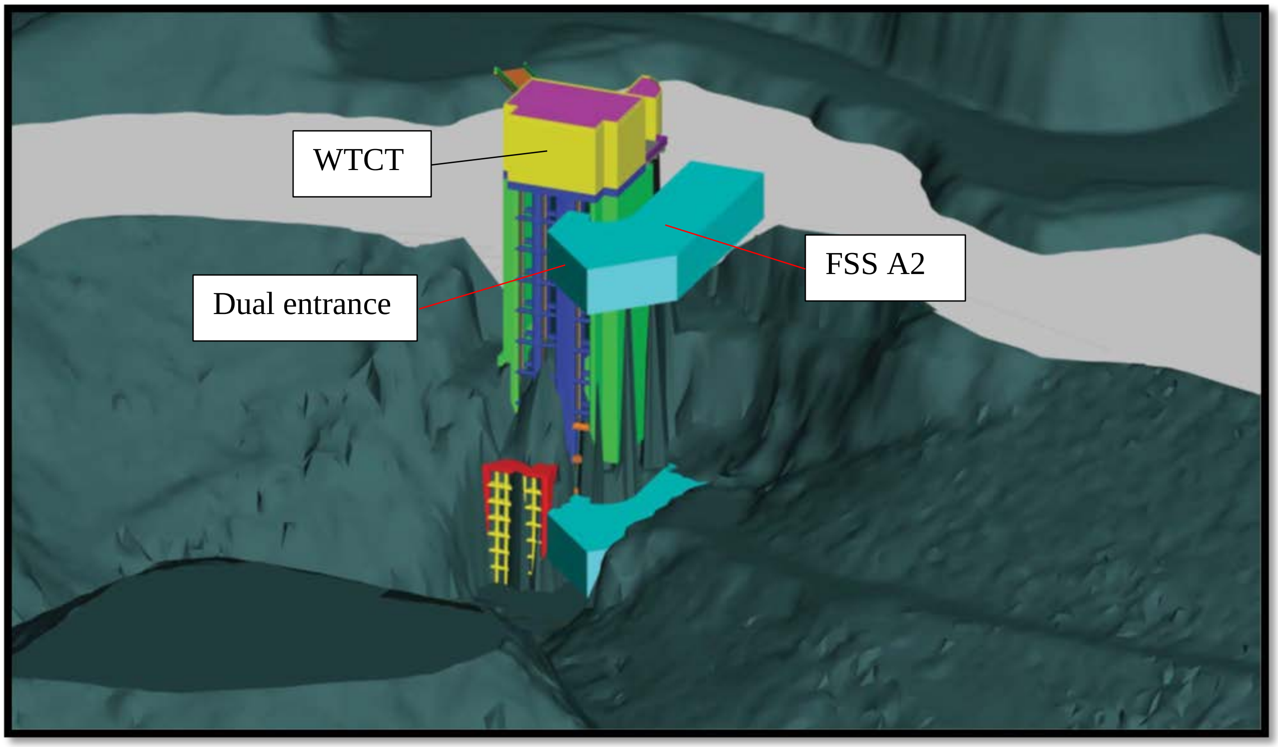

Figure 1-4. Dual Entrance Angled Floating Screen Structure

Configuration A3 is the Dual Entrance Inline FSS, which is in line with slot three of the water temperature control tower (WTCT). There are two entrances on the Dual Entrance Inline FSS with both barrels sized to pass 500 cfs. The entrances to the FSS are located 120 feet into the cul-de-sac. Figure 1-5 depicts configuration A3 hydraulically connected to slot three of the WTCT, showing the cul-de-sac topography.

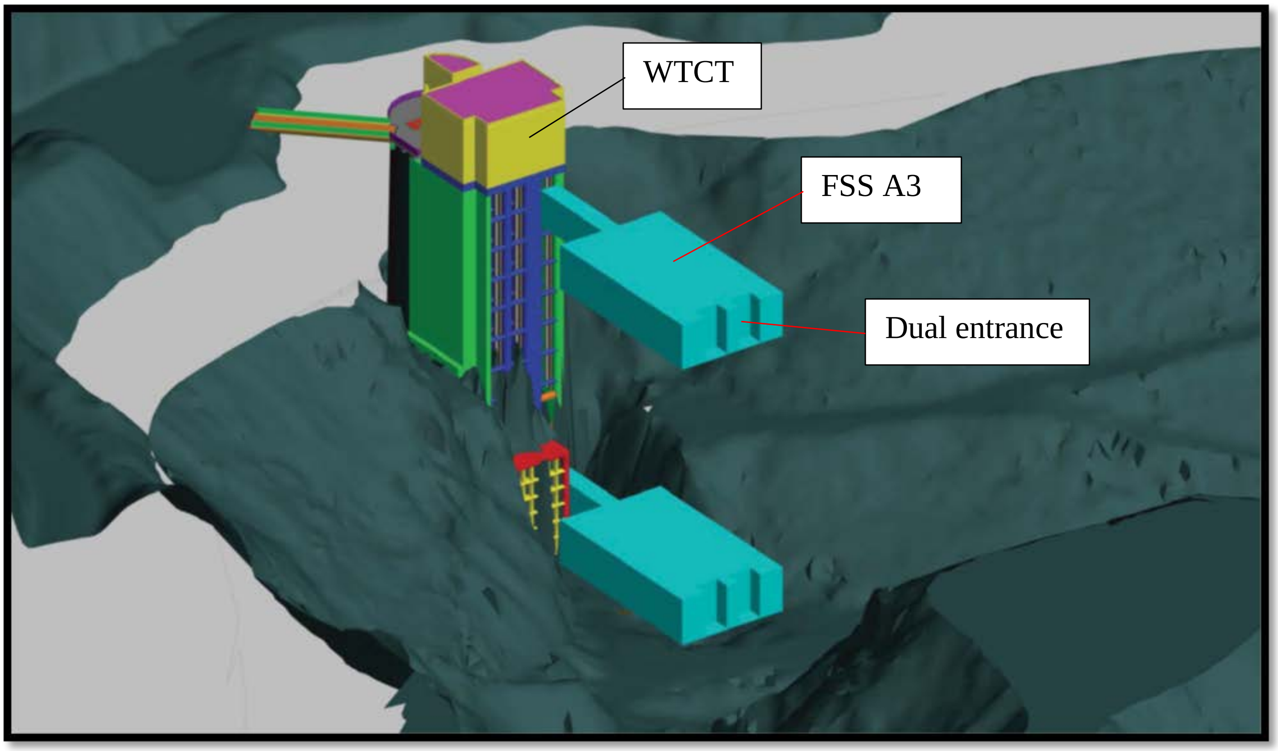

Figure 1-5. Dual Entrance Inline Floating Screen Structure

Configuration A2, Dual Entrance Angled FSS, was selected. It is advantageous to locate the entrance of the FSS as close to the WTCT as possible, as fish are known to congregate directly in front of the WTCT. Including two entrances instead of only one allows for better control of hydraulic conditions over the full range of design flows (300 to 1,000 cfs). The disadvantage of configuration A2 is that a retaining wall and excavation is required for the FSS to fit at lower pool elevations. See Figure 1-6. The retaining wall and excavation is discussed in Section 10, Geotechnical Design. In July 2018, a targeted Potential Failure Modes Analysis (PFMA) was performed to ensure that the retaining wall and excavation does not exacerbate any existing potential failure modes or introduce any new risk-driver potential failure modes. It was decided that the important benefit of locating the FSS entrance as close as possible to the WTCT, to maximize the potential to collect fish, outweighed the disadvantage of requiring a retaining wall and excavation.

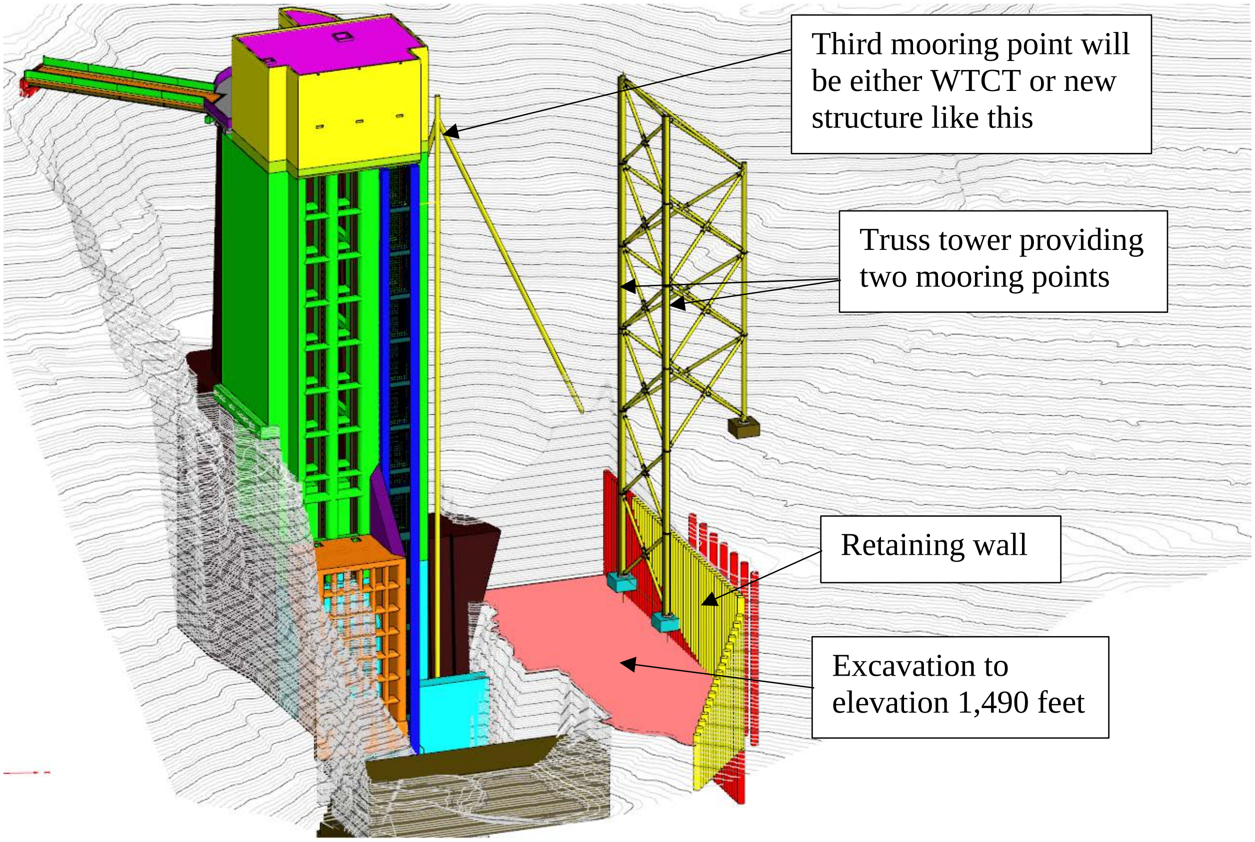

Figure 1-6. Retaining Wall, Excavation, and Mooring Truss Tower Concepts

b. Mooring Configuration

Three mooring configurations were evaluated: M1, M2, and M3.

Configuration M1 is the Stair Tower with Two Battered Dolphins. The stair tower is a 30-foot by 30-foot, 270-foot-tall structure. Each battered dolphin set is a cluster of three 8-foot-diameter piles. Two of the piles are angled and one is vertical. The height of each dolphin is 270 feet. This configuration provides three points of mooring for the FSS. Figure 1-7 depicts the Stair Tower with Two Battered Dolphins configuration.

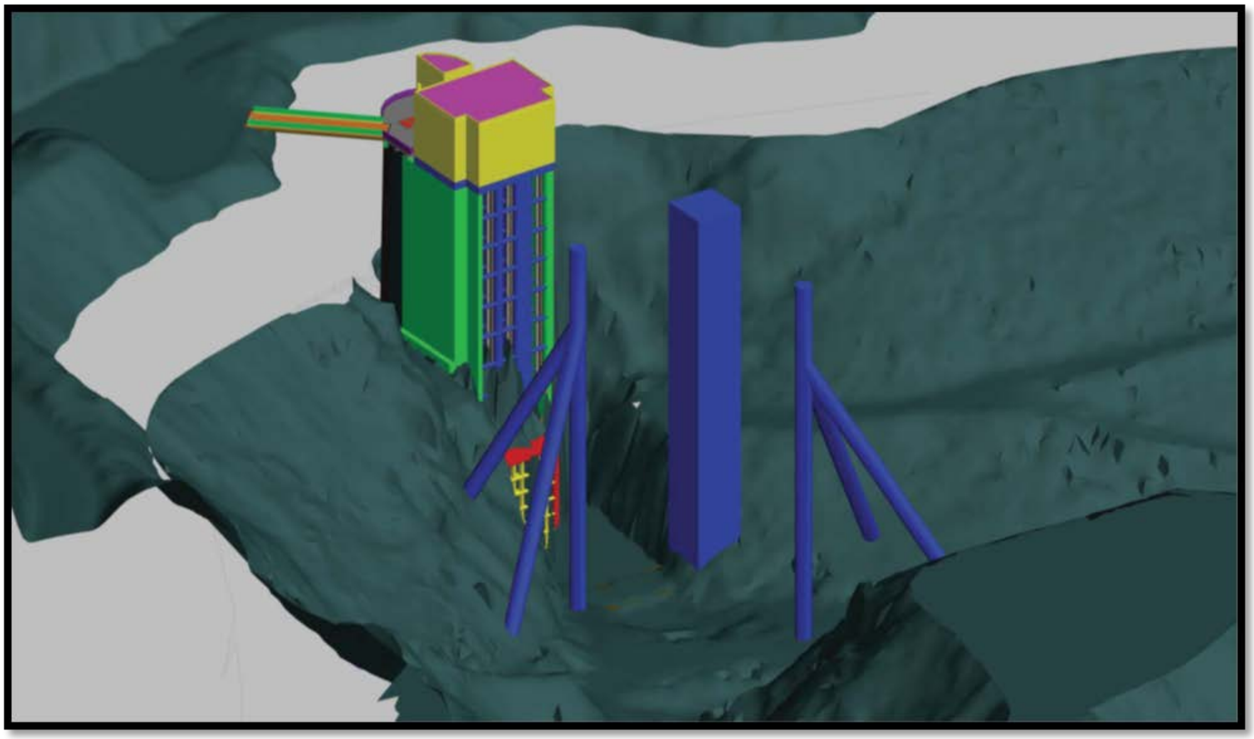

Figure 1-7. Stair Tower with Two Battered Dolphins

Configuration M2 is Three Battered Dolphins, comprised of three battered dolphin sets. Each battered dolphin set is a cluster of three 8-foot-diameter piles, with two of the piles angled and one vertical. The height of each dolphin is 270 feet. This configuration provides three points of mooring for the FSS. Figure 1-8 depicts the Three Battered Dolphins configuration.

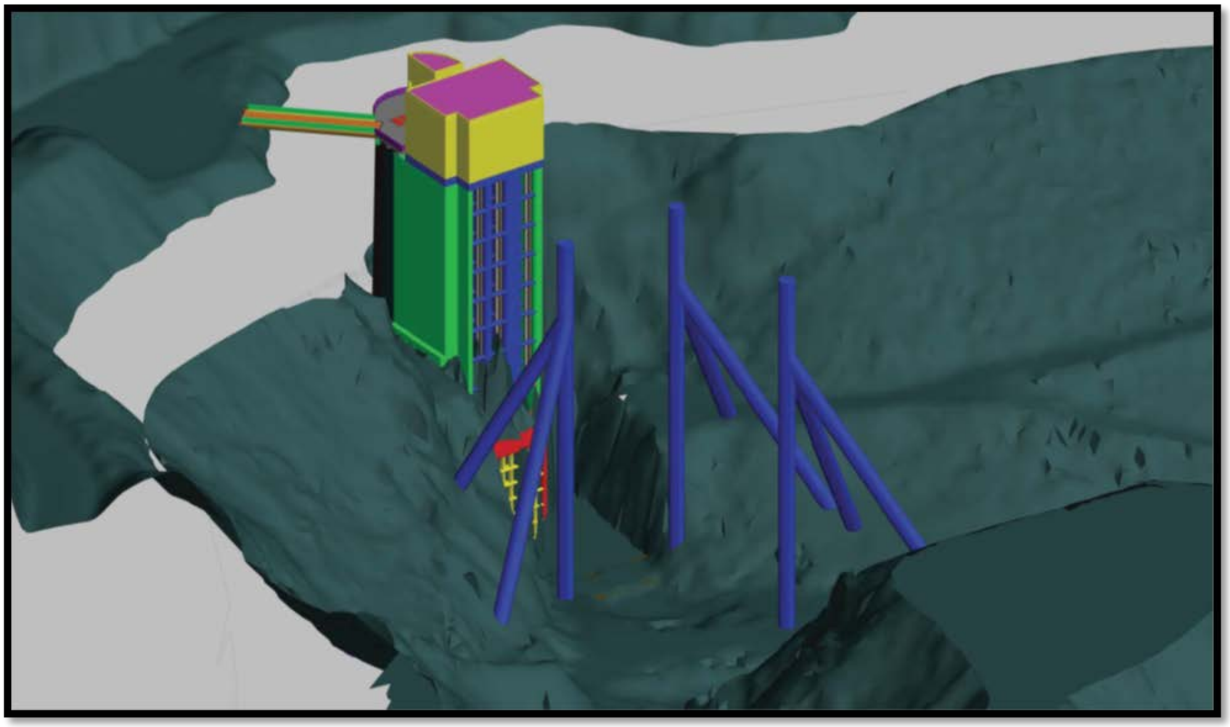

Figure 1-8. Three Battered Dolphins

Configuration M3 is the Truss Tower. The truss, with a triangular shape in plan view, would be fabricated using two feet diameter steel pipe piles. This configuration provides two points of mooring for the FSS. Figure 1-6 shows the Truss Tower configuration. To provide adequate mooring and to limit motions of the FSS, a third mooring point near the WTCT is required. This mooring point, currently under design, will be on the existing WTCT.

Configuration M3 was selected since it is most compatible with FSS configuration A2. Of the three configurations, the truss tower has the smallest footprint, which is a benefit given the close proximity of the FSS to the dam. The disadvantage of the truss tower is that it provides fewer mooring locations than the other two configurations. To remedy this disadvantage, a third mooring point will be provided on the WTCT.

c. <u>Fish Transport Systems</u>

During the EDR phase, there were two main categories of fish conveyance considered, piped bypass and truck transport. The bypass was deprioritized due to the assumption that the transportation system could meet the injury and survival criteria (for these criteria see Section 1.6.1 below), and assuming engineering risk and costs to construct a bypass would be higher. However, data collected in recent years has demonstrated that juvenile Chinook salmon collected from Cougar Reservoir are vulnerable to stress-induced mortality. Wild fish captured in the reservoir for population monitoring and fish passage research have shown mortality rates much higher than other populations (see Beeman 2012 & 2015, Herron 2017, and Monzyk 2015). This has raised recent concern that though the FSS may meet performance criteria for fish collection efficiency, it may not meet the criteria for survival and injury. Further, increased rates of dam passage mortality will make achieving the overarching population goals for reestablishing a Chinook run above the dam more difficult.

Due to increased concerns regarding mortality of juvenile Chinook salmon collected from Cougar Reservoir and trucked downstream, investigation of the engineering and biological feasibility of a volitional bypass system for the Cougar downstream fish passage project is continuing while this DDR is being completed. If the trap and transport system proves insufficient to meet survival criteria, then the downstream fish passage project may be modified in the future to add a volitional bypass system. To help ensure this potential modification can be made as efficiently and effectively as possible, consideration for future bypass features in the design will be identified in the individual sections throughout the DDR.

For the trap and haul (i.e. truck transport) option in the current design, a pod system with amphibious vehicles (AVs) will be used. The pod system was selected because it minimizes the number of fish transfers, which induce incremental stress to fish. AVs, which can travel on land and in water, are considered to be the best option in terms of cost and flexibility. The AVs will access the reservoir via the road on the upstream face of the dam. In addition to providing transportation of fish, the AVs will also provide crew access to the FSS. A separate access boat will also be able to moor to the FSS for crew access. Section 6, Mechanical Design, describes the pod system and AVs in detail.

A couple of structural systems for fish conveyance were considered before deciding to use AVs. One structural system, tied to mooring configuration M1, involved construction of a monorail between the M1 stair tower and the access road on the left abutment. Fish would be lifted in a hopper from the FSS, via a trolley hoist, and would travel along the monorail to a discharge location above a fish transport truck on the access road. Another structural system involved loading a fish hopper from the FSS to a barge. The barge would then move the hopper to the base of the WTCT, where the hopper would be lifted via a trolley hoist to a similar, but now shorter in horizontal distance, monorail system. These alternatives were deprioritized during the alternatives matrix review they did not fully address the biological, environmental, and operational and maintenance criteria.

d. Debris Management

Debris management is important for successful downstream fish passage operations. A new, more robust debris barrier will be installed in a location similar to the existing debris boom. The barrier will have a gate. Each year, at high pool, debris collected outside the barrier will be worked through the gate, moved to the dam upstream access road, and removed from the reservoir. The two FSS entrances will be screened with trashracks. Section 6, Mechanical Design, and Section 13, Operation and Maintenance, describe the debris management features and operations within the FSS. Debris will be removed from the FSS via a small barge. The barge will be moved to the dam upstream access road where the debris will be loaded into trucks for disposal.

1.6 FLOATING SCREEN STRUCTURE PERFORMANCE CRITERIA AND DESIGN

This subsection provides an overview of the downstream passage performance criteria and design tools. Details are provided in Sections 2 and 4.

a. Criteria

Performance criteria were developed jointly by NMFS and the Action Agencies (BPA and USACE) for the proposed Cougar FSS to guide design and assess performance after construction. An associated adaptive management framework was also developed to guide follow-on actions, as needed, to achieve performance criteria for the Cougar downstream fish passage project. The primary criteria for performance will be in terms of fish collection efficiency (FCE) and fish mortality and injury from capture to release. FCE is defined as the proportion of juvenile Chinook salmon that are collected by the FSS divided by the number in the measurement zone. The measurement zone for the Cougar project is the cul-de-sac. The mortality and injury metric is defined as the proportion of juvenile Chinook salmon that die or are injured divided by the total number collected by the FSS. Section 2 of this DDR describes the FCE and mortality/injury criteria in detail. Below is a summary:

- If FCE of 95% or greater is achieved with two years of study, no further evaluation is needed.
- If FCE ≥ 85% but < 95%, NMFS and the USACE will identify, and the Action Agencies will carry out, minor changes. Minor changes may be operational or structural to improve FCE. If FCE does not improve to 95% after testing the minor changes, then NMFS and the Action Agencies may agree to continue trying minor changes. NMFS and the Action Agencies may agree that further actions are not necessary or that efforts would not achieve the goals, in which case efforts would be focused on other RPA measures and no further minor changes would be taken on the FSS.
- If FCE ≥70% but <85% after two study years which meet the “study parameters,” the Action Agencies will carry out operational or facility adjustment(s) based on analysis of the completed facility.
- If FCE < 70%, the Action Agencies will complete adjustments first and then modification(s), with NMFS concurrence on the measures, based on analysis of the completed facility.
- Definitions of minor changes, adjustments, and modifications:
    - Minor Changes: Structural *changes* that can be made within the existing design, operational changes to the FSS that can be made within design specifications, and changes in dam and reservoir operations that can be completed within the existing rule curve and downstream flow requirements.

- Adjustments: Structural *additions* that were part of the original design (DDR), operational changes to the FSS that can be made within design specifications, and changes in dam and reservoir operations that can be completed within the existing rule curve and downstream flow requirements.

- Modifications: Physical *alterations or additions* to the physical passage facility that were not included in the original design and *require new design*.

Table 1-1. Mortality and Injury Standards for Juvenile Chinook in the Floating Screen Structure

Smolts Mortality or Injury	**Fry Mortality**	**Actions: Include Both Improvement Actions and Monitoring**
Design performance objective ≤ 2%	Design performance objective ≤ 2%	Objective met. No further actions required
If either mortality or injury is > 2% but ≤ 4%, then minor changes are required	If mortality is > 2% but ≤ 4% then minor changes are required	Minor changes to facility structure or operations
If either mortality or injury is > 4%, then operational changes or structural changes are required	If mortality is > 4%, then operational or structural changes are required	Operational or structural change

The FCE of the operating FSS will be determined through study. Study fish will be tagged with active tags (acoustic or radio) and Passive Integrated Transponder (PIT) tags and released into the Cougar reservoir. Acoustic or radio telemetry systems will monitor entrance of tagged study fish into the cul-de-sac (the measurement zone). Fish detected on these receivers will serve as the "number of fish" in the cul-de-sac (i.e. the denominator of the FCE equation). The FSS will also be equipped with a temporary PIT-tag reader. Study fish detected within the FSS will serve as the numerator of the FCE calculation.

b. Design Tools

Several modeling tools were used in the EDR phase to select the preferred alternative, the FSS. The tools included HEC-ResSim modeling, computational fluid dynamics (CFD) modeling, water quality modeling, hydropower modeling, and the Fish Benefits Workbook (FBW). Section 5 of the EDR describes these modeling tools. Two of the tools, CFD and the FBW, were further used in the DDR phase to design aspects of the FSS. Section 4 of this DDR describes in detail the use of CFD modeling and the FBW in the design of the FSS.

It is important to understand the use and limitations of the FBW. The following excerpts are from the EDR:

> Use: "The FBW is intended to be used as a relative comparison tool between operations and/or fish passage structural improvements." In the EDR phase, the FSS alternative "performed the best in the FBW simulations."

> "It can also be used to test model sensitivity to inputs (effectiveness values, passage survival rates, flow rates, active collection range, etc.). Understanding the inputs, calculations, outputs, and known model limitations is important to ensure the model results are used appropriately."
>
> Limitations: "The results from the Fish Benefit Workbook are not intended to be predictions of project survival rates, but they do offer a common comparison tool in order to rank alternatives and test the sensitivity to various inputs. This can help prioritize the time spent refining alternatives or guide research efforts to narrow down the level of uncertainty driven by specific input variables."

In the DDR phase, the FBW was used to model the performance sensitivity to various input parameters. See Section 4 for details.

The FBW does not directly predict FCE, the performance criterion described above. One important consideration is that FBW calculations are performed on a daily basis, with no allowance for fish that do not pass on a given day to pass on subsequent days. The measurement of FCE will occur over a multiple-day duration; fish may enter the FSS over the duration of the test.

As described above under Criteria, the performance of the FSS will be studied for two years after the beginning of operation. Minor changes, adjustments, and/or modifications will be considered depending on the measured FCE. As a minimum, the FSS has been designed in the DDR with attachment points for guidance nets.

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SECTION 2 - BIOLOGICAL DESIGN CONSIDERATION AND CRITERIA

2.1 GENERAL

This section describes the biological design considerations and criteria used to develop and evaluate design of the downstream fish passage project. It identifies biological and behavioral characteristics of the target fish species important to consider in the FSS design and function.

In its 2008 Biological Opinion (BiOp), the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife (USFWS 2008) concluded that the Proposed Action for continued operation and maintenance of the USACE Willamette Valley Project (WVP) is likely to jeopardize the continued existence of Upper Willamette River Chinook salmon and Upper Willamette Valley River steelhead (*Onchorhynchus mykiss*), which are listed as threatened under the ESA, and to adversely modify or destroy designated critical habitat for these species (NMFS 2008). NMFS provided the Action Agencies (USACE, BPA, and Bureau of Reclamation) with a Reasonable and Prudent Alternative (RPA) to supplement the Proposed Action. RPA 4.12.1, Cougar Dam Downstream Passage, will investigate the feasibility of improving downstream passage at Cougar Dam through structural modifications as well as with operational alternatives, and if found feasible they will construct and operate the downstream fish passage facility. The FSS will address RPA 4.12.1 in capturing and transporting juvenile Chinook salmon below Cougar Dam.

Upstream passage is provided above Cougar Dam for natural origin (unmarked) and hatchery origin (marked) adult spring Chinook salmon and bull trout through a trap and haul facility located downstream of Cougar Dam.

2.2 PRIMARY SPECIES OF CONCERN

Upper Willamette River Chinook salmon (*Onchorhynchus tshawystscha*) and bull trout (*Salvelinus confluentus*) are present in the South Fork McKenzie river sub-basin (Table 2-1).

Pacific lamprey (*Entosphenus tridentatus*), a native anadromous fish and species of concern, were historically widely distributed in the Willamette River basin including the reach of the South Fork McKenzie upstream of the location of Cougar Dam (Luzier et al. 2011, USFWS 2018 in review). Pacific lamprey are known to be present in the reach downstream of Cougar Dam (Schultz et al. 2015), and adult lamprey carcasses have been observed in the stilling basin at the base of the dam (Doug Gartlett, USACE, 2018 personal communication); however, no adult lamprey have been collected in the Cougar Dam adult collection facility's presort pool since opening the facility in 2010. The U.S. Fish and Wildlife Service's Pacific Lamprey Conservation Assessment (Luzier et al. 2011, USFWS 2018 in review) identified several factors associated with USACE dams that are thought to be limiting distribution and abundance of Pacific lamprey within the basin, including passage, flow alterations, and water quality. Dam passage is considered a key threat in the Willamette River basin. Since 2010, the Confederate Tribes of Grande Ronde have been investigating efficacy of translocation of adult Pacific lamprey from Willamette Falls to above Fall Creek Dam. This reintroduction effort was intended as a test case for potential application in other tributaries within the basin. It is possible that Federal, State, or Tribal fish and wildlife agencies will propose translocation of adult Pacific lamprey above Cougar Dam at some point in the foreseeable future as a component of basin-wide conservation and restoration efforts. As such, while Pacific lamprey may be currently extirpated upstream of Cougar Dam, it is possible that larval (ammocoete) or out-migrating juvenile (macrothalmia) life stages of Pacific lamprey may be collected in the FSS in the future.

Table 2-1. Distribution of Endangered Species Act-listed Chinook Salmon and Bull Trout

Location	Upper Willamette River Chinook	Bull Trout
SF McKenzie River-upstream of Cougar Dam	Present	Present
Cougar Reservoir	Present	Present
SF McKenzie River-Cougar Dam to McKenzie confluence	Present	Present
Mainstem McKenzie River	Present	Present

Provided below are estimated adult populations of each of the ESA-listed fish species:

- Natural-Origin Upper Willamette River Chinook 3,509 (USACE 2009)
- Bull trout 152 above Cougar (Written communication with Nik Zymonas 2017) and 250-300 (USFWS 2008) in the McKenzie sub-basin.

Though there is some minor inter-annual variation due to environmental conditions, the timing and size of juvenile Chinook migrants is consistent with their timing and size before project construction (USBCF 1960, Hogansen 2010). The majority of fish enter Cougar Reservoir in the late winter and early spring. The fry range in size from 40 millimeters (mm) to 60 mm (Romer at al. 2014). Once fry enter the reservoir, they tend to stay in the near-shore habitat until reservoir temperatures begin to increase and fry move offshore and down in the water column. In 2014, researchers at ODFW (Monzyk et al. 2014) reported that small subyearling Chinook were more abundant in the upper third of the reservoir in the spring and dispersed towards the dam from April to May. Peak migration of subyearlings in the South Fork McKenzie River is April to June, with a median date of May 16. By the end of June, the distribution of subyearling (size range 30 mm to 136 mm) Chinook in the reservoir was approximately 43 percent in the upper reservoir and 40 percent in the lower reservoir. Stream-type yearlings enter the reservoir in late winter and early spring, followed by a migration of fish from March to May which is dominated by fry size fish. Fry were also the dominant migrant life history type of fish downstream in the South Fork McKenzie above Cougar and at the dam site during pre-construction monitoring (1957-1960, USBCF 1960). In 2014, ODFW (Romer et al. 2014) trapped fish above Cougar Reservoir from February 26 to November 26, 2014. The trap fish for 251 d with the median fry migration in May and subyearlings being captured throughout the year (Figure 2-1). Very few yearlings were trapped above the reservoir.

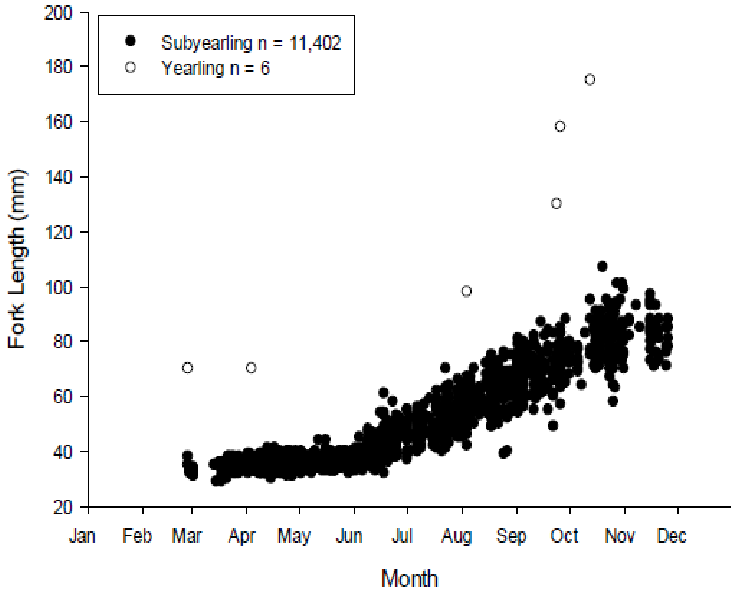

Figure 2-1. Fork Length of Subyearling and Yearling Chinook Salmon Collected in the South Fork Mckenzie River Trap Above Cougar Reservoir, 2014 (Romer et al., 2014)

Several studies have documented downstream juvenile Chinook passage through Cougar Dam (Ingram & Korn 1969, Taylor 2000, Hogansen 2010, Zymonas 2010, Beeman 2012, and Beeman 2014). Similar to the head of reservoir timing, there are trends throughout the 50 years of data on timing and the size of fish as out-migrants. The most notable trend throughout the studies are that the majority of migrants are large age 0 and 1+ fish, passing in the late fall during reservoir drawdown operations. The studies completed by ODFW and U.S. Geological Survey (USGS) were used in estimating the number of fish available for collection in the FSS.

Bull trout can have either resident of migratory life histories. Resident bull trout complete their entire life history in a stream or river in which they spawn and rear. Migratory bull trout spawn in streams or rivers, where juvenile fish rear for 1-4 years before migrating to a reservoir, lake, or in some cases, saltwater. Bull trout require cold, clear, clean water and habitat connectivity throughout their life history. The FSS will provide some habitat connectivity for adult bull trout migrating through the reservoir and being collected in the FSS and transported below the dam.

The number of fish available for collection in the FSS at Cougar Dam will vary daily, weekly, and monthly as reservoir elevations and water temperatures change. The anticipated fish numbers available for collection has been modeled and the number of fish expected to be collected ranges from 600 to 51,000 (Appendix B). These anticipated numbers were calculated by estimating the number of redds above Cougar Reservoir and the progeny produced from those redds. The number of successful spawning females above Cougar Reservoir was estimated at 2,100 (SP). Those successful spawning females have a fecundity of 3,800 eggs (F). The egg to fry survival was estimated at 30 percent (EF). The estimated fry entering the reservoir is calculated as SP*F*EF. To estimate the fry to migrant survival rate, the rate of 28.5 percent was used in the calculation. The 28.5 percent fry to migrant rate used in the calculation is from the work completed by Downey and Smith (1990). The estimated number of fry entering the reservoir (based on 2,100 redds) is

682,290. The number of fish anticipated to reach the FSS was calculated with data from the Fish Benefits Workbook. The workbook provided percentage of fish arriving each month for all three life stages (fry, subyearling, and yearling), and screw trap data from ODFW confirmed the anticipated numbers of fish available for collection in the FSS.

2.3 DESIGN CONSIDERATIONS

The FSS will be designed in accordance with the NMFS Fish Passage Design Criteria (NMFS 2011), USACE Fisheries Handbook of Engineering Requirements and Biological Criteria (Bell 1991), and The Surface Bypass Program Comprehensive Review Report (Sweeney et al. 2017).

During the EDR phase (USACE 2016) the PDT recommended a floating screen structure (FSS) with truck transport. Multiple factors are considered for surface flow collectors: approach, discovery, entrance, conveyance, and outfall. The location of a surface flow collector is important, and according to Bell (1991), juvenile fish follow flow during out-migration. The location of the FSS in the Cougar cul-de-sac is critical to the success of downstream passage at Cougar Dam. The PDT reviewed three different alternatives for placement of the FSS. Two of the alternatives places the FSS directly in front of the WTCT in the direction of Rush Island. The third alternative was placement next to the WTCT with the opening of the FSS facing Rush Creek. The third alternative was the preferred alternative, since the WTCT is the only outlet in Cougar Reservoir. CFD model runs during the EDR showed that flows come into the cul-de-sac and into the WTCT. Research indicated that fish congregate near the WTCT before passing the project. In January 2010, researchers at Pacific Northwest National Laboratory, under USACE contract, deployed a DIDSON acoustic camera to observe the near-field behavior and relative abundance of fish in the immediate forebay (in front of the WTCT) of Cougar Dam (Khan 2010). Data collected on the near-field behavior indicated that milling in front of the WTCT was the most common behavior throughout the study (Figure 2-2). All life stages of juvenile Chinook were present in front of the WTCT and were distributed both horizontally and vertically in the water column. The number of fish observations indicate that fish abundance increased quickly between the middle of March and the end of May, and then declined rapidly during high inflows and outflows, until observed numbers increased again in the fall during the fall out-migration period. Fish abundance ranged from ~200 in the early spring to ~6,000 in the late spring, generally tapering off to ~200 fish in the winter.

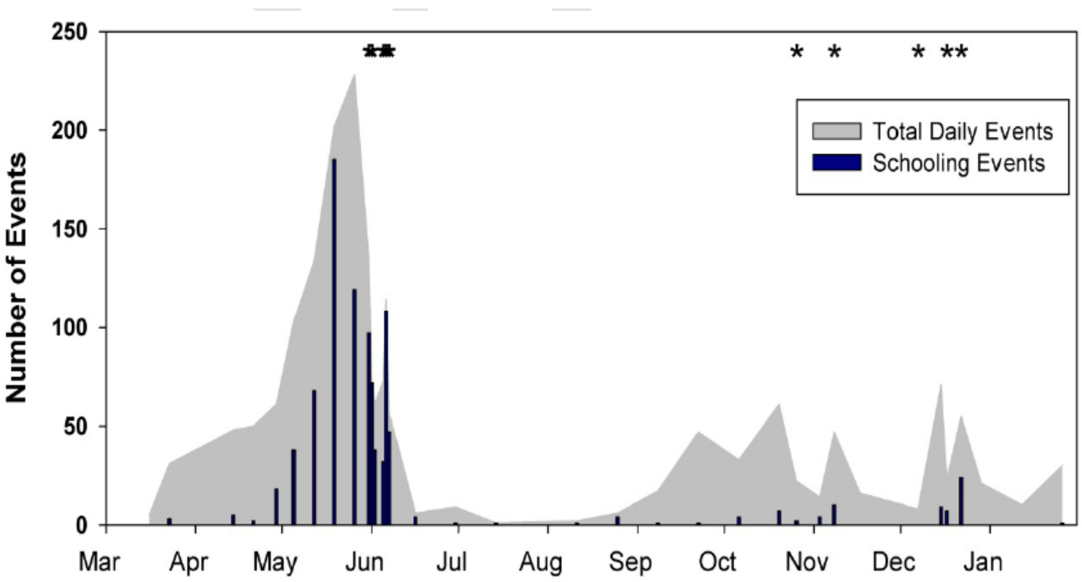

Figure 2-2. Schooling Events and Total Daily Fish Events in the Cul-De-Sac of Cougar Dam (Khan 2012)

The entrance of a surface collection facility is important as fish approach the surface passage route. The entrance of the FSS will be located near the WTCT, with an approximate depth of 25 feet. Research completed by USGS in Cougar Reservoir (Beeman et al. 2012) indicated that acoustically tagged fish occupied a depth in the 13 º Celsius range near the WTCT

Target species swimming speeds criteria and considerations. The location of the surface flow outlet and the entrance shape will create hydraulic conditions that will be encountered by out-migrating juvenile salmon. The assume design criteria for juvenile salmonid swimming speeds (Bell 1991, Jones 1974, and Webb 1971) are 0.5-1.2 feet per second (fps) for salmonids up to 2 inches and for salmonids greater than 2 inches, 1.0-2.1 fps. Criteria for bull trout and lamprey are not as well defined but assumed to be similar to those of juvenile salmonids. Three aspects of swimming speed are considered in the design criteria for fish passage facilities (Bell 1991). The aspects of swimming speed are cruising speed, a speed that can be maintained for long periods of time (hours), sustained speed, a speed that can be maintained for minutes, and darting speed, a single effort, not sustained.

Plots in Figure 2-3 are based on fish that were within 100 meters of the WTCT in 2011 when the discharge was 1,000 cfs and the elevation was 1,600 feet. The legend indicated values of the number of fish represented and the movement vectors represent the general movement directions of fish in the forebay.

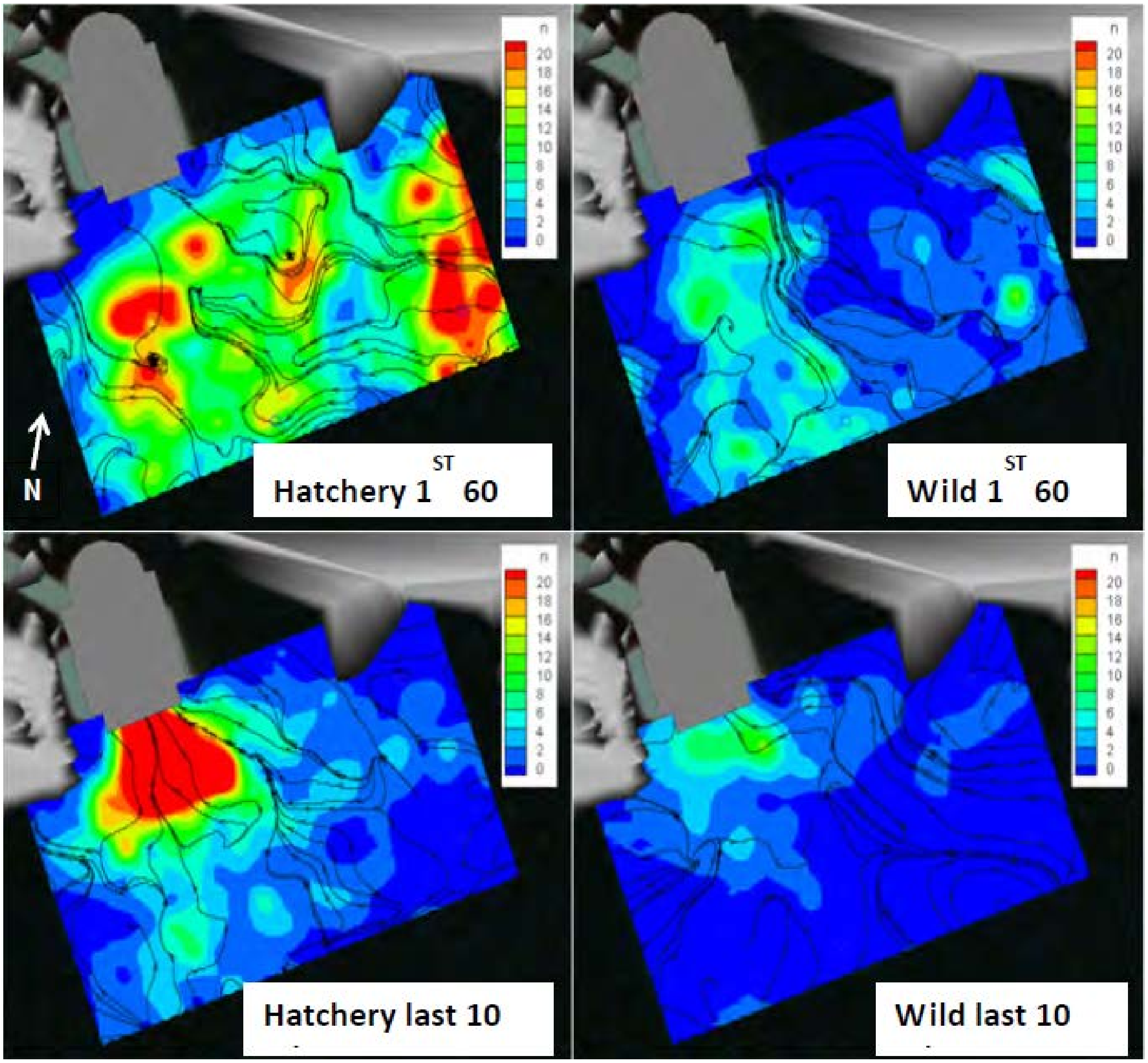

Figure 2-3. Flood Plots and Movements of Subyearling Chinook Salmon Released Into Cougar Reservoir, Oregon, Fall 2011 (Beeman, 2014)

Figure 2-4 shows graphs of mean daily fish depths (solid circles) within 20 meters of the portable floating fish collector entrance (top) and within 20 meters of the water temperature control tower (bottom) and hourly temperatures (in degrees Celsius) in Cougar Reservoir, Oregon, 2014. Vertical lines represent the daily minimum and maximum fish depths (Beeman et al, 2016).

These data support the selected location and fishing depth of the entrance for the preferred alternative selected in the EDR, and are developed further in this DDR.

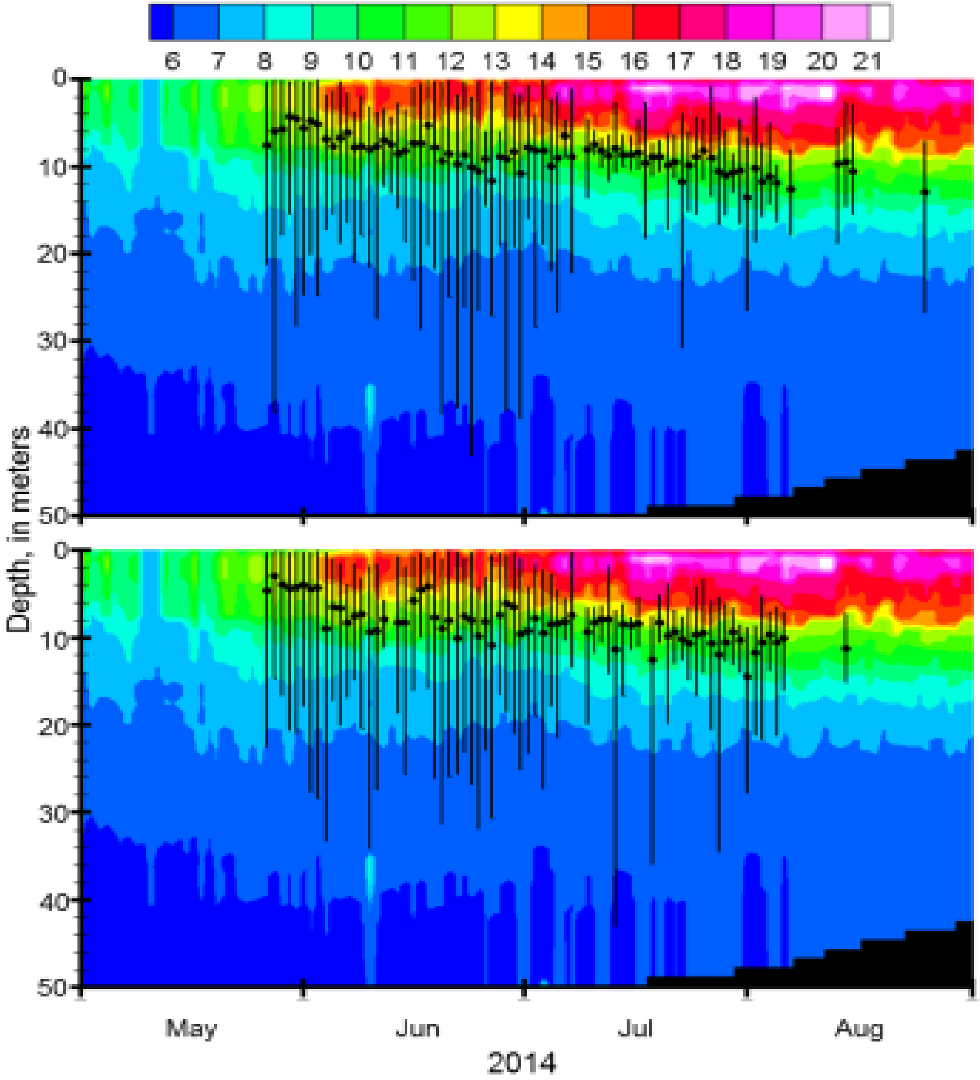

Figure 2-4. Mean Daily Fish Depths in Cougar Reservoir, Oregon - Temperatures Are in Degree Celsius (Beeman, 2016)

2.4 BIOLOGICAL CRITERIA FOR FISH FACILITIES AND SCREENS

Guidelines are provided by NMFS (NMFS 2011) for the design criteria of screens used in reservoirs and rivers to collect juvenile salmonids. Approach velocity must not exceed 0.40 fps for active screens. The approach velocity of screen should be less than 0.25 fps and be uniform over the entire screen surface area. Sweeping velocity should be maintained across the entire length of the scree and should never be less than 2.5 fps. Effective screen area must be calculated by dividing the maximum screened flow by the allowable approach velocity. Flow distributions and designs must provide for nearly uniform flow distribution over the screen surface. Providing uniform flow across the screen will minimize the potential for fish impingement.

Incline and vertical screens criteria: An incline screen face must be oriented less than 45° vertically with the screen length oriented parallel to flow (NMFS 2011).

2.5 BIOLOGICAL CRITERIA FOR FISH SORTING

Fish collection facilities on the Columbia and Snake Rivers utilize a wet separator to segregate small fish from large fish. The early separators used sloping pipes that fanned out so that fish would drop through the bars, with the smallest fish dropping through first (Gessel et al. 1985). The separators were considered dry since the bars were above water and a fine spray assisted fish movements across the bars. Original separators performed as designed, but the injury rates were higher than expected. The separators were replaced with wet separators, which kept fish submerged throughout the sorting process. A generic wet separator is a rectangular box partitioned into two tandem sections, with each section approximately 5 feet wide by 13 feet long and 4 feet deep. Following partial dewatering, all fish are deposited in the upstream end of the separator box. Separation bars just under the surface are spaced widely enough to allow smaller fish to pass through the bars, and larger fish would continue into the next section and pass through with a slightly larger gap than the first section (McComas, 1998). Fish too large to pass through either set of separator bars would pass through the end of the separator and be returned to the river or held in a separate holding tank.

Unlike the example above, the fish facility at Cougar only needs a single set of wet separator bars. The separator bar spacing will be sized for collection of small fish and medium fish (fork length < 200 mm). Fish larger than 200 mm will diverted to the adult holding tank at the downstream end of the separator. This is to help reduce risks of predation on juvenile Chinook during holding and transport.

Daily fish collection will be sub-sampled to ensure proper operations of the FSS and examine the fish for potential injuries caused by the operation of the FSS. The daily sub-sample will be a proportion of the day’s collection. The sub-sample will range from 0.25 percent to 25 percent of the daily collection and will be determined by the run timing of the fish. The sub-sample tanks will also be used as sampling tank and will be designed to hold 0.25 pounds of fish per cubic foot of water. The sub-sample tanks will be approximately 250-gallon tanks. The sub-sample tanks will also be used to anesthetize daily samples, and anesthetization for ESA-listed fish will be specified by the yearly permit required for ESA-listed fish.

2.6 BIOLOGICAL CRITERIA FOR FISH HOLDING AND TRANSPORTATION

Fish holding tanks will be sized to NMS short term holding criteria and loaded to hold 0.25 cubic feet of water per pound of fish for 24-hour holding. These tanks will also be used as transport tanks (here for referred to as transport pods) and only loaded to 0.15 cubic feet of water per pound of fish for transport during periods of peak fish passage. The size and number of the pods is driven both by the anticipated number of fish (see Appendix B) and the load capacity of the AV.

Collection rates and loading densities will be determined using methods similar to those at Little Goose Dam on the Snake River, and are determined by fish migration timing and samples rates are set accordingly (written communication with Scott St John, 2017). Weights and lengths are measured for each sample and those numbers are used to calculate the number of pounds loaded into each raceway. Little Goose raceways are designed to hold a maximum of 6,000 pounds of fish, where the FSS transport pods are designed to hold ~670 pounds (lbs) of fish (see Appendix

B). In order to obtain the needed subsample, the facility will include a fish sampling station (see Section 6.5.g).

An element of the sampling station will be a tank or system of tanks where fish can be anesthetized. Anesthetizing tanks will be designed to NMFS criteria (0.15 cubic feet of water per pound of fish). The anesthetizing tanks will also need to be able to accommodate the requirements of disposing of the effluent created by the use of the anesthetic (Aqui-S or equivalent). After fish are sampled, the fish will recover in a tank which will be of similar size to the anesthetizing tanks and will be designed to NMFS criteria (0.15 cubic feet of water per pound of fish).

If feasible the fish sorting and handling facility will include an automated fish counting device (see Section 6.3.f). The two systems of fish enumeration (the automated system and the sub sampling) will work in concert to ensure fish holding and transport densities remain within the criteria.

2.7 BIOLOGICAL CRITERIA FOR RELEASE SITES

The release site below Cougar Dam will need to meet the following criteria, as established in the NOAA Fish Passage Facility Design (NMFS 2011) document. The criteria for release locations and release mechanisms at the site should minimize predation by selecting an outfall location free of eddies and reverse flow and known predator habitat. The point of impact for outfalls should be located where ambient river velocities are greater than 4.0 fps and depths are sufficient for the receiving water. The Cougar Dam release location is approximately 458 feet downstream of the powerhouse (Figure 2-5) and utilizes the infrastructure currently in place for the adult collection facility (paved road, flushing water, and security). Velocities in the area of the release location were measured by USACE personnel on 17 July 2018. The measurements were taken approximately 80 feet downstream of the adult collection facility at three different locations. A Swoffer current velocity meter collected data at 5 feet, 10 feet, and 15 feet from the north river bank. Each location was measured three times and averaged. The velocity at 5 feet was 1.8 fps, at 10 feet it was 2.1 fps, and at 15 feet it was 3.4 fps. The deepest location measured at the proposed release site was 3.4 feet deep. This was measured 15 feet from the north river bank.

Release pipe/hose criteria: The release mechanism needed for fish collected at Cougar Dam will require that the pipe/hose be free of sharp edges or protrusions. The height of the release pipe/hose will need to accommodate different water levels throughout the year and river depth must be sufficient to ensure that fish injuries are avoided.

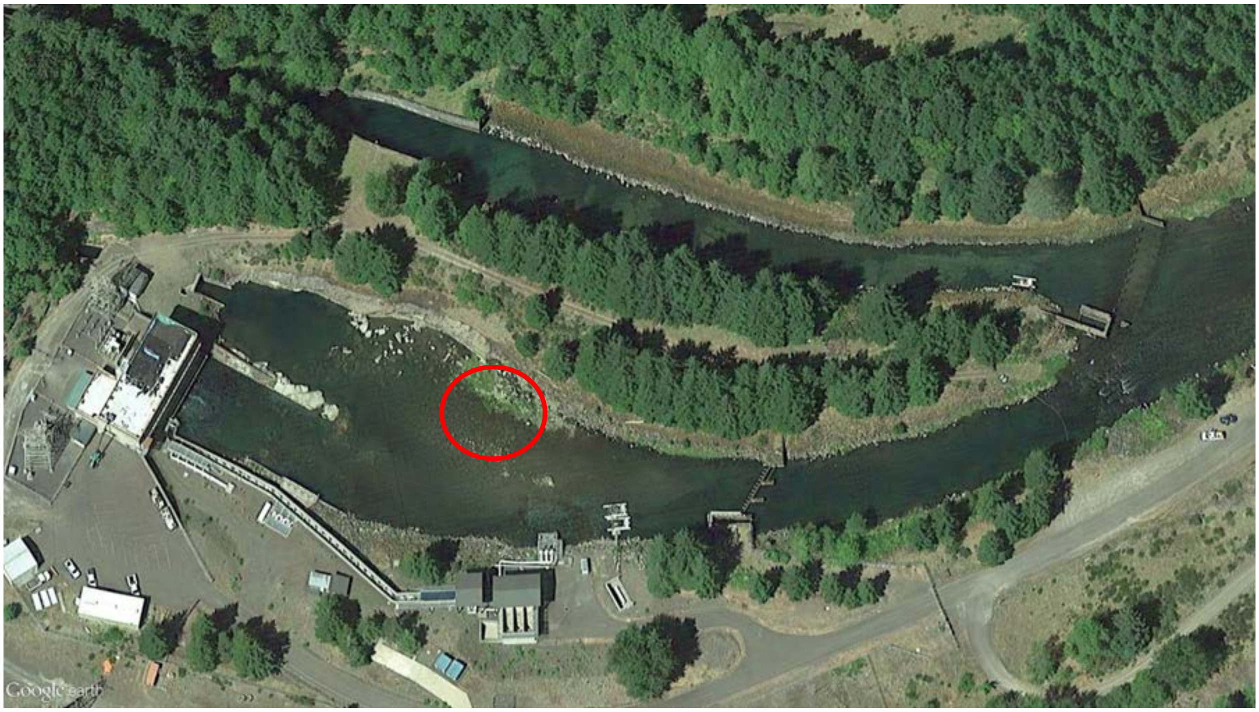

Figure 2-5. Approximate Release Location Below Cougar Dam

2.8 MISCELLANEOUS BIOLOGICAL CRITERIA

All surfaces in the FSS will be designed to avoid sharp edges or protrusions.

2.9 POST-CONSTRUCTION EVALUATIONS

There are three parts to this evaluation (NMFS 2011): (1) verify that the fish passage system is installed in accordance with the approved design; (2) measure hydraulic conditions to ensure that the facility meets guidelines and criteria, and (3) perform biological assessments to confirm that hydraulic conditions are resulting in successful passage (as defined in Section 1.6 above).

a. PIT-Tag Arrays for Post-Construction Evaluation

The post-construction evaluation of FCE and post collection survival will require the installation of PIT-tag arrays within the FSS. The arrays should be capable of detecting both full and half duplex tags.

b. Evaluation of Fish Collection Efficiency and Post Collection Survival

This evaluation will be conducted post-construction and requires the use of active tags and wild fish surrogates representative of active migrating fish. The FCE tests will be conducted the first year following completion of the FSS. Two years of tests are expected, but adjustments may be implemented after 1 year (see Section 1.6 above).

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SECTION 3 - WATER QUALITY

3.1 BACKGROUND

Construction of the water temperature control tower (WTCT) at Cougar Reservoir was finished in 2005, and enabled selective release of lake surface flows from Cougar Dam at elevation 1,690 feet to 1,561 feet. Since the completion of the WTCT, water temperature downstream of Cougar has resembled a more natural seasonal temperature change regardless of the water-year type and the maximum pool elevation. For example, a comparison of two low-water years, one before the temperature tower construction (2001) and one after construction (2015), shows that downstream temperatures are warmer during the spring and cooler during the fall since the temperature tower has been in place (Figure 3-1) (USGS, 2017).

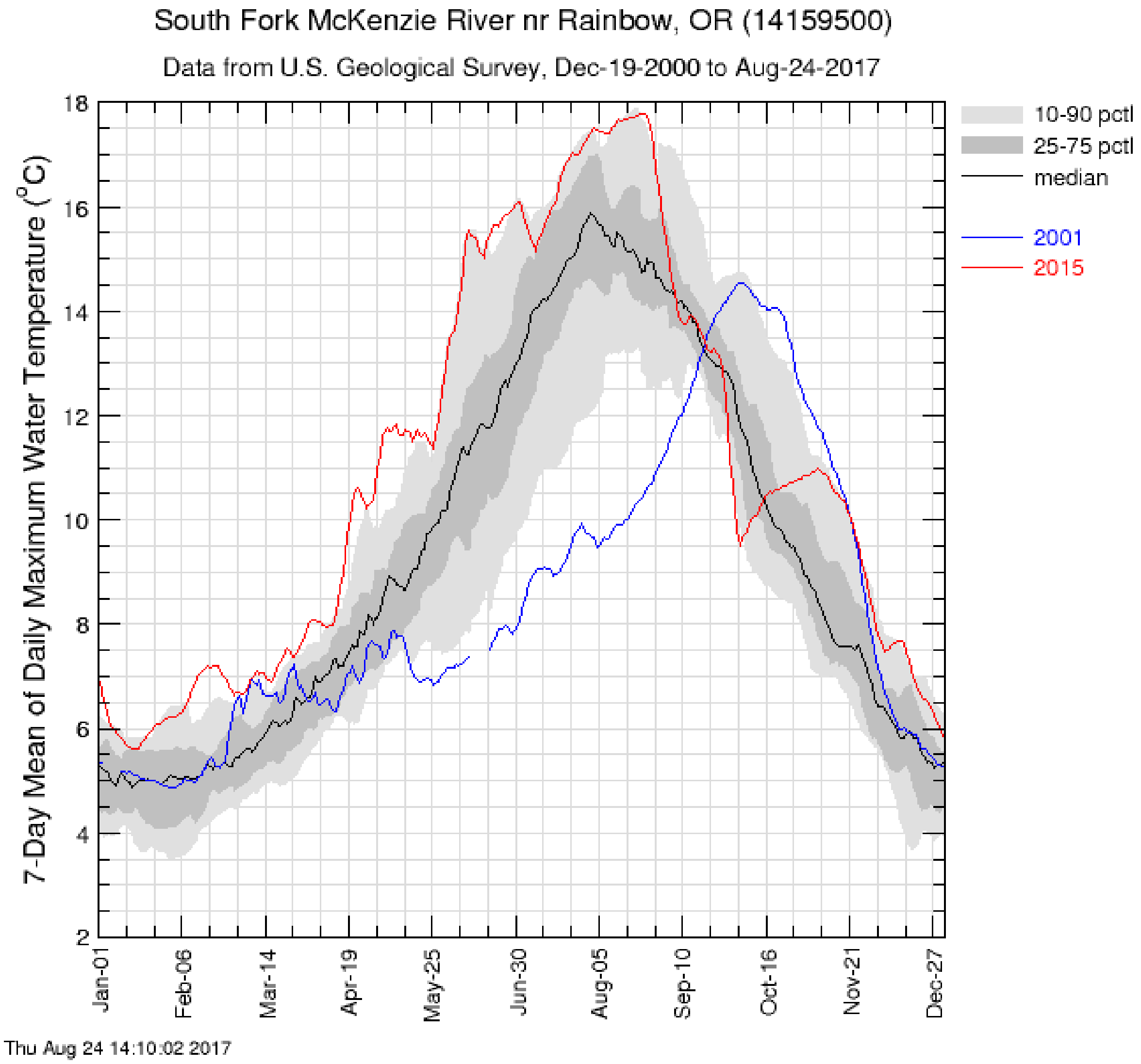

Figure 3-1. Comparison of Water Temperature Downstream of Cougar Reservoir at USGS Site 14159500 During 2001 and 2015 Calendar Years (USGS, 2017)

3.2 PREVIOUS WORK PREDICTING IMPACTS OF FLOATING SCREEN STRUCTURE ON DOWNSTREAM TEMPERATURES

Hydrodynamic water temperature models of Cougar reservoir were developed using CE-QUAL-W2, version 3.7 (Cole and Wells, 2011) and calibrated in calendar years 2005 and 2006 (Threadgill et al., 2012). Threadgill used this model to assess the temperature impacts of any modifications or enhancements to the temperature tower. This calibrated model was then applied to more recent calendar years with a variety of water-year types: 2001 (Deficit), 2004 (Insufficient), 2006 (Adequate), and 2008 (Abundant). Outflow boundary conditions were based upon RES-SIM modeling for Early Implementation of Interim Risk Reduction Measure (IRRM), which represents current reservoir operations, but are not actual releases as measured immediately below Cougar. A series of floating gates in the temperature model represent sliding weirs at the temperature control tower. A proposed floating screen structure (FSS) skimming all outflow up to 1,000 cfs from the surface of the lake year-round was simulated in each of the 4 calendar year scenarios mentioned above (Figure 3-2). It was assumed that this surface flow was routed directly from the FSS to the existing temperature tower (represented by multiple sliding weirs) for all lake elevations above 1,571 feet (minimum forebay elevation for WTCT operation). Releases above 1,000 cfs were routed to the regulating outlet bypass at 1,488.5 feet (centerline) elevation.

Results from Threadgill et. al. (2012) show a relatively greater range of temperatures during the spring than in summer and fall. As the lake is filling during spring, year-to-year variability in the timing of stratification, inflow temperatures, and meteorological conditions can lead to a large range in release temperatures compared with the fall. Release temperatures in the 4 years simulated generally follow the upper limit of the temperature target with exceedances that can last for a few weeks during July and August.

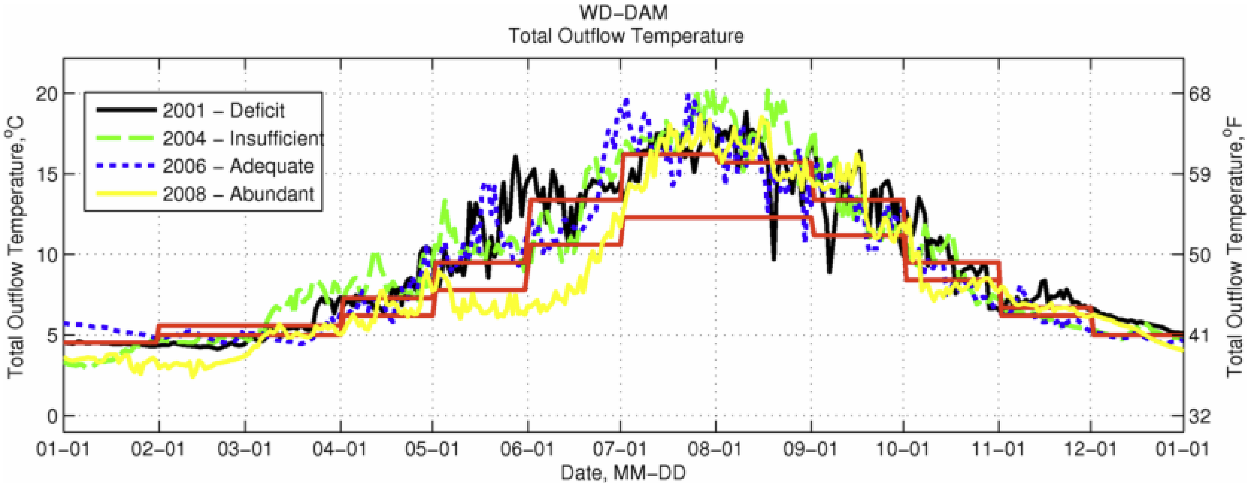

Figure 3-2. Comparison of Four Calendar-Year Scenarios at Cougar Dam With All Surface Flow Up to 1,000 cfs Through the Upper Weir Year-Round – Minimum and Maximum Temperature Targets Are Shown in Red (Figure From Threadgill et.al, 2012)

Building upon work done by Threadgill et. al. (2012), further work was done by Dan Turner (USACE, 2017) to evaluate the effects from a similar structure design and updated to CE-QUAL-W2 v3.72 (Cole and Wells, 2015). This involved simplifying the selective release ports in the model to one single floating outlet (10 feet) below the lake surface) instead of multiple sliding weirs. Additional model assumptions and refinements from previous work were as follows:

- The total outflow does not change from the baseline (IRRM) condition. If the total outflow is less than the minimum FSS flow, all the flow is routed through the surface outlet.
- The FSS surface flow is directly connected to the temperature control tower and minimal heat transfer exists between the FSS intake and the WTCT wet well.
- The sliding gates at Cougar are operated like a floating weir in that they track the elevation of the water surface at a depth of 10 feet.
- The simulated weir gates can be lowered to an elevation of 1,516 feet. For reference, minimum conservation is elevation 1,532 feet, so this configuration would allow for surface withdrawal year round. Under current operations, the upper weir gates can be lowered to elevation 1,562 feet and are operated when the water surface elevation is at or above 1,571 feet, which is how Threadgill et. al., (2012) simulated the FSS.
- The powerhouse intake to the control tower can be operated.
- The surface outlet (i.e. upper weir gates) can take in flow greater than the floating fish collector. For example, if the total outflow from the dam is 3,000 cfs but the collector has a capacity of 1000 cfs, 3,000 cfs could still be routed through WTCT weir gates for temperature control.

Work done by Turner (2016) in CE-QUAL-W2 v3.72 resulted in more controllable release temperatures overall that were less variable week-to-week as results from Threadgill using CE-QUAL-W2 v3.7. Two model predictions are presented below for the year 2004 with baseline conditions and all surface flow up to 1000 cfs (Figures 3-3 and 3-4, respectively). Under baseline conditions, the outlet temperature is able to track closely to target because of mixing between the upper weir gates and the lower penstock intake, especially from July through November. However, the 1,000 cfs flow scenario is constrained by requiring a surface withdrawal, thereby limiting temperature control during July-October when the outflow temperature generally exceeds the target (Figure 3-4). Given the outlet flow and elevation constraints, the model attempts to blend outlets to achieve the maximum of the monthly resource agency target (dotted lines in bottom plots of Figures 3-3 and 3-4). Simulations differ from current operations, in that the weir gates are held at a constant depth (10 feet) and deeper outlets are used when cooler, deeper water is needed to mix with the warm surface water to meet a lower temperature target. Current operations vary the depth of the weir gates to help achieve temperature target.

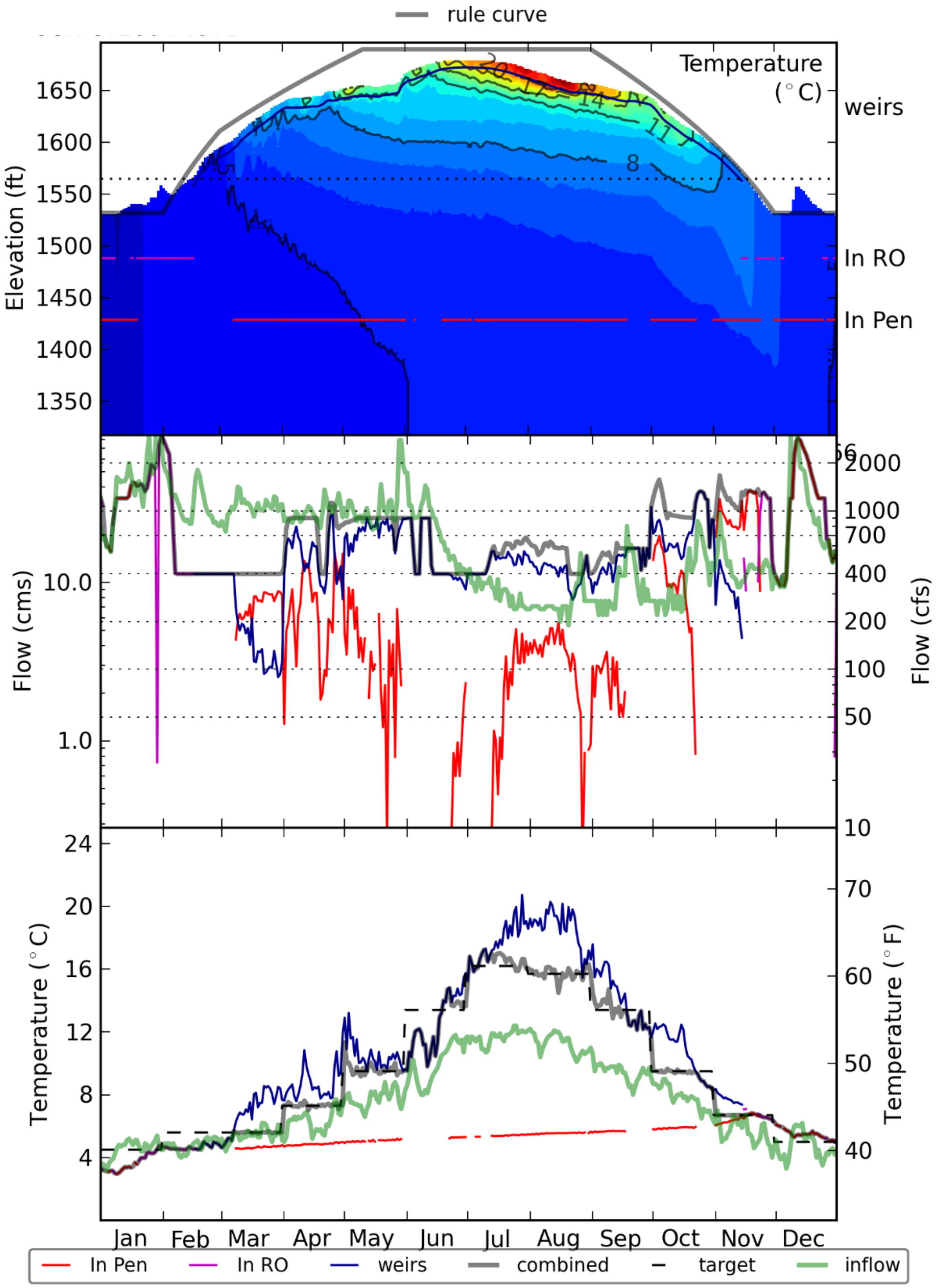

Figure 3-3. Model Results for 2006 Baseline Condition With No Minimum Flow Through the Floating Screen Structure (Labeled "Weirs")

NOTE: Upper: reservoir temperature and elevation of active outlets; Middle: release rates; Bottom: temperatures.

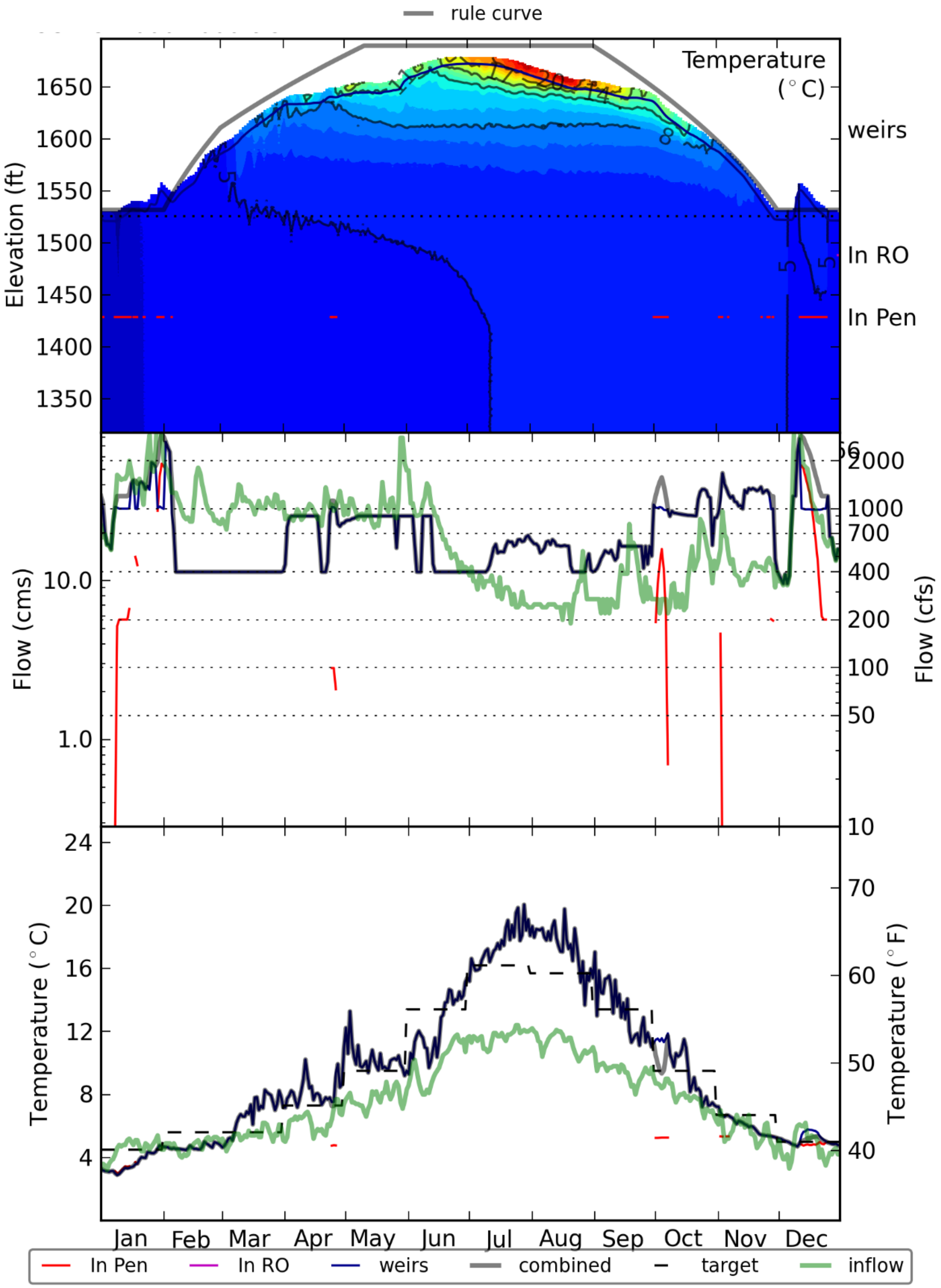

Figure 3-4. Model Results for 2004 with All Surface Flow up to 1000 cfs Through the Floating Screen Structure (Labeled "Weirs")

NOTE: Upper: reservoir temperature and elevation of active outlets; Middle: release rates; Bottom: temperatures.

3.3 PREDICTED IMPACTS OF FLOATING SCREEN STRUCTURE ON DOWNSTREAM TEMPERATURES: CURRENT WORK

Calibration of the Cougar CE-QUAL-W2 v3.72 model was checked and updated for CY 2006 using outflows as-measured in 2006, identical to those used by Turner (2016) and adapted from Threadgill, et.al (2012). Reports of leakage through the sliding weir structures have led to model calibration changes that better represent that reality. Three lower elevation outlet structures were added in the model (STR 3 through 5) to represent the bottom of the weir structure at 1,561 feet (Figure 3-5). Combined, these simulated "leaks" comprised 30 percent of the total outflow (MIN FRAC 3 through 5 set to 0.1), while the remaining 70 percent was designated to the WTCT weirs (MIN FRAC 1 set to 0.7. The outflow boundary conditions were edited to specify the dates when the sliding weir gates were used in the temperature control tower. All outflow was directed through the weirs when the pool elevation was within the range of the temperature control tower weirs (between elevation 1,561 feet and 1,680 feet). Otherwise, outflow was routed through the regulating outlet (RO) bypass outlet at elevation 1,488.5 feet. It was assumed that the penstock inlet was not used in 2006.

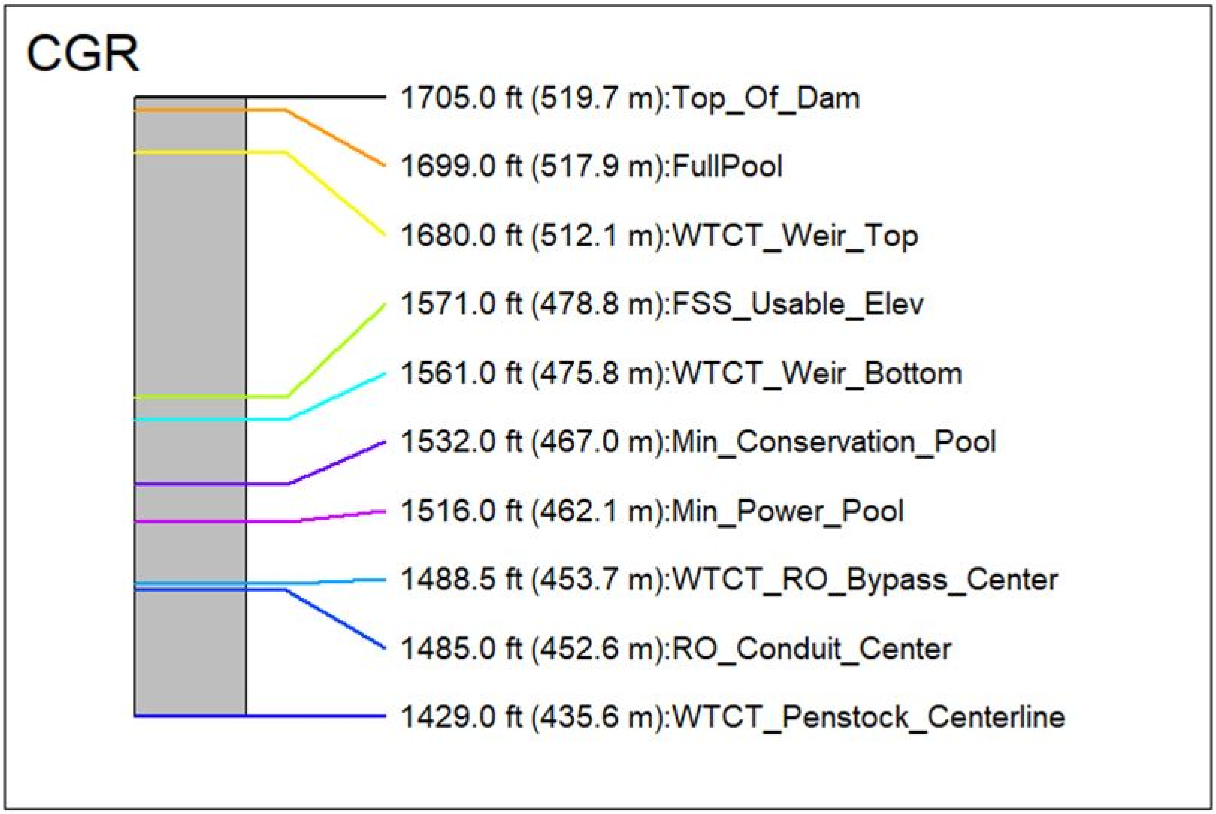

Figure 3-5. Important Elevations for the Cougar Data WTCT and Floating Screen Structure

The USGS water temperature data at site 14159500 (0.6 miles downstream of Cougar Dam) was used to compare the model to. The final adjusted calibration resulted in an overall mean error of 0.03 °C and mean absolute error of 0.63 °C (Figure 3-6). Through the calibration process, the WTCT weir depth was adjusted from previous water temperature simulations done from 10-foot to 11.5-foot depths, which are still within the operational depth observed by Cougar Dam operators (10-12 feet).

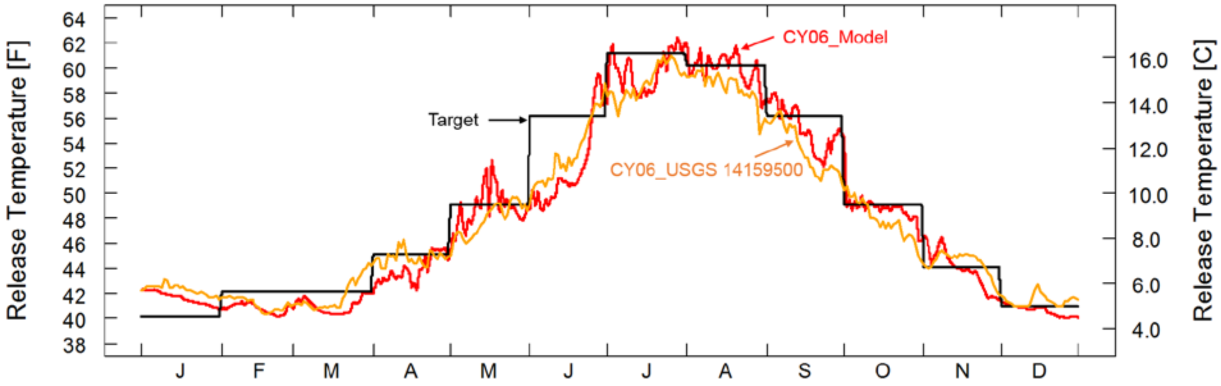

Figure 3-6. Simulated and Observed Water Temperature in Calendar Year 2006

The current proposed FSS (at 90 percent DDR) will have a floating depth of about 25 feet and operate down to a lake elevation of 1,528 feet (WTCT minimum usable level currently 1,571 feet). The current design also includes a greater head differential in the WTCT wet well (3 feet proposed) than that used in current operations (1 foot). It was estimated that this change in head difference between the lake and the wet well could translate into as much as 45 percent flow leakage through the leaks around the weir slots. Two scenarios were developed to address flow through leaks within the WTCT weir gate slots: (1) a 30 percent leak rate; assuming some measures are taken to minimize the leaks in the weir slot that will be connected to the FSS, and 2) a 45 percent leak rate; assuming additional leak flow caused by additional pressure from greater head differential and no measures to minimize leakage are taken. These two FSS scenarios were assessed in the four hydrology/meteorology years and compared to the baseline scenario in Figure 3-7. Assumptions in these scenarios are similar to the re-calibrated model described above with additional details seen in Table 3-1.

Table 3-1. Description of Water Temperature Simulation Scenarios

Structural Scenario	Description
baseline	-Existing WTCT (11.5-foot depth) with 30% leakage distributed through the depth of the weir slots via 3 model outlets
FSS_30prc	-Proposed FSS (25-foot depth) with 30% leakage distributed through the depth of the weir slots via 3 model outlets -WTCT weirs used in July and August during FSS maintenance period
FSS_30prc_1000cfsMax	-Identical to **FSS_30prc**, except outflows exceeding 1000 cfs routed through RO outlet instead of WTCT weir slots (see *CY08* scenarios for notable differences).
FSS_45prc	-Proposed FSS (25-foot depth) with potential 45% leakage due to greater head differential -WTCT weirs used in July and August during FSS maintenance period
FSS_45prc_1000cfsMax	-Identical to **FSS_45prc**, except outflows exceeding 1,000 cfs routed through RO outlet instead of WTCT weir slots (see *CY08* scenarios for notable differences).

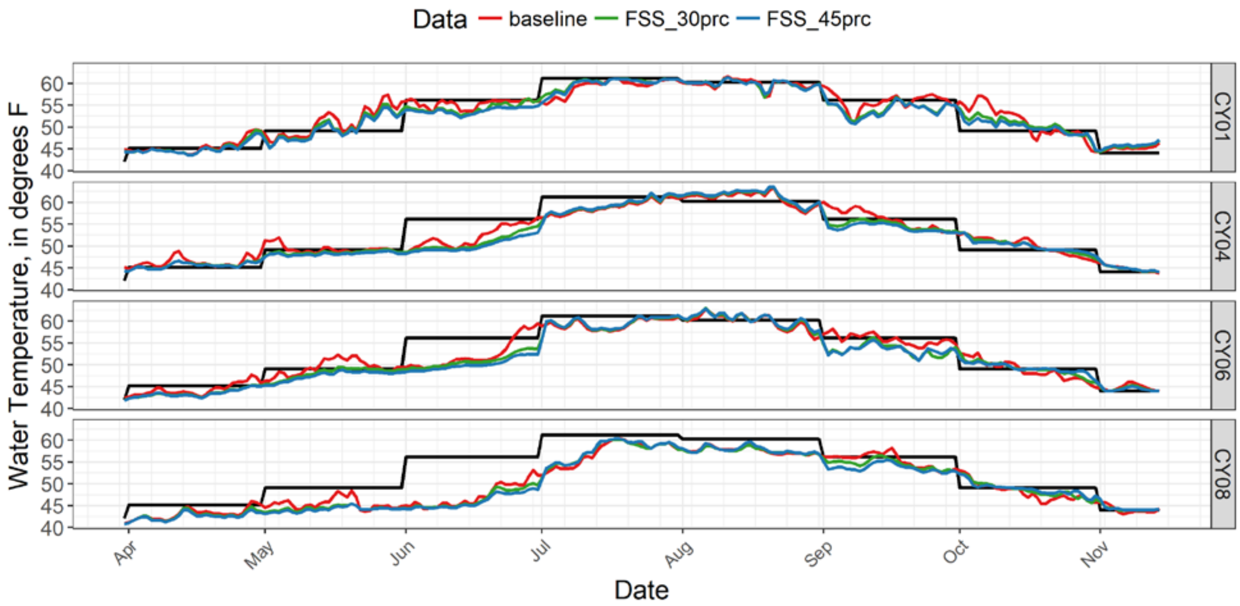

Figure 3-7. Simulated Water Temperatures Immediately Downstream of Cougar Dam in 4 Separate Calendar Years

Impacts from this deeper (25 feet compared to 11.5 feet) draw from the surface of the lake leads to some decreased temperature control in early summer while the thermocline is developing. The relatively deeper weir depth of 25 feet through the FSS is not able to access the most ideal warm water near the surface of the lake like the *baseline* scenario, which has an 11.5-foot weir depth. FSS scenarios in which greater leakage through the weir slots was simulated (*FSS_45prc*) displayed cooler temperatures in June and September than scenarios with the current leakage rate (*FSS_30prc*). Release temperatures from the FSS scenarios during July and August were similar to *baseline* scenarios due to the scheduled maintenance period and the use of the WTCT weirs during that time. During September through mid-October, baseline scenarios were generally able to release warmer water because of the shallower weir depth than the FSS scenarios. From mid-October to December, the baseline scenario releases are slightly cooler than the FSS scenarios because warmer surface water was released during the summer, leading to additional cold water storage for the autumn.

3.4 PREDICTED BIOLOGICAL IMPACTS OF FSS RELATED TO DOWNSTREAM TEMPERATURES

Biological evaluation criteria for adult and juvenile Chinook salmon was borrowed from the Middle Fork Willamette 60% Engineering Documentation Report (U.S. Army Corps of Engineers, 2015) for temperature control and fish passage alternatives (Table 3-2).

Table 3-2. Summary Table of Life Stage Temperature Criteria for Chinook Salmon

Use	**Date Range**	**Impact Type**	**Criteria (°C)**	**Criteria (°F)**	**Reference**
Migration	May-01 to Jul-15	delay	< 11.1	< 52.0	Based on run timing and temperature (USACE, 2015)
Holding	May-01 to Sep-15	sub-optimal	> 16.0	> 60.8	ODEQ core cold water criteria
Spawning	Sep-01 to Oct-15	sub-optimal	> 13.0	> 55.4	USACE (2015); ODEQ spawning criteria
Rearing	May-01 to Sep-15	Ideal	>14.0 <16.0	>57.2 <60.8	Brett, et.al. (1982); Sullivan, et. al. (2000)
Incubation	Sep-01 to Dec-31	extreme	> 15.6	> 60.1	Based on experimentation (Taylor and Garletts, 2007)
Incubation	Sep-01 to Dec-31	sub-optimal	> 10.1	> 50.2	USACE (2015)
Incubation	Sep-20 plus 1750 ATUs	early emergence	NA	NA	Standard reporting metric in Willamette River annual water quality report (USACE 2014) based on average Willamette Hatchery data.

Temperature impacts for each scenario are summarized in the following bullets and in Figures 3-8, 3-9, and 3-10:

- Cooler spring temperatures in June under FSS scenarios could potentially cause some delay in migration (increased percent of time under 51.8 °F in the migration timeframe).

- No detectable effect during the holding criteria timeframe; few scenarios spent much time above 60.8 °F.

- Potentially cooler summer temperatures releases in an adequate water year (2006) could lead to decreased percent of time in optimal rearing conditions.

- Cooler releases from FSS scenarios during the spawning timeframe in September.

- No detectable effect during the incubation timeframe or in emergence timing. FSS scenarios led to emergence as much as 5 days later than early spawners (September 1 spawn date) and as much as 2 days earlier emergence from late spawners (October 1 spawn date) compared with *baseline* scenarios (Figure 3-10).

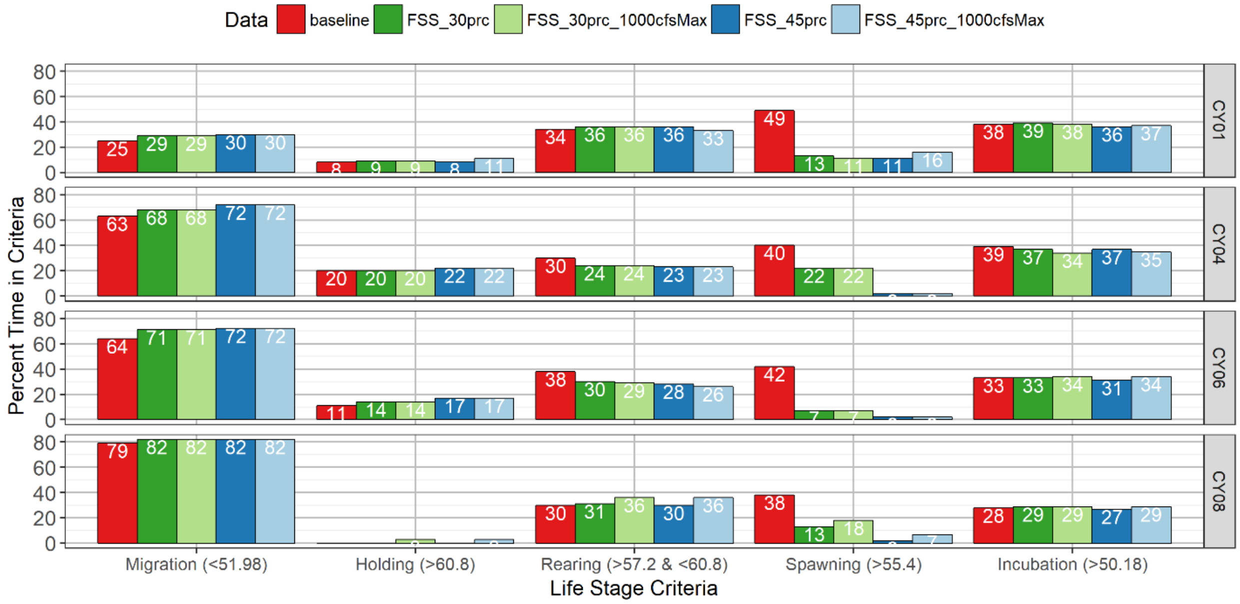

Figure 3-8. Comparison of Temperature Simulations at Cougar Dam for Different Life Stages of Chinook Salmon in Baseline (Red) and the Proposed Floating Screen Structure Configuration (Blue)

NOTE: Error bars indicate the 95th and 5th percentiles across the four calendar year scenarios simulated. Timeframes for each life stage criteria are shown in Table 3-2.

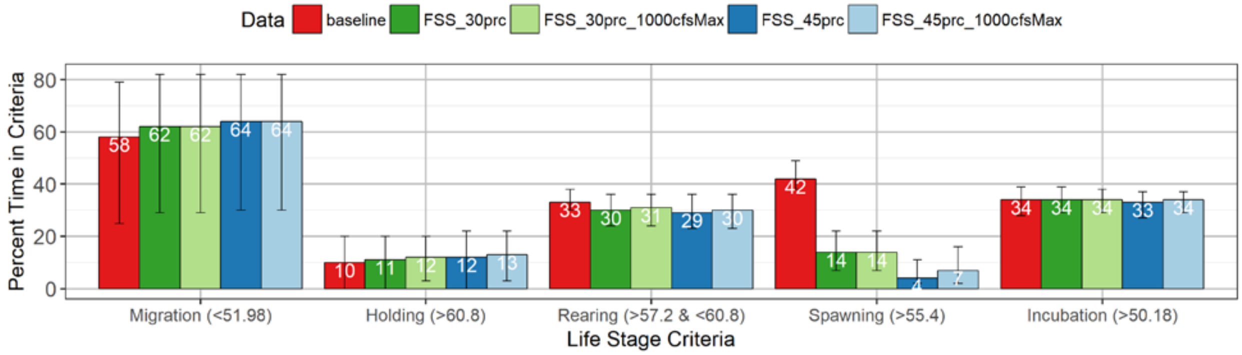

Figure 3-9. Comparison of Temperature Simulations at Cougar Dam for Different Life Stages of Chinook Salmon in Baseline (Red) and two Proposed Floating Screen Structure Configurations (Blue and Green)

NOTE: Error bars indicate the 95th and 5th percentiles across the four calendar year scenarios simulated. Timeframes for each life stage criteria are shown in Table 3-2.

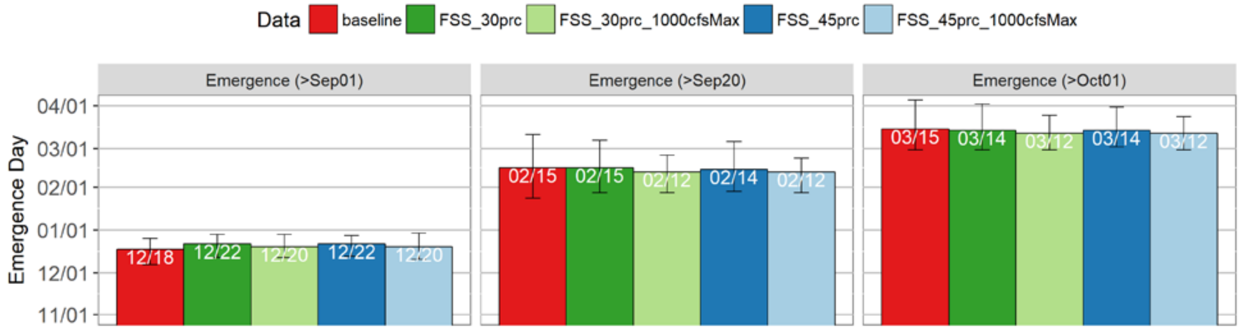

Figure 3-10. Comparison of Emergence Timing Averaged Over 4 Calendar-Year Scenarios at Cougar Dam Chinook Salmon in Baseline (Red) and Two Proposed FSS Configurations (Blue and Green)

NOTE: Error bars indicate the 95th and 5th percentiles across the four calendar year scenarios simulated. Timeframes for each life stage criteria are shown in Table 3-2.

The current design of the FSS incorporates two separate intake weirs with maximum flow capacity of 400 and 600 cfs, respectively. It is assumed that the configuration (width and direction) of the separate weirs on the FSS would not affect the temperature simulations in this report. In other words, the temperature model configuration (boundary conditions) would not change unless the depth of the floating weir intakes change or the minimum flow through the weirs changes.

3.5 TEMPERATURE EFFECTS FROM ATTEMPTED MINIMIZING OF COMPETING FLOW

Some concerns of competing flow between the WTCT weir gates and the FSS when dam outflow exceeds the FSS capacity of 1,000 cfs and reservoir level is above 1,571 feet have led to the proposed usage of the RO. While utilization of the RO bypass gates when the reservoir is stratified is not preferred due to impacts to downstream temperatures, limited usage during the early spring or late fall when the lake is not as deeply stratified may have fewer effects on downstream temperatures. To test this assumption, the 2008 calendar year scenario was used, where dam outflows exceeded 1,000 cfs during May and June. In the model, a total maximum release rate of 28.32 cubic meters per second (1,000 cfs) was allocated to the weir outlets using variable MAXFLOW in the w2_selective.npt file. This routes outflows exceeding 1,000 cfs to the RO outlet (1,488.5 feet) instead of the WTCT weir gates. Estimated fall emergence timing ranged between 6 to 16 days earlier in the CY08 scenario (comparing FSS_30prc to FSS_30prc_1000cfsMax and FSS_45prc to FSS_45prc_1000cfsMax), the only year in which this circumstance occurred in the four calendar-year scenarios of this study (Figure 3-11). In the 2008 scenario, this operation occurred during May-June.

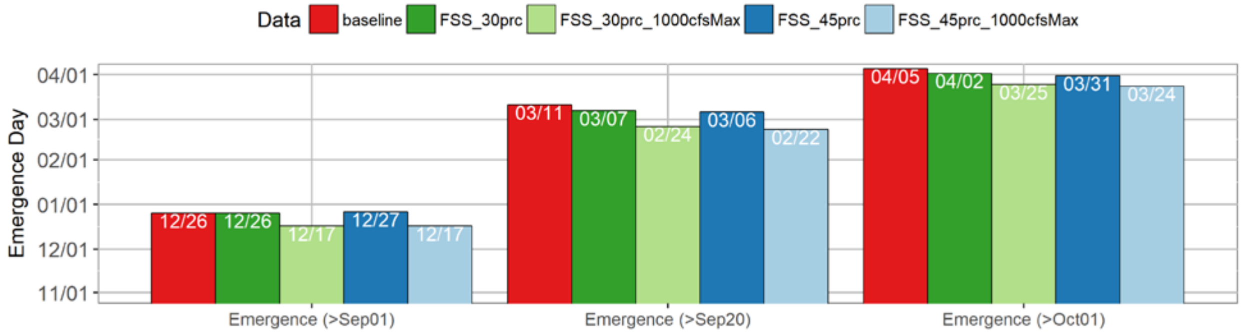

Figure 3-11. Comparison of Emergence Timing in 2008 at Cougar Dam Chinook Salmon in Baseline (Red) and Four Proposed Floating Screen Structure Configurations (Blue and Green)

3.6 ACCLIMATION POND ANALYSIS

Some concern exists regarding the potential difference in water temperature near the surface of Cougar Lake to that below Cougar Dam following successful capture and transport of juvenile fish. This led to an analysis of temperature model output to address the need of an acclimation pool to help adjust fish to water temperatures below the dam. The models and scenarios used in Section 3 of this report that represent 30 percent and 45 percent leakage through the temperature control tower weir gates (scenarios FSS_30prc and FSS_45prc) were used to help answer this question. A comparison of downstream blended temperature (labeled "Tout") with the FSS intake temperature (labeled "T1") is shown in Figures 3-12 and 3-13. Given that there is (1) typically minimal lake stratification in November-March, and (2) a scheduled maintenance period July-August, the two timeframes evaluated were June (Figure 3-12) and September (Figure 3-13).

Temperature difference between FSS intake and downstream temperatures during ranges from 4.2 to 0.8 degrees F in June (Table 3-3) and from 3.2 to 0 degrees F from September 1 to October 15 (Table 3-4) over the 4 years simulated. Mean difference in June ranged from 1.4 to 2.3 degrees F and from 1.0 to 2.0 degrees F from September 1 to October 15. These temperature differences are below current guidelines of 2 degrees C (Axel, et al., 2011) for transporting juvenile salmonids from one thermal environment to another, so design of a fish acclimation pond below Cougar is not needed at this time.

Figure *3-10..*

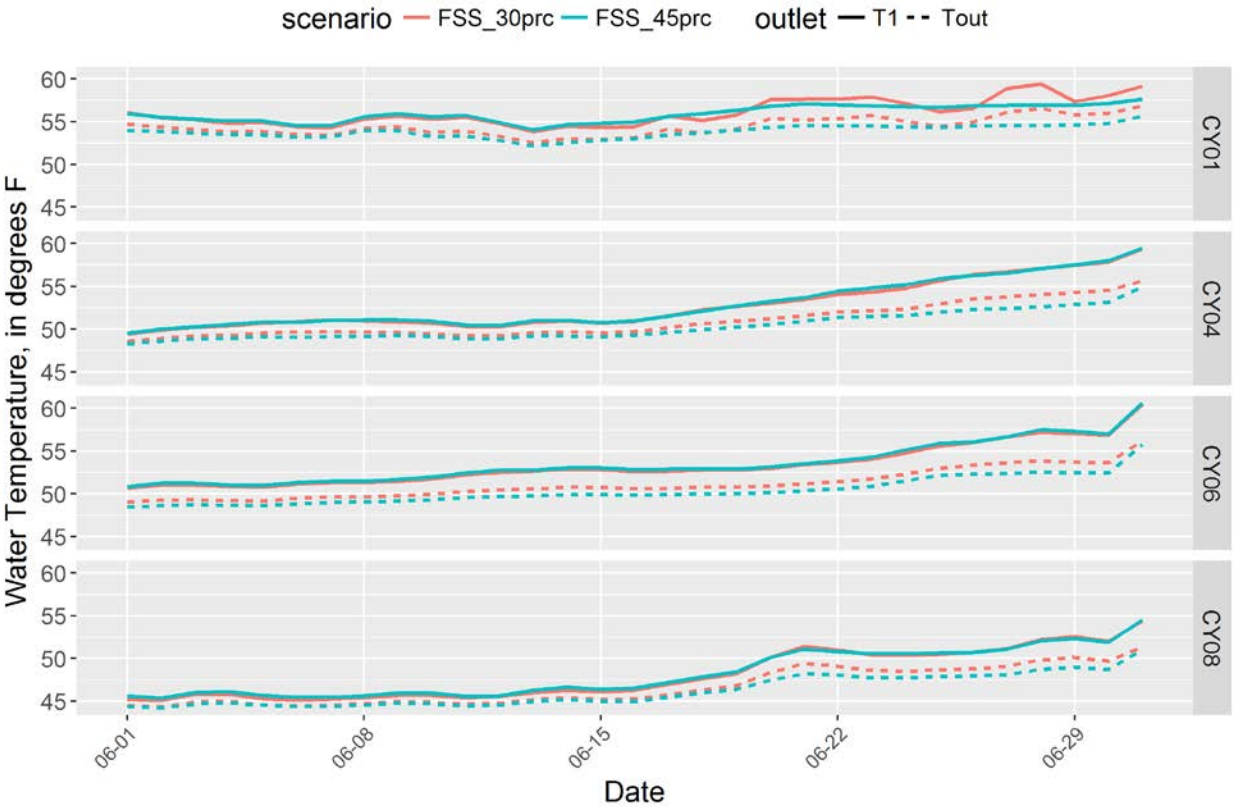

Figure 3-12. Temperature of Floating Screen Structure Temperature ("T1" solid line) Compared to Downstream Release Temperature Mix ("Tout" Dashed Lines) for Two Floating Screen Structure Scenarios in June of 4 Different Calendar Years

Table 3-3. Temperature Difference Between Floating Screen Structure Intake and Downstream Mixed Water Temperature for FSS_30prc Scenarios During June

Calendar Year	Minimum	Mean	Maximum
CY01	1.3	1.6	2.6
CY04	0.9	1.8	3.8
CY06	1.6	2.3	4.2
CY08	0.8	1.4	3.0

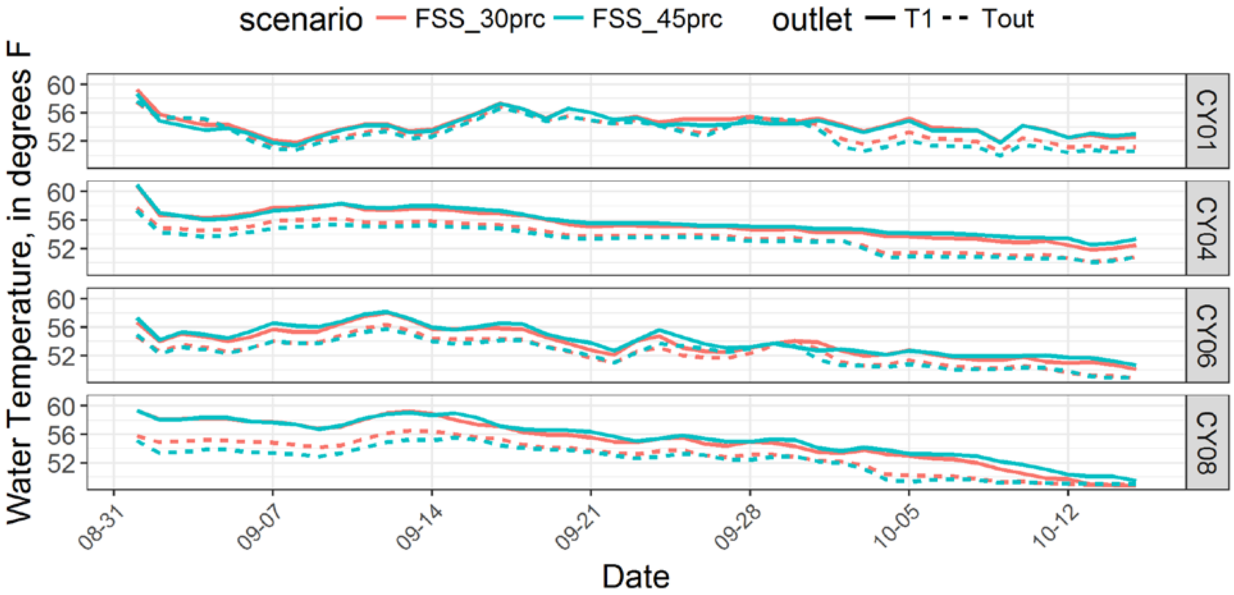

Figure 3-13. Temperature of Floating Screen Structure Temperature ("T1" solid line) Compared to Downstream Release Temperature Mix ("Tout" dashed lines) for Two Floating Screen Structure Scenarios in September 1- October 15 of 4 Different Calendar Years

Table 3-4. Temperature Difference Between Floating Screen Structure Intake and Downstream Mixed Water Temperature for FSS_30prc Scenarios During September 1- October 15

Calendar Year	Minimum	Mean	Maximum
CY01	1.2	1.0	1.7
CY04	1.7	1.7	3.2
CY06	1.3	1.3	1.8
CY08	0.0	2.0	2.9

3.7 TOTAL DISSOLVED GAS

Total dissolved gases saturation levels above the state standard of 110 percent saturation at Cougar tend to be associated with RO discharge greater than 500 cfs. Usage of the RO depends on when the powerhouse maximum capacity is exceeded (1,380 cfs with both turbines at maximum load). The FSS is designed to connect to weir gates on the temperature tower wet well, which then routes water to the RO bypass tunnel thereby routing outflow to the RO or powerhouse. So, RO usage with the addition of the FSS will not be determined by FSS functionality, but by the limits of the powerhouse as is currently the case. For this reason, no increase in the frequency of total dissolved gases exceedances is expected, even when the FSS is nonoperational.

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SECTION 4 - HYDRAULIC DESIGN

4.1 DAM FEATURES DESCRIPTION

a. Water Temperature Control Tower

The 302-foot-high water temperature control tower (WTCT) was constructed adjoining the original intake tower and began operation in May 2005. The WTCT is capable of selectively withdrawing water from different reservoir elevations to meet target outflows and water temperatures, providing more natural conditions for salmonids in the South Fork and mainstem McKenzie rivers. Plan, elevation, and section views of the WTC tower are provided in the reference drawings section of this report (see Appendix A for layout and modifications). The original intake tower includes a dry well (with operating equipment, stairs, and elevator), dual regulating outlet (RO) conduits, debris collection structure (trashrack), and access bridge. The original intake tower was modified for construction of the WTCT through addition of a wet well with nine adjustable weir gates for selective withdrawal and RO and penstock bypass gates. The WTC wet well serves both the power generating facilities and the RO works. The selective withdrawal gates for temperature control consist of nine 9-foot-wide by 47-foot-tall independently operated telescoping weirs. Six are located upstream of the ROs and three are located upstream of the penstock.

The RO bypass gates consist of two 9-foot-wide by 27-foot-high gated openings at centerline elevation 1,488.5 feet that pass water into the lower portion of the WTCT wet well.

The penstock bypass gate is a 9-foot-wide by 19-foot-high gated opening that passes water into the lower portion of the WTCT wet well. The penstock bypass gate will no longer be operational when the floating screen structure (FSS) is built; modifications are further described in Sections 5 and 6 of this report.

b. Turbines

The intake to the penstock from the WTCT wet well is an 8 foot 2 inch by 10 foot 6 inch rectangular section with a transition between the intake and the penstock. The 10-foot-6 inch-diameter main penstock is 1,030 feet long in rock. The penstock at the lower end branches into two 7-foot-6-inch-diameter conduits that lead to the turbines in the powerhouse. The power plant consists of two 12,500 kilowatt (kW) Francis units. The head of the turbines varies from a minimum of 266 feet between normal tailwater and minimum power pool to a maximum of 449 feet between tailwater and maximum or full pool. Flows through the turbines with varying pool elevation are summarized in the Pertinent Data Table at the front of this report.

c. Regulating Outlets

The ROs are located in the left abutment inside the WTCT wet well, 60 feet above the penstock intake at centerline elevation 1,485.0 feet. The two conduit entrances are 12.5 feet by 6.5 feet, and converge to a 13.5-foot-diameter RO tunnel. The overall length of the RO system is 993 feet. The existing ROs will discharge a maximum of 11,800 cfs at maximum conservation pool (1,690 feet) as shown in the Pertinent Data. Each RO conduit has two slide gates, one for normal operation and the other for emergency operation. In addition, there are bulkhead guides upstream from the emergency gate in which stoplogs can be placed. The two RO conduits join together downstream of the slide gates to form a single conduit to the outlet spillway and the tailrace.

d. Fish Facilities

(1) Historic Passage Facilities at Cougar Dam

A fingerling bypass system was integrated into the tower in 1963 during original intake tower construction for downstream fish passage. A profile of the fish facilities is provided in the recent Willamette Downstream Passage Design Requirements Report (AECOM/BioAnalysts, 2010). The original fingerling bypass system consisted of several intake port fish horns at different elevations on the intake tower. Flow into each horn was controlled with a butterfly valve, operated either fully open or fully closed. Fish and water entered the operating fish horn, passed to a 3-foot-diameter pipe and then to a 5-foot-diameter vertical fish well. The fish well discharged continuously into the RO upstream of the slide gate controlling the RO discharge. Water levels in the fish well varied depending on RO discharge and fish horn flow and could result in a long freefall for fish and varying depths to cushion the fall at the bottom of the fish well. The fish horn flow was dictated by head over the horn with a maximum of 350 cfs at 50 feet of head.

Testing from 1965 to 1967 proved the bypass to be ineffective at collecting and passing fish safely and the downstream passage system was abandoned in the late 1960s (Ingram and Korn 1969). The fingerling bypass fish horns on the intake tower were removed for construction of the WTCT modifications.

An adult collection facility downstream of the powerhouse was completed in July 2010 and is currently in operation. It is used to collect returning adult Upper Willamette River Chinook and bull trout for truck transportation and release above the dam, in lieu of a volitional fish ladder. In addition, other native anadromous fish collected at the facility are transported upstream for release.

(2) Current Downstream Passage at Cougar Dam

With the abandonment of the fingerling bypass system, Cougar Dam was left without a dedicated means of passing downstream migrants. The routes available are the existing operating outlets: the RO and the penstock. Delay and injury occur, as the outlet works were designed for power production and for regulating reservoir releases for authorized purposes including flood risk management. The RO entrances are 50 to 200 feet below the water surface posing significant difficulties with fish finding the outlets, especially at higher pool elevations. Passage through gates and conduits that were designed for large volume flows can pose significant problems for fish passage.

In addition, the flows into the WTCT are such that fish are found to be milling in the area in front of the weirs without a good attraction flow signature to guide them into the tower and to the outlets. Fish are attracted to the face of the tower but do not enter the tower at a high enough rate. Additionally, many fish that enter the tower can and do exit again.

e. Diversion Tunnel

The Cougar Dam diversion tunnel was used to divert the South Fork McKenzie River during the original construction of the dam. The original diversion tunnel was plugged and abandoned after construction of the dam was completed; however, it was later excavated and upgraded. While the diversion tunnel is not part of regular Cougar operations, the gate control structure has been maintained as a low-level outlet following construction of the WTCT. During 2016, the diversion tunnel was used to pass flow while the reservoir was drawn down below the regularly used outlets, to allow access to the lower parts of the WTCT structure and cul-de-sac for debris removal.

The original diversion tunnel consisted of a vertical-sided horseshoe-shaped tunnel 1,850 feet long with a 9.75-foot radius and no flow control devices other than an upstream bulkhead to stop the flow. The upstream portal is located in the channel at elevation 1,290 feet, and the downstream portal is located adjacent to the powerhouse with an outlet invert elevation of 1,250 feet. The diversion tunnel has an intake structure, separate from the RO and turbine intakes, with an invert elevation approximately 130 feet below the WTCT.

During original construction, another tunnel was constructed to divert Rush Creek. This was required for construction of the base of the intake tower. The Rush Creek diversion tunnel begins at elevation 1,475 feet and exits adjacent to the upstream portal of the main diversion tunnel near elevation 1,290 feet. The Rush Creek diversion tunnel was not plugged after construction.

In order to construct the WTCT, the original diversion tunnel was excavated, upgraded, and put back into service. The concrete plug (stations 16+58 to 16+93) was excavated, a steel liner and rock traps were installed between stations 16+93 to 17+90, gate structures were erected between stations 17+90 to 18+26, and the remaining portion of the channel tunnel was lined from the downstream end of the gate structure to the channel exit at station 25+97.

The gate control structures consist of two flow conduits, each measuring 6 feet tall by 2 feet 3 inches wide. Each conduit contains an emergency valve and an operating valve. At elevation 1,532 feet, each conduit has an approximate flow capacity of 110 cfs to 1,500 cfs at a 0.5-foot and 6.0-foot gate opening, respectively. Flow is pressurized upstream of the operating gates, with open channel flow downstream of the gate control structure.

4.2 PROPOSED DOWNSTREAM PASSAGE FACILITIES

a. General

The proposed FSS configuration has an at-tower location which takes advantage of flows provided by surface withdrawal through the tower for regular temperature control operations. The collector will work in conjunction with normal project outflows through the use of gravity flow. Modifications to the WTCT, with the addition of surface withdrawal capability below elevation 1,571 feet on the penstock side weirs, to elevation 1,528 feet, will provide the opportunity for year-round collection (Appendix A). Currently, temperature operations are limited to reservoir elevation above 1,571 feet. An added benefit of the modifications to the WTCT will provide additional capability in meeting downstream water temperature targets during dry water years, when pool elevations are low.

The FSS lends itself to the potential modifications toward improving fish collection efficiency (FCE) and survival, if needed, through operational adjustments, including entrance modifications and partial depth guidance and/or exclusion nets.

Truck transport was selected as the method of passage from the FSS holding to a downstream release site. This is a proven method of providing transport for upstream passage and has been implemented at several facilities in the Willamette and Columbia basins.

Amphibious vehicles (AVs) will be used in lieu of conventional fish transport trucks to drive/navigate directly to the FSS through all pool elevations.

b. <u>Flow</u>

The minimum project outflow is 300 cfs to maintain established downstream flow targets, and project outflow varies throughout the year. The FSS has been designed to operate with a flow range of 300-1,060 cfs gravity flow. The FSS high flow of 1,060 cfs was selected by considering several factors, including sizing of the structure and WTCT operations. Figure 4-1 shows outflow ranges and the monthly percentage of occurrences, over the period of record, within 50-cfs flow bands.

The FSS will be attached to the WTCT and will work in conjunction with current temperature operations. Surface water currently drawn through the penstock side WTC gates, from 300 up to 1,060 cfs, will first pass through the FSS, then the screened flow will pass into the WTCT on the penstock side of the WTCT (Figures 4-2, 4-3, 4-4). To best accommodate this range of flows, the FSS was designed with two separate collection channels, which will combine screened water to deliver to the WTCT penstock weir gates. The temperature control weirs located over the RO entrances will maintain their current functionality.

For project outflows above 1,060 cfs, the FSS will remain operational, with the excess flow passing through the existing lower RO bypass intake gates (centerline elevation 1,488.5 feet) and/or through the RO temperature control weirs located adjacent to the penstock control weirs (Figure 4-2). In order to accomplish this below the invert of the RO side temperature control weirs, the RO bypass gates will need be throttled at various gate openings, which deviates from their current full open/full closed operation. Testing of the RO bypass gates at various openings will be conducted in early fiscal year (FY) 2019 to determine the feasibility of this type of operation. Should there be issues with vibration, loading on the gate, or other functional problems, modifications to the gate may have to be considered, such as gate lip shape or hoist equipment changes. Decisions regarding the operation of the RO bypass gates will be presented in the final DDR and plans and specifications.

Minimizing false attraction to an outlet other than the FSS was one of the considerations in positioning of the FSS entrances. CFD results were used to examine flows in excess of the 1,060 cfs FSS capacity which would be diverted to the RO weir and bypass entrances, and flow signatures were studied in determining optimal entrance locations.

The RO bypass intakes centerlines are located at elevation 1,488.5 feet, more than 40 feet below minimum conservation pool (1,532 feet), which provides a buffer, even at the lowest elevation, between surface flow into the FSS and any flow through the RO bypass gates Further information on the CFD analysis can be found in section (4.5.e.).

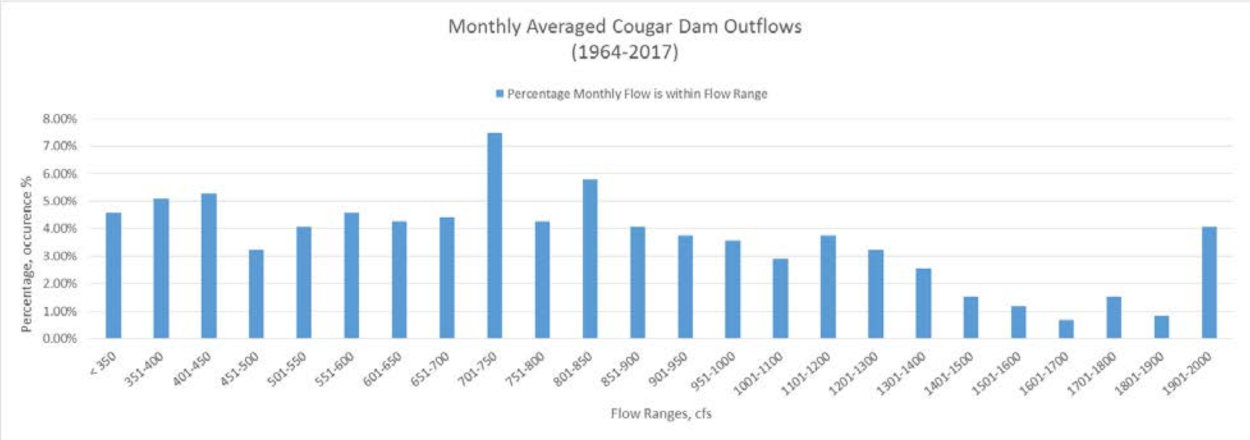

Figure 4-1. Cougar Dam Monthly Averaged Outflow

NOTE: Period of record adjusted for major operational changes during WTCT construction period.

4.3 GENERAL CRITERIA AND CONSIDERATIONS

The following general hydraulic criteria were applied to design:

- Civil Works: The civil works of the passage facilities must be designed in a manner that prevents undesirable hydraulic effects (such as eddies and stagnant flow zones) that may delay or injure fish or provide predator habitat or predator access. (NMFS 2011, Section 11.8.1.3)

- Trashracks: If trashracks are used, sufficient hydraulic gradient must be provided to route juvenile fish from between the trashrack and screens to the bypass. (NMFS 2011, Section 11.9.1.6)

- Screen Cleaning (Active Screens): Active screens must be automatically cleaned to prevent accumulation of debris. The screen cleaner design should allow for complete debris removal at least every 5 minutes, and operated as required to prevent accumulation of debris. The head differential to trigger screen cleaning for intermittent type cleaning systems must be a maximum of 0.1 foot over clean screen conditions or as agreed to by NMFS. A variable timing interval trigger must also be used for intermittent type cleaning systems as the primary trigger for a cleaning cycle. The cleaning system and protocol must be effective, reliable, and satisfactory to NMFS. (NMFS 2011, Section 11.10.1.2)

- Inspection: The completed screen and bypass facility must be made available for inspection by NMFS, to verify that the screen is being operated consistent with the design criteria. (NMFS 2011, Section 11.10.1.5)

a. Fish Passage Facility Flows

The following fish passage facility sizing and flow criteria and considerations were considered in this DDR:

- The bypass entrance and all components of the bypass system must be of sufficient size and hydraulic capacity to minimize the potential for debris blockage. (NMFS 2011, Section 11.9.1.1)
- Screens greater than or equal to 6 feet in length must be constructed with the downstream end of the screen terminating at a bypass entrance. (NMFS 2008, Section 11.9.1.1)
- Multiple Entrances: Multiple bypass entrances should be used if the sweeping velocity may not move fish to the bypass within 60 seconds, assuming fish are transported along the length of the screen face at a rate equaling sweeping velocity. (NMFS 2011, Section 11.9.1.2)
- Secondary Screen: In cases where there is insufficient flow available to satisfy hydraulic requirements at the bypass entrance for the primary screens, a secondary screen may be required within the primary bypass. The secondary *bypass flow* conveys fish to the bypass outfall location or other destination, and returns secondary screened flow for water use. (NMFS 2011, Section 11.9.1.4)
- Bypass Channel Velocity: To ensure that fish move quickly through the bypass channel (i.e., the conveyance from the terminus of the screen to the bypass pipe), the rate of increase in velocity between any two points in the bypass channel should not decrease and should not exceed 0.2 fps per foot of travel. (NMFS 2011, Section 11.9.1.8)
- Flow Control: Each bypass entrance must be provided with independent flow-control capability. (NMFS 2011, Section 11.9.2.1)
- Bypass pipes and joints must have smooth surfaces to provide conditions that minimize turbulence, the risk of catching debris, and the potential for fish injury. Pipe joints may be subject to inspection and approval by NMFS prior to implementation of the bypass. Every effort should be made to minimize the length of the bypass pipe, while maintaining hydraulic criteria. (NMFS 2011, Section 11.9.3.1)

- Bypass Flow Transitions: Fish should not be pumped within the bypass system. Fish must not be allowed to free-fall within a pipe or other enclosed conduit in a bypass system. Downwells must be designed with a free water surface, and designed for safe and timely fish passage by proper consideration of turbulence, geometry, and alignment. (NMFS 2011, Section 11.9.3.2)

b. Dewatering Screens

The following criteria and considerations for dewatering screens are considered in design of downstream fish passage facilities:

- Approach velocity: the approach velocity must not exceed 0.40 fps for active screens, or 0.20 fps for passive screens. (NMFS 2011, Section 11.6.1.1)

- Flow Distribution: The screen design must provide for nearly uniform flow distribution (see Section 15.2) over the screen surface, thereby minimizing *approach velocity* over the entire screen face. The screen designer must show how uniform flow distribution is to be achieved. Providing adjustable *porosity* control on the downstream side of screens, and/or flow *training wall*s may be required. Large facilities may require hydraulic modeling to identify and correct areas of concern. Uniform flow distribution avoids localized areas of high velocity, which have the potential to impinge fish. (NMFS 2011, Section 11.6.1.4)

- Screens Longer Than 6 Feet:

  - Screens longer than 6 feet must be angled and must have sweeping velocity greater than the approach velocity. This angle may be dictated by site-specific geometry, hydraulic, and sediment conditions. Optimally, sweeping velocity should be at least 0.8 fps and less than 3 fps.

  - For screens longer than 6 feet, sweeping velocity must not decrease along the length of the screen. (NMFS 2011, Section 11.6.1.5)

- Screen Material: Slotted screen face openings must not exceed 1.75 mm (approximately 1/16 inch) in the narrow direction. (NMFS 2011, Section 11.7.1.2)

- The screen material must be corrosion resistant and sufficiently durable to maintain a smooth uniform surface with long term use. (NMFS 2011, Section 11.7.1.4)

- Other components of the screen facility (such as seals) must not include gaps greater than the maximum screen opening defined above. (NMFS 2011, Section 11.7.1.5)

- The percent open area for any screen material must be at least 27 percent (NMFS 2011, Section 11.7.1.6)

- Placement of screen surfaces: The face of all screen surfaces must be placed flush (to the extent possible) with any adjacent screen bay, pier noses, and walls to allow fish unimpeded movement parallel to the screen face and ready access to bypass routes. (NMFS 2011, Section 11.8.1.1)

4.4 HYDROLOGY AND RESERVOIR OPERATIONS

River flows downstream of Cougar Reservoir have been regulated since completion of the dam in 1964. The maximum, median, and minimum mean daily regulated discharge from Cougar Reservoir is shown in Figure 4-2 for each day of the year, along with the water control diagram.

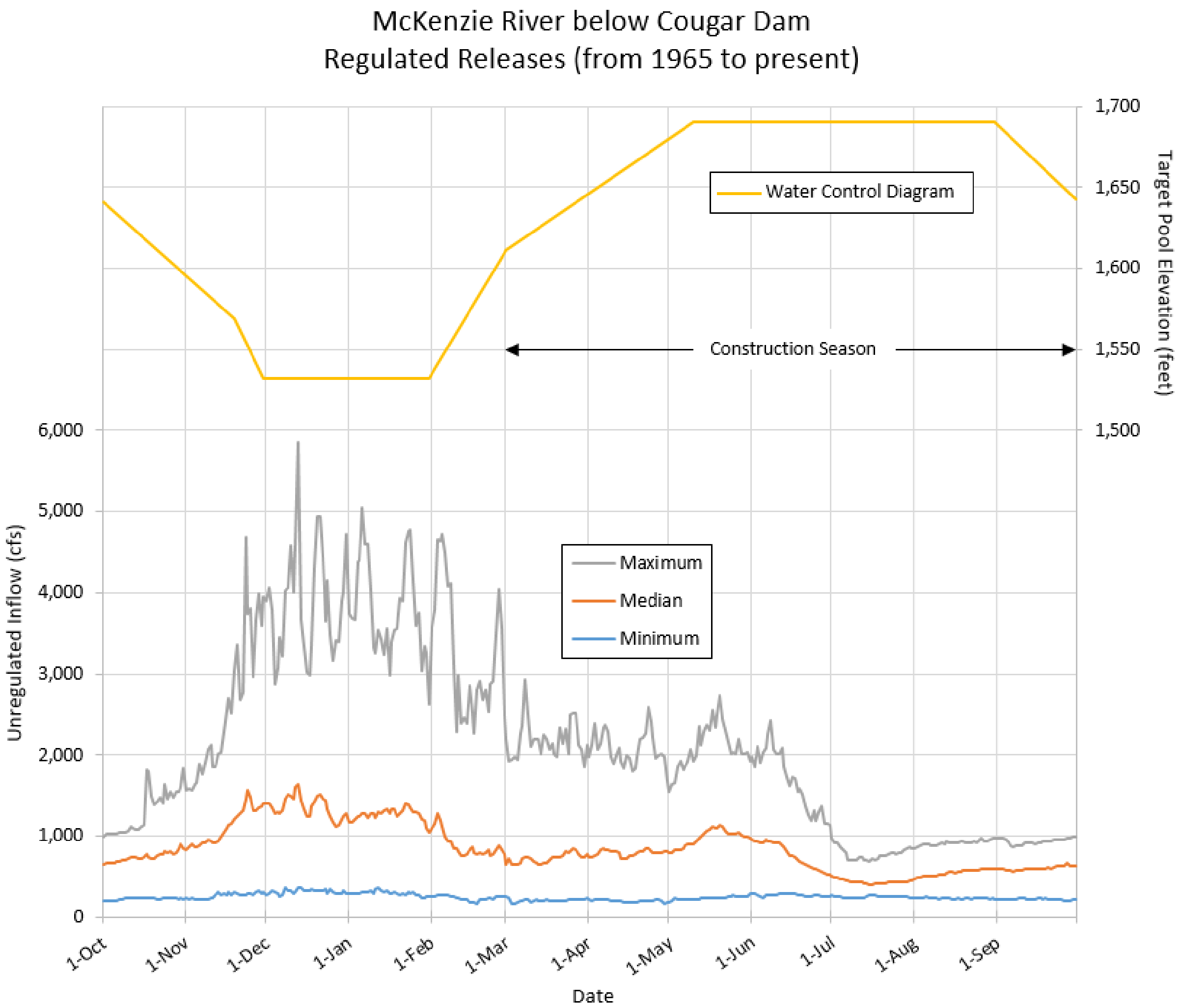

Figure 4-2. Cougar Dam Regulated Outflows

Examining exceedance (and non-exceedance) values for flow rate and pool elevations at Cougar Dam helps to determine what the average, minimum, and maximum outflows have historically been, and what can be expected to flow into the proposed FSS during different times of the year. Table 4-1 and Figure 4-3 show the outflow percentile from Cougar Reservoir with a period of record from February 1, 1964, to March 31, 2017. The 5th percentile shows that 95 percent of the Cougar Dam outflow exceeds 290 cfs. On the other side of the spectrum, the 95th percentile shows that 5 percent of the outflow for the period of record exceeds 2,100 cfs. The FSS design flow of

1000 cfs corresponds to approximately the 75th percentile (outflow exceeds 1000 cfs 25 percent of the time).

Table 4-1. Cougar Dam Outflow Percentile

Percentile	Flow (cfs)
5th	290
50th	700
95th	2,100

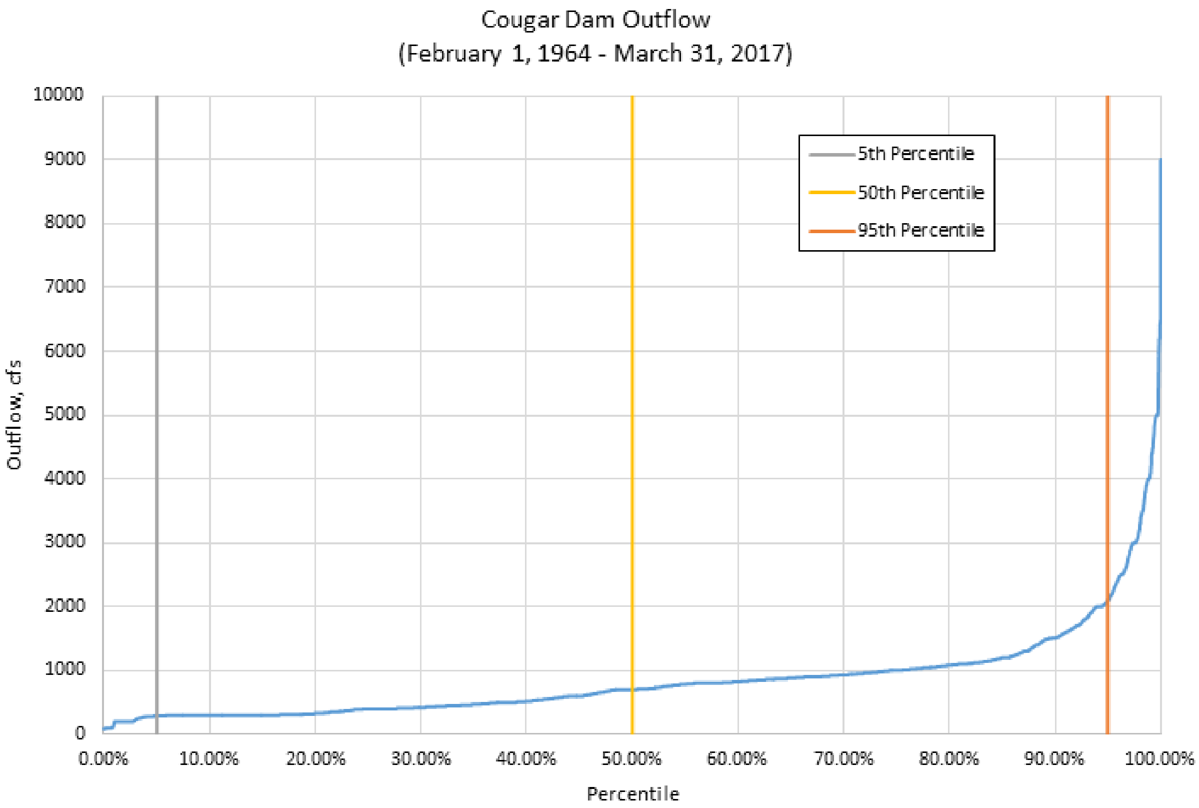

Figure 4-3. Cougar Dam Outflow Percentile

The reservoir attenuates inflow during flood events and is used to augment downstream river flows during periods of low inflow. Table 4-2 and Figure 4-4 show the outflow percentile of Cougar Dam, including only outflow when the daily averaged reservoir elevation is less than 1,571 feet.

Table 4-2. Cougar Dam Outflow Percentile for Elevation Less Than 1,571 Feet

Percentile	Flow (cfs)
5th	300
50th	900
95th	2,500

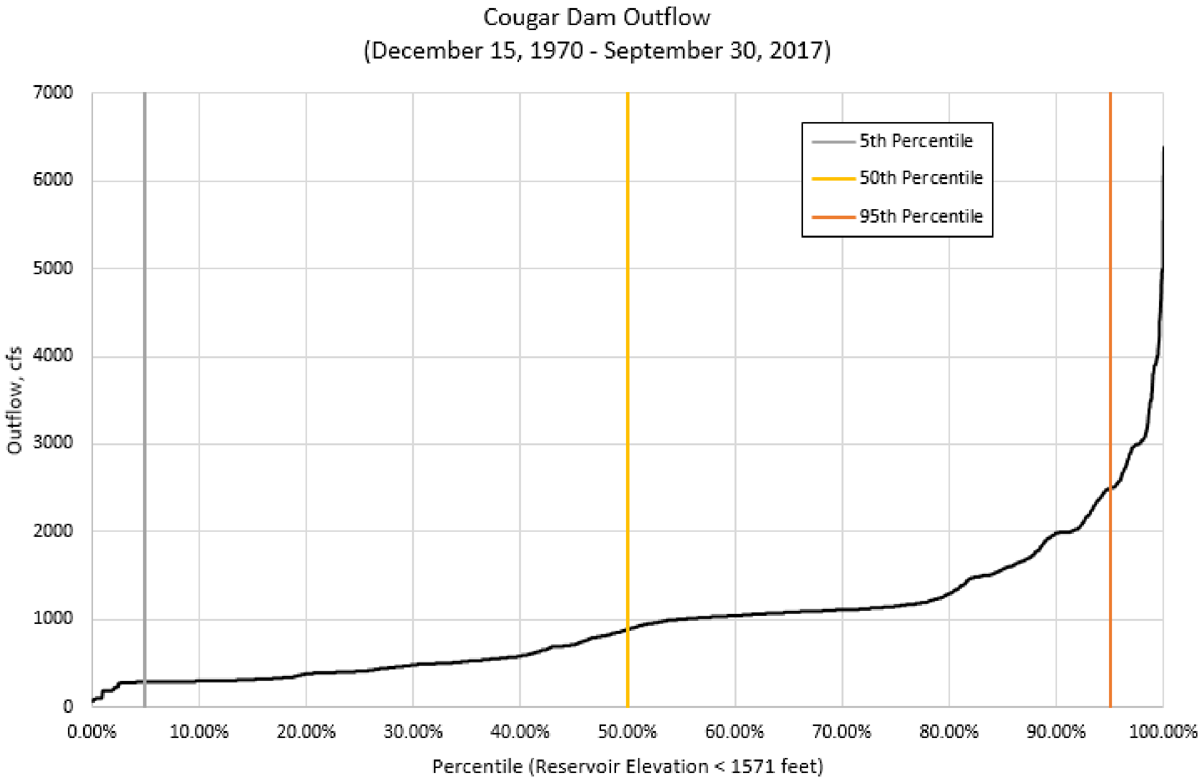

Figure 4-4. Cougar Dam Outflow Percentile – Reservoir Elevation Below 1,571 Feet

The reservoir is drawn down during flood season (December to February), so it is expected that there will be higher outflows while the reservoir's water surface elevation is less than 1,571 feet (Table 4-2 and Figure 4-4). Additional temperature control operation will be available with WTCT modifications down to minimum conservation pool. Alternatively, the reservoir elevation is higher during lower flow periods through the summer months. Table 4-3 and Figure 4-5 show the Cougar outflow percentiles when the reservoir is at or above 1,571 feet elevation. Lower flow is expected for elevations greater than 1,571 feet compared to elevations less than this. Flow data for these higher elevations are presented in Table 4-3 and Figure 4-5, where 95 percent of flow does not exceed 1,890 cfs.

Table 4-3. Cougar Dam Outflow Percentile for Elevation Greater Than 1,571 Feet

Percentile	Flow (cfs)
5th	290
50th	700
95th	1,890

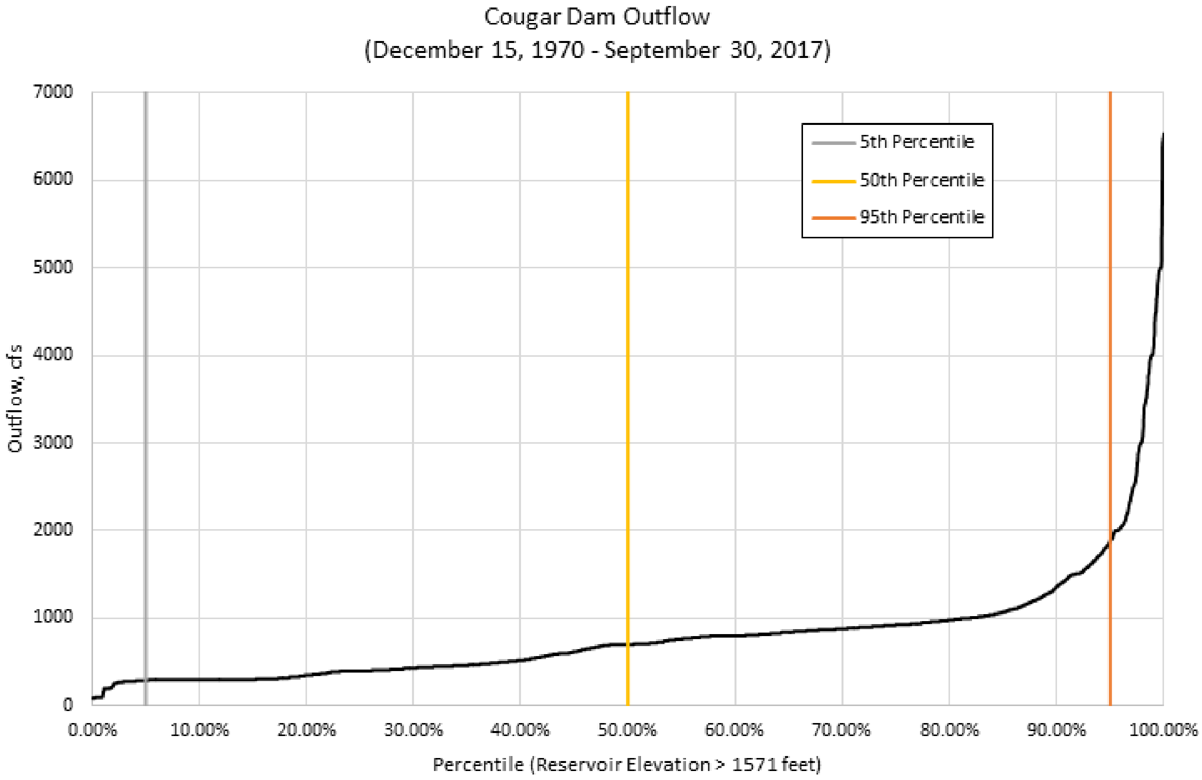

Figure 4-5. Cougar Dam Outflow Percentile – Reservoir Elevation Above 1,571 Feet

4.5 HYDRAULIC DESIGN

a. General

Three configurations were considered for the FSS following the alternatives study (EDR): (1) Single Entrance Configuration, and (2) Dual Entrance In-line with WTCT Configuration (3) Dual Entrance Angled Configuration. Each were expected to meet the original design criteria and capacity requirements for gravity flow of up to 1,000 cfs. Original figures showing these options are shown in Figures 1-3 through 1-5.

The dual entrance angled configuration was selected to move forward in the design process for reasons outlined in Section 1.5.

b. Floating Screen Structure Configurations

(1) Single Entrance Configuration

This configuration is similar in entrance and screen configuration to other juvenile fish collectors currently in operation in the region (Oregon/Washington states) with the following general features:

- One V-screen entrance with capacity of 300-1,000 cfs.

- Two sets of primary dewatering screens (one on each side of channel) to separate attraction water.

- Two sets of secondary dewatering screens to eliminate remainder of attraction water and maintain “capture” velocity of 7-8 fps.

- Fish transport system, including raceways, basic separation and hoppers for truck transport.

(2) Dual Entrance In-line with WTCT Configuration:

The purpose of this configuration is to meet criteria and design flow requirements, while providing a way to position the FSS closer to the WTCT, which has been identified as a goal of the DDR, providing an advantage for both fish collection and operations and maintenance. Having two entrances will also allow for more control of hydraulic conditions in the FSS than a single entrance, considering the flow differential of up to 700 cfs. The dual in-line configuration is comprised of the following general features:

- Two parallel 500-cfs V-screen intakes to screen a total of up to 1,000 cfs.

- Dual sets of primary dewatering screens (one set for each dewatering channel) to separate attraction water.

- Dual sets of secondary dewatering screens to eliminate remainder of attraction water, and maintain “capture” velocity of 7-8 fps.

- Converging screened flow channels (free of fish and debris) to WTCT wet well entrance.

- Fish transport system, including raceways, basic separation, and hoppers for truck transport.

(3) SELECTED ALTERNATIVE: Dual Entrance Angled Configuration

This configuration meets criteria and design flow requirements, while providing a way to position the FSS as close as possible to the WTCT and provide entrances closer to the area of known congregation of juveniles. Having two entrances will allow for more control of hydraulic conditions in the FSS than a single entrance, considering the FSS operational differential of up to 700 cfs (300-1,060 cfs). The dual entrance angled configuration consists of the following general features:

- Two V-screen intakes with approximate 600 cfs and 400 cfs flow rate split for a total screening flow capacity of 1,000 cfs. Capacity of exterior and interior is 605 cfs and 455 cfs respectively.

- Dual sets of primary dewatering screens (one set for each dewatering channel) to separate attraction water.

- Dual sets of secondary dewatering screens to eliminate remainder of attraction water, and establish and maintain "capture" velocity of 7-8 fps.

- Converging dewatering channels (fish free water) to WTCT wet well entrance.

- Fish transport system, including raceways, basic separation, and holding facilities for truck transport.

c. Intake Location and Orientation

Prior to finalizing a layout, the location of the FSS to optimize attraction to the entrance was carefully considered. Fish are known to congregate in the area in front of the WTCT weirs as verified by Research, Monitoring, and Evaluation studies in the Cougar cul-de-sac. A key and critical feature and risk driver for setting the groundwork in transition from the EDR to the DDR was placement of the FSS in a location where fish congregate in addition to providing needed attraction flow at the entrance. It was agreed that positioning the FSS entrance as close as possible to the WTCT would provide the best opportunity for collection, given the preference for this location.

The intake and orientation of the dual entrance collector was investigated using a CFD model. The main goals of the dual entrance, angled collector are to have a more compact collector that will fit near the tower and utilize the dam as a natural guidance structure for fish. Being positioned close to the RO side temperature control weirs, this could also take advantage of dam outflow in excess of 1,000 cfs as augmented attraction flow. From recent Research, Monitoring, and Evaluation studies, it has been found that most of the juvenile fish congregate in front of the tower, so angling the collector entrances towards that area and providing a more fish-friendly flow signature than the temperature control weirs or bypass gates should encourage more juveniles to pass through the FSS.

A three-dimensional (3-D) CFD model had already been developed for the forebay and cul-de-sac, including the water control tower, for previous work at Cougar Dam. The selected FSS configuration was "imprinted" onto this existing model to evaluate flow patterns in the vicinity of the collector, as well as potential large scale hydraulic changes in the cul-de-sac which could be associated with the FSS entrance location, forebay elevations, and operational patterns.

A rigid lid model was used for the CFD efforts. This does not show the correct dynamics of the water surface, as a free-surface CFD model; however, it does give an accurate depiction of flow in the forebay and into the collector within the water column. Using a rigid lid model, the simulation time is significantly lower for each run than with a free-surface CFD model. Inputs into the CFD model were taken as the 95 percent and 5 percent exceedance values for historic outflow for a given operating pool elevation from Cougar Dam over the last 30 years, as well as the average outflow over this period of record. The flow rates used in the simulations only deviated from the exceedance flows when current operations of the dam deviated from the statistical flow values derived from historical data.

These values were computed for three different reservoir elevations of interest, corresponding to the Cougar Dam rule curve (see Table 4-4 below).

Table 4-4. CFS Flow Conditions

Run	**Elev**	**Description**	**Notes**	**Q FSS**	**Q Temp Weir 1**	**Q Temp Weir 2**	**Q RO Bypass 1**	**Q River (split)**		**Q River**
								Q East Fork	**Q South Fork**	
	(ft)			**(cfs)**	**(cfs)**	**(cfs)**	**(cfs)**	**(cfs)**	**(cfs)**	**(cfs)**
1	1,610	5% exceedance, drafting		1,000	350	350	0	680	1020	1,700
2	1,610	Avg. Flow, filling		900	0	0	0	360	540	900
3	1,610	95% exceedance, filling		310	0	0	0	124	186	310
4	1,571	5% exceedance, drafting	Still using RO Temp Weir	1,000	340	340	0	672	1,008	1,680
4b	1,571	5% exceedance, drafting	Switching to RO Bypass	1,000	0	0	680	672	1,008	1,680
5	1,571	Avg. Flow, drafting		620	0	0	0	248	372	620
6	1,571	95% exceedance, drafting		250	0	0	0	100	150	250
7	1,532	5% exceedance		1,000	0	0	2,540	1,416	2,124	3,540
8	1,532	Avg. Flow		1,000	0	0	330	532	798	1,330
9	1,532	95% exceedance	min conserv. pool	320	0	0	0	128	192	320

d. Dual Entrance Angled Collector

The dual entrance angled collector was developed with the intent to bring the entrance of the FSS as close to the existing WTCT as possible within the smallest reasonable footprint. This yielded an entrance placement adjacent to the coarse trashracks for the RO bypass intake (Figure 4-2). The angled entrances to the collector and bend of the collection channels allow for greater length of the port collection channel resulting in higher inflow capacity. The starboard collection channel was then sized for a maximum capacity of 455 cfs and the port collection channel was sized for a maximum capacity of 605 cfs. The geometry of the collection channels is further described in Sections 5 and 6.

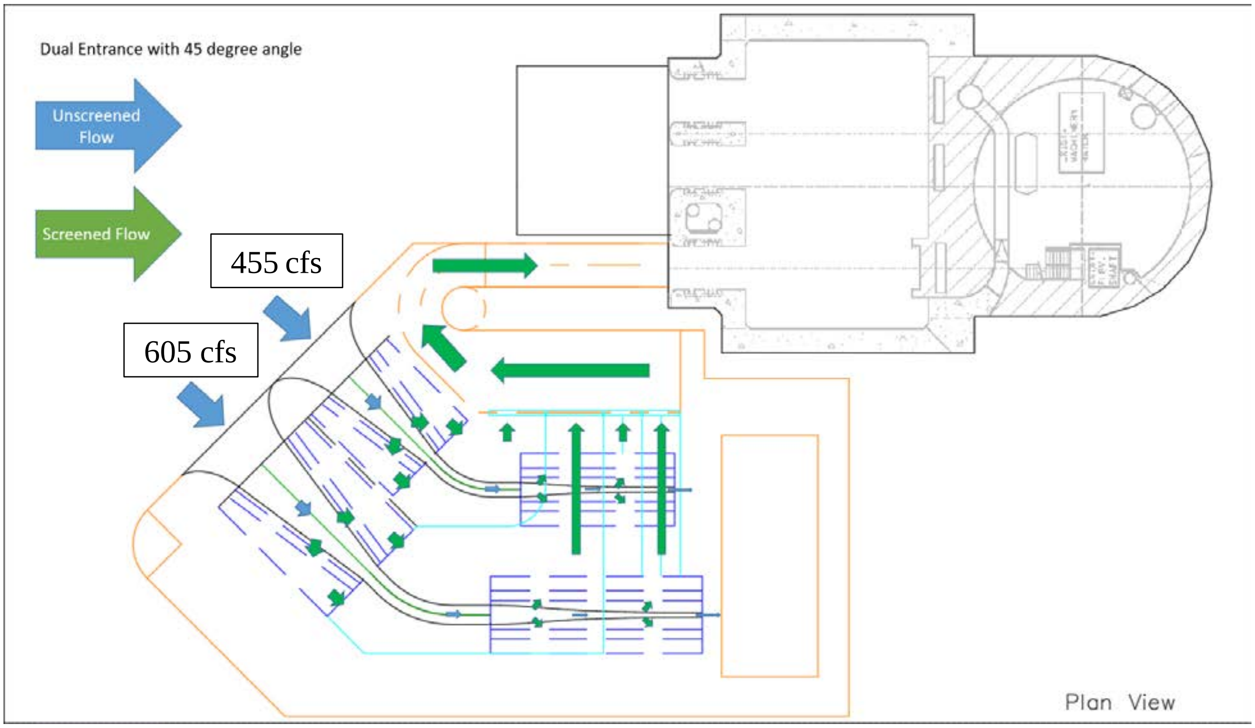

Figure 4-6. Dual Entrance Angled Configuration Plan View

Note: Holding raceways as indicated in the figure are subject to change.

The entrance cross section for the dual entrance angled collector extends down to capture depth of 25 feet. The entrance configuration and dimensions are described in greater detail in Section 4.3.e.

An additional consideration is head loss through the FSS system and insuring that continued operation of the WTCT within safe limits is possible as this configuration has the advantage of space considerations but must still take the full flow to the WTC entrance (green arrows Figure 4-2). Preliminary head losses have been calculated for the dual entrance angled collector and are described in Section 4.3.f., but will be updated and validated with ongoing physical modeling and a free-surface CFD model, which will take place concurrently with the plans and specifications phase of the project.

e. Computational Fluid Dynamics Modeling

(1) Intake Location and Orientation

The dual entrance angled configuration computational fluid dynamics modeling was used to evaluate several of the criteria within the cul-de-sac and near the tower related to the proposed design. Figure 4-3 shows the extent of the model, which was run as a rigid lid model with steady-state conditions. Flow was introduced into the model between the South Fork and the East South Fork of the Mackenzie River, where it converged and traveled towards Cougar Dam and into the cul-de-sac area. The flow outlets from the model included the two FSS outlets, the two RO temperature weirs, and the RO bypass gates. All post-processed images from the CFD modeling are contained in Appendix D, Hydraulic Design.

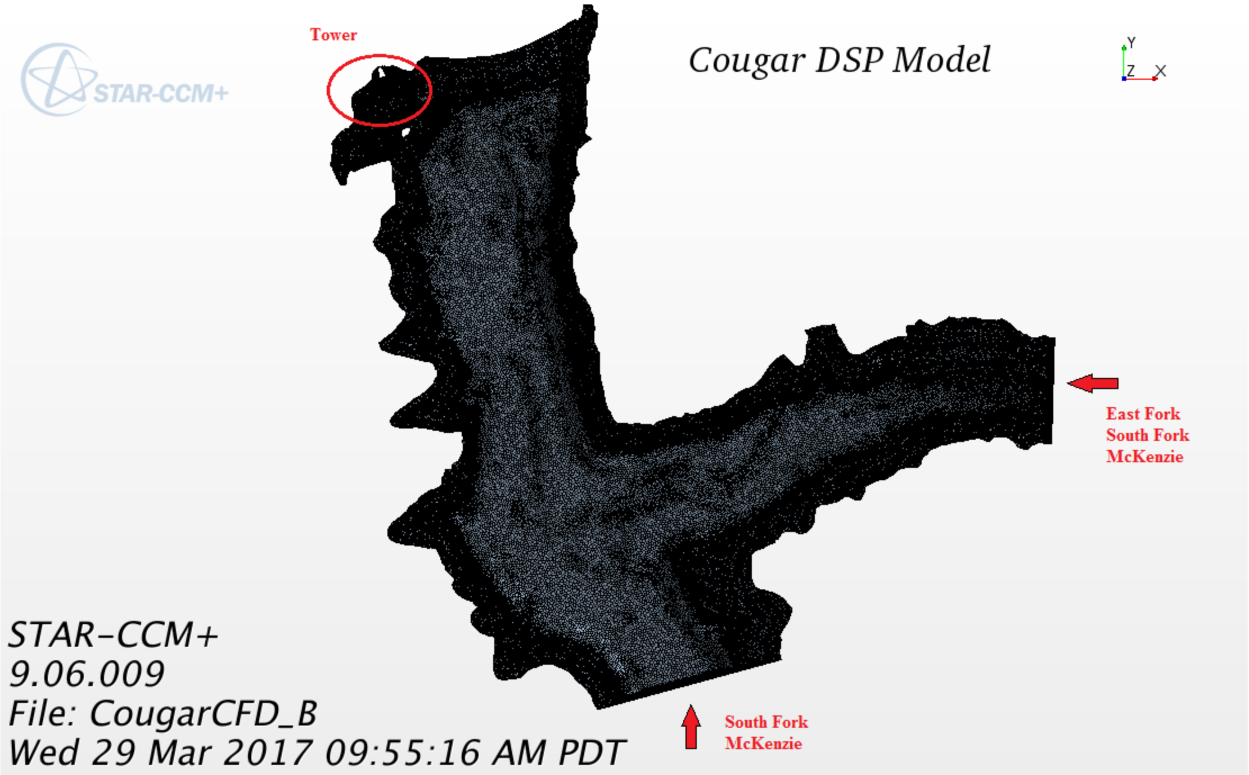

Figure 4-7. CFD Model Extents

Rush Creek was not included as a flow inlet for the original model, and after a basin-area comparison analysis it was concluded that the flow from Rush Creek would have little to no effect on the hydraulics in the cul-de-sac.

The dual entrance angled collector was evaluated at three different reservoir elevations: 1,610 feet, 1,571 feet, and 1,532 feet. These elevations represent a relatively pool near the maximum conservation pool, a transition pool where flow is passed through either the temperature control weirs or the RO bypass, and the minimum conservation pool.

Analyzing the results based on elevation, the 1,532-foot elevation at 1,330-cfs river flow demonstrates a condition where flow in excess of 1000 cfs can be used as attraction flow for fish. This run had 600 cfs passing into the port FSS collection channel entrance, 400 cfs into the starboard collection channel entrance, and the remaining 330 cfs passing through the RO bypass gates. As can be seen in the top of Figure 4-4 below, there is strong flow signature (higher relative velocity) between Rush Island and the dam into the cul-de-sac that continues to a lesser degree into the area in front of the FSS entrances/tower. The bottom of the figure shows an isometric view with isosurface velocity contours. A flow signature of around 0.6 fps extends out around 5 feet into the forebay from the FSS entrances, but the same signature from the RO bypass (invert elevation 1,475 feet; centerline elevation 1,485 feet) does not extend outside of the coarse trashrack from the RO bypass gates. Surface oriented juvenile fish are anticipated to be attracted by higher flows into the FSS entrance/tower area rather than diving down to the RO bypass where the flow signature is significantly diminished by the time it meets the coarse trashrack.

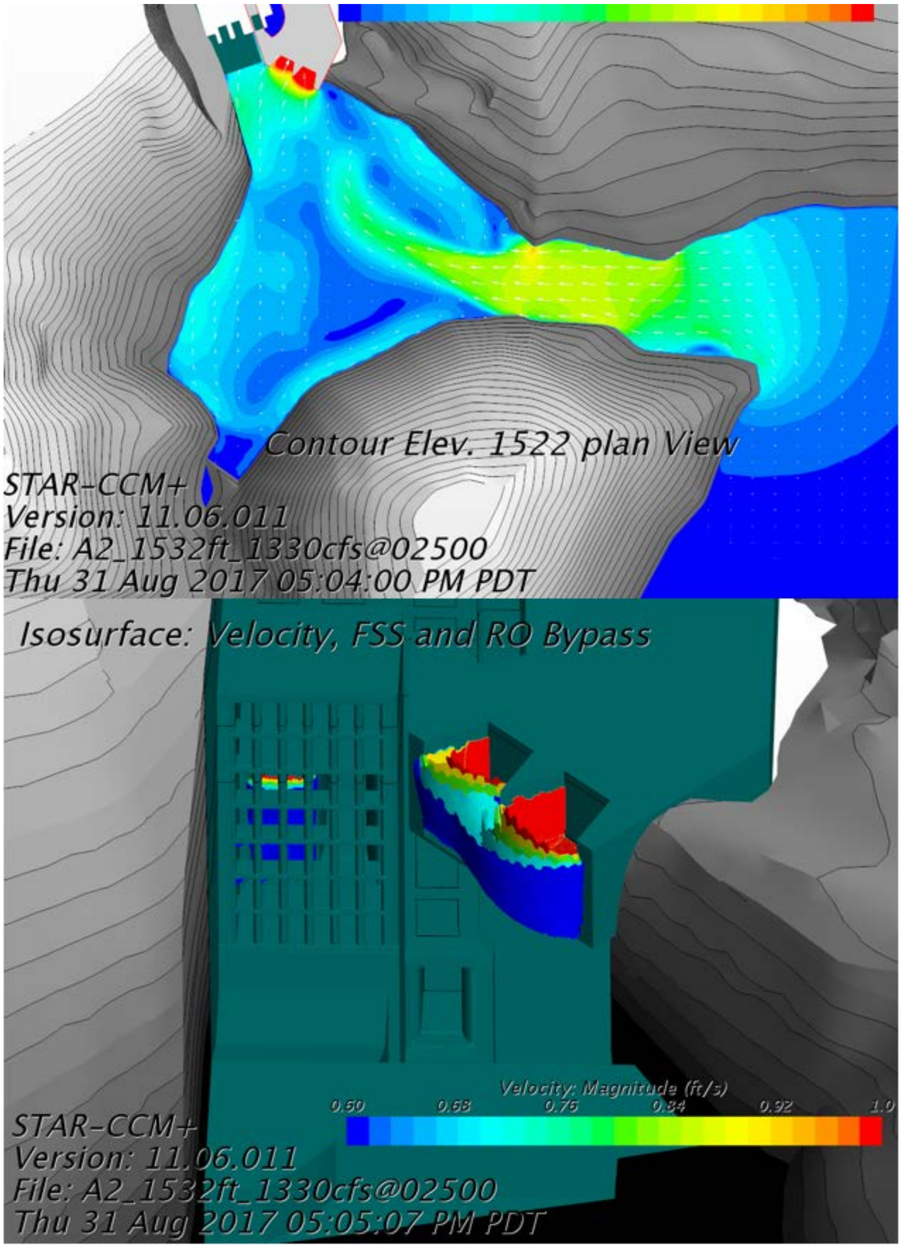

Figure 4-8. Elevation 1,532 Feet, Flow Rate 1,330 cfs. Top: Velocity Contours at Elevation 1,522 Feet. Bottom: Isosurface Velocity Contours at Flow Outlets

At forebay elevation 1,571 feet, both the RO bypass and the temperature control weirs could be used at this intermediate pool level. Both situations were evaluated in the CFD model for comparison, with 1000 cfs passing through the FSS as described for the 1,532-foot runs, with the remaining flow either split between the temperature control weirs or passed through the fully-open RO bypass.

As shown in Figure 4-10, the velocities into the cul-de-sac are lower than when the reservoir elevation is at 1,532 feet due to reduced constriction at the entrance to the cul-de-sac, but the overall pattern of higher velocities into the front of the FSS/tower area is still apparent. This similar pattern is consistent using either the temperature control weirs or the RO bypass to pass flow above 1,000 cfs.

Streamtrace post-processing images were created for both the temperature control weir and RO bypass runs. Using the bypass, the signature in front of the coarse trashrack is more dispersed, and appears similar to the 1,532-foot model. The elevation 1,571-foot model run depicted in the images below has a higher flow rate passing through the RO bypass (680 cfs compared to 330 cfs) which increased the signature in front of the coarse trashrack, but the bypass is now further separated from the FSS entrance due to the increase pool elevation. Using the weirs to pass the excess flow shows a very similar attraction signature as does the FSS entrances with regard to the streamtrace images.

It should be noted that the fine trashracks on the temperature control weirs were not modeled in the CFD runs. This is due to the extremely fine spacing on the prototype trashracks, which would be unreasonable to include in a model of this size.

According to recent RM&E reports, it is found that fish tend to hesitate in front of these fine trashracks on the weirs, possibly due to the fast acceleration of flow through the trashracks themselves. Because of this, it is anticipated that fish would be attracted to the area in front of the tower/FSS entrances by the bulk flow of the FSS and weir flow, but would reject the passing through weir slot trashracks and prefer to pass into one of the FSS entrances.

The remaining image in Figure 4-9 shows vertical cross sections through the centerline of each modeled flow outlet. This shows in greater detail the outlet velocities throughout the water column each flow outlet. Similar to the streamtrace image of the same model run, the flow signature for the weirs appears similar to that of the FSS entrances. Due to the weir slot trashracks it is anticipated that fish will to prefer entering the FSS rather than the temperature control weirs.

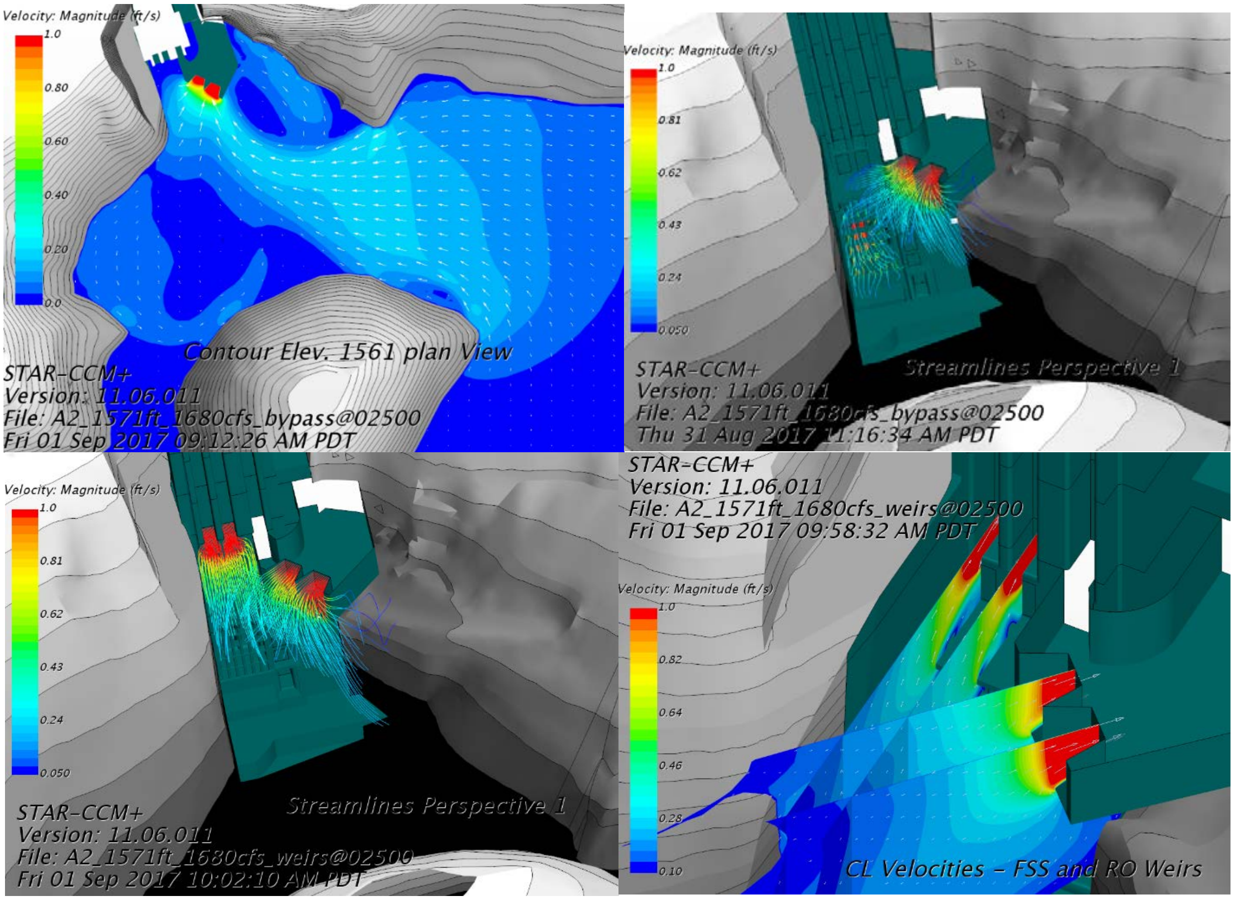

Figure 4-9. CFD Elevation 1,571 Feet Q= 1,680 cfs Top Left: Velocity Contours Elevation 1,561 Feet with Bypass; Top Right: Streamtrace Floating Screen Structure and Bypass; Bottom Left: Streamtrace FSS and Temperature Control Weirs; Bottom Right: Vertical XS Velocity Contours FSS and Weirs

The final elevation investigated in the CFD model was a pool level of 1,610 feet at a project discharge = 1,000 cfs. Shown in Figure 4-10 below, the maximum outflow from the FSS (,1000 cfs) has the same overarching flow conditions of higher velocities towards the front of the tower, but with lower velocities in the cul-de-sac until you get closer to the FSS. Even if the flow signature is not as pronounced as the lower forebay elevations, for reservoir outflows of 1,000 cfs and below the FSS is the only outlet from the dam and will not have any competing flow for juvenile fish. The last image is of velocity contour isosurfaces for the 1,000 cfs run at a reservoir elevation of 1,610 feet, which produces a fairly uniform flow signature in front of both entrances to the collector.

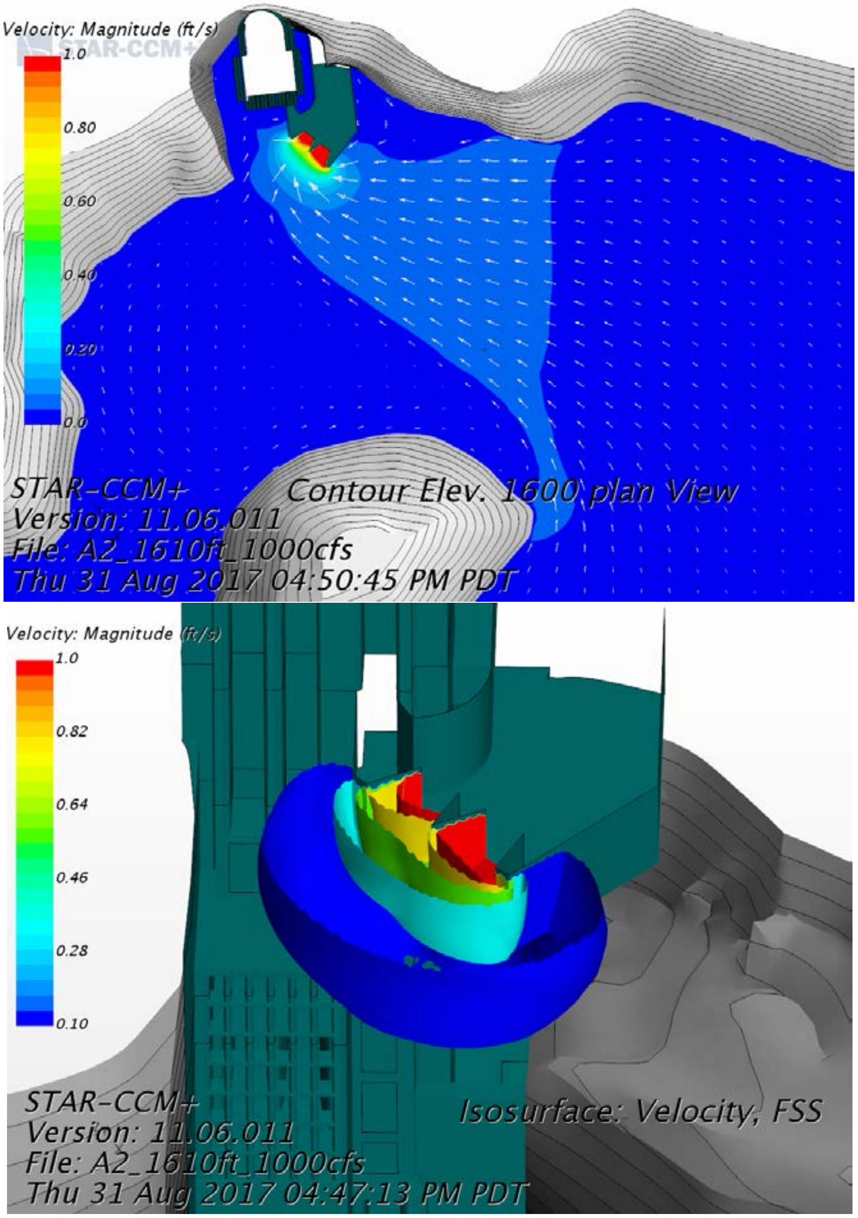

Figure 4-10. CFD Run Elevation 1,610 Feet, Flow Rate 1,000 cfs;
Top: Velocity Contours at Elevation 1,600 Feet Plan View;
Bottom: Isosurface Velocity Contours Floating Screen Structure Flow

After analyzing the CFD results for the dual entrance angled collector, it was determined that this configuration adheres to the outlined criteria of utilizing flow in excess of 1,000 cfs for attraction of juvenile fish towards the FSS, while extending a flow signature within the upper portion of the water column near the tower, where juveniles are known to congregate.

(2) Updated Layout Runs

As the design of the FSS progressed to accommodate differing channel flow rates, entrance shaping, and mooring tower location, the CFD model was updated and rerun. The updated models were used to verify that the patterns seen in the previous CFD modeling were still present with the updated design, to evaluate the current design for entrance shaping, to aid in development of the physical model domain, and to provide dynamic hydraulic pressures on the FSS to the naval architects. Models were run at elevations 1,571 feet and 1,532 feet, with a starboard collection channel flow rate of 455 cfs, a port collection channel flow rate of 605 cfs, and full FSS flow of 1,060 cfs. The updated models confirmed the previous patterns seen within the model, and provided insight into the anticipated flow signature in front of the FSS entrances. See images below of plan view of updated model components, and entrance signatures for both starboard and port collection channels.

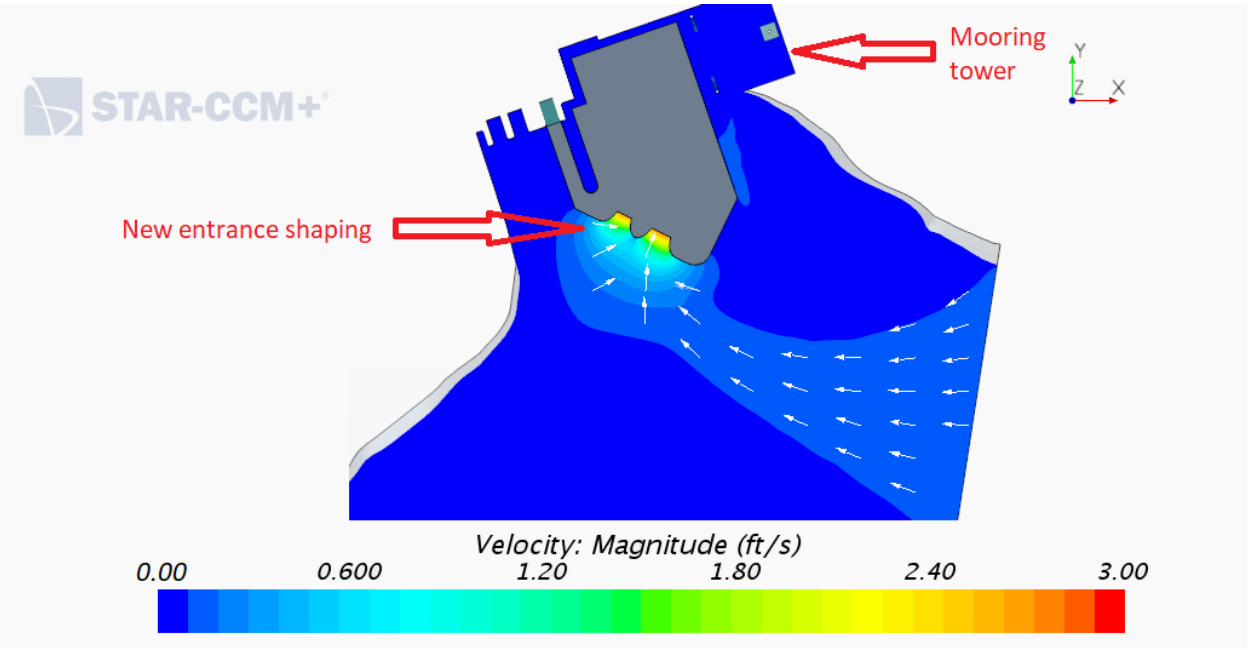

Figure 4-11. Plan View of Updated CFD Model Runs; 1,000 cfs at Elevation 1,571 Feet

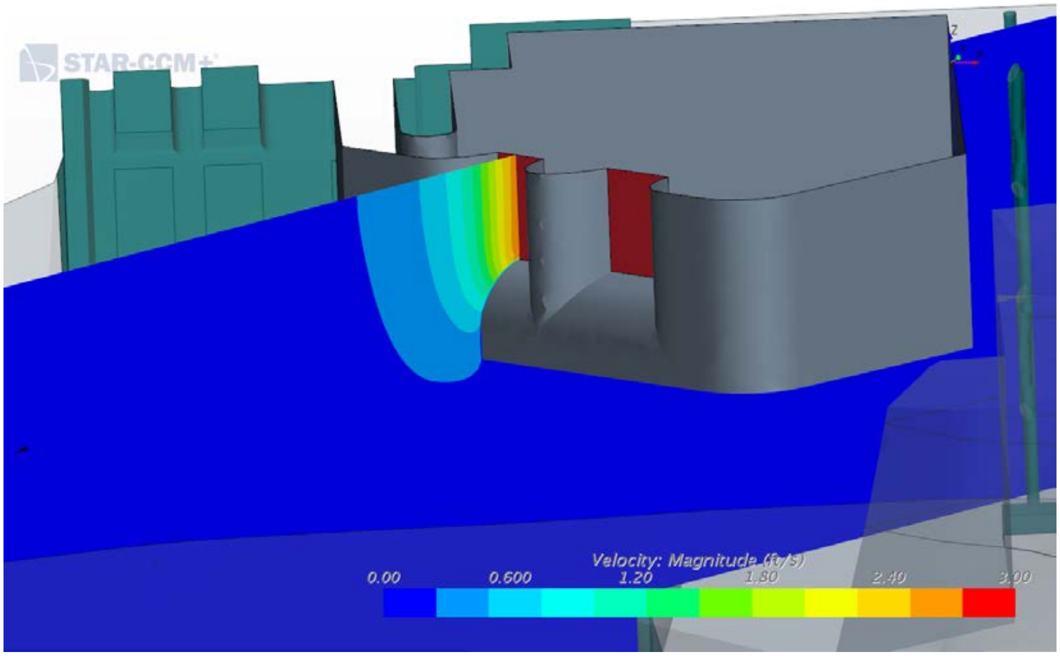

Figure 4-12. Interior Barrel Flow Signature; 455 cfs Interior Channel, 1,000 cfs Floating Screen Structure Flow at Elevation 1,571 Feet

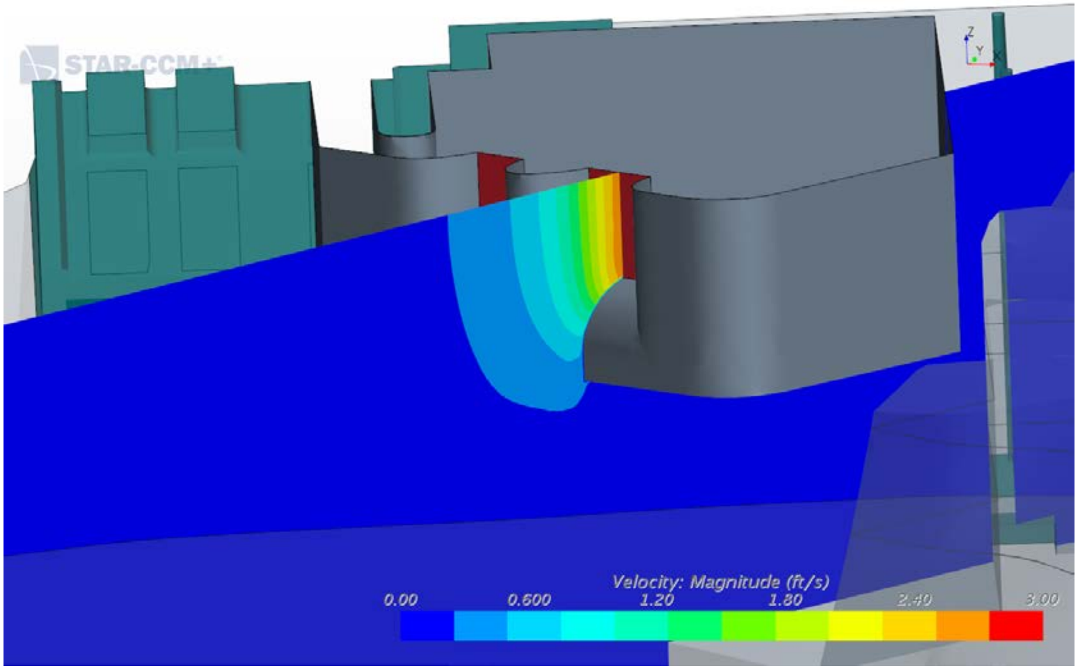

Figure 4-13. Exterior Barrel Flow Signature; 605 cfs Exterior Channel, 1,000 cfs Floating Screen Structure Flow at Elevation 1,571 Feet

f. Dewatering Screen System

(1) General

For the purpose of this description, flow that has passed through a screen and no longer contains fish or debris will be referred to as screened flow and flow that has passed adjacent to the screens and still contains fish and debris will be referred to as unscreened flow.

Unscreened flow first passes through the primary screen corridor where the bulk of the attraction flow is screened out. The primary screens consist of uniform depth wedge wire screens with a porosity of 48 percent. The primary screen corridor, through which fish will be traveling, will contract and produce a gradual acceleration of the unscreened flow. This primary screen corridor will be used to modulate the screen outflow for various project flows (300-1,000 cfs).

The remaining unscreened flow then passes through the secondary screen corridor which decreases in depth and accelerates in the direction of flow. The secondary screen corridor will operate through lateral dewatering through varied height wedge wire wall screens. The screens will converge in the downstream direction to assist in meeting and maintaining capture velocity.

Floor screens are not recommended in the primary or secondary dewatering channels (subcritical flow) due to potential debris issues, and have not been recommended by operators of other facilities where floor screens have been employed because they are problematic for operation and maintenance in general. They have been shown effective in supercritical flow with shallow depths, and where the direction of flow is following the direction of gravity (channel is on a negative slope).

Screened flow passing through the wedge wire screens of either primary or secondary corridors will be baffled with the aid of perforated plate paneling to normalize the flow field through the screens and controlled with the use of overflow weirs. In the primary screen corridor, weirs will be adjusted to account for any flow above the prescribed flow leaving through the secondary screens and into the back of the vessel. Screened flow from the primary screen corridor weirs will fall into a dedicated plenum on each side of the screen with the flow direction normal to the unscreened flow. In the secondary screen corridor, these weirs will be tuned to a set rate of dewatering and will not be adjusted during flow regime changes. Screened flow from the secondary corridor weirs will also fall into dedicated plenums on each side of the screen channel and will flow in the opposite direction of the unscreened flow. For further description of the internal flow routing, see Section 4.5.h, Screened Flow Routing and Control (System Head Loss).

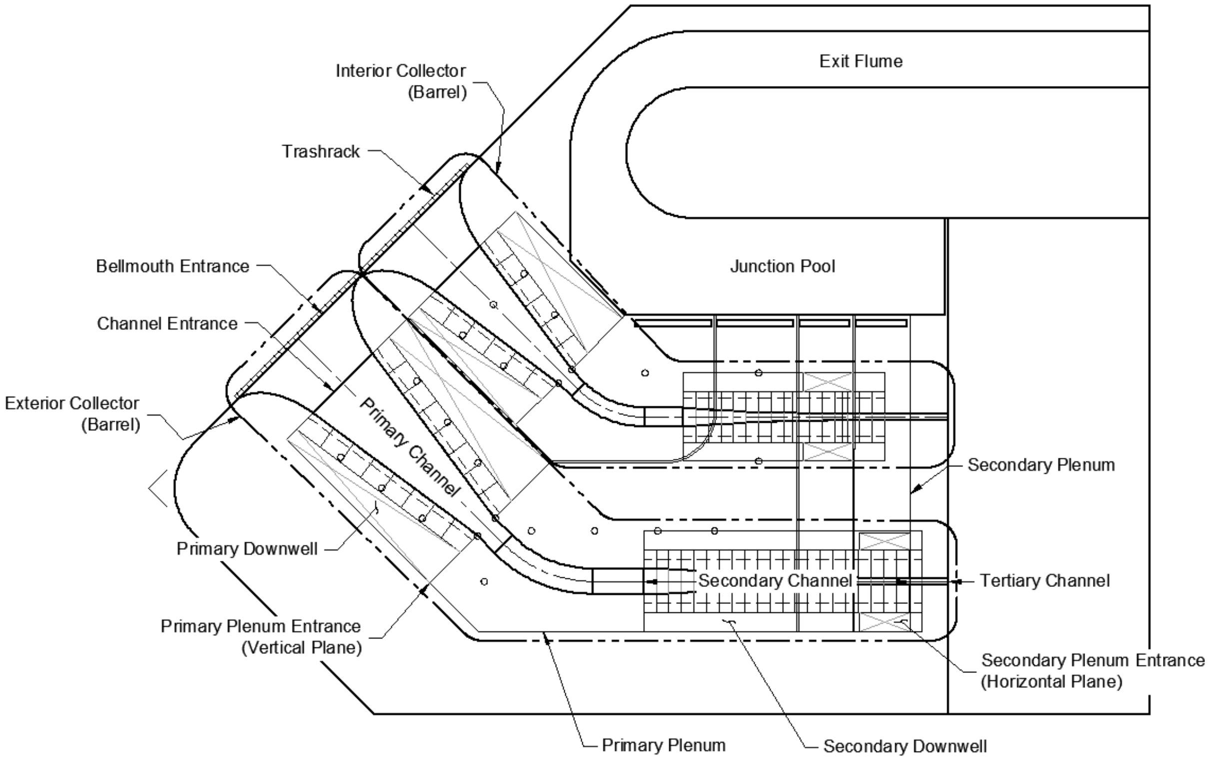

Figure 4-14. Dual Entrance Angled Configuration Plan

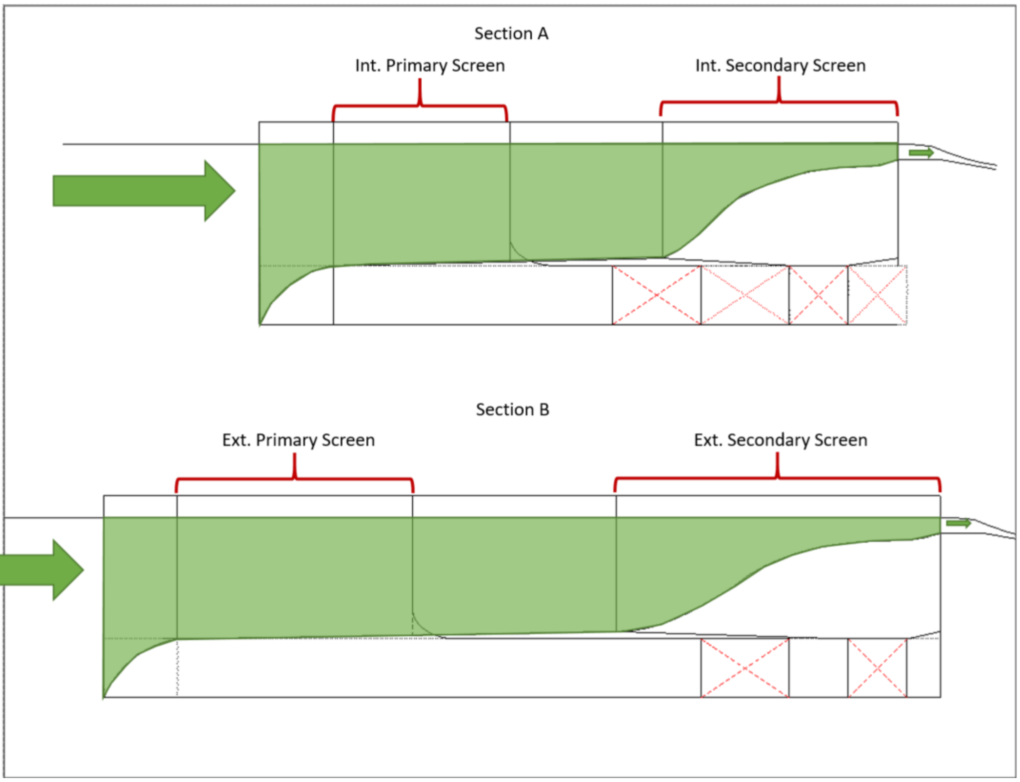

Figure 4-15. Dual Entrance Angled Floating Screen Structure - Elevation View Screens

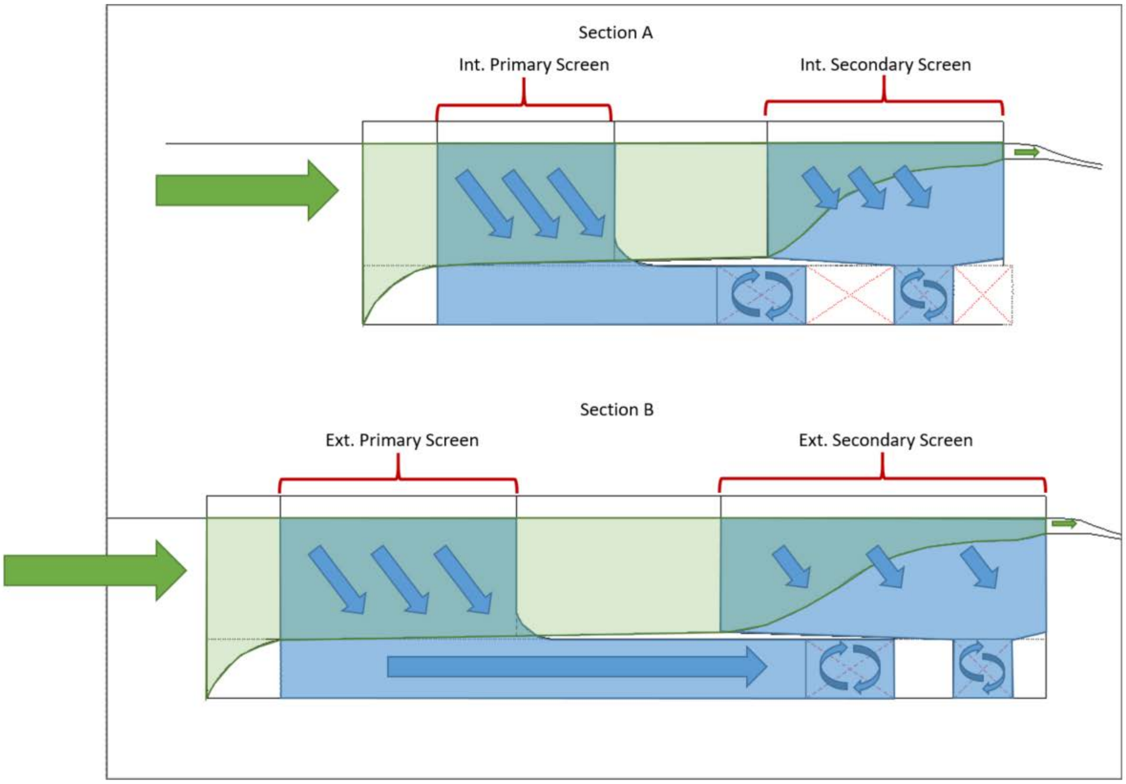

Figure 4-16. Dual Entrance Angled Floating Screen Structure - Elevation View Plenum Flow Paths

(2) Hydraulic Profile Computations

A hydraulic spatially varied profile computational program was developed to assist in sizing of the starboard and port collection channels. Flow through each collection channel is subcritical up to the end of the secondary screening corridor where the *unscreened flow* passes through critical depth at approximately 12 cfs. This critical depth was used to initialize the spatially varied flow profile.

A standard step gradually varied flow computation was used to compute the backwater profile from the critical depth at the control to the downstream most end of the secondary dewatering screens.

The hydraulic spatially varied profile program was then written with sidewall dewatering through wedge wire screen, a porosity plate and over a control weir with a constant water surface elevation downstream of the control weir. The primary and secondary screen dewatering corridors are made up of incremental panel lengths with individual control weirs. These panel lengths are sized to maintain a uniform dewatering flowrate through the screen.

A wedge wire screen porosity of 48 percent was selected with a discharge coefficient of 0.75. A porosity plate with a 22 percent porosity was selected with a discharge coefficient of 0.6. A free surface discharge coefficient (Cw) of 3.93for the weir was selected.

A series of unit width flow rate equations were developed for screen and porosity plate flow and weir flow in free surface discharge or submerged discharge. Sample schematics for the hydraulic profile are included in Figures 4-17 through 4-20.

Screen flow is determined by the equation below.

$$q = C_d Por_o H\sqrt{2g\Delta h}$$

Where: $q = unit\ width\ \ discharge$
$C_d = discharge\ coefficient$
$Por_o = porosity\ of\ the\ medium$
$H = height\ of\ medium\ subjected\ to\ flow$
$g = gravitational\ constant$
$\Delta h = headloss\ through\ medium$

This was written within the program as the following:

$$q_{sc} = C_d Por_o (WSE_{ch} - z_{fl})\sqrt{2g(WSE_{ch} - WSE_{wier})}$$

Where : $q_{sc} = unit\ width\ screen\ discharge$
$WSE_{ch} = water\ surface\ elevation\ of\ the\ unscreened\ flow\ in\ the\ channel$
$z_{fl} = channel\ floor\ elevation\ (bottom\ of\ screen\ elevation)$

$WSE_{weir} = water\ surface\ elevation\ upstream\ of\ the\ weir$

Free surface weir discharge is determined by the equation below.

$$q = C_w h^{1.5}$$

Where: $C_w = free\ surface\ discharge\ weir\ coefficient$
$h = hydraulic\ head\ on\ the\ weir\ crest$

This was written within the program as the following:

$$q_{fsw} = C_w (WSE_{weir} - z_{weir})^{1.5}$$

Where: $q_{fsw} = unit\ width\ free\ surface\ weir\ discharge$
$z_{weir} = weir\ crest\ elevation$

The Villemonte equation (King and Brater) shown below was used to determine submerged weir discharge.

$$\frac{Q}{Q_1} = \left[1 - \left(\frac{H_2}{H_1}\right)^n\right]^{0.385}$$

Where: $Q = submerged\ weir\ discharge$
$Q_1 = free\ surface\ weir\ discharge$
$H_2 = depth\ of\ downstream\ water\ surface\ on\ the\ weir\ crest$
$H_1 = depth\ of\ upstream\ water\ surface\ on\ the\ weir\ crest$
$n = exponent\ of\ the\ free\ surface\ discharge\ equation$ (1.5)

This was written within the program as a coefficient to be applied to the free surface discharge equation where downstream water surface elevation submerge the weir crest. The downstream water surface elevation is assumed constant through plenum along the screening corridor.

$$C_v = \left[1 - \left(\frac{WSE_{ds} - z_{weir}}{WSE_{weir} - z_{weir}}\right)^{1.5}\right]^{0.385}$$

Where: $C_v = submergence\ coefficient$
$WSE_{ds} = water\ surface\ elevation\ downstream\ of\ the\ weir$

Submerged weir discharge is given as:

$$q_{sw} = C_v q_{fsw}$$

Where: $q_{sw} = unit\ width\ submerged\ weir\ discharge$

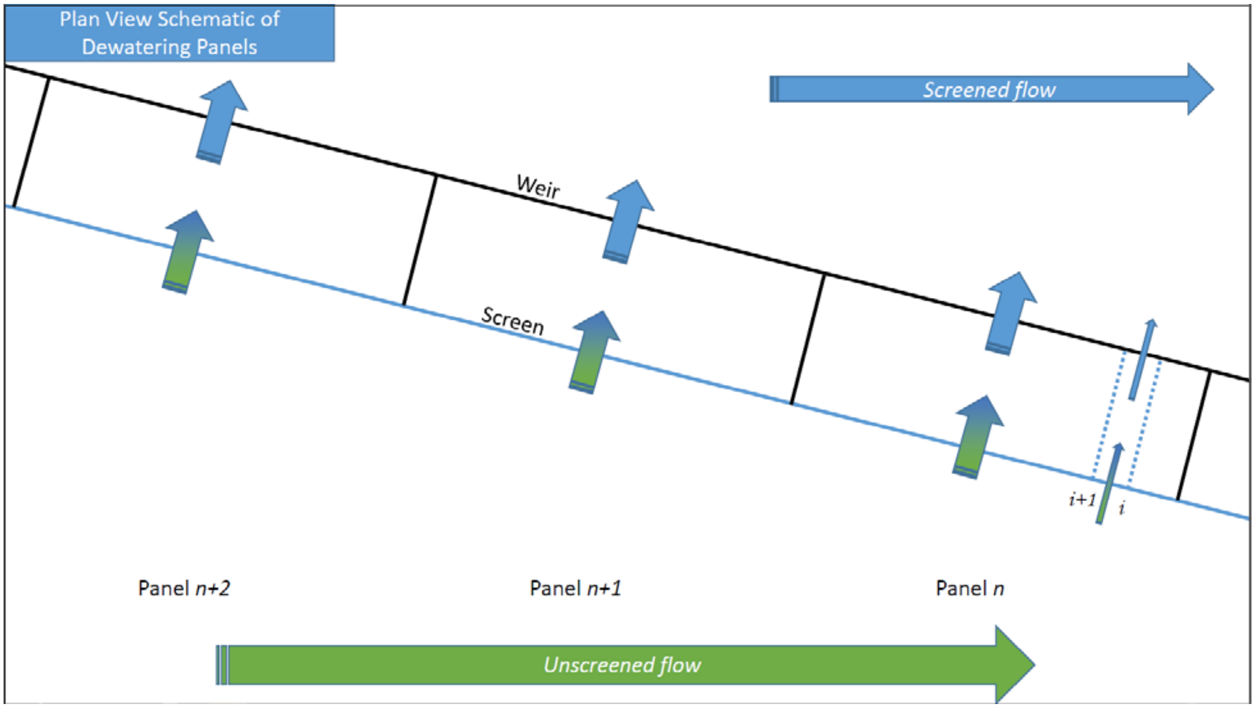

Figure 4-17. Plan View of Panel in Dewatering Schematic

For each panel, a distance between step (*i)* and (*i*+1) is defined for the program to advance upstream. Unit width discharge through the screen/porosity plate and over the weir is solved via the secant method in a built in application with Mathcad 15. *Unscreened flow* in dewatering screen systems has negligible energy loss due to friction. The boundary layer is reduced by or entrained into the lateral screened flow. This allows for the assumption of constant total energy (elevation + depth + velocity head) along the dewatering screens and computation of the upstream step water surface elevation based on the geometry of the screen channel an upstream flow rate.

Subsequent calculations will confirm these results match the results from standard spatially-varied flow equations shown in open channel text books.

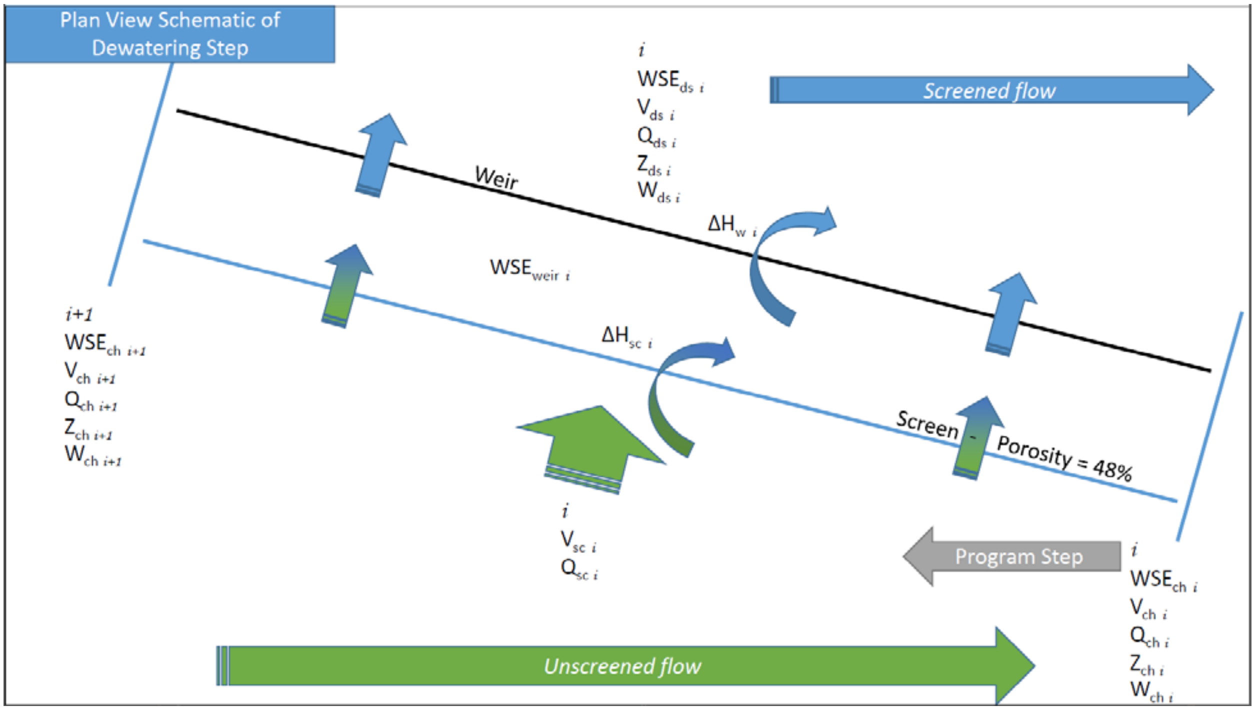

Figure 4-18. Plan View of Dewatering Step Schematic

The specific energy equations is written as:

$$y_1 + \frac{{Q_1}^2}{2g{A_1}^2} + z_1 = E = y_2 + \frac{{Q_2}^2}{2g{A_2}^2} + z_2$$

Where:
$y_1 = upstream\ depth$
$Q_1 = upstream\ unscreened\ flow\ rate$
$A_1 = upstream\ cross\ sectional\ flow\ area$
$z_1 = upstream\ channel\ floor\ elevation$
$y_2 = downstream\ depth$
$Q_2 = downstream\ unscreened\ flow\ rate$
$A_2 = downstream\ cross\ sectional\ flow\ area$
$z_2 = downstream\ channel\ floor\ elevation$

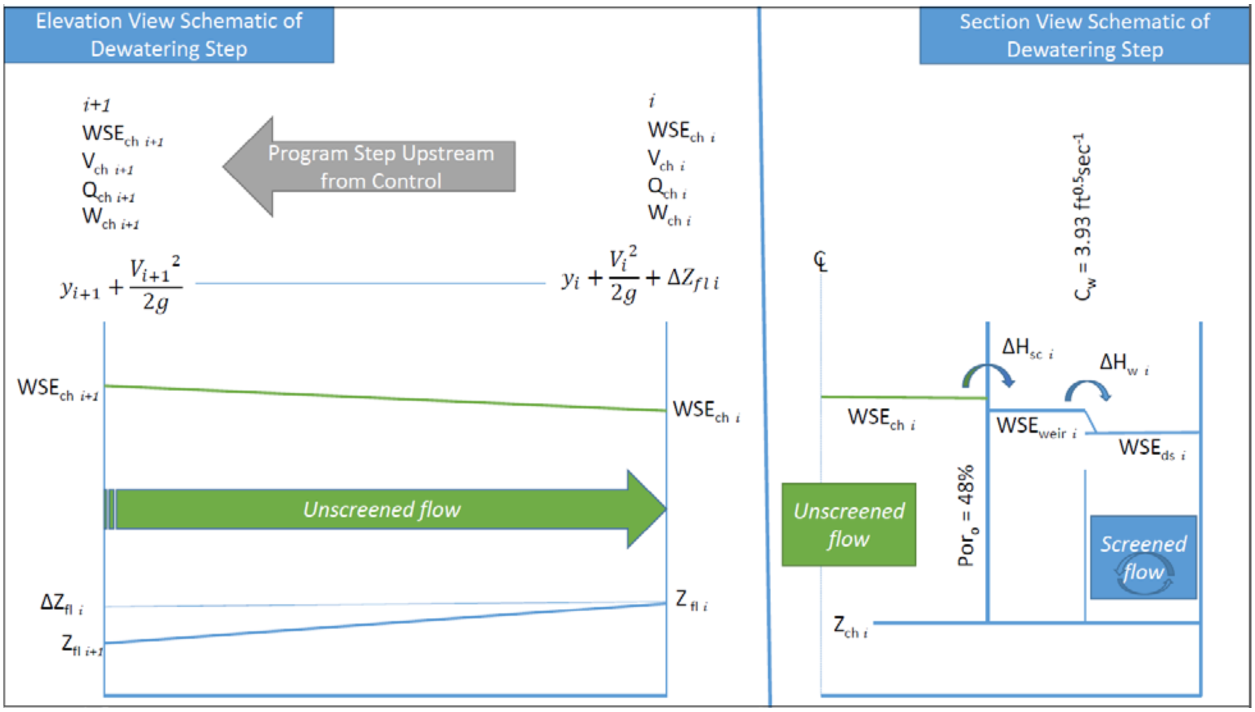

Figure 4-19. Elevation and Section View of Dewatering Schematic

Draft computations for a 500-cfs flow rate primary and secondary dewatering screen system is located in Appendix D.

(3) Dewatering Screen Geometry

Initial primary screen sizing was estimated based on the 0.2 fps per foot hydraulic strain rate criteria (NMFS 2011) and the through screen velocity criteria of 0.4 fps (NMFS 2011). This rendered roughly 16 feet deep and 30 feet long. Secondary screen length was estimated based on capture screen flow at other floating screen structures such as that at Swift reservoir.

The geometry is further refined through iterative computations of the spatially varied flow to meet capture velocity targets, approach screen velocity targets, and hydraulic strain rate targets in the *unscreened flow*.

The downstream control for each collection channel was selected to be a 1-foot-wide rectangular channel transitioning to a super critical slope. The unscreened flow from the termination of the secondary screens was determined to be 12 cfs. This is required in order to meet and maintain capture velocities (7 fps) through to the control.

The gradually varied flow profile was then carried back through 6.0 feet subcritical flow in unscreened channel until the flow Froude number was equal to or less than 0.85. Flows with Froude numbers exceeding 0.85 in screened systems are considered to be unstable and would render unsteady flows. Secondary dewatering channel geometry and dewatering weirs are controlled by the limiting Froude number at the downstream end of the secondary dewatering. Transitioning upstream within the secondary dewatering corridor, the channel floor elevation decreases progressively. The upstream section of the secondary dewatering corridor is where *unscreened flow* approaches capture velocity. Geometry is largely controlled by maximum rate of increase in velocity, 0.2 fps per foot, as defined by the NMFS criteria. Approach screen velocity has some influence on the geometry in this section. Initial floor and channel width through the secondary screen was established as elliptical approximations as shown in the figure below. This rendered increases in velocities in excess of the limiting criteria in the upstream portion of the secondary dewatering. The upstream floor slope was then adjusted to meet the velocity gradient criteria.

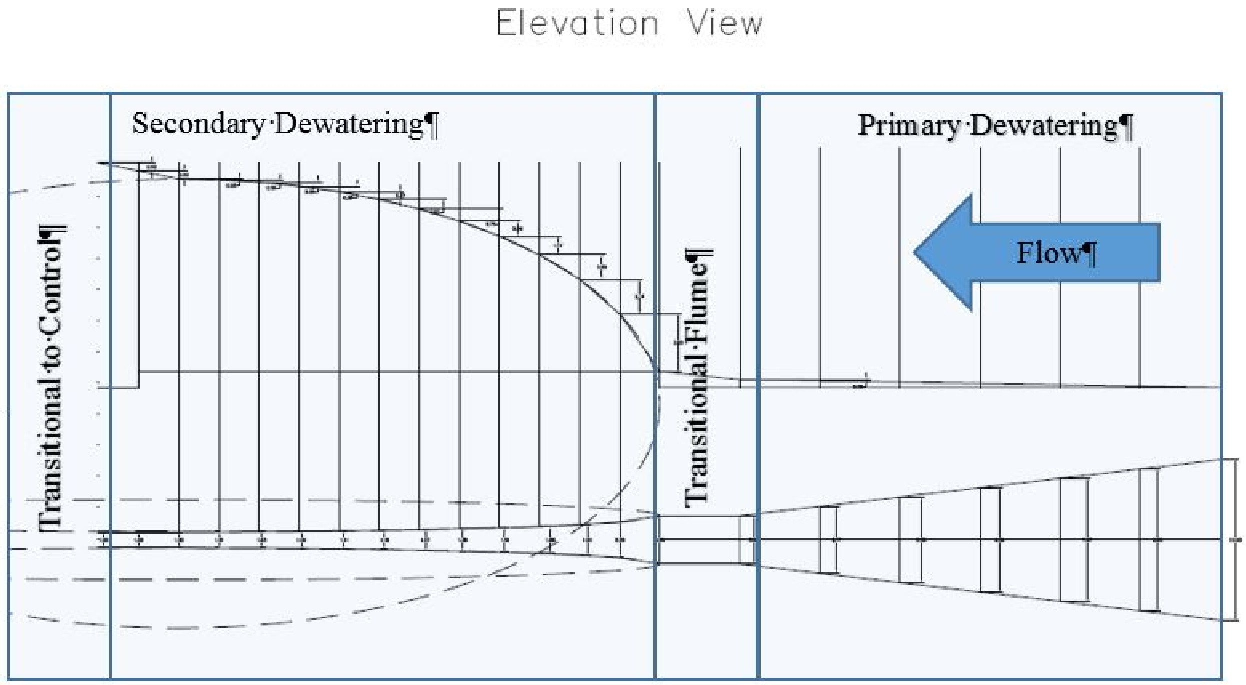

Figure 4-20. Elevation and Plan View of Dewatering Schematic

The transitional flume from secondary screens to primary screens has no screens and is not limited in geometry by approach screen velocity criteria. Gradual acceleration along the channel is achieved through increasing the channel floor elevation.

The primary screening corridor removes the bulk of the flow from the *unscreened flow*. This section is constant depth screening, which allows for greater variability of dewatering rates and facilitates screen cleaning with brushes. The dewatering weirs in this section will modulate the incoming flow rates into each collection channel. The geometric design of the collection channel and control weir settings are primarily dictated by the maximum approach velocity to the screen.

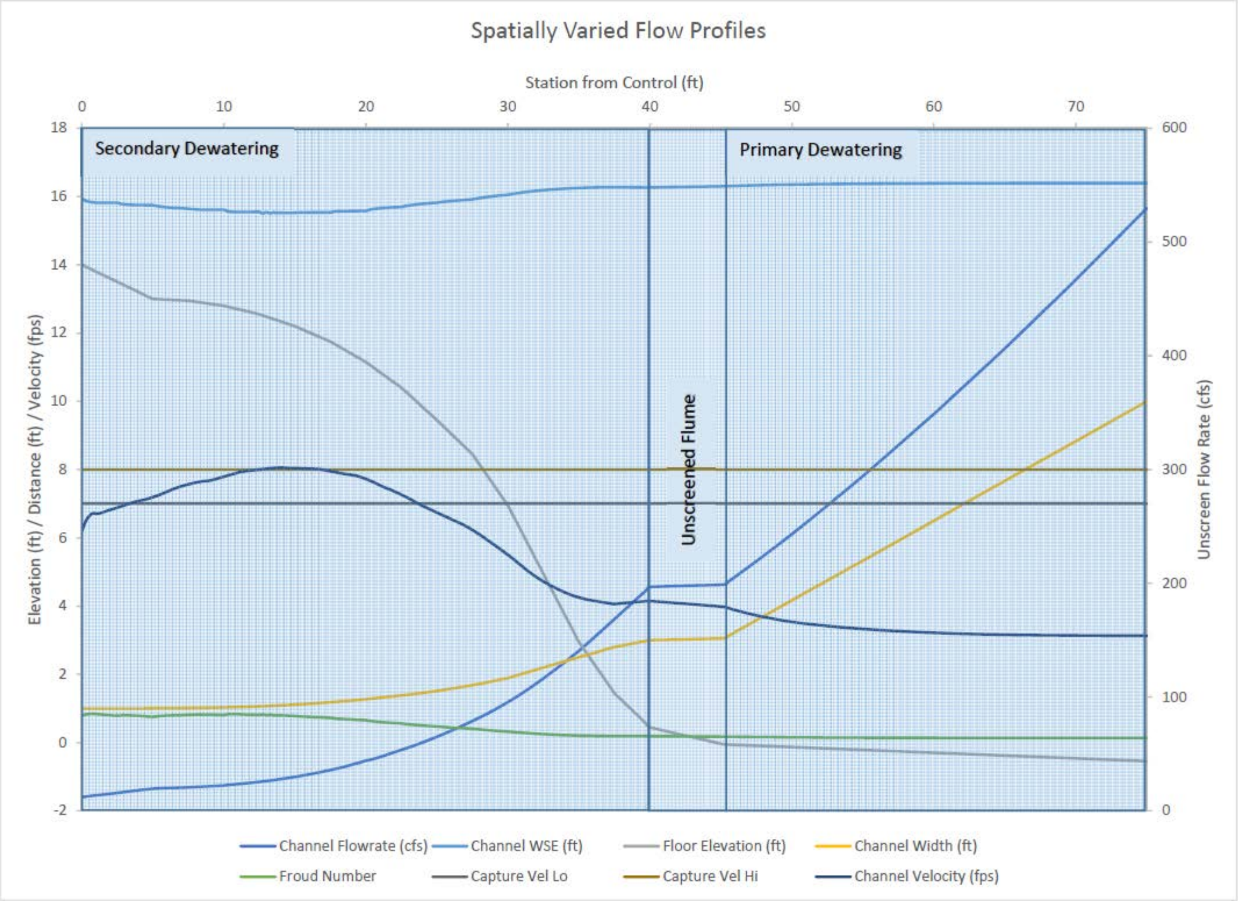

Figure 4-21. Spatially Varied Flow Profiles

g. Floating Screen Structure Entrance Transition

The FSS has an entrance transition from the leading face of the screen structure into each of the collection channels. This entrance transition extends in depth down to 25 feet below the water surface such that approaching flow and fish within this column of water may be directed into either collection channel. Biological studies detailed in Section 2 indicate juvenile fish reside within this depth when approaching or attempting to pass the tower. The entrance transition is intended to develop uniform flow acceleration into each collection channel to avoid resulting in fish rejection. Velocity shadows, eddies, or overly turbulent zones where predator fish may hold or where passing fish may reject should not develop. The entrance transition is crucial in developing uniform velocities entering the screening corridors such that "hot spots" or areas of screen approach velocity above 0.4 fps do not occur. Due to the dual entrance configuration, single collection channel operation will result in a low velocity zone in the channel entrance that is not running.

A preliminary design of the entrance was included in the CFD models used to evaluate entrance location. This was a constant slope floor ramp ascending from 25 feet below the water surface to the floor of the primary dewatering screens and a constant contraction in width to the entrance of the primary dewatering corridor. Initial evaluation of the constant slope entrance transition had several undesirable characteristics, such as pulling flow from below and behind the entrance face, thereby reducing the velocity signatures in front of the FSS. While the model was not intended for near-field evaluation of the entrance, it does indicate that a simplified entrance does not yield the preferred hydraulics.

Upon further refinement of the internal geometry of the collection channels, design of this transition was also updated. An elliptical shape was chosen for the wall transitions and a warped curvilinear shape was chosen for the floor to form bell-mouth entrances for each collection channel (as seen in Figures 4-12 and 4-13). This entrance transition shape will reduce hydraulic losses into the FSS as well as confine flow to develop a uniform approach to the collection channels primary screen corridor. The entrance transition section between the two collection channels will form geometry that will facilitate uniform flow transition when one collection channel is operating and the other channel is not.

h. Screened Flow Routing and Control (System Head Loss)

Conduit and conveyance channel geometry design were based on head loss, velocity criteria, and alignment constraints. Velocity criteria include capture velocity targets as close to entrance as possible (7-8 fps general guideline), velocity normal to the dewatering screens (0.4 fps, NMFS 2011), and velocity change in longitudinal direction (0.2 fps per foot).

Friction losses were based on the Darcy-Weisbach friction formula (Equation 1) for closed conduit section of the pipe,

$$h_f = f\frac{L}{D}\frac{V^2}{2g} \quad \text{(Equation 1)}$$

Where h_f is the head loss due to friction, f is the friction factor, L is the length of conduit, D is the conduit diameter, V is the fluid velocity in the pipe, and g is the acceleration due to gravity. The friction factor f was developed from the Swamee-Jain explicit friction factor equation listed below,

$$f = \frac{0.25}{log\left[\frac{k_S}{3.7D}+\frac{5.74}{Re^{0.9}}\right]^2} \quad \text{(Equation 2)}$$

Where k_s is the equivalent sand grain roughness of the pipe, and Re is the Reynolds number for the fluid passing through the conduit. Equation 2 was developed in the ASCE *Journal of Hydraulics Division* article “Explicit equations for pipe-flow problems.”

All configurations are likely to be dominated by minor losses for the screened flow head losses. Minor loss coefficients (K_o) are selected from D.S. Miller’s *Internal Flow Systems* 3^{rd} *Ed* (2014) and applied to the velocity head ($V^2/2g$) to determine the minor loss due to a junction, bend, orifice, etc.

$$h_o = K_o\frac{V^2}{2g} \quad \text{(Equation 3)}$$

The dual entrance angled configuration has many advantages, but it also represents the potential for head loss through the system (from the cul-de-sac to the wet well), based on losses through dual sets of screens and the travel path of the flow from the FSS to the WTCT (reference Figure 4-1, green arrows). The head loss path through the intake, into the primary screens and through the FSS, and into the wet well is expected to be the most conservative head loss path, and will be addressed as design proceeds through potential operation adjustments to the WTCT (without compromising temperature operations).

Preliminary modeling results in a total head loss of 2.74 feet, which exceeds the current operational constraint of the alarms and programmable logic computers (PLCs) in the WTCT of 2 feet of head loss from the cul-de-sac to the wet well. Supporting hydraulic calculations for head loss computations may be found in Appendix D. This analysis is being further refined through design iterations and a physical scale model of the FSS is being developed which will also assist in validating theoretically determined head losses through the FSS. The physical model is described in additional detail below. The alarms and operations of the WTCT will be adjusted to the new head loss from cul-de-sac to wet well value once the FSS is operational.

Head losses in the flow path within the FSS include: trashrack, entrance, screens, porosity plates, primary and secondary screen control, friction and bend losses in the conveyance plenums, combining flow into the junction pool, flume from junction pool to the tower entrance, a flow control ramp weir, “cup” connection to the water control tower, tower trashrack, and flow entrance from the FSS to the WTCT wet well.

There are four different routes possible for flow to go through the FSS. These routes are shown in Figure 4-22 and Figure 4-23 as Routes A, B, C, and D. Routes A and C go through the primary screens and Routes B and D go through the secondary screens to get to the WTCT wet well.

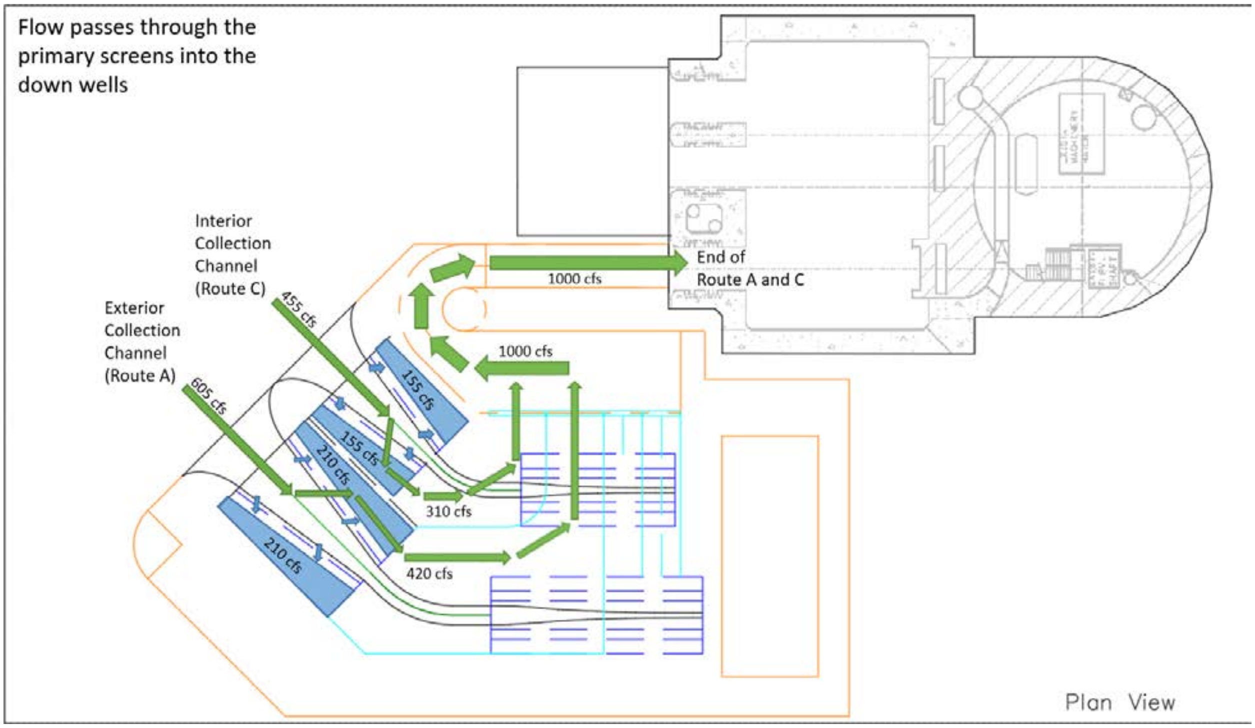

Figure 4-22. Flow Routes Through Primary Screens of Port and Starboard Collection Channels

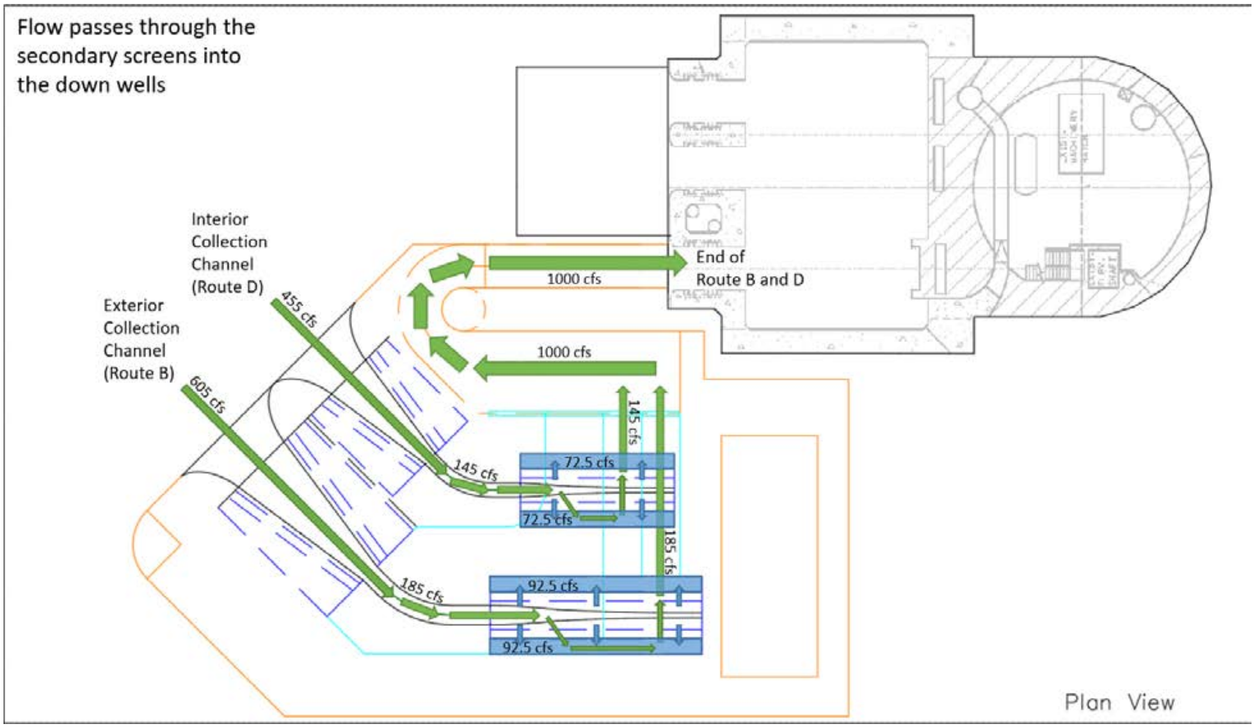

Figure 4-23. Flow Routes Through Secondary Screens of Port and Starboard Collection Channels

The most substantial head losses were from the primary and secondary screen control (adjustable weirs), the bend loss in the plenum for flow through the primary screens (Routes A and C, see Figure 4-22), the exit loss to the junction pool, the bend after the junction pool, and the exit loss to the wet well. The controlling route is Route A because it has the largest head loss of the four routes. Route A has a total head loss of a little over 2 feet. Decreasing flow and increasing the area of flow decreases head loss within the FSS. A smaller K_o value would also decrease head loss, but the loss coefficient depends on the type of head loss and is typically more difficult to adjust.

i. Physical Model of Floating Screen Structure

A 1:10 scale model of the FSS is currently under development and will be used to verify computed head losses through the FSS which will inform future operations once the FSS prototype is in operation. In addition, the model will be used to make minor adjustments to the entrance shape of the FSS if it is deemed necessary after observation of flow characteristics near the entrance of the model using the existing configuration. The model will be constructed with a removable section which allow for simulation of the bathymetry at two different pool elevations, 1,571 and 1,532 feet, which will allow for comparison of effects of bathymetry on entrance conditions between CFD and physical model.

j. Cup Weir – Connection of Floating Screen Structure to Water Temperature Control Tower

The FSS will be connected to the WTCT by a “cup” structure, which will allow movement of the FSS along the path of the forebay. The design and features of the cup are further described in Section 5 of this report. A future physical model to test the operation of the cup/flume connection may be helpful to validate function and hydraulic characteristics.

A ramped control weir in the flume connection to the cup will be used if there is a need to adjust water elevation in the FSS system with respect to the WTCT. The weir will be fully open at the 1,060-cfs flow condition, as this is the controlling case for maximum head loss through the system. This weir will be modulated at lower flows, to maintain a standard head loss through the system and a constant flow rate through the secondary dewatering system. The original concept for this weir was a simple sharp crested weir, but due to issues with the size of gate needed, storage and operation, the ramped weir design was adopted (Figure 4-24).

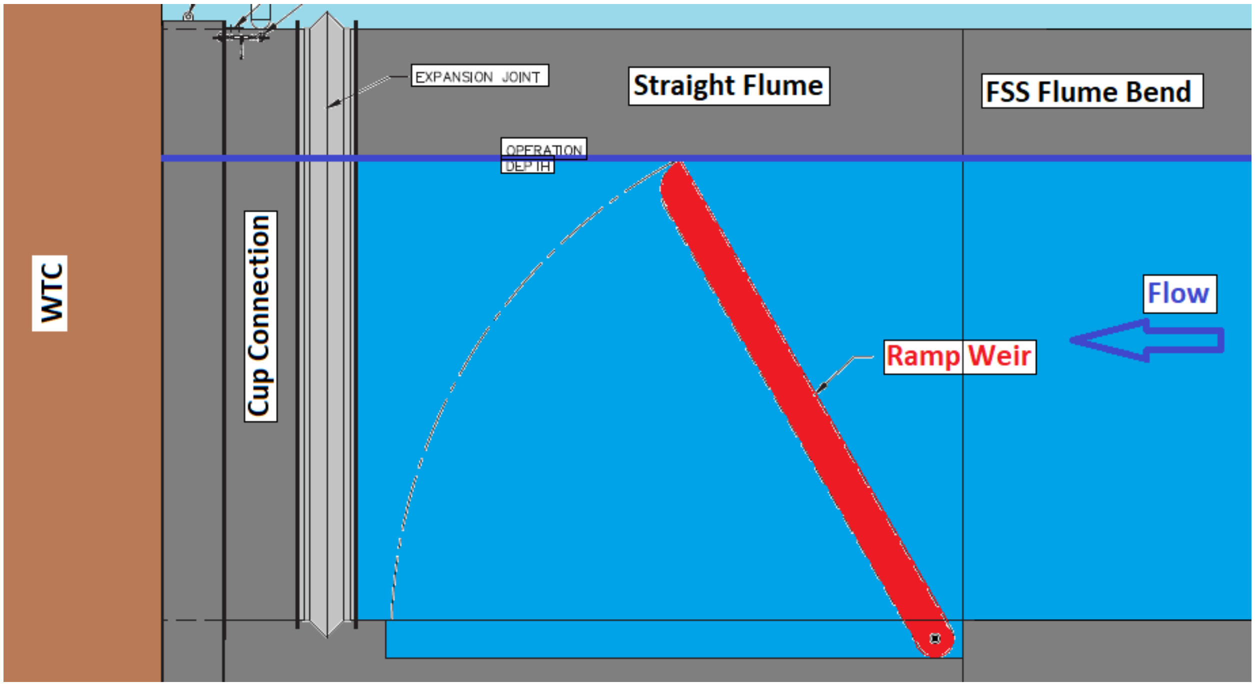

Figure 4-24. Ramp Weir Concept

k. Proposed Flushing Inlet

The connection of the FSS to the WTCT interferes with the current penstock bypass gate structure. Because of this interference, the orifice for the penstock bypass gate will be permanently closed. In order to maintain operational flexibility, and provide a method for back flushing debris off of the internal trashracks, a new flushing inlet will be installed on the east side of the WTCT. This inlet will be used in tandem with the regulating outlets, to force flow in the opposite direction of normal operations through the internal trashracks, at a velocity high enough to dislodge debris and route it through the regulating outlets and downstream. Further details of the flushing inlet can be found in Section 5 of this report.

l. WTCT Leakage

Leakage into the tower from the temperature control weirs as well as the RO bypass gates are of concern, since much if not all of the project outflow at lower flows will be required to maintain FSS operations. Leakage around the temperature control weirs is estimated at over 300 cfs, and around the RO bypass gates at more than 130 cfs. Considering the desired FSS flow of 300-1,060 cfs, this amount of leakage would significantly interfere with the FSS operation as designed. The leakage will be addressed by adding seals to these gates, further described in Section 6, Mechanical Design.

m. Fish Holding

The port and starboard collection channels are each designed to be dewatered to 12 cfs through the secondary screens. Downstream of the secondary screens there will be an adjustable set of tertiary dewatering screens and separator bars which will dewater to approximately 1 cfs or less. Design of the tertiary screen system is ongoing and will be presented during the plans and specifications phase of this project.

The holding system will consist of three 750-gallon pods that will hold the fish on the FSS as well as for transfer to amphibious vehicles (AVs) for release downstream. Further description of the holding, separation, and release systems and AVs can be found in Section 6 of this report.

n. Fish Release

Fish release will be via AVs to a location downstream of the dam.

o. Potential Modifications

Accommodations for future additions that could improve FCE, if needed, have been considered.

For the DDR, the following features have been considered for future improvements:

(1) Guidance/Exclusion Nets

Potential forces on the FSS structure caused by attached nets have been considered in the hull design. Point load transfers were estimated from drag forces computed for flow through a net, by assuming net total depth of 60 feet (partial depth guidance net), with the top 20 feet solid material and the lower 40 feet ¼-inch openings.

(2) Dam Bypass

Potential future improvements could include dam bypass to pass juvenile downstream migrants with limited to no handling and holding. Considerations in the DDR for the possibility of adding bypass include providing block-outs for potential connection to the FSS for attachment of a bypass pipe. The configuration of these features are in development and will be addressed further in future alternative studies. Considerations for clear space needed around the FSS in the vicinity of any additional features for bypass was also considered and the rock excavation plans address these needs.

4.6 REFERENCES

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SECTION 5 - STRUCTURAL DESIGN

5.1 SCOPE AND PURPOSE

This section describes the structural portions of the Cougar downstream fish passage project. The primary structural features of the facility are:

- Floating screen structure (FSS).
- Mooring tower.
- Modifications to water temperature control tower (WTCT).
- Tangent pile retaining wall.

5.2 GENERAL

The Cougar Dam intake tower is located at 44.1278° N latitude and 122.1452° W longitude. It is 346.0 feet in height from an invert at elevation 1,400.0 feet to the top of the machinery building at elevation 1,746.0 feet. The deck at the top of the tower is located at elevation 1,705.0 feet. The tower plan dimensions are approximately 118 feet in the longitudinal direction (upstream/ downstream) and 70 feet in the lateral direction. A significant portion of the tower below elevation 1,583.75 feet is anchored and bonded to rock. The tower is entirely freestanding above elevation 1,583.75 feet.

The Cougar Dam project was completed in 1963. The intake tower was structurally modified for temperature control between 2000 and 2005, with temperature control online in 2005. The new portion of the tower contains a wet well with inside plan dimensions of 38 feet by 60 feet above elevation 1,534.5 feet.

5.3 CRITICAL FEATURE CLASSIFICATION

Critical features are the engineering structures, natural site conditions, or operating equipment and utilities at high hazard projects whose failure during or immediately following an earthquake could result in loss of life.

With respect to seismic design and evaluation, critical project features are those that are expected to retain a pool coincident with a major earthquake event. Failure of a critical project feature caused by earthquake ground motion can result in loss of life from a sudden uncontrolled release of impounded water. Features ancillary to the critical project feature that are considered important with respect to preventing an uncontrolled post-earthquake release of impounded water are also to be designated as critical.

The intake tower and rockfill retaining structure will be classified as critical structures. Damage to these structures can result in inability to lower the pool following a seismic event.

5.4 ENGINEERING PROPERTIES OF CONSTRUCTION MATERIALS

The engineering properties of construction materials are:

Concrete: All Cast-in-Place Structures
New concrete f'_c = 4,500 psi
Existing concrete f'_c = 4,000 psi
Modulus of elasticity E = 3,600,000 psi
Poisson's ratio $\nu = 0.2$

Steel Reinforcement: All Structures
New: American Society for Testing Materials (ASTM) A615 Grade 60 f_y = 60 ksi
Existing: ASTM A15 (replaced by A615) Grade 40 f_y = 40 ksi

Structural carbon steel and structural stainless steel: Areas of use shown on drawings
ASTM A36 (carbon steel) f_y = 36 ksi; f_u=58 ksi
ASTM A992 (carbon steel) f_y = 50 ksi; f_u=65 ksi
ASTM A500 Gr. B – HSS Round (carbon steel) f_y = 42 ksi; f_u=58 ksi
ASTM A500 Gr. B – HSS Rect. (carbon steel) f_y = 46 ksi; f_u=58 ksi
ASTM A240 (stainless steel) f_y = 30 ksi
ASTM A276 (stainless steel) f_y = 30 to 45 ksi depending on Type selected

Structural Aluminum: Areas of use shown on drawings
Type 6061-T6 f_y = 40 ksi
Type 5052-H32 f_y = 28 ksi

f'_c = Specified compressive strength of concrete
f_y = Specified yield strength
f_u = Specified ultimate strength

5.5 DESIGN LOADS

The loads to be applied to the structure are summarized below. The following paragraphs explain the selection of each load. Some loads that are not amenable to a tabular summary are not shown (e.g., uplift)

Table 5-1. Summary of Loads

Type	Uniform Load	Concentrated Load
Dead Loads		
Concrete Dead Load	150 pcf	
Steel Dead Load	490 pcf	
Aluminum Dead Load	170 pcf	
Fluid Loads		
13-ft hydrostatic head differential (WTCT)	810 psf	
Live Loads		
Walkways Live Load	100 psf	300 lb
Stairways Live Load	100 psf	300 lb
FSS Deck Load	180 psf	8000 lb (Under monorail)
Wind		
Wind on FSS (@33 ft above ground)	66 mph (xx psf)	
Wind on other structures (@ 33 ft)	115 mph (xx psf)	
Snow		
Ground Snow Load	45 psf	
Ice		
Design Ice Thickness (@ 33 ft above ground)	0.25 inches	
Imposed Wind Load	30 mph	
Design Ice Density	56 pcf	
Seismic (See Table 5-3 for values)		
Operating Basis Earthquake	144-year event	
Maximum Design Earthquake (WTCT)	2475-year event	
Maximum Design Earthquake (FSS)	975-year event	
Traffic		
Design Vehicle	Liebherr LTM 1070-4.2	
	HL-93	18 kip
Trash		
Piled Douglas fir	16.25 pcf	

pcf = pounds per cubic foot
psf = pounds per square foot
lb = pound
ft = foot/feet
mph = miles per hour
kip = 1000 pounds-force

a. Dead Loads

Dead loads consist of the weight of concrete, metal, and fixed equipment. Concrete unit weight is assumed to be 150 pounds per cubic foot (pcf). Steel unit weight of 0.283 pounds per cubic inch, or 490 pcf, is based upon American Institute of Steel Construction (AISC) values for structural plates and shapes. Aluminum unit weight of 0.098 pounds per cubic inch is based on Aluminum Association values for structural shapes and plates.

b. Hydrostatic

The hydrostatic loads against the structure include internal and external pressures for all design load conditions. The unit weight of water is assumed to be 62.4 pcf.

c. Uplift

Uplift at the base of the hydraulic structures is assumed to be 100 percent of the adjacent river pressure over 100 percent of the base area. At internal planes, uplift is assumed to vary linearly from hydrostatic head at the external surface of a hydraulic structure to the hydrostatic head at any internal surface. Uplift pressures are assumed to remain unchanged during an earthquake.

d. Live Loads

The live loads are based on ASCE 7-10 Table 4.1, with an increased load for walkways and elevated platforms used due to the industrial nature of the facility. The live load for the deck of the FSS was selected as 180 pounds per square foot (psf), per consultation with the naval architect and the standards generally used for these types of structures. The live loads used for the design are summarized in Table 5-2.

Table 5-2. Design Live Loads

Type	Uniform Load (psf)	Concentrated Load (lbs)
Walkways/elevated platforms	100	300
Stairs and exit ways	100	300
Deck Loading on FSS	180	8000 (Under monorail)

e. Wind and Snow Loads

Wind load analysis is based on the 2014 Oregon Structural Specialty Code, Chapter 16. The minimum basic wind speed of 115 miles per hour (mph) (which translates into a velocity pressure of xx psf at the maximum design height of xxx feet) is chosen from Figure 1609A in the code. Exposure C is chosen for the computation of the design wind pressure. This will be used for fixed structures, and for strength limit states of the mooring tower and FSS attachments.

According to consultation with naval architects (Glosten), this wind speed is higher than that generally used for ships or other floating plants. An anemometer was placed by the U.S. Geological Survey on top of the WTCT, which is a much more appropriate location for determining the wind load on the FSS. This anemometer had a short recording period, but Glosten was able to perform a peak-over-threshold analysis of the data and correlate it with that available at the Eugene airport to develop a more appropriate site-specific value of 66 mph. This report is shown in Appendix H.

This value will be used for serviceability limit states for the mooring systems. This is appropriate because of the timing of the design wind event versus the critical position of the FSS. The worst positioning of the FSS during a wind event is in the maintenance position at maximum conservation pool; that is, when there are 25 feet of sail area above the waterline at pool elevation 1,690 feet. This maintenance draft will be primarily occurring in the summer, when it is unlikely for the design wind event to occur. The lesser consequences of excessive movement (damage to hydraulic connection) and the low probability of occurrence make this a reasonable risk to assume.

The basis of the snow load is Snow Load Analysis for Oregon, Structural Engineers Association of Oregon, 2014, an online tool at http://snowload.seao.org. This shows that the location of 44.1278° N and 122.1452° W has a ground snow load of 45 psf.

f. Ice

Design for ice loads will be in accordance with ASCE 7-10, Chapter 10. Per Figure 10-2, the design ice load will be 0.25 inches at 33 feet above ground level, with a 30 mph gust. The ice thickness at other elevations above ground must be calculated as shown in the chapter. An ice density of 56 pcf will be assumed in calculating weight.

g. Seismic Loads

USACE Headquarters funded a regional site-specific seismic study that identifies and quantifies seismic hazards for 13 USACE dams in the Willamette Valley of Oregon, including Cougar Dam as a demonstration project. A new study has been initiated to update the site-specific seismic criteria for Cougar. This study was completed by Amec Foster Wheeler Environment & Infrastructure, Inc. in 2017, and it is used as the basis for the design earthquakes.

EM 1110-2-6053 provides guidance for determining the design earthquakes for concrete hydraulic structures. The operating basis earthquake (OBE) is the earthquake event reasonably likely to occur during the service life of the facility, and the facility will be designed such that it can be placed immediately into operation after the OBE. An earthquake with a 144-year return period, corresponding to a 50 percent chance of exceedance during a 100-year design life, will be used for the OBE for all components of this facility. This earthquake was developed using probabilistic seismic hazard analysis in AFW 2017. The peak spectral acceleration of this event is 0.0725 g at a period of 0.15 seconds. The full spectrum is shown in Table 5-3.

The maximum design earthquake (MDE) is the maximum level of ground motion for which the structure will be designed. For non-critical structures and components (components whose failure is not reasonably likely to result in loss of life), an event with a 975-yr return period has been selected, which has a 10 percent chance of exceedance during a 100-year design life. The peak spectral acceleration of this event is 0.314 g at a period of 0.15 seconds, and the full spectrum is shown in Table 5-3.

The intake tower and the rockfill retaining structure will be evaluated to an MDE that corresponds to the maximum credible earthquake (MCE). The MCE is the largest earthquake that can be reasonably expected to occur at the site. Several MCEs determined by deterministic seismic hazard analysis were provided in AFW 2017, as well as a random crustal earthquake. At Cougar Dam, the sources for the deterministic MCEs were the Cascadia Interface and the White Branch Fault; the Cascadia Interface event was greater than the White Branch event at all periods, so the White Branch event was neglected for design. After consultation with Geotechnical Design, the 2,475-year uniform hazard response spectra (UHRS) response spectrum was selected as approximating the MCE, and is therefore used for design purposes. The peak spectral acceleration of this envelope is 0.493 g at a period of 0.15 seconds, with the full design event shown in Table 5-3.

A tripartite plot showing all the design earthquakes can be found in Figure 5-1.

Table 5-3. Acceleration Response Spectrum for Design Earthquakes

Spectral Period (seconds)	**Spectral Acceleration (g, 5% damping) for Return Period (years)**		
	144 (OBE)	**975 (Non-critical MDE)**	**2475 - MCE (Critical MDE)**
0.01	3.26E-02	1.45E-01	2.33E-01
0.03	3.66E-02	1.52E-01	2.41E-01
0.05	4.46E-02	1.81E-01	2.85E-01
0.075	5.74E-02	2.38E-01	3.74E-01
0.1	6.80E-02	2.91E-01	4.51E-01
0.15	7.25E-02	3.14E-01	4.93E-01
0.2	6.56E-02	2.92E-01	4.53E-01
0.3	5.46E-02	2.47E-01	3.86E-01
0.5	3.74E-02	1.85E-01	2.98E-01
1	1.91E-02	1.09E-01	1.78E-01
2	8.55E-03	4.61E-02	7.83E-02
3	5.07E-03	3.15E-02	4.76E-02
5	2.84E-03	1.69E-02	3.00E-02
7.5	1.51E-03	9.86E-03	1.58E-02
10	1.05E-03	6.16E-03	1.09E-02

Source: AFW 2017 Seismic Study

NOTE: V_{S30} = 1000 m/s, consistent with Cougar Dam Dacite on the site

Analysis of the tower structure will be via finite element modeling with the added-mass concept to account for hydrodynamic effects, as detailed in EM 1110-2-2400, Appendix D.

During a seismic event, hydrodynamic effects, or water-structure interaction, can impose significant loads upon a hydraulic structure, causing hydrodynamic forces to occur. The water inside and surrounding the structure alters the dynamic characteristics of the structural system, increasing the fundamental mode of vibration and modifying the mode shapes. This increases the forces required to restrain the structure.

The hydrodynamic added mass on the intake tower was modeled by extending the method developed by Chopra. Here, the internal and external added mass will be determined at each elevation as directed in EM 1110-2-2400, and then distributed equally to all nodes in contact with water at that elevation. For parts in contact with water but not modeled (e.g., the temperature control weirs), the mass that would have been attributed to them is distributed to the nodes where they bear on the tower.

Figure 5-1. Tripartite Plot of Design Earthquakes

h. Operation, Maintenance, Construction, and Temporary Loads

Cranes, trucks, boats, barges, and other maintenance and construction equipment loads will be evaluated when that equipment is selected by the contractor. If there is some particular piece of equipment that must be used for construction identified during the plans and specifications phase, a representative model will be selected in consultation with Cost Engineering, and the structure will be evaluated for that at that time.

i. Trash Loads

Debris and trash loading will be a factor in some areas. Any place that may collect trash will be evaluated for the loading imposed, and if possible the surface will be angled to prevent trash from accumulating. For this reservoir, trash consists of snags that have fallen into the reservoir from areas upstream, primarily Douglas fir. Hardy (1996) has given methods for estimating the weight of a pile of woody debris. The stated density of Douglas fir is 28 pcf; however, since woody trash does not present structural issues unless it sinks, we will assume that the trash loading consists of wood with a unit weight of 65 pcf. The maximum packing ratio that can occur in piles created mechanically is 25 percent; to be conservative, this number will be used. After accounting for the packing ratio, a pile of woody trash will be assumed to impose a load of 16.25 pcf, calculated from the *gross* pile volume. Additional loads from flowing water acting on trash (as in trashracks) will be added as necessary.

j. Bridge Loading

The critical operational load on the bridge and intake deck will be the Liebherr LTM 1070-4.2 crane used by the Willamette Valley Project. The total crane weight is 105.6 kips when driving on its wheels. The data sheets can be found in Appendix F and here: https://www.liebherr.com/external/products/products-assets/311339/liebherr-189-ltm-1070-4-2-td-189-01-us12-2017.pdf

The existing bridge was last evaluated in 2017, and is capable of carrying an HL-93 load.

k. Existing Structural Limitations

The existing WTCT wet well was designed to not exceed 10 feet of head differential between the reservoir level and the water level inside the wet well. Pressure relief panels on the regulating outlet bypass gates will open when this differential exceeds 7 feet (per Request for Information 95 from original tower construction). Analysis has demonstrated that a higher head differential will not control over seismic for any component within the tower, so there is justification for using 13 feet as the design head differential. The FSS requires a 3-foot head differential to maintain flow, and increasing the design head differential may be necessary to avoid reducing the difference between normal loading and extreme load. New facilities and modifications to existing facilities will be designed so that they will withstand this 13-foot differential between the forebay and wet well (810 psf over the entire surface of the wet well), as well as current seismic loadings.

During the plans and specification phase, consideration will be given to recalibrating the pressure relief panels to operate at a higher setpoint. The smaller difference between the normal operating condition and the operation of the panels will increase the risk of a panel operation when not necessary to protect the tower. However, with a higher design head differential a higher setpoint will not increase the risk to the tower. The benefits to reducing a spurious operation must be balanced against the expense and difficulty of recalibration.

5.6 DESIGN STANDARDS

The following standards will be used to conduct detailed design of components.

a. Concrete

Concrete structures will be designed according to EM 1110-2-2104; where that standard references ACI 318, ACI 318-14 will be used.

b. Steel

Steel structures that do not control water will be designed according to AISC 360-16. Structures that control water will be designed according to the provisions of ETL 1110-2-584, whether or not they meet the strict definition of "Hydraulic Steel Structure," as the design and detailing requirements in that letter will provide better behavior in service. Where AISC 360 is referenced, AISC 360-16 will be used.

Welding on non-bridge steel structures will be performed according to AWS D1.1 for structures that do not control water. For bridges or structures that control water, welding will be performed to AWS D1.5.

c. Aluminum

Aluminum structures will be designed according to the Aluminum Design Manual, 2015 edition.

5.7 DESIGN OF COMPONENTS

a. Mooring System

The mooring system must maintain the position of the FSS with a sufficiently small watch circle (i.e., the circle described by the center of the FSS when it moves under lateral loads) during all normal loadings and over all reservoir elevations from 1,516 to 1,699 feet. Preliminary analysis by URS determined that wind provided the controlling load case. Further analysis by Glosten and Moffet & Nichol (2018) provided more refined loads. The mooring option selected is a truss tower shown in Figure 5-2, providing two mooring points on the port side of the FSS. A third point will be provided on the WTCT. This option attempts to minimize the amount of rock excavation and the impact to the toe of the dam.

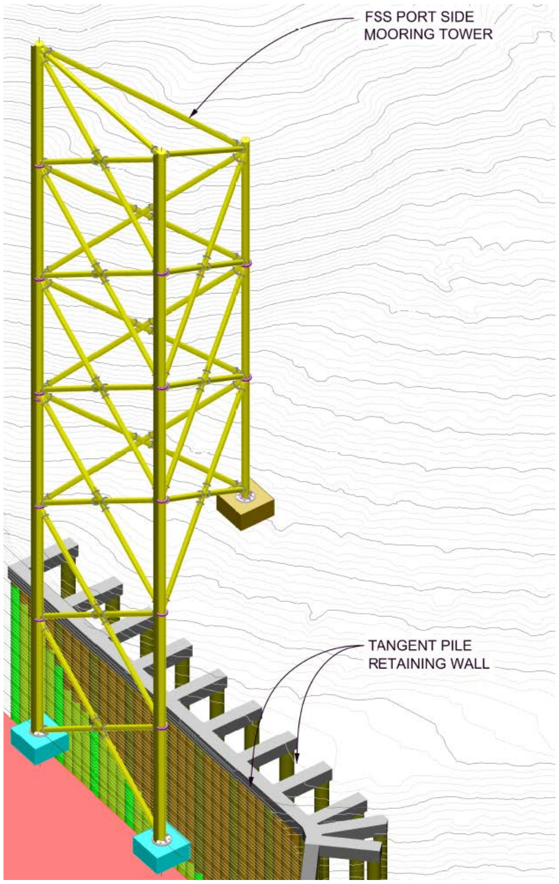


Figure 5-2. 3-D Model of Truss Tower Option

The rear footing is located at the elevation of the existing crane pad. The two front footings are below the lowest elevation of the floating fish collector.

The steel truss tower will be fabricated out of 24-inch-diameter pipe piles that are 1 inch thick. The diagonal braces are 16 inches in diameter and are .375 inches thick. The columns and diagonals will have bolted connections.

The primary load for design will likely be wind loading acting on the FSS; deflections must be held to less than 3inches to avoid overstressing the hydraulic connection to the tower.

b. Tower Modifications

Modifications to the existing WTCT will be performed to support the FSS's ability to collect fish via a gravity-head system. The primary concerns are permitting the flow of water at rates of up to 1,000 cfs through the hydraulic connection to the tower, and minimizing leakage to the maximum extent possible to avoid needing larger head differentials to generate the required flow rates.

(1) Penstock Slot Face Extension

Providing a proper seal to the tower will require modification of the penstock gate slot structures. In its current configuration, a 2-foot chamfer exists between the upstream face of the weir slots and the exterior wall of the machinery room. The concrete face of the penstock slot will be built out 2 feet into the forebay. This will bring the slot face flush with the machinery room upstream wall and allow the FSS, flume, and cup to ballast up to a maintenance draft at maximum conservation pool at elevation 1,690 feet and permit the FSS to float in the fishing position at the maximum pool elevation of 1,699 feet. The new face of the penstock slot will receive new steel nose plates to provide a sealing surface for the hydraulic connection to the FSS. The existing upstream coupling beams in the slot will be integrated into the new extension, retaining their existing elevations and thicknesses. The new face extension will allow the FSS to pass flow (collect fish) from forebay elevation 1,690 feet down to elevation 1,503 feet. Elevation 1,503 feet was chosen to allow the FSS to operate at forebay elevation 1,528 feet. Operation at elevation 1,528 feet will be slightly diminished (discussed in Section 5.6.b (3)).

(2) Penstock Bypass Gate Slot Deck-over & Penstock Bypass Inlet Plug

The penstock bypass gate slot will be decked over at each coupling beam, except at elevations 1,664 feet and 1,683 feet. This will be accomplished by placing a new reinforced concrete deck spanning across the gap from the downstream face of each coupling beam to the beginning of the vertical slot assembly for the temperature control weirs. The new decks will provide a consistent path for water flow to the wet well and eliminate any potential leakage paths through this section of the penstock slot. The reasoning for this design is explained in Appendix F.

The coupling beams at elevations 1,664 feet and 1,683 feet will not have a deck installed at their locations. This is to provide for a method of maintaining water temperature control operations during high-pool maintenance periods. The project staff has designated the summer season as the time for maintenance of the FSS and other auxiliary systems. The forebay elevation in the summer is at or near maximum conservation pool. The FSS will be ballasted out of the water to a shallow draft to facilitate dewatering of sumps and plenums. This creates a condition where the forebay has direct communication to the wet well from under the cup apron and over the most upstream temperature weir within the penstock slot with the FSS in the maintenance draft position. In order to block this flow, the original penstock bypass gate will be lengthened (by the addition of two extra identical segments) and lowered from the machinery room to rest on the newly created deck at elevation 1,645 feet within the penstock bypass gate slot. The gate will span between the deck at elevation 1,645 feet and the coupling beam at elevation 1,683 feet, providing continuity of blockage between the apron and temperature weirs. The repurposed penstock bypass gate will be redesignated as a maintenance bulkhead and will normally be stowed in its dogged position in the machinery room above. The existing hoist and sheave will also be repurposed to operate the bulkhead.

A solid plug of reinforced concrete will be used to fill the penstock bypass inlet at the base of the WTCT starting at elevation 1,419.5 feet and extending up to approximately elevation 1,448 feet. The plug will render the penstock bypass gate unnecessary and also eliminate the nuisance turbine debris issue the project is currently addressing. The remaining trashrack back-flush function of the penstock bypass gate will be carried out by the new trashrack flushing gate, discussed below.

(3) <u>Penstock Bypass Slot Shear Wall</u>

To allow the FSS to collect fish down to the minimum conservation pool, the existing 5- to 8-foot-thick downstream internal shear wall, currently at elevation 1,561 feet, will be demolished down to elevation 1,458 feet to accommodate a new lower weir storage area and final sill elevation of 1,507 feet. The elevation of 1,507 was chosen to allow the FSS to operate normally at forebay elevation 1,532 feet. Operation of the FSS between elevation 1,507 feet and elevation 1,503 feet will be diminished to 800 cfs due to the protrusion of the shear wall as the FSS descends below elevation 1,507 feet. This diminished flow was found acceptable during product development team discussions.

To support the removal of this wall, three new reinforced concrete beam/columns ("intake opening beams") will be constructed so as to mimic a continuation of the upstream coupling beams back to the wet well. The top and bottom faces of each new beam/column will be aligned with the corresponding existing upstream coupling beams and extend downstream approximately 4 feet 6 inches. See Figure 5-3 for a layout through the inlet.

As mentioned above, the weir storage area will also be lowered to allow all the temperature weirs to move out of the flow while maintaining their seal to one another. The new weir storage area will terminate approximately at elevation 1,458 feet and will feature a "tiered" configuration so that each weir drops approximately 8 inches lower than the previous upstream weir. This tiered configuration will allow a sealing system to remain engaged with the skin plate of the next downstream weir while the weirs rest in their fully lowered position.

(4) <u>Wet Well Internal Trashrack System</u>

The existing vertical and sloped trashracks will be demolished and a new sloped trashrack will be constructed starting at the regulating outlet (RO) gallery deck elevation 1,470 feet and extending at a 45-degree angle to the WTCT wall at approximate elevation 1,494 feet. The new sloping trashrack will remain largely uninspectable during normal operation. With this in mind, the trashrack will be designed to withstand 15 feet of differential head, simulating a catastrophic debris load.

Since the downstream shear wall in the penstock slot is to be demolished down to a final elevation of 1,507 feet, the existing vertical and sloped trashracks will make steady, even flow a challenge for the FSS while it operates over the elevation range of the existing racks. For this reason, all the existing internal trashracks will be removed. The new lower elevation sloped rack (mentioned above) will provide hydraulic benefits to the FSS in general, especially during transition periods, along the tower face at lower pool elevations. The elimination of the existing racks systems in favor of a single rack system minimizes the amount of uninspectable rack surface area. However, since the new rack has less surface flow area, the new rack must be designed to withstand to a higher velocity and mitigate the effects of vibration due to the higher velocity. This new sloped trashrack system shall be designed for higher speed flows (up to ~2 fps water velocity).

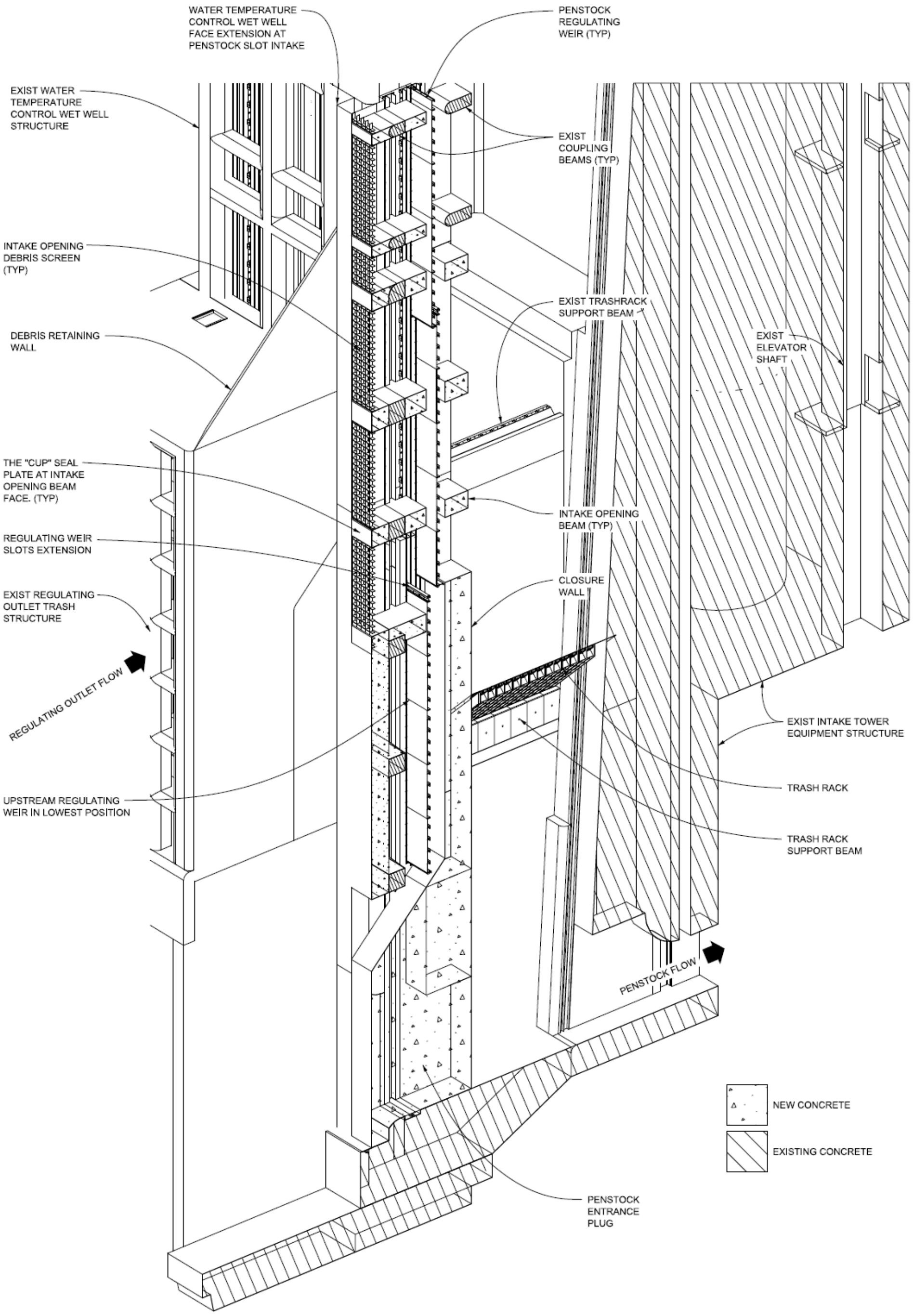


Figure 5-3. Section Through Penstock Slot Showing Proposed Modifications

(5) Penstock Slot Upstream Trashracks

All existing external trashracks on the penstock slot will be removed to allow for the new wet well face extension to the tower. New trashracks will be fabricated and installed within the spaces between coupling beams from elevation 1,700.0 feet to 1,461.5 feet. The trashracks shall be aligned with the new face extension of the penstock slot and will be inset so as not to interfere with FSS movement.

(6) Internal Trashrack Flushing Gate

Due to the decommissioning of the penstock bypass inlet and gate system, the PDT considered it necessary to include functionality for back flushing the internal trashrack during a heavy debris load situation. A new flushing orifice and gate have been designed to facilitate the back flushing function. The orifice will measure 10 feet wide by 12 feet tall, with its invert located at elevation 1,475 feet along the WTCT eastern facing wall. The orifice will be controlled by a vertical roller/slide gate. The means of lifting the gate is currently in design. The orifice gate is intended to be used when the differential pressure across the internal trashrack reaches a one foot of differential head.

Upstream of the lift gate will be a trashrack system designed for high water velocity. The flushing gate will be used as the inlet to the wet well to establish a 6 fps back-flushing flow through the flushing gate trashrack with the RO gate(s) as the only outlet. The goal is to develop a back-flushing flow of 1 fps (480 cfs) across the trash bars of the internal sloping trashracks system (in the reverse direction) to release impinged debris. For details on the back-flushing procedure, see Section 4, Hydraulic Design.

(7) Debris Retaining Wall

Currently, woody debris tends to accumulate on top of the RO trash structure over the course of the year. These debris piles can be extremely large and contain several massive logs and root balls. In order to prevent this debris from interfering with FSS translation up and down the face of the penstock slot, a triangular wall will be constructed on the RO trash structure's eastern edge, deflecting debris away from the path of the FSS, retaining it on the trash structure's roof. The top of the wall will be angled at 45 degrees so that no debris accumulates on the top of the wall itself.

(8) Third Floating Screen Structure Mooring Location on the Water Temperature Control Tower

The FSS must be moored on its starboard side in addition to the two points on the mooring tower to keep FSS movement down to a reasonable level during the design wind event. This third point will be located on the eastern wall of the WTCT wet well. The unfactored load during this event will be 41.4 kips, acting in the north-south direction, per calculations from Appendix H. The mooring point must provide a stiffness of 277.3 kips/feet to be effective. The rail for this mooring point will be supported on triangular frames 5 feet 0 inches on center attached to the tower.

The mooring point must also be evaluated for the OBE. For events larger than the OBE, the mooring point will be designed as a weak point to break away to avoid the WTCT-FSS-mooring tower acting as a complete system during major seismic events. This will avoid failure of the WTCT during overload conditions. For events larger than the OBE, it is acceptable for damage to occur.

(9) Platform for Cable Reels

The cable reels to supply power to the FSS will be located on a platform off of the intake deck of the WTCT. Per communication from Moffat & Nichol, a tentative reel will weigh 3.4 kips, and have plan dimensions of 12 feet by 5 feet. To hold these, and allow room for maintenance, a steel-framed platform 15 feet by 16 feet will be constructed. Two 15-foot girders will be supported by knee braces, with 16-foot interior beams at the third points connecting them. The reels will be supported by the interior beams approximately 6 feet from the upstream girder. Tentative design shows that the interior beams and exterior girders will be W12×16, and the knee braces will be W12×40. Galvanized steel grating will span the 5 feet between the interior girders to form a walking surface, with a design live load of 100 psf.

c. Rockfill Retaining Structure

The location of the FSS requires excavation of the toe in the left upstream groin of the dam. To avoid movement of the rock shell after this excavation, a retaining wall will be constructed from tangent piles. A grade beam will connect the tops of the piles.

The piles will consist of a pipe pile drilled through the embankment and into the bedrock beneath to act as a steel casing. The steel casing is necessary to contain the concrete during placement due to the large voids in the embankment. The wall will be designed as a composite section in accordance with AISC 360-16 Chapter I. Sacrificial thickness will be added to the casing

The large size of the voids in the embankment will not permit the use of tieback anchors. To avoid very large pile sizes, a second row of piles will be drilled behind the main wall. One of these tieback piles will be placed behind every fourth tangent pile, and a reinforced concrete tension member will run from the grade beam at the top of the tangent pile wall back to these tieback piles. The tangent pile wall will be analyzed as fixed at the base and pinned at the top.

The Geotechnical Engineering Section has developed the loads for this wall. A moist unit weight of 110 pcf and a friction angle of 41 degrees was used. The MDE with the water surface at maximum conservation pool was the controlling load case.

Tentative designs had the top surface of the retaining wall at approximately 1,532 feet. This necessitated a pile diameter of 42 inches with twenty #9 longitudinal bars (in previous design iterations, the steel casing was neglected). The alignment of the wall will be finalized at 10 feet clear of the port side of the FSS near the stern, and 22½ feet clear of the FSS where necessary to provide clearance for the crew access boat. The wall will likely get somewhat taller, however, since the decision to account for the strength of the casing has been made, but the pile diameter will likely not increase much. The final wall elevations will be determined early in the plans and specifications phase.

d. Service Walkways on Floating Screen Structure

Once the final location of all equipment in the fish handling areas has been determined, the Structural Engineering Section will have the responsibility to design the access walkways to allow operations and maintenance. These walkways will have a walking surface of commercially-available expanded metal walkways (Grip-Strut® or similar product). The supporting structure will be heavy steel framing, tentatively channel sections supported by rectangular HSS columns. The walkways will be designed as steel structures that do not control water.

e. Equipment Supports on Floating Screen Structure

The Structural Engineering Section will select supporting members to carry the dead and live loads of the equipment to the foundations provided by the naval architect. These will be designed as steel structures that control water.

5.8 DISCARDED DESIGN OPTIONS

The following options were considered and discarded during the design process.

a. Mooring Options

(1) Option 1 – Battered Piles

The A-E firm URS who was contracted to design possible mooring systems came up with the battered pile system. This system would utilize one vertical pile that is socketed 50 feet into the bedrock and then braced with other piles that intersect the vertical pile at its midpoint. Both these bracing piles would also be socketed into bedrock. This option is shown below in Figure 5-4. The A1 configuration of the FSS would work with these battered piles if it was feasible to drill 10-foot-diameter piles 50 feet into bedrock. It was decided with input from the geotechnical engineers and construction engineers that it is not feasible to drill an 11-foot-diameter hole 50 feet into bedrock. This option would also be drilling into the toe of the dam, which will not be performed due to dam safety concerns. An individual pile is shown in Figure 5-4, and a plan view of the option is shown in Figure 5-5.

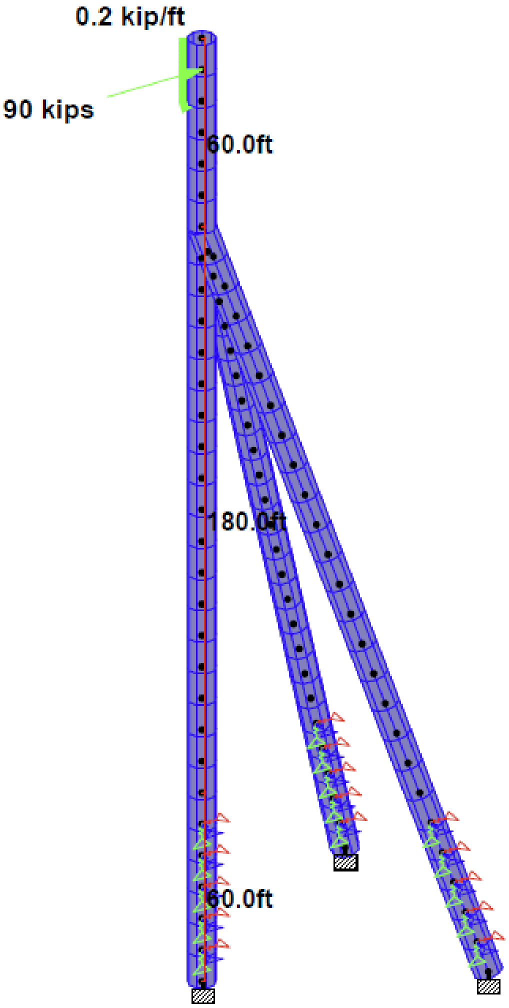


Figure 5-4. Battered Pile Option

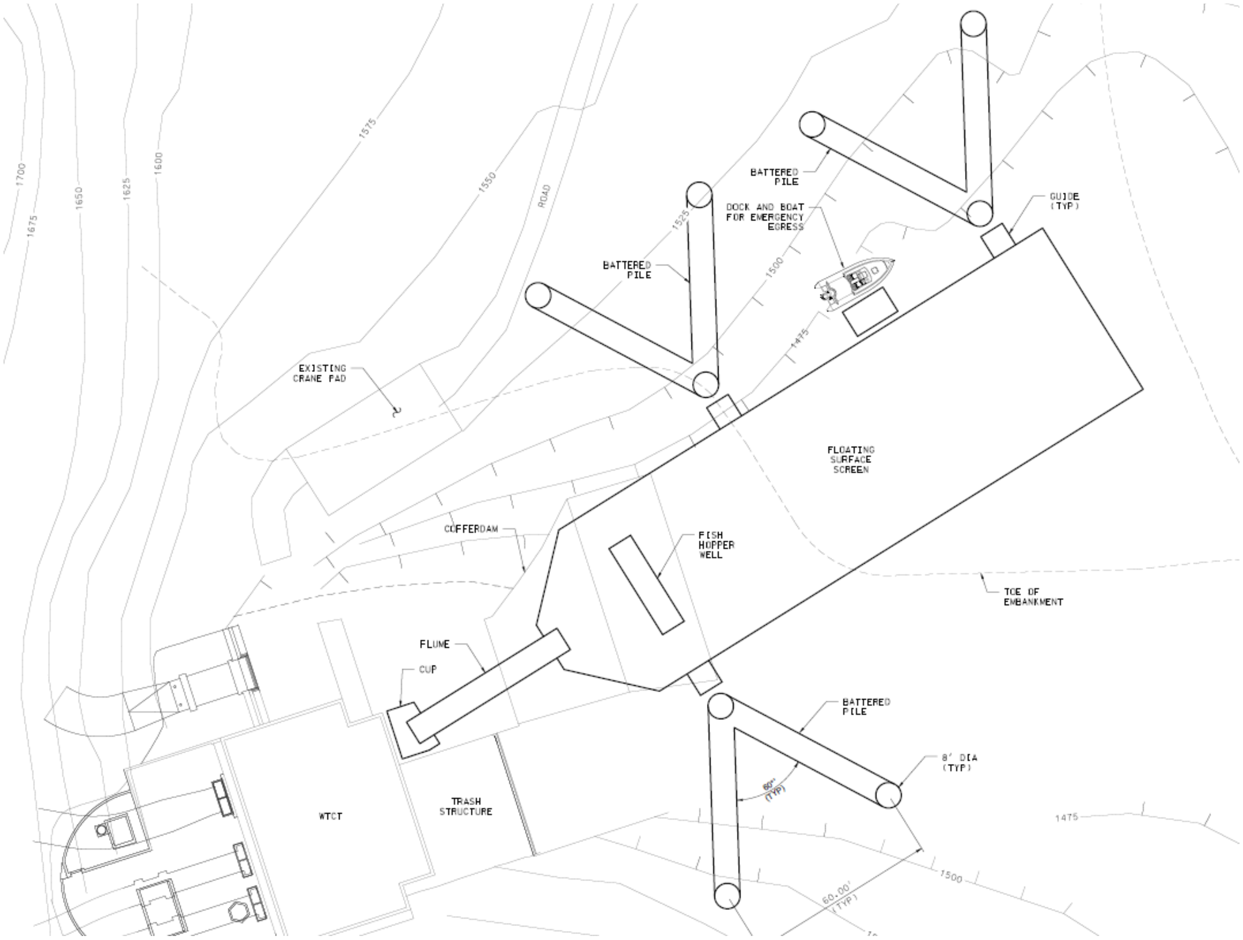


Figure 5-5. Floating Screen Structure A1 Configuration with Three Sets of Battered Piles

(2) Option 2- Mooring Tower

URS also developed a mooring tower design, shown in Figure 5-6 and Figure 5-7. This option involves building a 250-foot concrete tower on the side of the FSS. The tower would have a set of stairs inside and a set of rails on the outside face to guide the FSS during pool elevation changes. This option would also utilize the battered piles to anchor the opposite side of the FSS. This option was discarded because it is only compatible with a rectangular FSS design that was not selected.

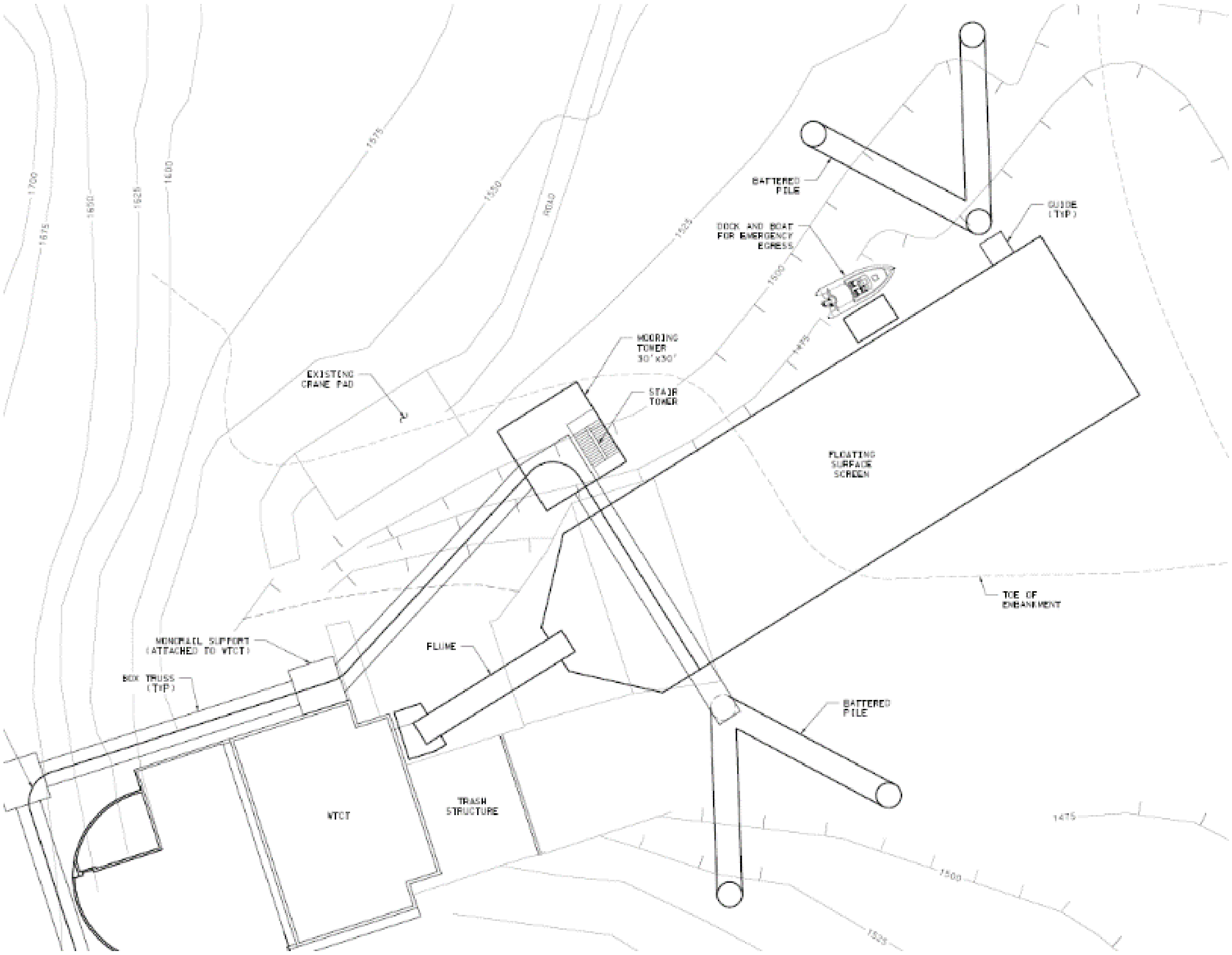


Figure 5-6. Concrete Mooring Tower with Battered Piles

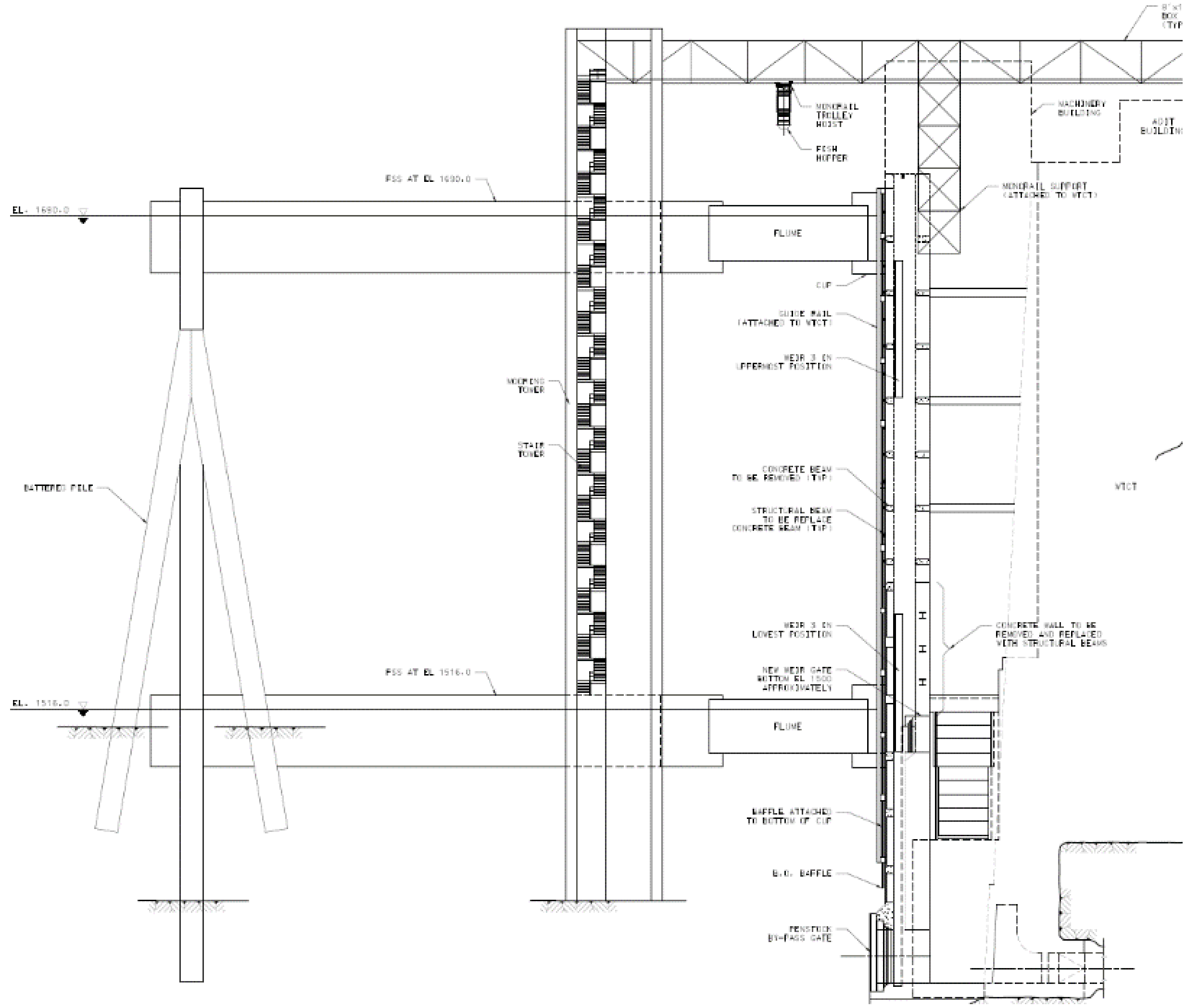


Figure 5-7. Concrete Tower with Stairs

5.9 REFERENCES

The structural design will conform to the following reports, criteria, Engineering Manuals (EMs), Engineering Regulations (ERs), Engineering Technical Letters (ETLs), Technical Manuals (TMs), and industry codes.

Amec Foster Wheeler Environment & Infrastructure (AFW). 2017. Seismic Hazard Analysis for Six Dams in the Willamette Valley, Oregon.

American Concrete Institute (ACI). ACI 318-14, Building Code Requirements for Structural Concrete.

American Institute of Steel Construction (AISC). Steel Construction Manual (LRFD and ASD), 15th Edition.

American Society of Civil Engineers (ASCE). ASCE 07-10, Minimum Design Loads for Buildings and Other Structures.

American Welding Society (AWS). 2007. Structural Welding Codes for Steel and Aluminum.

American Welding Society. 2008. AWS D1.1, Structural Welding Code – Steel.

American Welding Society. 2016. AWS D1.5, Bridge Welding Code.

International Code Council. 2014. Oregon Structural Specialty Code

Hardy, Colin. 1996. General Technical Report PNW-GTR-364: Guidelines for Estimating Volume, Biomass, and Smoke Production for Piled Slash. US Forest Service, Pacific Northwest Research Station.

U.S. Army Corps of Engineers. 2016. ER 1110-2-1806, Earthquake Design and Evaluation for Civil Works Projects.

U.S. Army Corps of Engineers. 2005. EM 1110-2-2100, Stability Analysis of Concrete Structures.

U.S. Army Corps of Engineers. 2003. EM 1110-2-2104, Strength Design for Reinforced-Concrete Hydraulic Structures.

U.S. Army Corps of Engineers. 2007. EM 1110-2-6053, Engineering and Design - Earthquake Design and Evaluation of Concrete Hydraulic Structures.

U.S. Army Corps of Engineers. 2003. EM 1110-2-2400, Structural Design and Evaluation of Outlet Works.

U.S. Army Corps of Engineers. 2014. ETL 1110-2-584, Design of Hydraulic Steel Structures.

U.S. Army Corps of Engineers. 2009. Regional Seismic Hazard Assessment: Willamette Valley in the Pacific Northwest Region.

SECTION 6 - MECHANICAL DESIGN

6.1 GENERAL

This section describes the mechanical portions of the Cougar Downstream Passage Facility. The mechanical features are divided into the categories below.

6.2 FSS – Collection Channels

6.3 FSS – Fish Sorting Area

6.4 FSS – Plenums and Junction Pool

6.5 Fish Transport

6.6 Debris Management

6.7 Crew Access

6.8 Water Temperature Control Tower Modifications

6.9 Miscellaneous Mechanical Features

6.10 Abandoned Concepts Documentation

The main structure in the Cougar downstream fish passage project is the floating screen structure (FSS). An overall plan representation of the FSS is shown in Figure 6-1. The FSS will be a floating vessel that draws water from the reservoir through two channels in which flow is controlled. The channels are dewatered as fish are passed along into storage tanks. The screened water is then guided into the water temperature control tower (WTCT), where it is passed through Cougar Dam to feed into the South Fork McKenzie River.

The mechanical components related to the FSS vessel systems (ballast tanks, ballast pumps, etc.) can be found in the Section 7, Marine Design, prepared separately by the architect-engineer (A-E) firms Moffat & Nichol, and Glosten.

6.2 FLOATING SCREEN STRUCTURE – COLLECTION CHANNELS

The FSS will have two discrete collection channels, which will draw water and fish into the hull of the vessel. These collection channels are highlighted in Figure 6-1 below. The two collection channels are designated as the "starboard collection channel" and the "port collection channel." The smaller of the two channels, the starboard collection channel, will be optimized to intake 400 cfs of collection water, and the port collection channel will be optimized to intake 600 cfs of collection water. Further details on the hydraulic design of the collection channels can be found in Section 4, Hydraulic Design.

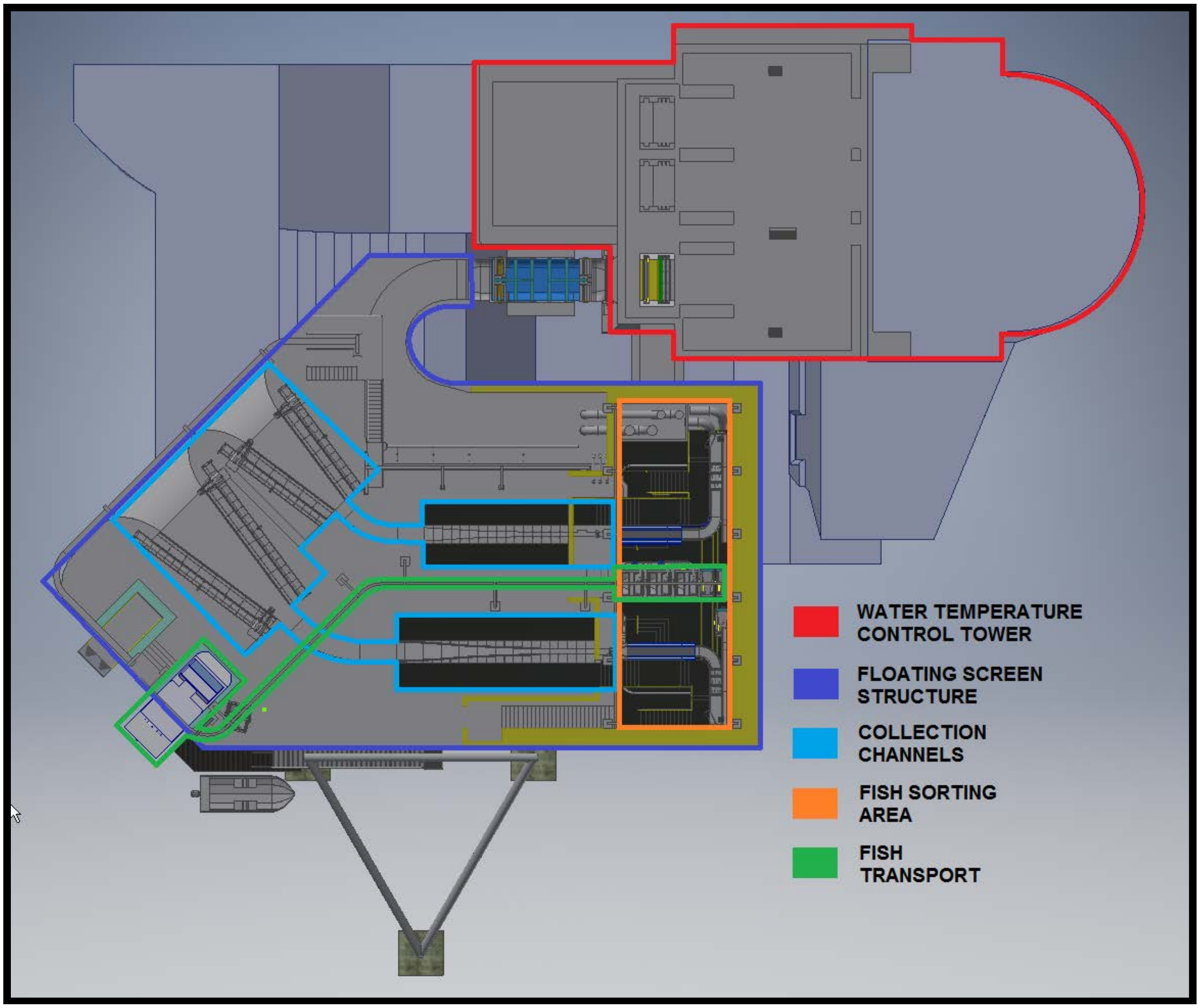


Figure 6-1. Floating Screen Structure Overall Plan

Each channel is comprised of two main areas – the primary screen and secondary screen areas. CAD representations of the primary screen area are shown in Figure 6-2. Further details on the individual components and features contained within the primary screen area are described in Sections 6.2.a to 6.2.e below.

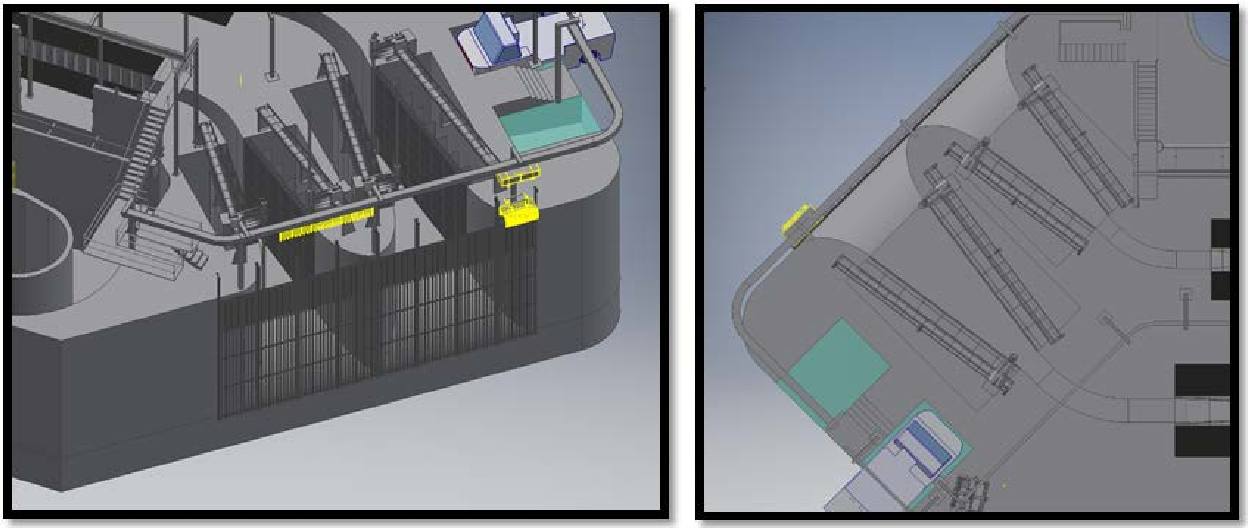


Figure 6-2. Primary Screen Areas, Isometric and Plan Views

Computer-aided drafting (CAD) representations of the secondary screen area are shown in Figure 6-3. Further details on the individual components contained within the secondary screening area are described in Sections 6.2.f. – 6.2.l. below.

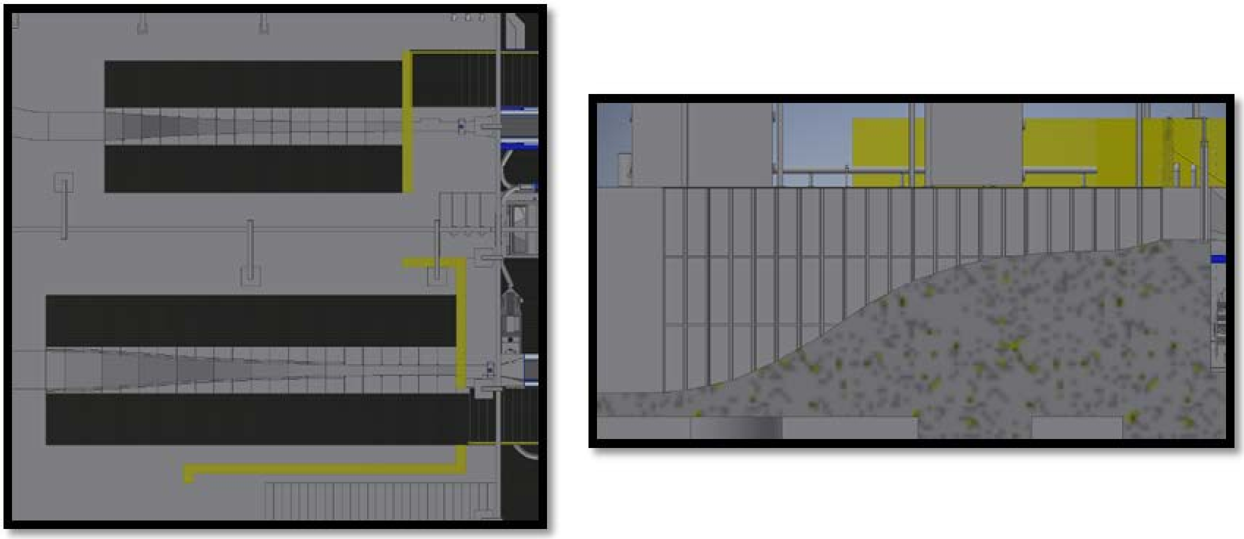


Figure 6-3. Secondary Screen Areas, Plan and Section Views

a. Debris Bars

The entrance to each collection channel has a set of debris bars, installed on the external hull wall of the FSS to prevent large woody debris and other trash from entering into the collection channel. These debris bars are serviced by an overhead trash rake. See Sections 6.6.b. and 6.6.c. of this report for details on the debris bar and trash rake system.

b. Primary Fish Screens

The side walls of the primary screen areas of each collection channel will be lined with vertical fish screens. These screens allow pass-through flow of water into the plenums while keeping fish in the collection channel. A sweeping velocity across the face of the intake screens will guide any fish that enter the collection channel further back into the FSS. This sweeping velocity gradually increases from <1 fps at the entrance of the FSS and the beginning of the primary screen section. Capture velocity (7-9 fps) is not achieved within the primary screen area. The transverse flow through the intake screens will be limited to NMFS fry criteria velocity, which is not to exceed 0.4 fps.

The intake screens will be stainless steel, horizontally oriented, and mechanically fastened profile bar screens. Each intake screen slot will be 4 feet wide. Within each intake screen slot will be six 4-foot by 3.25-foot banded profile bar screens, stacked vertically and fastened. The floor of the primary screen area will be gently sloped, but the height of the intake screens will remain constant through this section. This stack of intake screens will be 19.5 feet tall, providing 3 feet of screened freeboard throughout the primary screen area. These features are similar between the port and starboard collection channels.

The wall length of the port and starboard collection channels is not identical. The starboard collection channel primary screen area is approximately 24 feet long, and the port collection channel primary screen area is approximately 32 feet long. This requires six 4-foot-wide screen slots for the starboard collection channel, and eight 4-foot-wide screen slots for the port collection channel. This arrangement equates to 48 screens on each side of the external channel, and 36 screens on each side of the internal channel, for a total of 168 fish screens panels.

A profile bar will be similar to Hendrick's Screen Company stainless steel profile bar [B-69]/[B-6S]/[B-6], with NMFS fry-criteria spacing and 50-percent porosity. A banded profile bar screen of this type weighs approximately 7 psf. Therefore, a 5-foot by 3-foot screen will weigh around 91 pounds. This size screen will be removable by means of a small davit crane or manual "cherry picker" hoist, and manipulated by hand once on the deck of the FSS. Removal, service, and maintenance of the screens will be infrequent.

c. Primary Perforated Plate Diffusers

Behind each intake screen (when viewed from the centerline of the collection channel) will be a fixed porosity plate. The porosity plate will be a stainless steel perforated plate, sufficiently stiff to withstand the small hydrostatic force applied across the panel. The perforation holes will increase in size from top to bottom of the plate, gradually increasing the open area of the porosity plate relative to the depth beneath water surface elevation. This porosity increase will serve to equalize the velocity profile of the water passing through the intake screens as it travels toward the adjustable intake control weirs. A depiction of the arrangement and placement of this plate can be found in Figure 6-4.

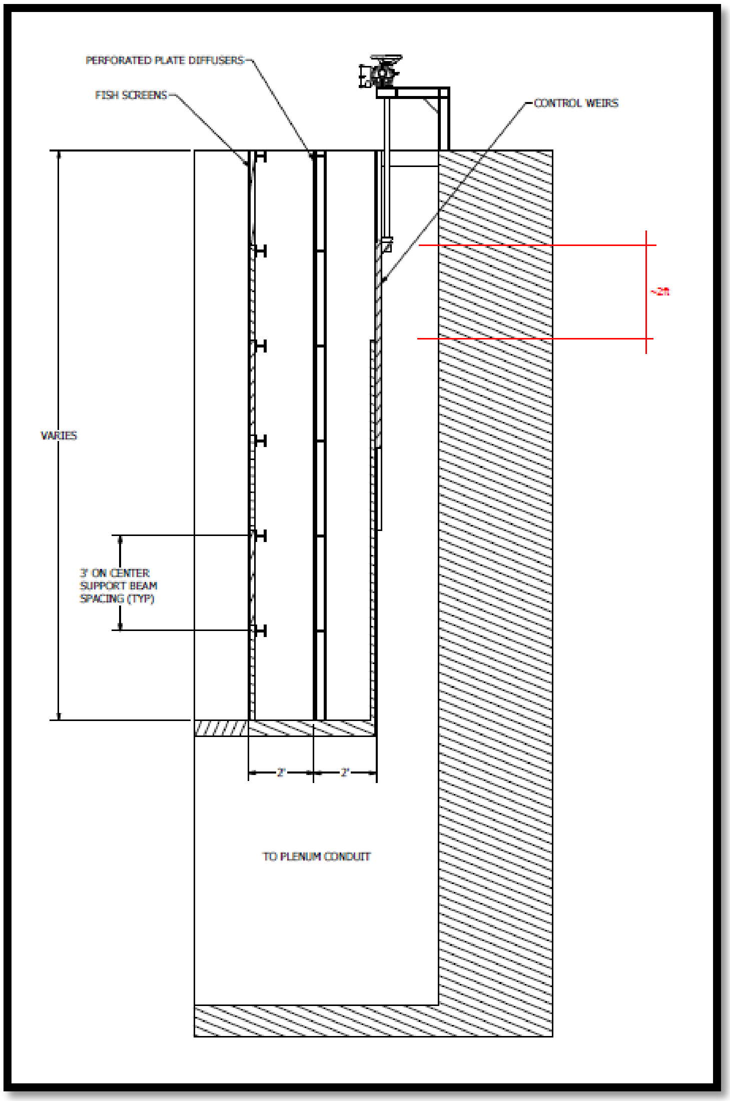


Figure 6-4. Primary Screen Cross-Sectional Arrangement

d. Primary Control Weirs

Behind each porosity plate will be adjustable intake control weirs. These carbon steel overflow weirs will control the flow rate of water being dewatered out of each 4-foot section of the primary dewatering screen section. Control of this flow rate is critical to maintaining desirable hydraulic characteristics throughout the primary dewatering screen section.

(1) Control Weir Gates

Each control weir will be a 4-foot-wide, 2-foot-tall, welded carbon steel structure. The control weir will be constructed from a ¼-inch steel skin plate, welded to a carbon steel support structure made of 2-inch by 2-inch steel tubing. The control weir gates will travel vertically within steel guides. Rubber bulb seals will be installed to prevent leakage around and under the control weir gates.

(2) Control Weir Actuators

Because the FSS will be tunable for varying intake flow rates (300 to 1,000 cfs), the intake control weirs must be adjustable automatically and with a fine degree of precision. Each weir will be adjustable by a lead screw and an electric actuator mounted vertically above each weir. The adjustments of the intake control weirs will be based on ultrasonic level transducers positioned on both sides of the control weir to determine relative water surface elevation.

The port collection channel primary screen section will have eight 4-foot-wide intake control weirs on each side, with each weir being independently adjustable through the lead screw actuator described above. The starboard collection channel will be arranged similarly, but with six control weir assemblies on each side. Twenty-eight sets of control weirs and actuators will be required for both primary screen areas, combined.

The electric actuators will be similar to Rotork IQ20 multi-turn actuators. Precise sizing of the actuators has not been completed at this time. With the large quantity of control weir actuators being used, special attention will be given to their serviceability, and a sufficient number of spares will be provided through the contract.

e. Primary Screen Cleaners

See Section 6.6.d. of this report for information on the primary screen cleaners, as part of the debris management system.

f. Secondary Fish Screens

The secondary fish screen section is located downstream of the primary fish screens and the collection channel bend. The secondary fish screen section is used to further dewater the collection channel, and specifically to increase the velocity of the water in the channel up to the target capture velocity of 7 fps. CAD representations of this area can be found in Figures 6-5 and 6-6. See Section 4, Hydraulic Design, for further details on the velocity profiles.

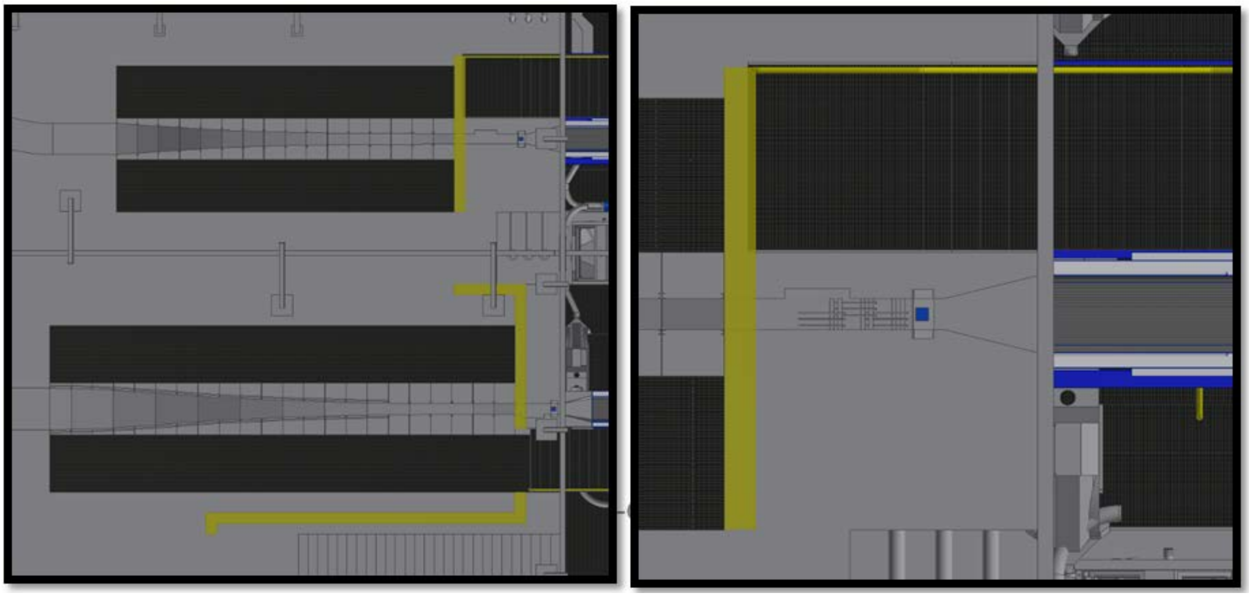


Figure 6-5. Secondary Fish Screen Area (left) and Collection Channel Throat (right)

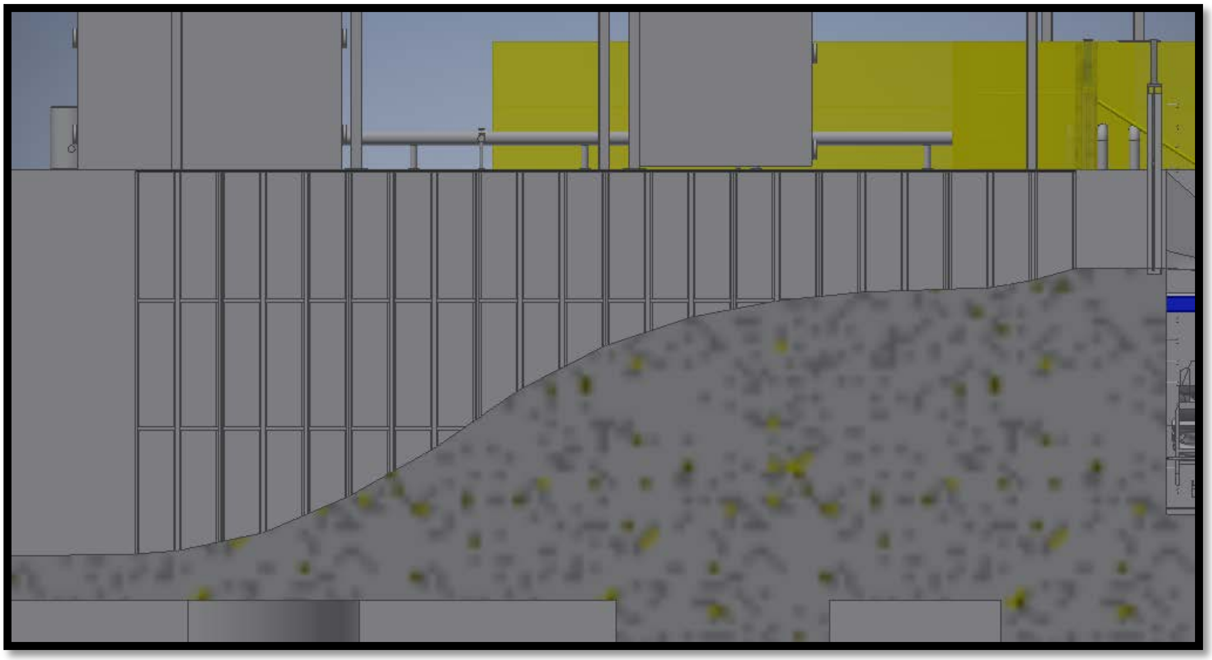


Figure 6-6. Secondary Fish Screen Area Section (Port Collection Channel Shown)

The secondary fish screen section has a ramped floor, which slopes up from -16 feet below water surface to -1.5 feet below water surface. The sidewalls of the section are lined with profile bar fish screens, similar to the primary fish screens, which constrict from a 4-foot-wide channel at the beginning of the screened section (3 feet wide for the internal channel) to 1 foot wide at the end of the screened section (referred to from here on as the "throat" of the collection channel).

The secondary fish screen area side walls will be constructed similar to the primary fish screen area, with multiple individual screens stacked in slots to create one continuous side wall. Each secondary screen panel is 2 feet wide, though the height of each panel differs with its location within the secondary screen area. The profile bar will be similar to Hendrick's Screen Company stainless steel profile bar [B-69]/[B-6S]/[B-6], with NMFS fry-criteria spacing and 50-percent porosity. Individual screen panels will be sized to remain under 50 lbs, and will be removable by means of a small davit crane or manual "cherry picker" hoist. Removal, service, and maintenance of the screens will be infrequent.

g. Secondary Perforated Plate Diffusers

Behind each secondary screen will be a fixed porosity plate, similar to the arrangement in the primary fish screen area. The porosity plate will be a stainless steel perforated plate, sufficiently stiff to withstand the small hydrostatic force applied across the panel. The perforation holes will increase in size from top to bottom of the plate, gradually increasing the open area of the porosity plate relative to the depth beneath water surface elevation. This porosity increase will serve to equalize the velocity profile of the water passing through the intake screens as it travels toward the adjustable intake control weirs. A depiction of a similar arrangement and placement of this plate can be found in Figure 6-4.

h. Secondary Control Weirs

Behind each porosity plate will be adjustable intake control weirs. These carbon steel overflow weirs will control the flow rate of water being dewatered out of each 2-foot section of the secondary fish screen section. Control of this flow rate is critical to maintaining desirable hydraulic characteristics throughout the primary dewatering screen section.

(1) Control Weir Gates

Each control weir will be a 2-foot-wide, 2-foot-tall, welded carbon steel structure. The control weir will be constructed from a ¼-inch steel skin plate, welded to a carbon steel support structure made of 1-inch by 1-inch steel tubing. The control weir gates will travel vertically within steel guides. Rubber bulb seals will be installed to prevent leakage around and under the control weir gates.

(2) Control Weir Actuators

Unlike the primary control weirs which need to be finely adjustable, the secondary control weirs only need to have full-open and full-closed capability. Each weir will be actuated open and closed with a lead screw and an electric actuator mounted vertically above each weir.

The port collection channel secondary screen section will have 22 control weir gate assemblies, each 2 feet wide, for a total length of 44 feet. The starboard collection channel will have 16 control weir gate assemblies, for a total length of 32 feet.

The port collection channel primary screen section will have eight 4-foot-wide intake control weirs on each side, with each weir being independently adjustable through the lead screw actuator described above. The starboard collection channel will be arranged similarly, but with six control weir assemblies on each side. Twenty-eight sets of control weirs and actuators will be required for both primary screen areas, combined.

The electric actuators will be Rotork IQ20 multi-turn actuators, or similar. Precise sizing of the actuators has not been completed at this time.

i. Water Burst System

See Section 6.6.c. of this report for details on the water burst system, which is part of the debris management plan for the secondary fish screen area.

j. Channel Isolation Gates

Each collection channel (or “barrel”) can be hydraulically isolated from the fish sorting and holding areas by an isolation slide gate installed at the transition between secondary dewatering channel and the tertiary dewatering (and fish grading) section. These isolation gates will allow the tertiary dewatering section and everything downstream of it to be dewatered for maintenance and special fish handling purposes. The isolation slide gates will be 1 foot wide by approximately 3 feet tall, and designed to support roughly 2 feet of hydrostatic head, which is the maximum depth of water at the end of the secondary dewatering channel. The gate will have a resilient bottom seal, and side seals to prevent leakage up to the expected differential pressure.

The collection channel isolation gate must be automatically controlled, and able to close rapidly, on the order of less than a second, to prevent flooding of the FSS sump in the fish handling area during an emergency event. The gate will be constructed to fall into place under its own weight, once a pneumatic pin holding the end loop of a hoist wire in place has been actuated out of the way. This hoist wire can be connected to with a manual winch located nearby in order to return the gate to the open position once the collection channel is returned to service.

Other ideas such a pneumatic cylinder or a lead screw and actuator were explored. However, because the isolation gate will be approximately 3 feet tall, using a pneumatic cylinder to actuate the gate rapidly may be impractical and overly complex. A lead screw and actuator assembly will operate too slowly, and is therefore also impractical.

This isolation system is critical to control inflows to the back of the FSS during a potential power outage. A redundant/failsafe system design will be explored in plans and specifications.

k. PIT-Tag Detectors

An antenna housing for a PIT-tag detector will be placed just downstream of the capture section. The antenna housing will consist of a non-conducting core and an aluminum shield to protect against interference. The antenna housing will be 1.5 feet long, sit in the side wall of the flume, and the height will match the water column, about 1.5 feet. Note: the use of variable frequency drives may cause interference with the antenna. Shielding and or distance from source of interference will be needed. This portion of the flume will be kept at capture velocity or higher in order to prevent the fish from swimming into and out of the antenna, thus minimizing the potential for multiple counts.

The PIT-tag antenna will detect both full- and half-duplex tags, through the use of a dual receiver.

l. <u>Channel Throat Incline Debris Bars</u>

See Section 6.6.f. for information on the channel throat incline debris bars, which are a component of the debris management plan for the fish collection channels.

6.3 FSS – FISH SORTING AREA

Approximately 12 cfs of water and fish and pass through each fish collection channel (24 cfs total, when both channels are operating), past the isolation slide gates, and into the fish sorting area. This fish sorting area will is where the bulk of the fish handling work will take place on the FSS. The fish sorting area is where all of the fish entering the FSS will be separated from debris, sorted based on size, counted and sampled, and placed in transportation pods. A plan view and section view of the fish sorting area can be found in Figure 6-7.

Fish and water exiting the fish collection channel will follow opposing helical paths through the fish sorting area, ultimately arriving toward the center of the vessel at the lowest point in the area. A section view of this path is shown in Figure 6-8.

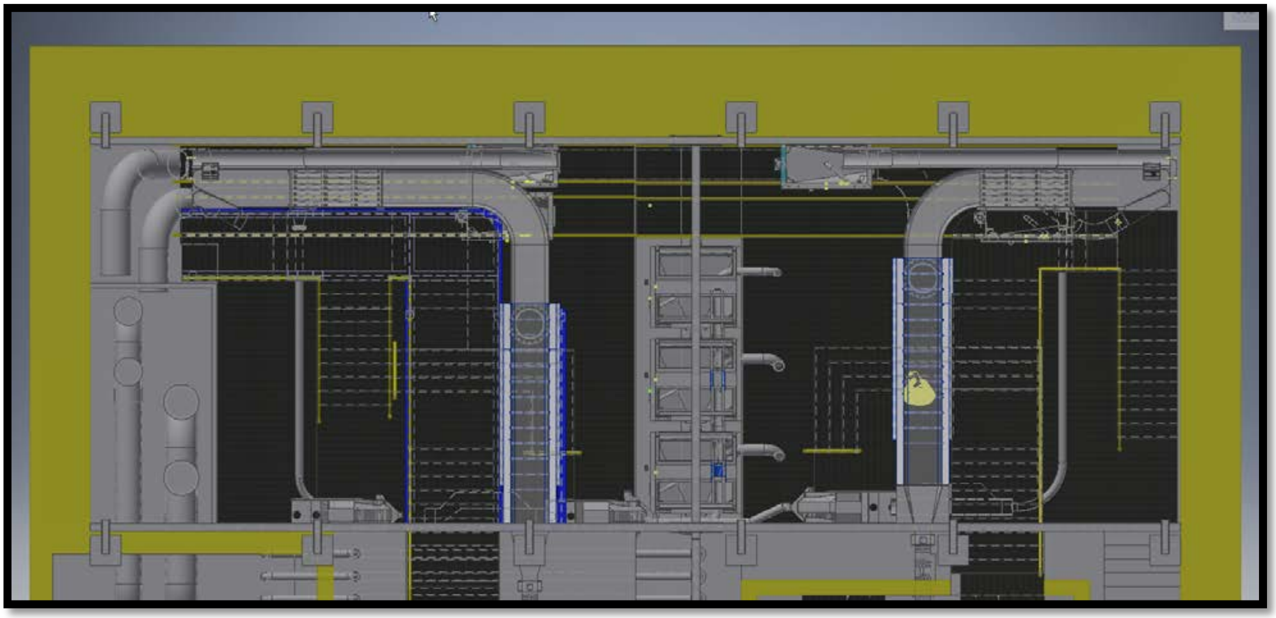


Figure 6-7. Fish Sorting Area Plan View

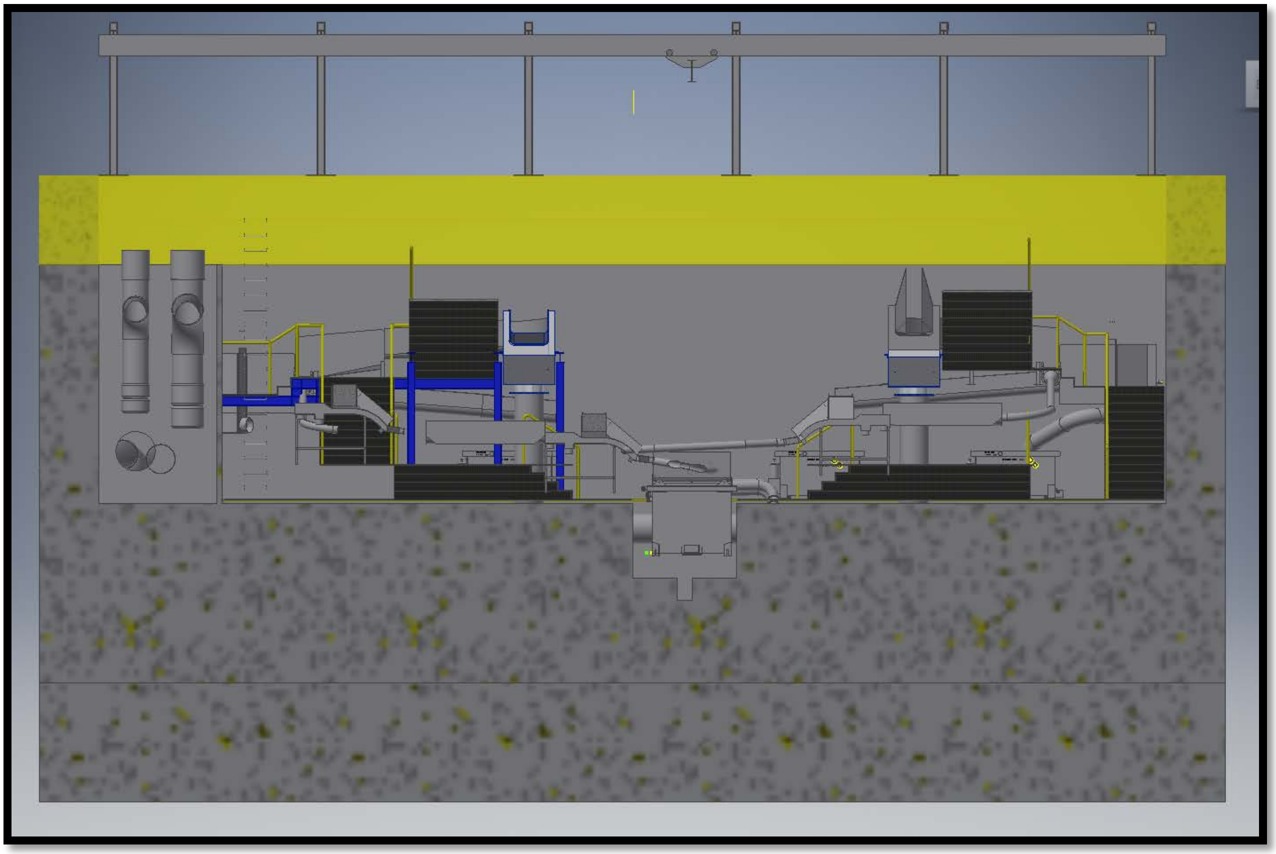


Figure 6-8. Fish Sorting Area Section View

a. Tertiary Dewatering Screens

The 12 cfs of water entering the fish sorting area from each collection channel will immediately pass through the tertiary dewatering screens. These screens will dewater a majority of this 12-cfs flow, allowing only a small amount of water to pass through and travel down the exit flume with the fish and debris.

The tertiary dewatering screens will be constructed of perforated plate on the bottom and both side walls, which allows water to drain through and collect in the solid plate superstructure surrounding the perforated plate flume. Figure 6-9 shows a CAD representation of the tertiary dewatering screen.

The tertiary dewatering screen will be 15 feet long and 2.5 feet wide (wetted surface area). This footprint has been chosen based on Hydraulic Design calculations that indicate the full 12 cfs of water entering the screen can be removed through the perforated plate. Adjustment panels will be slid into place beneath the perforated screens to fine tune the amount of water allowed to drain through the screen, thereby determining the precise pass-through flow that will continue down flume with the fish and debris.

Water drained through the tertiary dewatering screens will collect beneath the perforated plate, and be gravity drained via 24-inch pipe directly to sump 1, where it will be pumped back up into the junction pool. See Section 6.3.k. for details on sump 1 and the drain/supply piping between it and the tertiary dewatering screens.

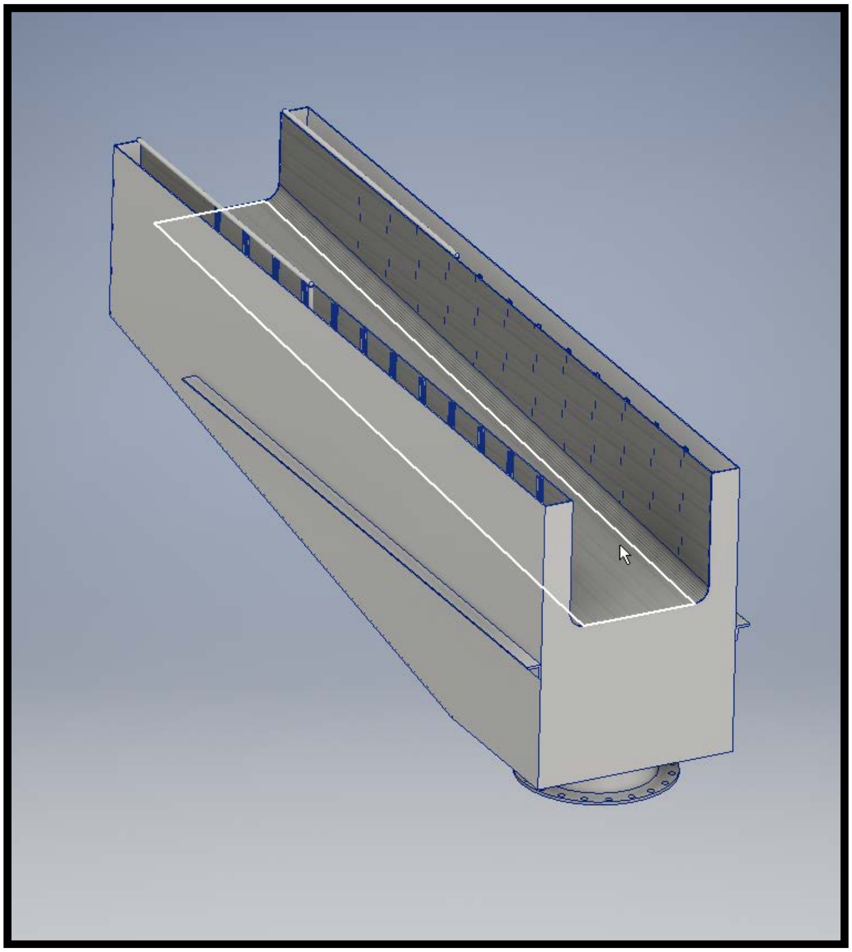


Figure 6-9. Tertiary Dewatering Screen

b. Transition Fish Flume

Downstream of the tertiary dewatering screen, the fish and remaining water will travel through a transition fish flume. The width of this fish flume is still being determined, and will be dictated by the exit geometry of the tertiary dewatering screen. The transition fish flume will make a 90-degree bend to the right (to the left for the internal collection channel), and connect directly to the separator bars. The slope of the transition fish flume will be a constant -5 percent.

The transition fish flume may also contain a switch gate to divert flow to the high-head bypass pipe, which prevents fish from continuing on to the separator bars, sampling station, and transport pods. The requirement for such a switch gate is still being determined, as is detailed in the Section 1 of this report.

c. Separator Bars

After the tertiary dewatering screens, captured fish will be sorted (see Figure 6-10). The smaller fish will be separated from the large fish. The smaller fish will fall through bar grating screens into the first chamber of the fish sorter. The smaller fish will be transported via pipe to the fish sampling area, through the fish counter and then into one of three 750-gallon totes. A quick-acting, pneumatically operated switch gate will divert flow toward whichever tank is currently accepting fish. The large fish will pass over the bar grating and fall into the adult holding tank. The large fish can then be transferred to the 250-gallon adult transfer tank via a water to water process (see Section 6.5.b., Adult Fish Pods, for details).

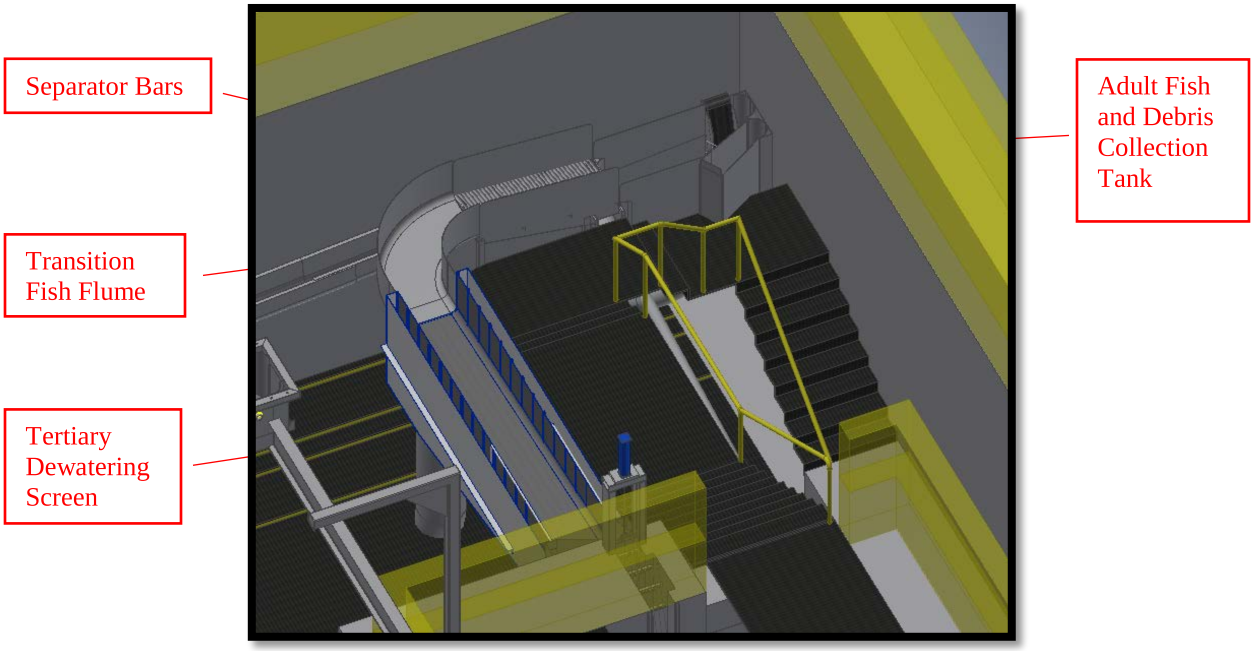


Figure 6-10. Separator Bars and Sorting Equipment

d. Adult Fish and Debris Collection Tank

Downstream of the separator bars is the adult fish and debris (AFD) collection tank (AFD tank). Any fish too large to pass through the separator bars, and any debris that makes it to this point in the collection system, will pass into the AFD tank. The AFD tank will be supplied constant recirculation water from the tertiary dewatering screen chamber, and adult fish and debris will comingle.

Adult fish will reside in the AFD tank until an operator chooses to move them to an adult fish pod for transport off the FSS. This process consists of manually crowding the large fish into an area of the AFD tank, and then passing the fish through a water-to-water transfer to the adult pod for transport off the FSS.

A rotating debris screen will run continually to skim floating debris off the surface of the AFD tank water, and deposit the debris into a chute for conveyance to the debris pod.

(1) Adult Fish Pods

For details on the design and salient features of the adult fish pods, see Section 6.5.b. of this report.

(2) Debris Pods

For details on the design and salient features of the debris pods, see Section 6.6.i. of this report.

e. Fish Transport Pipes

Downstream of the separator bars, the juvenile fish will pass (with approximately 30 gallons per minute [gpm] of water) into a length of fish transport pipes. These pipes will be stainless steel, 6-inch welded pipe. Access hatches will be cut into the top of the pipe to verify smoothness of welded joints, and to allow FSS operators to clear debris from pipes easily during collection.

All fish transport pipes will be sloped to maintain supercritical flow (>1-percent grade), and to provide sufficient overhead workspace at the various workstations in the fish sorting area of the FSS. For specific pipe slopes, flow depths, and flow velocities in each fish transport pipe, see Section 4, Hydraulic Design.

f. Fish Counting Station

At the end of the first fish transport pipe, the collected juvenile fish will be sent through a fish counting station. A Vaki Single-Channel Micro Fish Counter (see Appendix G for more information) will be used to accurately count and catalog the size and number of fish collected by each channel of the FSS. The Vaki Fish Counter is a device currently in use by the U.S. Fish and Wildlife Service at the Eagle Creek National Fish Hatchery in Estacada, Oregon. The Cougar PDT has communicated with USFWS staff at Eagle Creek and is confident in the function and reliability of this device.

In order to accurately count the fish travelling through the Vaki Fish Counter, water flow accompanying the fish must be reduced to approximately 5 gpm within the fish counter. The extra water from the fish transport pipe will be dewatered from the Vaki Fish Counter first chamber, and bypassed around the counter, rejoining the main fish path prior to the fish sampling station. Methods of dual-purposing this flow bypass pipe to provide fish bypass around the Vaki Counter (when the counter needs to be serviced or maintained) will be investigated during plans and specifications.

g. Fish Sampling Station

A fish sampling station will be located just downstream of the Vaki Fish Counter, and physically underneath the tertiary dewatering screens. The fish sampling station has an automatic, pneumatic switch gate to divert the main stem flow of water and fish into a sampling trough, where the fish are held until an operator can process the collection. The intent is to collect a 1-percent sample based on time (~36 seconds/hour) of all fish coming through the collection channel and into the fish sorting area.

Fish diverted to the sampling trough will be supplied with recirculation flow (flowrate to be decided by the volume of the sampling station, in accordance with NMFS holding criteria), which will pass through the trough and back into the main flow.

h. Switch Gates

Two switch gates are required to select which transport tank the fish will be deposited into. The switch gates are telescoping segments of flume which are nested in each other. When the switch gate is open the fish are allowed to exit onto a ramp below. This ramp below is actually another flume that directs the fish into the selected transport tank. When the switch gate is closed the fish are passed along to the second switch gate, whose position determines whether the fish will be deposited in the second or third transport tank. It is preferred that the flume from the switch gate to the transport tank not extend into the vertical “air space” of the transport tank. The flume will be elevated above the top of the transport tank in order to create the free jet of water that passes over the edge of the tank and plunges into the water.

i. Bridge Crane

A bridge crane will be used in the fish sorting area to provide access to each piece of equipment for maintenance and installation. See Section 6.5.c.(1) of this report for further details.

j. Monorail Crane

A monorail crane will connect to the bridge crane and carry the transport pods (juvenile, adult, and debris) to the front of the FSS to be loaded onto the amphibious vehicle (AV). See Section 6.5.c.(2) of this report for further details.

k. Sump 1

(1) Sump 1 Piping System

The up to ~24 cfs of water from the tertiary screens will be transported via 24-inch pipe to sump 1. The pipes will attach to the bottom of the tertiary screens and travel under the grating of the floor. The pipe run will be located at the stern of the vessel in order to avoid conflict with the location of the fish transport tanks.

(2) Sump 1 Pumping System

The water in sump 1 is below the water in the junction pool and will need to be pumped up into it. The amount of head to be added is approximately 2-3 feet (depending on the results of the physical model head loss study, and real world installation conditions), so the pump system will be conservatively designed to supply 4 feet of head.

This is a low-head pump application, and as such axial flow pumps and screw pumps are logical choices.

The use of axial flow pumps could require several pumps to allow for variations in the amount of flow. The flow will vary from ~12 cfs when one collection barrel is operating to ~24 cfs when the FSS is collecting fish from both collection barrels. Using a multiple axial flow pump configuration would require at least two pumps to be run via variable frequency drives in order to track with the water level in sump 1. This system complexity, along with potential electromagnetic interference of the variable frequency drives with critical PIT-tag antennas in the collection channel, has driven pump selection away from axial flow pumps.

The use of a screw pump would reduce the overall complexity of the pump system due to its ability to handle changing flows. The nature of the Archimedes screw is such that the pump will simply take in less water as the level in the sump drops. The relative efficiency of the screw pump will remain above 90 percent even when pumping only 12 cfs. The screw pump will be sized to handle 24 cfs at 85 percent of capacity. Due to the space constraints in the back of the FSS vessel, the angle of installation will be 38 degrees. The capacity of a three-flight (triple helix), 1.7-meter-diameter drum is approximately 29.9 cfs (see Appendix G). The capacity of a two-flight (double helix), 1.8-meter-diameter drum is approximately 27 cfs. The screw pump will be of the enclosed screw variety. The top of the stationary tube will be mounted on a pivot to allow raising the lower end to vary the flow rate or to perform standard maintenance.

l. Sump 2

(1) Sump 2 Pumping System

The juvenile fish pods, adult fish pods, debris pods, as well as the sloped floor of the entire fish sorting area will gravity drain into sump 2. From there, three sump pumps will pump the water into the junction pool. Two of the pumps will be capable of handling the flow; while the third pump serves as a redundant back-up.

Approximately 30 gpm of recirculation water from each fish pod (three juvenile, two adult), and overflow water from the adult fish and debris collection tank will drain to sump 2. This continual water flow, combined with the miscellaneous and incidental drainage from the fish sorting area, will produce between 250-400 gpm of inflow to sump 2, which must be continually pumped to the junction pool.

(2) Sump 2 Piping System

The three sump pumps will be connected to three individual pipe networks that will outlet directly into the junction pool. The piping systems will daylight into the junction pool above the reservoir water surface elevation (considered the maximum possible water level in the junction pool) and will discharge vertically downward into the pool. No check valves will be required on these outlets. Isolation butterfly valves at the pump connection and discharge locations may be added to facilitate maintenance.

6.4 FSS – PLENUMS AND JUNCTION POOL

a. Plenum Isolation Gates

There are two primary plenum orifices measuring 12 feet wide by 8 feet tall, and there are two secondary plenum orifices measuring 8 feet wide by 8 feet tall. All four orifices are in-line and located at the north side of the FSS closest to the starboard collection channel secondary screen area.

In order to isolate the collector channels individually, flow must be closed through the appropriate plenum orifices to allow the use of only one collector channel at a time. Limiting the system to one collector channel lowers flows through the FSS during cases where lower flows are desirable.

Each orifice is part of a slot that measures 28 feet to the top deck. The primary plenum isolation gate assemblies feature a floating bulkhead gate (FBG) that fits into the slot and measures 1 foot deep, 12 feet wide, and 20 feet tall. The secondary plenum isolation gate assembly also features an FBG that measures 1 foot deep, 8 feet wide, and 20 feet tall. Each FBG features an educator pump placed at the bottom of the gate that can either fill or drain the gate. To close a plenum orifice, the operator will actuate the corresponding FBG by turning on a submerged well pump and closing the valve on the discharge line of the eductor. When the gate fills with water, to the point of being negatively buoyant, it will slowly sink into place. To open a plenum orifice after an FBG has been seated, an operator will open the valve on the discharge line of the corresponding eductor and use the well pump to supply the motive force necessary for the eductor to engage in the Venturi effect. The suction forces caused by the Venturi effect from the eductor will lift the necessary amount of water out of the gate for it to become neutrally buoyant, then the operator will close the valves at the entrance and discharge of the eductor and turn off the well pump.

(1) Primary Plenum Floating Bulkhead Gate

The dry weight of the primary FBG will be 9,500 lbs. These dry weights include all of the skin plates, internal stiffeners, and rollers. The weight of water required to be displaced in each primary slot is roughly 15,000 lbs. Thus, the total gallons of water required for the FBG to become neutrally buoyant is 1,135.6 gallons. Once the gate is filled to neutral buoyancy, an additional 15.3 gallons will be required for the FBG to sink. The additional gallons to sink the gate accounts for the resistance caused by the water load on the side of the gate. All supporting calculations can be found in Appendix G.

(2) Secondary Plenum Floating Bulkhead Gate

The dry weight of the secondary FBG will be 6,700 lbs. These dry weights include all of the skin plates, internal stiffeners, and rollers. The weight of water required to be displaced in each secondary slot is roughly 10,000 lbs. Thus, the total gallons of water required for the secondary FBG to become neutrally buoyant is 802.4 gallons. Once the gate is filled to neutral buoyancy, an additional 10.2 gallons will be required for the FBG to sink. The additional gallons to sink the gate accounts for the resistance caused by the water load on the side of the gate. All supporting calculations can be found in Appendix G.

b. Gate Guide Slots

Rollers from the FBGs will contact A36 steel C-channels on the sides of the gate slots and allow the FBGs to travel in the slot. Approximately 1-foot-thick guide slots were selected to allow enough clearance for water to submerge the gate. Although a 1-foot depth was used for the FBG calculations, in reality the actual fabricated gates will likely be smaller. Having a slot large enough to accommodate the correct amount of water around the gate, and large enough rollers, drove the decision to widen the slots to 1 feet.

c. Fill and Drain Pump System

Because the availability of power to the FSS is a major constraint, the pump fill eductor system will be the primary method to raise and lower the FBGs; see Appendix G for sizing and product information. The eductor only requires a motive force through an inlet, while an electric chain hoist is much more energy intensive. The total amount of gallons to fill each FBG will be supplied by the same submersible well pumps used to supply the motive force to the eductor. It was assumed that the FBGs will rarely be pumped dry, and thus a separate pump is not needed.

The eductor pump for the primary and secondary plenum gate assemblies will have an approximate inside diameter of 1 inch, and will allow water to travel through a total of 50 feet of hose in 3 minutes with only 3.55 gpm. To supply the required motive force gpm to the eductor, a standard 5 gpm, 0.5-horsepower (hp), submersible well pump will be used (similar to the product shown in Appendix G). The well pump will be placed in the junction pool and supply the inlet of the eductor.

Head loss calculations are shown in Appendix G for a 0.75-inch-diameter pipe because industrial hose reels standard diameters are 0.75 inches. In reality, the eductor diameter will be sized for its system curve to match the system curve of the well pump. For this application, the actual diameter will be driven by how quickly the gate will be expected to rise and fall and the operating constraints of the well pump, and this can fall within a range of 0.5 inch to 1 inch. The well pump supplying the motive force must fall within its operating range to avoid burning up the motor during an over-speed situation. More friction in the line, and the corresponding head losses, may be desirable depending on the size rating of the well pump versus what gpm is actually needed for the primary and secondary eductor motive force.

d. Maintenance Considerations

During maintenance, when the FBGs must be lifted completely out of the slot, or in the event of a pump failure, an electric trolley hoist system rated for 10,000 lbs was selected. An American wide flange W 8x28 trolley beam was selected to accommodate a load of 7,000 lbs and has a maximum deflection of 0.52 inches (falling within the allowable deflection of 0.54 inches). The allowable beam deflection was chosen by taking a beam length of 216 inches divided by 400 inches. See Appendix G for more details. These calculations are conservative and only consider a single point load supported on both ends. In this system there will be three or more support beams, putting the system well below the acceptable level of deflection. A manual chain hoist was considered, but due to the length of the chain fall and the level of exertion required to perform the option manually, this option is not being used.

6.5 FISH TRANSPORT

a. Juvenile Fish Pods

Juvenile fish will be transported off of the FSS via dedicated juvenile fish pods. The fish pods will be free of debris and larger predatory fish, which are sorted out at the separator bars upstream. Three identical juvenile fish pods will reside in the fish sorting area, aligned beneath the centerline of the fish transport monorail system.

(1) Tank Features

Juvenile fish pods are 750 gallons and roughly 56 inches by 64 inches by 56 inches tall. The corners of the fish pod are radiused. Recirculation water flows into the pod from behind the radiused corners, while water is removed via a siphon system from the center of the pod. This configuration of inlet and outlets is conducive to allowing a gyre to set up in the pod. The fish will generally align themselves with the direction of flow in the gyre.

The bottom of the tank is sloped to the exit, which is opened manually via a slide gate. To simplify fabrication, the bottom of the tank and the exit are flat. The sides of the tank are also sloped to direct water and fish towards the exit. The exit has a short external chute that acts as a receiver for a long detachable discharge chute. The discharge chute is held up via a wire rope. The wire rope connects to the discharge chute about two-thirds of the way down and to a hook or D-loop on the top of the transport tank. This method is similar to that used on other fish transport tanks and trucks.

Aeration water is introduced to the pod via a flexible hose with a cam and groove fitting that connects to a fitting near the top of the pod. The water source is a head box of the side of the tertiary screen. This will provide a few feet of head to help drive the gyre. The amount of flow will be adjustable via a flow control valve near the tertiary screen; a closure valve will be included in hose to the pod. During holding, the anticipated aeration flow will be to exchange the tank every hour; this equates to 750 gallons per hour or 12.5 gpm. During loading, the total inflow of water is a combination of aeration flow and the water coming in with the fish.

During loading and holding, water will exit via a safety siphon into an H pipe; this will allow the operator to set the water level in the fish pod. This set up is similar to those used in aquaponic systems. The automatic siphon will be connected to the fish pod via a cam and groove fitting similar to that used for the aeration flow. An air lift pump can be inserted into the other leg of the H pipe; see (2) Pod Life Support Systems below.

These dimensions may change slightly to better serve the stability of the AV while en route to the release site. The Naval Architect is investigating the stability of various AVs on the market.

(2) Pod Life Support Systems

During loading and holding operations, aeration flow will continue to be supplied from the water box on the side of the tertiary screens.

In the event that no water is available from the tertiary screens, i.e. the FSS has stopped collection and the isolation gates have deployed, air lift pumps on 12-volt battery backup will be used to aerate and recirculate the water. The air pumps needed for the air lift pumps will be sized during plans and specifications. They are not expected to exceed 120 watts.

While on the AV, another air lift pump will be used to aerate and recirculate the water in the fish pod.

b. Adult Fish Pods

Adult fish will be transported off of the FSS via dedicated adult fish pods. The adult fish will be transferred from the AFD collection tank (see Section 6.3.d.) into the adult fish pods. These pods can be lifted from the fish sorting area, via the fish transport monorail, and loaded onto the AV for transport to a release site. The adult fish pods will be free of debris (sorted out in the collection tank). Two identical pods will reside in the fish sorting area, beneath the separator bars, and mounted on a horizontal rail system that allows each pod to be moved underneath the monorail path. The method for moving these pods from their resting home (near the separator bars) to the hoisting location (beneath the monorail) is yet to be determined.

(1) Tank Features

The Adult Fish Pods are 250 gallons each, and roughly 30 inches by 64 inches by 38 inches tall. The corners of the fish pod are radiused. The length of the adult fish pod is set to match that of the juvenile fish pod to help with the loading configuration on the AV.

(2) Pod Life Support Systems

The life support systems are similar to those used for the juvenile fish pods, and will include recirculation water in the loading/holding location, and backup airlift pumps in case of emergency loss of fresh water flow.

c. Overhead Crane Systems

(1) Bridge Crane

An underhung bridge crane will service the fish sorting area at the back of the FSS. It will be sized for the largest pick, which is currently the [ ] estimated at [ ] lbs. The crane will be rated for 7.5 tons to avoid loads during normal operations that would require a critical lift plan. The bridge crane will share the electrical power source of the monorail crane. The trolley and hoist shall be capable of moving from the bridge crane onto the monorail. A locking system that aligns the bridge beam to the monorail is needed. During normal operations the bridge beam will remain in this locked position, which is directly overhead of the fish transport pods.

(2) Monorail Crane

The monorail crane will travel from the back of the FSS to the AV slips. The monorail will allow the fish transport pods to be loaded on to the AV. The monorail will also be capable of taking the 250-gallon debris tank from the fish sorting area and dumping the debris onto the debris barge. The beam for the monorail will be approximately 12 feet above the deck; this will allow for the fish transport tank to be ~27 inches above the deck. The monorail will cross over the port side collection barrel at the black flume section, which is just downstream of the primary screens. Pedestrian access will need to be provided over this area.

The electrical power conductors for the monorail crane will be housed inside a closed rail.

d. Amphibious Vehicle Slips

(1) Loading Location

The AV slips are located to port side primary screens of the port side collection barrel. The AV slips are currently sized at 12 feet wide, ingress into the FSS at 16 feet, and are 9.5 feet deep. The bottom of the AV slot will be sloped up to help debris slough off. The 8-foot-wide space between the AV slips will be just above water level during fishing operations and have a set of stairs up to the main deck. This will allow for easy debarkation from the AV.

(2) Loading Process/Method

The monorail will bring the fish transport pod(s) over the side of the AV and then lower the pod onto the AV. Guides/latches similar to those used to affix overseas containers to semi-truck trailers will be used to locate and secure the transport tanks to the AV. Currently, the path of the monorail loads the AV from the side so as not to pass a load over the cab of the AV. A second reason for this loading path is the unknown or uncertainty of the height of the AV. A load path over the front of the AV would require a taller monorail crane, which would in turn require the shelter over the back of the vessel to also become taller.

e. Amphibious Vehicles

Fish will be transported away from the FSS using AVs. The AV will access the FSS by driving down the dam access road on the upstream side of the earthen dam, out into the reservoir, and across to the FSS. After docking in the AV slip at the FSS, the fish transportation system described above will deposit the 750-gallon juvenile fish pod onto the cargo area of the AV. The AV will then travel back across the reservoir, up the dam access road, and down to the fish release site below Cougar Dam (see Section 9, Civil Design, for details on this site location).

Two AVs will be provided for the transportation of fish and crew in order to guarantee continuous operation of the FSS. The AVs will be commercially available, but will be customized vessels capable of transporting the required 750-gallon load of fish, plus a 250-gallon adult fish pod, over both land and water. The mechanical appendix (Appendix G) of this DDR report provides further details on one possible AV product.

(1) Sizing and Salient Features

A specific model/manufacturer for the AV is still being identified. Ballpark estimates on the AV features have been provided by multiple manufacturers, and are reported in Table 6-1.

Table 6-1. Amphibious Vehicle Salient Feature Comparison

Manufacturer	Sea Lander Marine, LTD	CAMI, LLC
Chassis Length	TBD	32 ft
Chassis Width	TBD	8.5 ft
Turning Radius	TBD	26+ ft
Gross Vehicle Weight (loaded)	TBD	?
Gross Vehicle Weight (unloaded)	TBD	?
Draft (loaded)	TBD	?
Draft (unloaded)	TBD	24 in

(2) Stability Calculations and Architect-Engineer Task Order Results

The Naval Architect (Glosten) is performing stability calculations for multiple AV manufacturer’s vehicle designs. The results of these calculations are included in Section 7.

(3) Release Site Information

For fish release site information, see Section 2, Biological Design Consideration and Criteria, and Section 9, Civil Design.

6.6 DEBRIS MANAGEMENT

a. Overall Debris Management Plan

Debris from the Cougar Reservoir will be managed with a multi-stage debris system. At each stage in the system (working from open reservoir to the WTCT wet well), progressively smaller and smaller debris will be filtered out and removed from the water system. Each stage of the debris management system is described in further detail in this section.

(1) Debris Boom

The purpose of the debris boom is to impede large debris (tree trunks, root balls, large logs) from entering the cul-de-sac area of the reservoir. A debris boom will cross the reservoir from the upstream side of Rush Island to the east bank of the reservoir, upstream of the spillway, and will include a boat gate for access to the FSS. Depending on the anchorage points of the debris boom, a secondary boom may be needed to isolate the cul-de-sac area from debris entering between Rush Island and the west slope of the reservoir. Figure 6-11 illustrates the location of the debris boom. See Section 9, Civil Design, for more details on the design of the debris boom, anchorage, and disposal of debris.

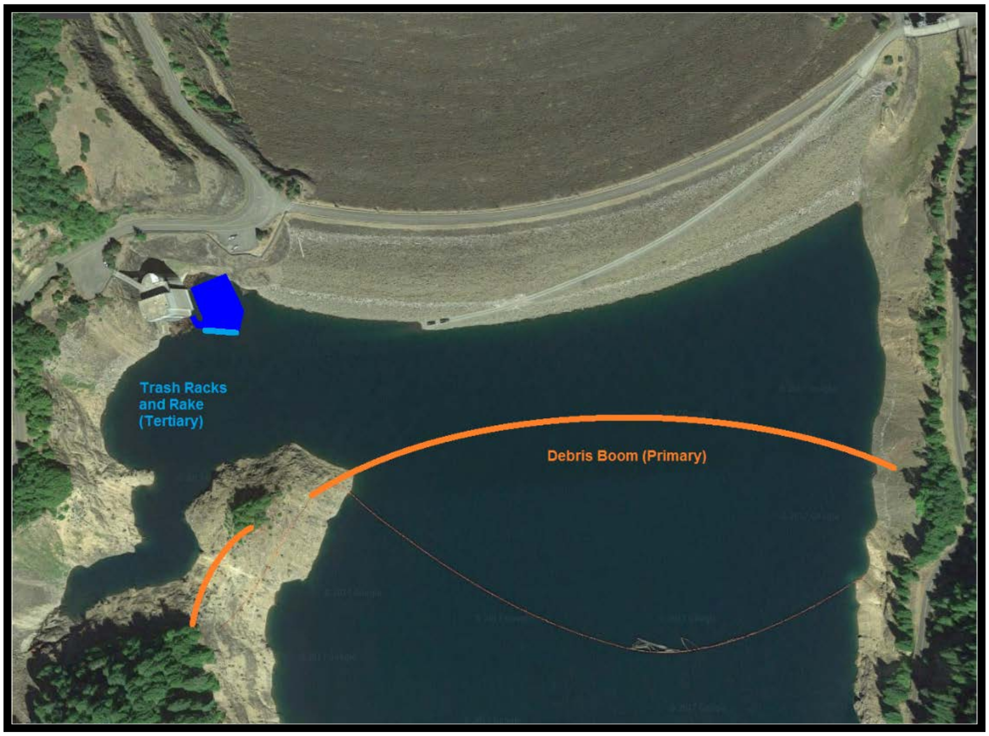


Figure 6-11. Debris Management System

b. Channel Entrance Trashrack

The front of the FSS intake will have trashracks to impede medium-sized debris (large branches, medium-sized logs, and other woody debris) from entering the FSS collection channels. The trashracks are to consist of full-height polyethylene vertical bars on 8-inch centerline spacing, with the top 4 feet reduced to 4-inch centerline spacing. Leading and trailing edges of the vertical bars will contain rounded edges to improve hydraulic flow. The racks will be assembled as units and fastened to support frames. The support frames will be painted carbon steel and be mechanically fastened to the FSS structure for removal during inspection and maintenance. Vertical guides for the wheels of the trash rake will be incorporated into the support frames.

c. Channel Entrance Trash Rake

The trashracks at the entrance of the collection channels will accumulate debris and will need to be cleaned, which will be performed with an overhead raking system. The rake system will consist of a galvanized steel claw, underhung hoist, overhead rail, and structural supports (see Figure 6-12). The claw will be constructed of vertical bars spaced to match the upper section of the trashrack with open ends, allowing for the removal of long debris. The claw is lowered down the face of the trashrack, accumulating debris, and when it reaches the bottom the hydraulic power unit actuates the hydraulic cylinders to close the claw. The hoist then raises the claw fully and the whole unit traverses the overhead rail to the dump site and releases the load into the debris barge; see Section 6.6.j.(2), Debris Barge. Capacity for the rake will be a minimum of 1,100 lbs, with approximately 80 feet of vertical travel and 120 feet of horizontal along the FSS. The system will have the option of operating automatically based off the water level differential sensors, automatically by pushbutton, or by manual local controls. The system will also have a maintenance platform allowing for full access of the claw and hoisting box.

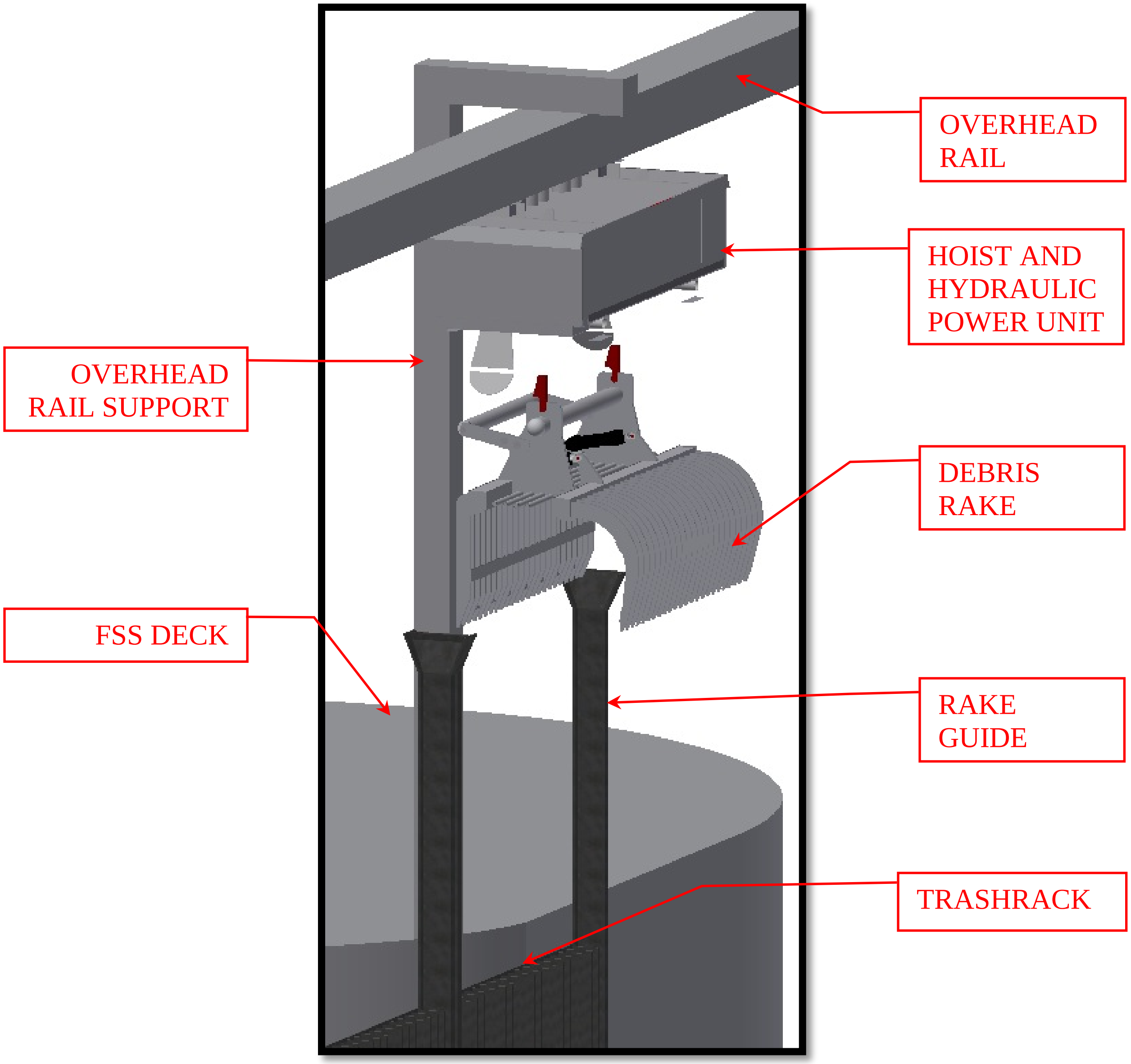


Figure 6-12. Trash Rake System

d. Primary Screen Cleaners

The primary dewatering screen sections will be cleaned by traveling screen cleaners. These screen cleaners are similar to those seen on other fish collectors in the Northwest. A total of four traveling screen cleaners will be needed. The rail structure of the screen cleaners will be elevated above the deck ~7-8 feet to allow access to the screens during maintenance. The screen cleaner boom for the brush will be about 30 feet long to accommodate the additional height. The additional height is not a concern as manufacturers offer systems with brushing depths up to 40 feet.

To ensure a proper hydraulic flow profile through the collection channel, the adjustable dewatering screens will be cleaned [on a cycle/when needed]. The 5-foot-long brushes will operate horizontally and will adjust vertically at the end of each pass, and before starting a new pass. This system will operate automatically based on both elapsed time between cycles and differential head between the screened and unscreened water surface elevations.

e. Water Burst Screen Cleaner System

The secondary dewatering screen sections (after the curved and blank flume sections of the intake channels) are too narrow to be cleaned by the traveling screen cleaners, so a water burst cleaning system will be used to prevent debris build up on the secondary dewatering screens. An array of water burst nozzles will be installed behind the dewatering screens, with the nozzles pointing perpendicular to the flow of water to burst flushing water through the screens and blow debris into the bulk flow of the secondary dewatering screen section.

The nozzles will be sequenced to facilitate flushing debris downstream. To ensure full cleaning of the screens, the array of nozzles will travel approximately 12 inches laterally across the backs of the screens by way of a 3-hp wire rope hoist and rollers.

Dedicated 15-hp water pumps, including backup pumps, are needed to provide the flow. These pumps will be mounted on the deck and draw water from the screened plenum before pressurizing it and sending it through the nozzles. The water pumps will be located between the secondary dewatering screen sections of the two barrels and connected to the nozzle array via flexible water hose to allow for travel. The nozzles will have a 95-degree flat fan pattern at approximately 100 psi and 7 gpm each. Cleaning will be set on a timer, but can also be triggered by a head differential on the screens.

f. Channel Throat Incline Debris Bars

In the throat section of each collection channel (just upstream of the isolation slide gates), incline debris bars will be installed. These bars will be near-vertically inclined, 1.5-inch stainless steel pipe, affixed to horizontal unistrut cross bracing. The collection channel flow will pass through three sets of three bars, staggered horizontally, and collect passing debris before the water enters the tertiary dewatering screen.

The incline debris bars have been modeled after a successful design implemented at the North Fork Fish Collector on the Clackamas River. Figure 6-13 shows the North Fork incline debris bars.

Figure 6-13. Inclined Debris Bars (North Fork Fish Collector)

g. Tertiary Dewatering Screen Debris Management

The tertiary dewatering screen will be full accessible along its length via an elevated work platform running alongside the screen system. FSS operators will be required to manually remove any debris that is not swept downstream through the tertiary dewatering screens and into the AFD collection tank.

h. Adult Fish and Debris Collection Tank

Debris that makes it past trashracks at the front of the vessel and the incline debris bars will be on the size order of small branches/twigs/leaves/needles. The smaller items like the pine needles will likely follow the smaller fish into the fish transports pods, while the larger debris will continue on into the AFD collection tank, described in Section 6.3.d of this report.

i. Debris Pods

Debris pods will be approximately 250 gallons. The debris pods will have screened areas to allow for excess water to exit. The debris pods will be transported via the crane/monorail out of the back of the FSS to the debris barge at the front of the FSS. Once over the debris barge, the debris pod will dump its load onto the barge.

j. Debris Transport

(1) Monorail Crane

The monorail crane will be used to move debris from the back of the FSS to the front of the FSS. This process is very similar to moving a fish transport tote, with the except that the end point is the debris barge rather than the AV.

(2) Debris Barge

The barge will be of a pontoon design for stability reasons. For design purposes, it is assumed that the debris is waterlogged. The exact size of the debris barge will be determined during plans and specifications in order to better match the slips as needed by the AV. For now, a barge with a deck size of 8 feet by 16 feet and 36-inch-diameter U-shaped pontoons would have capacity of approximately 8,000 lbs. Assuming that the barge itself weighs 2,000 lbs, the payload is about 6,000 lbs. Assuming a packing factor of 0.3, the walls on the debris barge will need to be about 2.5 feet high. The ends of the debris barge will have drop gates. When emptying the debris barges at the dam access road, the drop gates will provide a gangway between the barge and the road.

(3) Debris Offload Location/Process

Several debris barges will be required, likely four or five barges. Once a debris barge is loaded up at the FSS, it will be toed out to a mooring point behind the debris boom. The debris barges will wait to be emptied until the larger debris caught by the debris boom is dealt with on a yearly (minimum) basis. Willamette Valley Project Operations will oversee the debris removal from the reservoir; a separate contractor may be used. The envisioned process is for the barge to be brought over to the dam access road where a backhoe will empty the content of the barge into a dump truck.

The vessel used to tow the debris barge is still being determined. Options include the existing crew access boat, one of the AVs, or another vessel. This will be further detailed in plans and specifications.

6.7 CREW ACCESS

a. Site Access Plan

Primary crew access to the FSS will be via the AV. The AV will have seating for six people, but could carry many more if it is not transporting a fish pod.

b. Articulating Gangway for Floating Screen Structure Access

The FSS will have gangway that attaches to the FSS on the port side just fore of the mooring connection to the mooring tower. The other end of the gangway will sit on a dock that floats alongside the FSS. During normal operations the rise of the gangway will only be a couple of feet. During the maintenance period when the FSS is ballasted up, the gangway will be much steeper, at about 38 degrees. The tread on the gangway will be articulating so that the treads stay level.

c. Amphibious Vehicle Slip for Floating Screen Structure Access

The block out for the AV slips are 12 feet across and span 16 feet into the FSS. The area between the slips will be just above the water line and have stairs that access the main deck. During normal operations, the crew will embark at this location and walk to the back of the FSS to get to the fish collection area. During maintenance periods when the FSS is ballasted up, the AV slip will be out of the water and not useable for crew access onto the FSS. When the FSS is ballasted up, access will be from the dock and gangway.

d. Floating Screen Structure Deck Access/Work Areas Plan

The FSS operations crew will have walkable access to a majority of the FSS main deck. This access is necessary to maintain fish friendly collection channels, maintain equipment, and access the various debris management and hydraulic control features on the FSS. Figure 6-14 shows the deck areas planned to be accessible to crew without added fall protection or other safety measures. Note the "FSA ACCESS" labels, which denote booby hatches granting access to the fish sorting area, which is detailed in the next section.

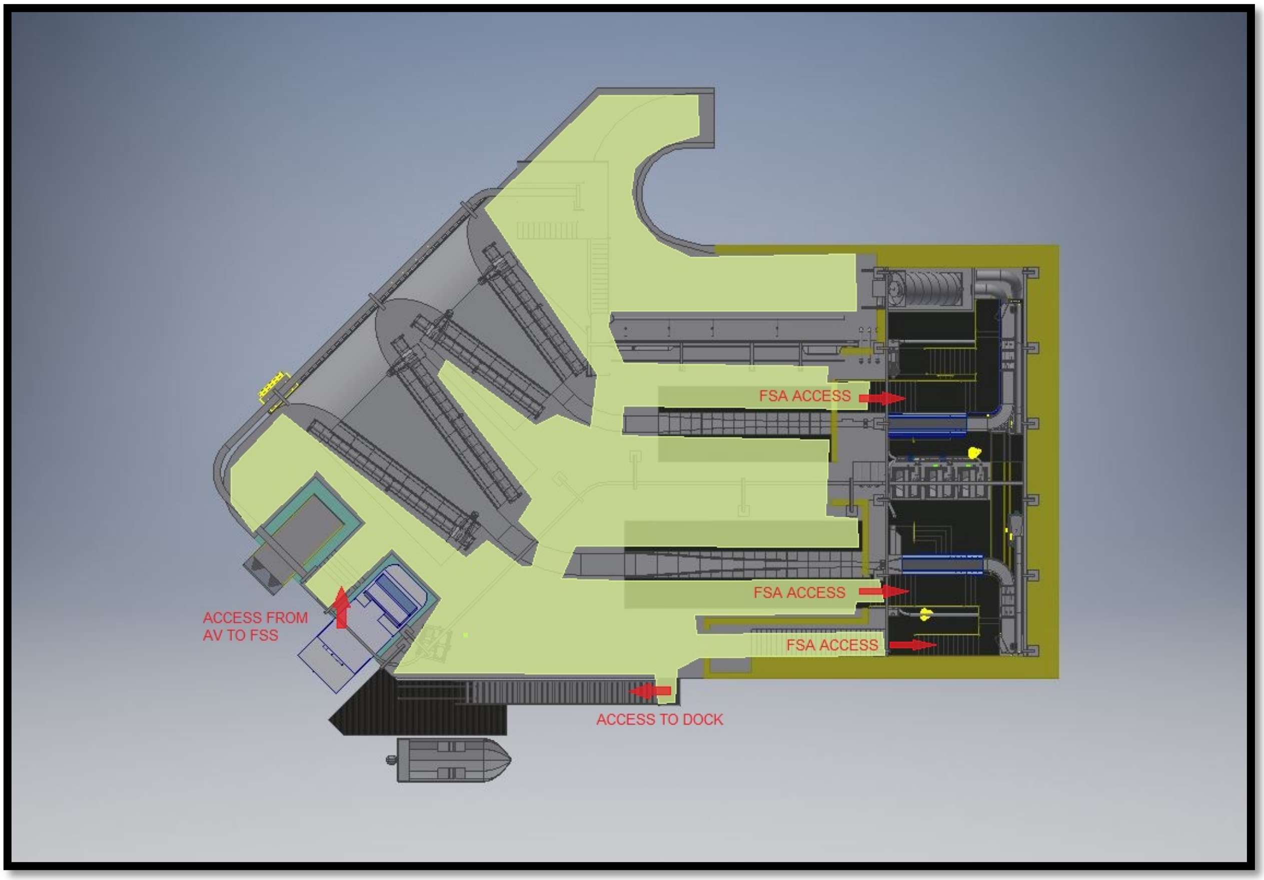


Figure 6-14. Floating Screen Structure Deck Crew Access Plan

e. Floating Screen Structure Fish Sorting Area Access/Work Areas Plan

The fish sorting area has a complex arrangement for crew access, consisting of multiple elevated walkways and stair segments. These walkways provide ergonomic access to the fish flumes, tanks, screens, and other features along the hydraulic path from collection channel to juvenile fish pods. Figures 6-15 and 6-16 present these elevated walkways in plan and section view format. The figures are color coded to loosely associate the three basic levels of walkways within the fish sorting area.

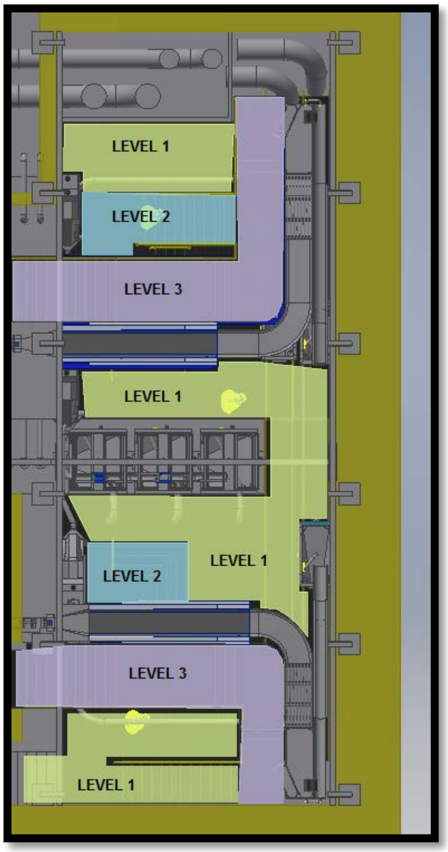


Figure 6-15. Fish Sorting Area Crew Access Plan

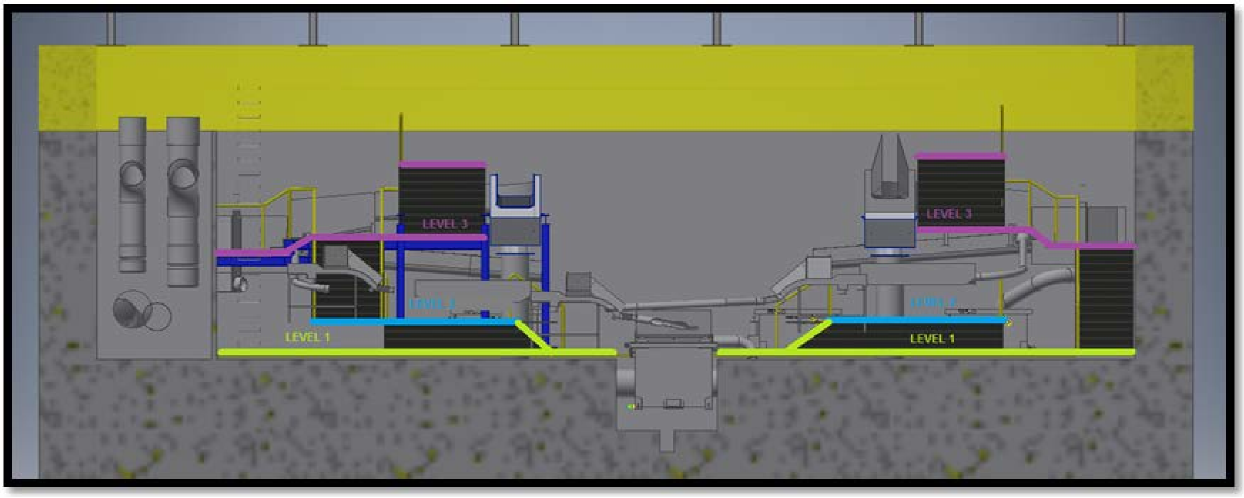


Figure 6-16. Fish Sorting Area Crew Access Section

f. <u>Floating Screen Structure Crew Boat</u>

The FSS crew will utilize an existing USACE boat located in the Willamette Valley. The boat is roughly 8.5 feet wide by 21 feet long, powered by an outboard motor, and capable of handling 2,500 lbs of cargo or 8-12 people. The bow of the boat has a drop door to ease loading/unloading of cargo and personnel. The boat can be launched and retrieved from the access road on the dam face, from the Echo day use area, or the Slide Creek Campground. The main purpose of the crew boat will be shuttling cargo and crew to and from the FSS, but it will also serve as a secondary egress in case of emergency. When not in use, the crew boat will be tied to the dock at the bottom of the FSS gangway.

6.8 WATER TEMPERATURE CONTROL TOWER MODIFICATIONS

Several modifications will be made to the mechanical components of the WTCT to enable operation of the FSS. Because FSS operation is expected to require an increased tower head differential, leakage through the tower is expected to increase. The modifications described below will reduce leakage through the tower gates and facilitate FSS maintenance. In addition to these modifications, the gates and guide slots will be refurbished.

a. <u>Weir Gate Modifications</u>

The weir gates do not currently utilize a sealing system of any type, and due to their size they are largest source of leakage through the WTCT. The weir gates are configured such that the body of the gates travel within their guide slots. This configuration allows the relatively simple addition of rubber seals to the downstream side of the gates. Discussion with a Seals Unlimited representative about this design concluded with a recommendation for bulb-type seals. However, other seal shapes may be feasible and will be considered in the design phase of the project. Regardless of final shape, the rubber side seals will seal against the downstream guide plate of each slot; see Figure 6-17 below. To improve seal life, the existing carbon steel guide slots will be blasted, repaired as necessary, and recoated. To add the side seals, two backing plates must be welded to the downstream side of the each gate to provide a single plane for mounting. The rubber seal is then held in place by a retaining plate and removable hardware. The addition of rubber seals is expected to reduce leakage around the sides of the gates to nearly zero.

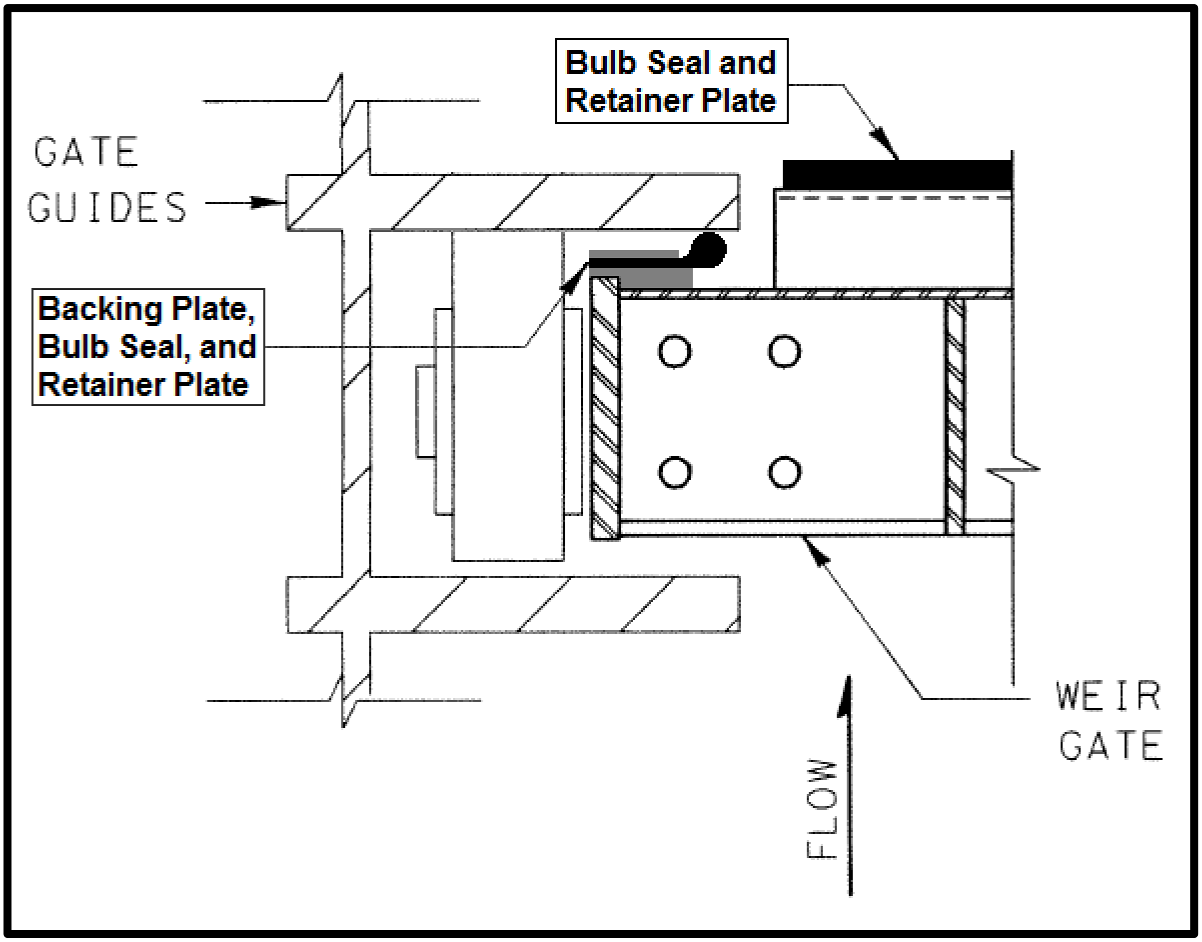


Figure 6-17. Weir Gate Seal Configuration

In addition to leakage around the sides of the gate, water leaks through the interface between weirs gates and between the bottom gate and the concrete sill. The original gate design includes metal seal plates and ultra-high molecular weight blocks to minimize leakage. The designed gap is approximately 1/8 inch, but the as-built drawings detailing this sealing interface are lined out and marked “VOID”. Neither Cougar Dam project staff nor original design PDT members can confirm whether or not the ultra-high molecular weight blocks or seal plates were actually installed. The gates cannot be inspected at this time because they are in use. An inspection will be performed during the next outage period. Regardless of current configuration, new rubber bulb seals will be fastened to the metal seal plates with removable fasteners and a steel retaining plate.

An additional modification must be made to the most upstream weir gate in the penstock bypass stack. The addition of structural beams across the slot provides an opportunity to increase gate sealing efficiency. Two hollow center bulb seals will be installed on the upstream side (skin plate) of this weir gate, approximately 4 feet apart. The seals will be large and relatively low-durometer to facilitate sealing while head differential pushes the gate away from the beams. These rubber seals will be fastened to the gate using retaining plates and removable hardware and will seal against the new steel clad concrete beams. The reason for two seals is to allow for the different beam spacing near the weir gate parking spot.

Structural design is currently investigating modifications to the lifting beam that would extend the sealing plane from the skin plate to the lifting beam, allowing it to be held out of the flow path. The center bulb seal design will function the same whether mounted to the skin plate or a possible new lifting beam seal plate. This detail will be settled during the detailed design in plans and specifications.

b. Penstock Bypass Gate Modifications

As discussed in Section 5, Structural Design,, the existing penstock bypass gate opening will be filled with concrete. However, the penstock bypass gate itself will be reused to maintain temperature control capabilities during FSS maintenance operations. The sill height of the temperature control weir gates above the existing penstock bypass opening will be lowered to approximate elevation 1,507 feet. This is approximately 54 feet lower than the existing sill height. This change reduces the maximum top elevation of the weir gates by the same amount. At full pool and maintenance conditions, there could be a gap between the bottom of the FSS flume and the top of the upstream weir gate. In this condition, water would spill over the top weir gate, limiting the ability to control temperature. To maintain this capability, the existing penstock bypass gate will be placed to stop flow through the gap between the flume and the upstream weir gate. This gate does not have a sealing system, but leakage around it is low compared to the other gates. Additionally, the FSS would not be operating during maintenance operations, reducing the need for a “sealed” tower. Consequently, no physical changes will be made to the penstock bypass gate, but it will operate in a different manner than it currently does.

c. Regulating Outlet Bypass Gate Modifications

The existing regulating outlet (RO) bypass gates do not have a sealing system and allow a significant amount of leakage into the WTCT. The RO bypass gates are configured differently than the weir gates in that only the roller wheels ride in the guide slots. Additionally, there is not a single plane on either the up or downstream side of the gate on which to mount a seal. A series of steel mounting plates and stiffeners will be welded to the upstream side of each RO bypass gate to create a single plan for seal mounting. “L-type” rubber seals will be mounted to this new upstream side face of the gate and secured by a steel mounting plate and removable hardware; see Figure 6-18. New stainless steel guide plates will be installed into the tower concrete to provide a sealing surface for the L-type seals. These guide plates will be flush with the existing concrete and will run the entire height of the RO bypass opening, from approximate elevation 1,475 to 1,505 feet. They will be affixed to the tower using concrete anchor hardware in a similar manner to the existing steel gate guides.

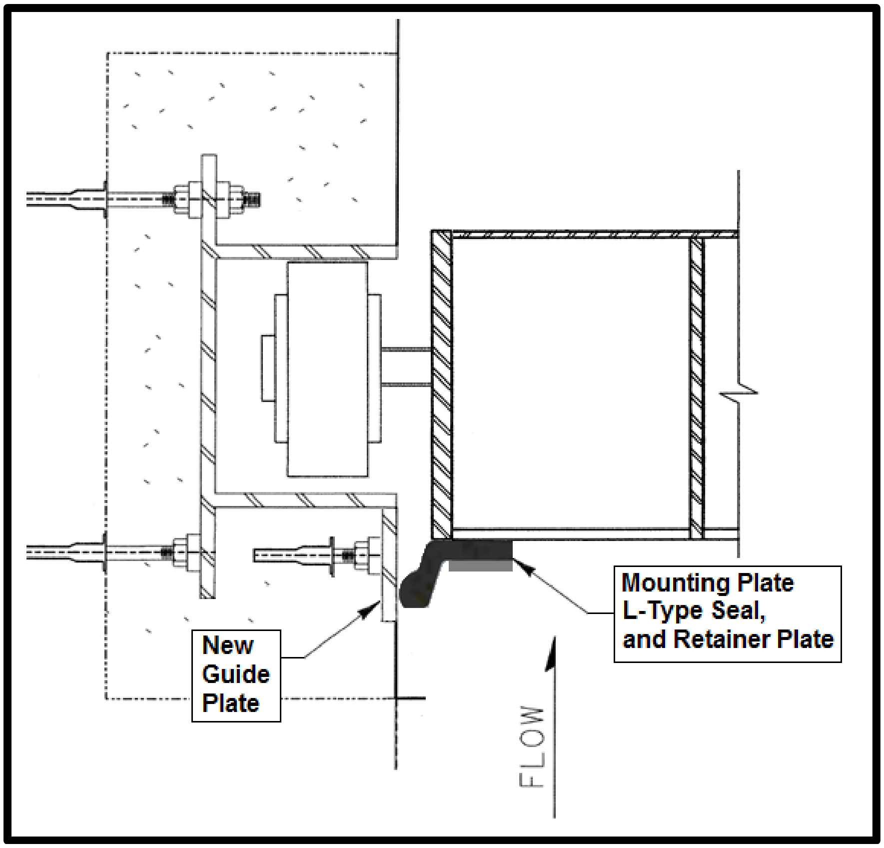


Figure 6-18. Regulating Outlet Bypass Gate Side Seal Configuration

Another leakage path is over top of the RO bypass gates. The existing design includes a 2-inch gap around the entire top plate. This gap will be reduced by installing a rubber bulb seal around the upstream sides of the top plate. This seal will be secured with a steel mounting plate and removable hardware. A rubber transition piece will connect this top plate seal to the L-seal on each side of the gates.

d. Water Temperature Control Tower Hoist Equipment Modifications

The existing hoist equipment does not require any modification to provide continued safe operation. Calculations detailed in Appendix G demonstrate that the addition of rubber seals and associated hardware will not significantly increase hoist loads and operation will continue to be within required safety factors.

6.9 MISCELLANEOUS MECHANICAL FEATURES

a. Compressed Air System

A small compressed air system will be provided in order to supply a small number of pneumatically controlled devices on the FSS. A complete list of compressed air demands has not been finalized at this point in the DDR. The likely uses for compressed air include:

- Actuators for fish sorting switch gates.

- Collection channel isolation gate.
- General facilities air for maintenance air tools.

b. Wash-Down Water System

The facility's wash-down pumps will supply water for wash-down, cleaning, and pressure washing activities. The pumps will sit within wet wells in the primary and secondary dewatering plenums. The water will be screened for debris. The wash-down system must automatically drain when the pump turns off. This will prevent problems with pipes freezing and bursting during sub-freezing temperatures. The number and location of hose bibs will be determined as the design progresses. The concept behind having several smaller wash-down systems is to reduce the complexity of piping and system requirements.

c. Sensors and Feedback Systems

Various sensors and feedback systems will be required on the FSS, both for the stability/safety/integrity of the vessel from a naval perspective, and for fish and hydraulic monitoring/tuning. The specific systems and sensors that will be required have not been identified in detail during the DDR phase of this project. Known sensor needs are listed below.

(1) Vessel Level, Tilt, Pressure Sensors

These feedback systems to be identified and designed based on recommendations and feedback from the Naval Architect during plans and specifications.

(2) Hydraulic (Fishways) Flow and Level Sensors

An ultrasonic level transducer will be installed to measure the water surfaces of the forebay and the flume, and the data will be sent to the PLC. During testing and facility set-up, the head drop across the FSS will be used to set the weir gate to the desired level to maintain the target flow through the FSS.

The purpose of the flow monitoring equipment will be three-fold:

- Confirm the hydraulic system of the FSS is operating as designed.
- Provide accurate values for flow leaving the FSS.
- Provide accurate values for fish passage velocities. Flow monitoring will help not only with the "tuning" of the structure but also help to inform the designs of future FSSs.

(3) Fish Monitoring Equipment

[Details are needed from the biologists]. It is likely that future monitoring will take place to understand fish behavior as they enter and pass through the FSS. If the location and attachment needs of such monitoring equipment can be provided, then mounting locations can be planned for and included in the drawings.

d. Vessel Hull Corrosion Protection

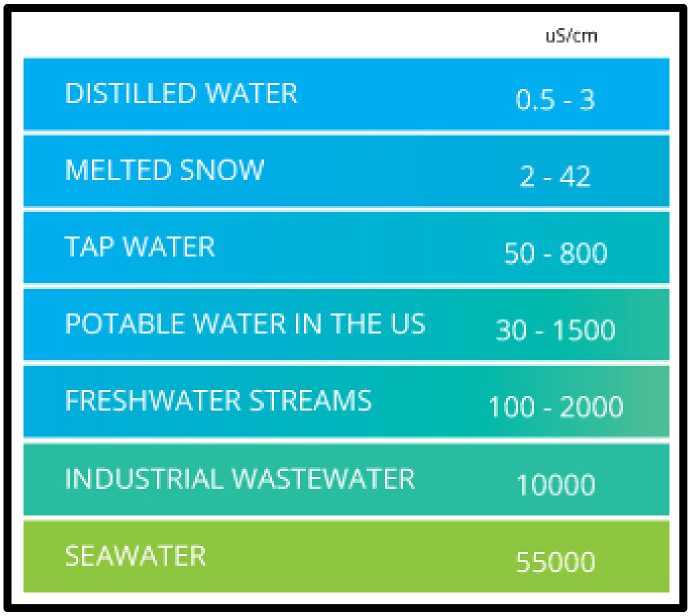
The Cougar FSS will use a paint coating system as a means for corrosion protection of the hull. Neither an impressed current system or a cathodic protection system is required. Justification for this decision can be found below.

Cathodic protection can be used on submerged construction because of the potential difference between the water and the metal. There are two main approaches for this, but both of them apply a flow of electrical current from an external source (anode) through the substrate and on to the metallic structure that is being protected. The first type, galvanic, utilizes sacrificial anodes that are more negative than the metal being protected so that as corrosion occurs, the sacrificial anode is consumed. The second type, impressed current, utilizes an external direct-current power supply to create the electrical current flow, allowing for longer lasting anodes. However this comes at the cost of an expensive and complex system.

In determining which system, if any, would be required at Cougar Dam, the water quality needs to be taken into consideration. Water's resistivity and conductance quantify its ability to resist or conduct electrical flow, respectively. According to the USGS National Water Information System, the specific conductance of water in the McKenzie River near Vida, Oregon, is on average 50 microseimens/centimeter at 25 degrees Celsius. Figure 6-19 likens this conductivity to tap water. The inverse of this yields a resistivity of 20,000 Ω-cm or 200 Ω-m. Figure 6-20 likens this resistivity to rain water.

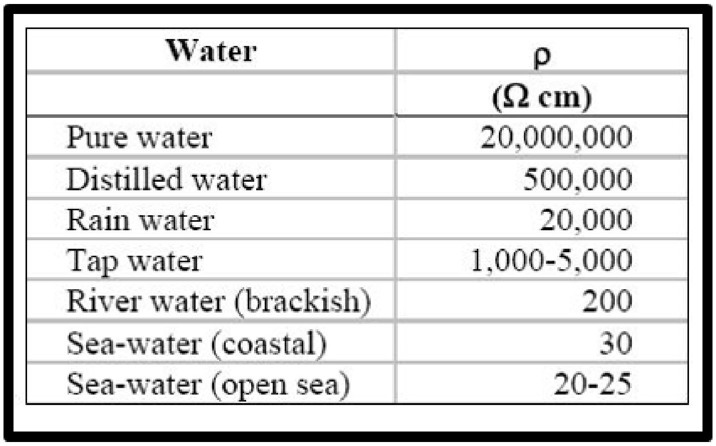
Based on the low conductivity and high resistivity, corrosion at Cougar Dam will not occur at a quick rate, therefore not needing an impressed current system or galvanic system. Corrosion protection will be enforced through a paint coating system and inspection every 10 years. A coating system cannot stop corrosion, but will severely slow it down. The specific type of coating is yet to be determined.

For further discussion on hull protection, see Section 7, Marine Design.



	uS/cm
DISTILLED WATER	0.5 - 3
MELTED SNOW	2 - 42
TAP WATER	50 - 800
POTABLE WATER IN THE US	30 - 1500
FRESHWATER STREAMS	100 - 2000
INDUSTRIAL WASTEWATER	10000
SEAWATER	55000

Figure 6-19. Conductivity Ranges for Water



Water	ρ
	(Ω cm)
Pure water	20,000,000
Distilled water	500,000
Rain water	20,000
Tap water	1,000-5,000
River water (brackish)	200
Sea-water (coastal)	30
Sea-water (open sea)	20-25

Figure 6-20. Resistivity Ranges for Water

e. <u>Guide and Lead Nets (Adaptive Management Measures)</u>

These features are part of the adaptive management measures identified to date. Provisions will be made for these measures, but they will not be fully implemented during initial construction.

(1) <u>Guide Nets</u>

Nets may be placed between the mooring tower and the face of the dam. These nets will take fish that are following the face of the dam and guide them past the mooring tower and into the front of the FSS collector. Hard points have been designed into the FSS structure to connect to one end of the guide nets. The other end of the guide nets will be determined once the target reservoir levels have been determined for net deployment.

(2) Lead Nets

Nets will be placed from the front of the two entrances to across the cul-de-sac area. Their purpose is to bisect the cul-de-sac area and provide another wall/shore line for the fish to follow to the intake of the FSS. A second net may be placed at the front of the FSS if it is thought to improve collection efficiencies.

Nets may also be used inside the entrance of the FSS to reduce the amount of milling around in the entrance by the fish. The nets will be orientated with the direction of flow into the FSS similar to the Upper and Lower Baker collectors.

6.10 ABANDONED CONCEPTS DOCUMENTATION

The following paragraphs document design concepts that were investigated and found to be lacking or unfeasible. These concepts are listed below in an effort to avoid rehashing ideas that have already been explored and abandoned.

a. Attraction Water Booster Pumps

The FSS is designed as a primarily gravity-flow system. However, the total head loss through the system must not exceed the allowable head differential in the existing WTCT as determined by Section 4, Hydraulic Design. Preliminary calculations by the A-E firm show that the expected head losses through the FSS may require additional booster pumps to be installed to assist the gravity flow of water through the system (see Cougar Dam Downstream Fish Passage 90 Percent Supplemental Report – URS). However, upon closer investigation the PDT determined that the use of attraction water booster pumps to maintain 1,000 cfs inflow when the tower is only passing 400 cfs is not plausible. There is not enough existing power capacity to pump this additional flow. Additionally, there was concern that venting 600-650 cfs out of the sides/bottom of the FSS would result in a mixing of the water in the cul-de-sac, thereby impacting the temperature control mission of the tower.

b. Fish Lift

During the 60 percent design phase, an issue with stress caused by copepod parasites came to light, and design philosophy was altered in order to provide the fewest amount of transfers/fish handling possible. This led toward a design where the holding tank and the transport tank are the same vessel. The concept of using an educator pump as a fish lift to move fish from the back of the FSS to a holding tank has been abandoned. As a matter of documenting the earlier phases of the design process, the following explanation of the concept is provided. In concept, a full-port configuration of an eductor pump could be used to move the .5 cfs and fish to deck level. The more commonly known and used eductor (Venturi) pumps use a single high pressure nozzle to draw the medium into the pump and impart momentum to the medium, thus inducing a flow. The single nozzle pumps are most commonly used for mixing fluids. A full-port configuration eductor pump differs from those eductor pumps that rely on a single jet for the motive supply. The manufacturer of the full-port eductor pumps successfully passed 50,000 coho fingerlings and later 25,000 spring Chinook smolts. The conclusion of the report is that “the passing of fingerling salmonids or salmonid smolts through the Venturi-driven eductor does not appear to generate detectable damage."

c. Adjustable Fish Grader

An adjustable width bar sorter/grader was considered for sorting the fish. Experience with the adjustable grader on the portable floating fish collector led the PDT toward the addition of multiple replaceable bar screens, all with different opening widths. These bar screens can be easily removed and switched out throughout the fishing season to match with the current size of fish entering the facility. This design removes unnecessary complexity introduced by an adjustable sorter.

d. Collection Channel Gantry Crane

An overhead gantry is not needed for the operation and maintenance of equipment in the collection channel areas. Small mobile shop cranes (cherry picker hoists) will be provided for the equipment too large to lift out by hand.

e. Fish Crowders

When dealing with the smaller fish the design intent is to remove the need for crowders from the system. The removal of crowders from the system is beneficial in that it removes a potential stressor to fish that may already be stressed from the copepod issue. In the current configuration, the smaller fish are captured and directed directly into holding tanks. These holding tanks are also the transport tanks, which will be lifted by the monorail and set on the AV for downstream release. There is no need to crowd the smaller fish.

f. The Bridge Plug

As the design has progressed, it was determined that the redundant penstock bypass gate would be repurposed for use as a weir gate in the upper water column. The allowed for the 2-inch horizontal concrete beams to be extend across the gate slot and to the upstream surface of the upper temperature control weir. Since the apron portion of the "cup" attachment to the tower will span between sets of horizontal beams, the development of a "bridge plug" is no longer needed.

6.11 REFERENCES

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SECTION 7 - MARINE DESIGN

The naval architect A-E on the PDT, Glosten, provided a narrative memorandum documenting marine design. The narrative memorandum in its entirety is included in Appendix H. The main body of the memorandum has been copied below and formatted to fit this DDR. The memorandum in Appendix H includes an executive summary. For consistency with other sections in this DDR, the executive summary was not included below. The reader is referred to Appendix H for Glosten's executive summary of the naval architecture and marine design.

7.1 CONCEPT ARRANGEMENTS

a. Arrangement and Geometry

The origin of the FSS is located at the bottom, middle edge of the fish sorting area. The fish sorting area is considered the bow and the fish channel entrance are considered the stern.

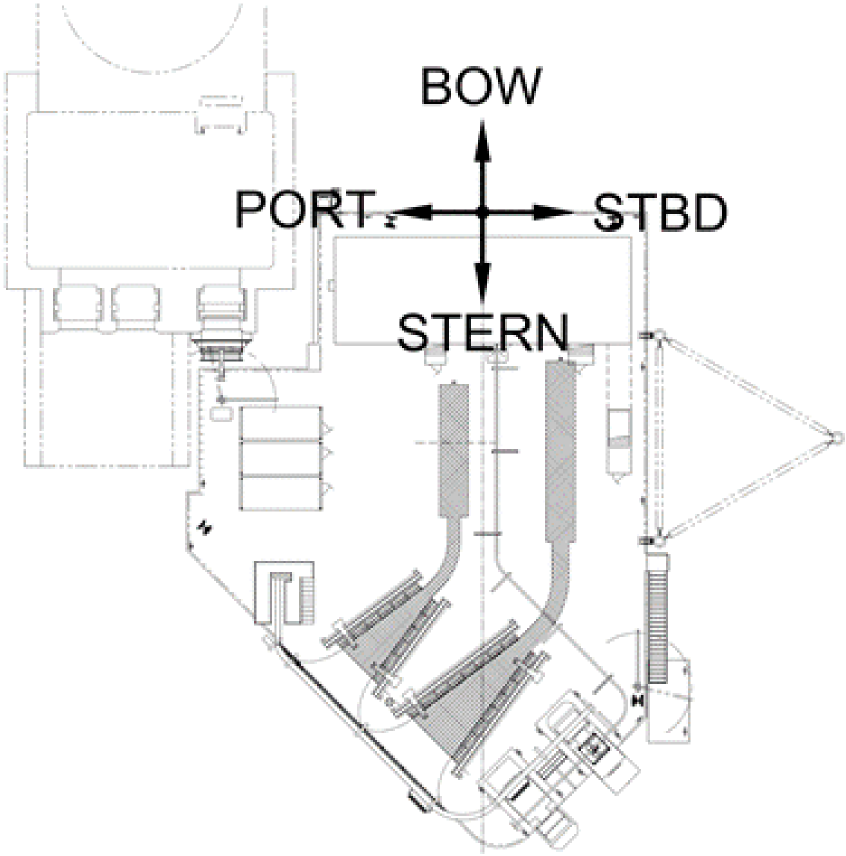


Figure 7-1. Origin and Coordinate System

This is opposite of the coordinate system developed by Portland District and should be changed to match in final design drawings and calculations for consistency.

The arrangement of the floating screen structure (FSS) is primarily determined by the arrangement of the fish collection system. The extents of the FSS buoyant volume are bounded by the water temperature control tower (WTCT) and the reservoir shore. The depth of the structure is set such that the maintenance draft can be achieved and the damage stability requirement at the operating draft can be met.

The maintenance draft should allow the junction pool and plenum bottoms to be dry for inspection and maintenance. If this draft cannot be achieved, a stoplog can be included at the end of the flume. The bilge system, as discussed in Section 7.4, is designed to be able to dewater the junction pool and plenum bottoms.

Portland District has requested mooring slips for the amphibious vehicles (AVs) used to access the FSS. The slips have been integrated into the hull, but they will need to be evaluated again once the amphibious vehicles have been selected to ensure they are of adequate size.

A discussion of the construction is located in Appendix I.

(1) Subdivision Arrangement

The FSS subdivision arrangement used the integrated structural bulkheads of the fish collection system, specifically the barrels, plenums, and junction points, as natural boundaries of the subdivision. This allows for a more rigid structure and reduces stress concentrations. The subdivision was also designed to pass the damage stability requirements (see Section 7.5.f.).

(2) Fish Sorting Area

The fish sorting area and fish equipment arrangements are controlled by Portland District, so no design basis is provided here.

(3) Utility Trunk and Pump Room

Piping, valving, and pumps will be located in a utility trunk on the inner bottom level. This simplifies access to piping and valving for maintenance and inspection. A vertical access is planned in way of the utility trunk and overhead crane rail. This vertical access is sized to allow for personnel access and replacement of pump and piping components.

(4) Vertical Access Trunks

Vertical access trunks will provide access to the utility trunk. The access should be designed to allow equipment needing maintenance or service to pass through this trunk.

Other access trunks will be provided for other voids and spaces as required.

(5) Above Deck

Above deck space will accommodate the electrical switchboard and control room, biology equipment storage, and day room. These spaces can be contained within modified 20-foot, 0-inch containers. Doors; window; insulation; and heating, ventilation, and air conditioning (HVAC) can be integrated into the containers to provide access, ventilation, and temperature control. The specification of these container buildings will provide for roofs that shed water to avoid corrosion issues.

Sanitary services are not planned on the FSS. The recommended alternative is to provide floating portable bathrooms accessible from the FSS, due to the greater serviceability of such facilities over facilities located onboard the FSS. An Incinolet (i.e. incinerator toilet) might be considered as another alternative for the FSS, as it does not require any plumbing and can be serviced on the FSS. The electrical loads for an Incinolet are included in the design of the FSS electrical system (see Section 7.8).

(6) Final Configuration for Primary Plenum

The final configuration of the primary plenum is shown in Appendix J. In this configuration, both down wells were arranged to have equal areas. This configuration is slightly different from the one used as the basis for the preliminary design. As the modification was proposed after the completion of the design calculations and drawings, the preliminary design could not be updated. The dimensions of the primary structural members are not anticipated to be affected by this modification. The final design will be performed using the dimensions shown in Appendix J.

b. Corrosion Protection

Galvanic corrosion is a concern for a metal structure like the FSS, although the conditions in Cougar Lake are relatively benign compared to most environments where cathodic protection is necessary. There are concerns about the impact that cathodic protection systems may have on the fish and surrounding environment. An impressed current cathodic protection system would provide protection but would require relatively large voltage potentials and electrical current flow in the water around the platform, which is believed to be dangerous to the fish. Sacrificial anodes would also provide protection, but the most efficient type in freshwater (magnesium) has a potential negative environmental impact, and other anode types are ineffective in freshwater.

Coatings should therefore be used as the primary means of corrosion protection for the main steel FSS structure. For submerged equipment and other appendages where coatings are not feasible, metals such as stainless steel that are less susceptible to corrosion should be used.

The FSS hull, fish channels, and other appendages should be inspected regularly to monitor the condition of coatings and unpainted surfaces so that areas of concern are caught quickly. Installation of sacrificial anodes should be considered for areas where corrosion is found to be an issue.

c. Fire Detection and Fire Suppression System

A fire detection system is planned to be installed on the FSS in way of, but not limited to, the electrical equipment in the switchboard and control room and fish sorting area. A fixed fire suppression system is not required; however, U.S. Coast Guard (USCG)-approved handheld fire extinguishers will be installed around the FSS.

d. Material Handling

Access to the FSS is only available from one corner of the structure, and there is limited access around the perimeter. There is a large amount of equipment on the deck of the FSS, including the part of the deck opposite to the corner where access is located, so it will be necessary to transport equipment and material across the deck.

Portland District has provided overhead rail systems for the pods (fish storage tanks), debris collection, plenum gates, and to service the fish sorting area. These systems are not part of this section.

Some large and/or heavy equipment will need to be loaded during maintenance or upgrade periods. A material handling crane should be installed near the floating dock and amphibious vehicles slips to load such equipment onto the FSS. The crane, which can be fixed jib and manually operated, should be sized to load the largest piece of equipment required to be loaded on the FSS in maintenance mode.

A second material handling crane should be installed to service the flume and cup connection. This can also be a fixed jib crane that is manually operated. Reference 3 shows the suggested locations for both material handling cranes.

e. Access and Safety

FSS access arrangements will provide for two methods of transport to and from the FSS: amphibious vehicle and fast skiff. Amphibious vehicles will be the primary mode of transport for personnel, the pods, and equipment. The fast skiff will be a secondary means of transport.

The main point of access when the FSS is in the operational condition will be the amphibious vehicle slips integrated into the FSS hull structure. There will be two side by side slips, located under the overhead rail systems that service the fish sorting area and the debris collection system.

The design includes a floating dock that is connected to the FSS with a vertical track, allowing access to the FSS during maintenance and providing another access point at the operational draft. A gangway will provide access between the FSS and floating dock. In the maintenance condition, the floating dock will be the only means of access, so the gangway must be capable of operating in both the maintenance and operational condition. The angle of the gangway will range from 10 to 45 degrees. To accommodate this, the gangway should be equipped with articulating steps.

The utility trunk is intended to be a normally accessible, non-confined space. As such, it requires ventilation, lighting, and fire detection. For ventilation, in addition to the two points of entry, a ventilation fan and duct will be installed to provide air circulation.

Access is required into each void and tank of the FSS. Bolted plate manhole covers should be installed through decks and longitudinal bulkheads to allow for access. Two points of access per void or tank should be provided to allow for sufficient ventilation as these will be classified as confined spaces. Temporary ventilation will be installed when access to voids and tanks is required. Access to the flumes, plenums, and barrels were designed to be through voids or tanks so that the ladders are not located within the flow. The vertical manholes are located in an area of low flow so as not to introduce unnecessary head loss in the system.

Ladders must be designed in accordance with Occupational Safety and Health Administration (OSHA) regulations, which also require that platforms be installed where maximum ladder length is exceeded.

Safety equipment that must be installed on the FSS per OSHA regulations includes, but is not limited to:

- Life rings with a minimum of 90 feet of rope.
- Boarding ladders integrated into the hull structure, and on the floating dock.
- A life-saving skiff.

Life lines or handrails must be installed around the perimeter of the FSS. The open barrels, and access panels should be covered with grating flush with the deck.

Grating bars should be spaced narrowly enough to prevent bird and bat access. Any doors and access ports to the FSS interior or fish sorting area should be left closed except when those spaces are being accessed or made safe for access. All other incidental openings to the fish sorting area and FSS interior should be covered or otherwise secured to prevent bird and bat entry.

f. Survey and Inspection

Surveys and inspection will need to be carried out without drydocking, with the exception of fish equipment surveys, which will occur when the FSS is in maintenance mode and can thus be accomplished in the dry. This section therefore does not apply to fish equipment.

Surveys of the internal parts of the FSS will use the manhole access points discussed in Section 7.1.e. to achieve access to the areas to be surveyed. These will be confined space entries and the appropriate protocols shall be followed. It is recommended that these internal surveys be carried out once yearly while the FSS is in the maintenance draft.

Surveys of the external parts of the FSS will be performed by divers. This includes the inspection and maintenance of the ballast sea chest screens. The American Bureau of Shipping (ABS) Underwater Inspection in Lieu of Drydocking (UWILD) designation will be followed to facilitate these inspections. UWILD is a marine industry standard that allows divers located outside the hull to carry out inspections where drydocking is not practicable. The FSS may need to be relocated away from the WTCT to perform these inspections. It is recommended that an underwater survey be carried out after one year of operation. If this initial inspection does not reveal any structural or corrosion issues, underwater inspection frequency can be reduced to every 3-5 years subsequently.

Survey needs were considered during the design development of the cup and apron system concept. The design of the apron sealing system allows the inspection of the seals in the dry at the maintenance draft. The cup sealing to the WTCT face system is designed to be removable from the top of the cup.

The sliding surface cannot be inspected without removing the cup and flume. A hoist or temporary crane can be installed on the top of the WTCT to facilitate the removal and installation of the cup and flume. This is further discussed in Section 7.3.

7.2 HULL FORM AND SCANTLING PLAN DEVELOPMENT

The hull form has been developed to accommodate the requirements of the fish collection system arrangement. The design requirements include integrating the fish collection passages (barrels, plenums, and junction pool) into the hull structure. Therefore, the hull form was developed around the fish collection passages.

To keep the plenum and junction pool dry in the maintenance operation, the plan boundary of the FSS was maximized to its extents in order to develop as much buoyancy as possible in that condition while reducing the depth of the inner bottom tanks.

The hull form has been modified to allow sufficient internal stair access and the amphibious vehicle slips.

The form of the fish collection passage entrances and passages themselves were defined by Portland District.

As this floating structure does not conform to any existing ABS regulatory standards, an Approval in Principle was developed. The Approval in Principle is an agreement between ABS and the owner or owner’s representative upon the application of rule sets for the structural and mechanical design. As this floating structure will be located on a reservoir and will require ballasting to operate, the closest applicable standard is Tank Barges section in the Rules for Building and Classing Steel Vessels on Rivers and Intracoastal Waterways. However, since there is a significant draft change between maintenance condition and operational condition, the Rules for Building and Classing Steel Floating Drydocks is also applicable. The details of the Approval In Principle are included in Reference 30. The hull welds will be performed in accordance with ABS rules.

The scantling plan has been developed based on the Approval In Principle and with respect to the Operational Load Cases discussed in the next section.

a. Operational Load Cases

The operational condition of the FSS is 31 feet of draft, with a nominal 25 feet of fishing draft (meaning that fish enter the FSS at a depth of 25 feet). This draft will be maintained from 0 cubic feet per second (cfs) to 1,000 cfs flow. Trim and heel must be minimized while in these operational conditions, which will be accomplished using ballast tanks.

b. Maintenance Load Case

The maintenance condition of the FSS is a fully unloaded condition to bring the bottom of the plenum and junction pools above the water line. This is a ~5.4-foot draft for concept design; however, it is dependent on the final weight and center of gravity of the FSS.

c. Floating Screen Structure Plan & Elevations

See References 2, 5, 6, and 7.

d. Finite Element Analyses

The global finite element model was created in FEMAP version 11.2, a finite element analysis pre/post processing software package developed by Siemens. The structure was meshed from surfaces representing the molded side of the hull, decks, and bulkheads. Additionally, instead of modeling deck beams, girders, and webs with beam elements, these components were also explicitly modeled and meshed using surfaces and plate elements. The only beam elements used in the model are the stanchions in the structural model.

To correctly model the vessel's lightship weight (its weight when fully constructed and ready for service, excluding the weight of any crew, cargo, supplies, etc.), distributed non-structural mass and mass elements were added to the model. This additional mass represents structure not explicitly modeled as well as equipment and outfit.

FEMAP does not prescribe to a specific unit system, allowing any unit system to be used. For this analysis the FEM is modeled using inches and pounds-force. Consequently, the units of acceleration are in/s2, and mass is measured in snails (lbf*sec2/in).

A Cartesian global coordinate system was used in this FEM, with the origin located at the forward perpendicular, on baseline. The x-axis is oriented along the longitudinal axis of the platform, with +X going forward. The y-axis is oriented transversely with +Y going to port. Therefore, the z-axis is oriented vertically with +Z pointing up.

The structure of the FSS has been evaluated against the anticipated operational loading. The results of this analysis show that the global scantlings are adequate and comply with the strength and buckling requirements. The results also show that there are localized areas of stress concentrations near the entrance of the outer barrel, and near the fixed constraint. These areas of high stress appear to be the results of modeling rather than structural deficiencies. It is recommended that a refined mesh model be developed during the detailed design phase to evaluate these local stress concentrations. The resulting stress levels can then be analyzed to determine if additional reinforcements are required to achieve acceptable strength and fatigue properties. Further details are provided in Reference 9, which includes both the finite element analysis model itself and a summary report.

7.3 FLUME AND CUP CONNECTION SYSTEM STRUCTURAL DESIGN

a. Water Temperature Control Tower to Floating Screen Structure Interface Concept Design

Water flow through the FSS is driven by a differential head created by lowering the water level in the wet well of the WTCT below the pool level of the lake. This means that the downstream end of the FSS must be connected by a nearly watertight channel to the WTCT to function, and that this channel should remain nearly level with the FSS. The pool level of the lake has an elevation range throughout the year of about 180 feet, and it is intended that the FSS be functional over as much of this range as is practical.

The FSS is a floating structure. Although constrained by moorings, the FSS will move in response to wind and waves. This motion must be accounted for to ensure the seal to the WTCT is maintained and that excessive loads are not applied to the WTCT.

The following requirements form the basis of design for the WTCT to FSS interface:

- Maintain a differential head of 3 feet with a maximum flow of 1,000 cfs and leakage of around 5 cfs at the seal.
- Cover a 45-foot vertical distance to integrate sealing with the WTCT internal weir gates.
- Slide up and down the WTCT to maintain operations over the full range of expected pool elevations.
- Stay level with the FSS to maintain the desired hydraulic conditions.
- Isolate motions from wind and waves (surge, sway, yaw, roll, pitch) from the seal and WTCT.
- Must be capable of installation and removal on an as-needed basis.
- Prefer to maintain seals without removal of FSS from WTCT.

b. Design Development

The starting concept for this phase of the design incorporated vertical guide rails on the dam, a cup structure with rollers and flexible seals that moved up and down along the rails (9 feet wide by 25 feet deep channel with 20 feet of apron below), a long flume with articulation between the cup and the FSS. Motions due to wind and waves had not been calculated at this time and a watch circle of two feet diametrically was assumed. Many of the challenges associated with this interface are addressed by this concept.

The design differential head leads to a large normal force between the cup and WTCT. This means friction forces between the seals and the WTCT that will restrict vertical movement. Soft rubber seals have a high coefficient of friction, so the concept is to restrict the normal force on these seals by taking most of it in the rollers. Spring loading the soft seals was also considered as a means of limiting the friction forces on these seals.

Mechanical articulation (universal joints) at each end of a long flume address sway, yaw, roll and pitch motions. A telescoping section at the end of the flume counteracts surge. This relatively complex approach is driven by the assumed 2 feet of FSS motion.

The next step was to investigate simplification of the design while motions for the FSS were calculated.

- Composite (Torlon) bearing plates to replace rollers.
- Bellows joints to replace mechanical hinges and telescoping section (easier seals).
- HDPE flume structure to eliminate bellows joints (not pursued as structure was still too stiff to eliminate need for articulation/bellows joints/telescoping section)

Analyses of the FSS motions (including constraints provided by the mooring system of +/- 1/8" at connections) identified much smaller amplitudes (+/- 3.2 inches as opposed to +/- 2 feet). Appendix G, Mooring and FSS Relocation Analysis, provides details on the calculated motions summarized below in Table 7-1.

Table 7-1. Motion Amplitudes at Flume

	Motion Amplitudes at Flume			Design Target	Revised Design Target[1]
Mode	**90-deg**	**45-deg**	**0-deg**		
Surge [in]	1.2	1.9	2.1	2.0	4.0
Sway [in]	2.2	1.3	-0.4	3.25	6.5
Yaw [deg]	-0.05	-0.08	-0.06	0.1	0.2

[1] Revised design target within typical deflections for two bellows joints in series.

These reduced motions allow additional simplification/optimization; a shorter flume is feasible, and a single bellows joint can achieve the desired isolation.

The seal design concept was based on the assumption that bearing surfaces on WTCT are coplanar and that the bearing surface tolerance is +/- 1/8 inch. The concept design uses vertical pneumatic seals to engage the cup/apron seals to the WTCT to reduce leakage as differential head is established. The intent of this concept is that once a head differential is established, the pneumatic seals can be depressurized. Placing horizontal seals on the dam to allow maintenance without cup removal was considered but was not pursued, as divers would have been required for removal and replacement.

Maintenance features for this concept design include removable rails to allow installation and removal of the cup when attached to the FSS, a simple joint between flume and cup to allow removal of FSS without cup (for low pool condition, apron on cup extends

14 feet below bottom of FSS), and a WTCT mounted hoist for the cup. For hoist capacity, see the Flume Connection System Weight Estimate and Radii of Gyration in Appendix F, which gives the flume connection system's wet and dry weight. The concept design also includes a removable plate for the horizontal apron seals that can be lifted out of the cup for maintenance while the cup/flume/FSS stays in its moored position.

c. Final Concept Design

(1) Water Temperature Control Tower

The final concept design utilizes coplanar steel bearing surfaces with a tolerance of +/- 1/8 inch. For the guide rails, one side will be removable, and the other side welded; an option is for the removable side to be removable only at the maintenance draft. A hoist is included to raise the cup for maintenance; a buoyancy tank (maximum design submergence of 45 feet) will be added to the cup to reduce its submerged weight, resulting in a dry weight of 44,500 lbs and a wet weight of 13,100 lbs.

(2) Cup

The cup will utilize composite (Torlon) bearing plates mounted to the sides of the cup and apron. Vertical wing D seals will be mounted to the sides of the channel, and horizontal wing D seals will be mounted to the lifting apron plate. Pneumatic vertical seals are also included in the design and are mounted to the sides of the entire cup (channel and apron) to prevent leakage at start up. A buoyancy tank is added to reduce the cup's submerged weight, and two lifting points will be incorporated, either via a spreader bar or a removable top frame. The lower connection to the flume is achieved using stabbing guides (below the bottom of the flume), and the upper attachments will utilize steamboat ratchets and securing plates (in the dry). The procedure to install the cup and attach to the flume is as follows:

1. Lower the cup into the rails on the WTCT.

2. Guide flume and cup into alignment using the guide plates and stabbing guides.

3. Use steamboat ratchets to bring cup and flume bolting faces together.

4. Install bolts in the cup/flume bolting ring.

The cup seal will accommodate some variation on the intake tower bearing surface via the throw (compressibility) of the soft seals. Should future damage to the intake tower surface occur such that variations in the surface exceed the seal throw limit, then either new seals with more throw will need to be procured, or the intake tower bearing surface will need to be repaired

(3) Flume

Sockets will be incorporated below the bottom of the flume to achieve connection with the stabbing guides on the cup, and upper attachments will be included for steamboat ratchets and securing plates. A flat rubber gasket at cup interface will be used to achieve a seal. Restraints are included to maintain its vertical orientation relative to the FSS, while simple bearing pads allow for horizontal plane motions and pitch and roll. A bellows joint with reinforced rubber and bolted flange connections to the flume allows for surge, sway, yaw, roll, and pitch. The connection to FSS itself will be welded, with the option of a bolted flange to facilitate future modifications. A flat rubber gasket may be added if needed.

(4) Recommendations

As the interface between the WTCT and FSS is critical to the operation of the FSS, we recommend that a full-scale prototype be built and tested to verify the interface concept. We are unaware of an existing, proven seal system of the kind proposed. If the seal system does not function, the FSS will not function. Therefore, it would be prudent to limit project risk by verifying the seal system's functionality before investing in FSS construction.

The following operational factors should be verified during seal system prototype testing:

- Initial seal can be established to start hydraulic flow as the water level in the WTCT's wet well is lowered.
- Leakage at operating flow condition is at an acceptably low level.
- Seal can be maintained with acceptably low leakage as the sealing system shifts up and down the WTCT face with changing lake levels.
- Friction forces for vertical movement are manageable.

Prototype testing will also provide an opportunity to fine-tune the balance between hard bearing surface and soft seal throw to improve sealing. This prototype should be tested at full scale, with bearing surface deformations built in to mimic field conditions. It may be possible to fine-tune the cup prototype and use it for the actual FSS installation, thereby reducing project costs.

Additionally, maintenance of the seals and low water navigation of the FSS lead us to recommend that the cup be removable from the FSS and that a hoist be provided on the WTCT to raise and lower the cup.

d. Flume and Cup Plan & Elevations

See Reference 11.

7.4 BALLAST AND BILGE SYSTEM

a. Ballast System

The FSS ballast system controls draft, trim and heel. The system is designed so that major components can be installed and maintained in all operating conditions. Ballast pumps, main headers, valves actuators, and instrumentation are located in an operator-accessible utility trunk. The current design includes 46 ballast tanks, 42 of which are 100 percent full for the operating condition, and four of which are partially full as trim/heel tanks.

Major draft adjustment is only required for FSS maintenance. Since this is an infrequent operation, manual valves and control are provided. Minor draft, trim, and heel adjustments are required when the operating condition of the FSS changes over the range of flow rates into the FSS. Since this is a frequent operation, actuated valves and PLC control are provided. It is recommended the automated ballast control system switch between preset ballast states upon command by the operator. An upgrade to continuous trim and heel control can be added at a later date if deemed necessary to maintain required attitude tolerance. Draft, heel, and trim adjustments are all accomplished via the same two pumps.

(1) Draft Control

Draft of the FSS is controlled by filling or discharging from the 46 ballast tanks. The capacity of the ballast system is sufficient to change from maintenance draft to operation draft, and vice versa. The ballast tank arrangement and capacity allow for level trim and heel of the FSS at all drafts.

Separate port and starboard ballast headers are located in the utility trunk. Each of the two headers is served by a single pump. Cross-connects are provided between the two pump suctions and discharges for redundancy. Piping branches from the headers to each tank are isolated by a gate valve. The tank valves are manually operated locally from within the utility trunk.

Ballast uptake is through a seachest. The seachest is covered with a strainer plate to protect the pump from debris. In this case, the strainer plate also prevents fish from entering the ballast system. Seachest strainer plates provide a free area of one and a half times (1.5x) the combined area of the inlet valves. The maximum opening size is 3/32" to prevent intake of fry. Ballast discharge is via overboards located above the operational draft waterline. Each pump (port and starboard) is provided with a dedicated seachest suction and overboard discharge. A suction and discharge connection is also provided to the junction pool.

The two ballast pumps are sized to discharge the amount of water required to reach maintenance draft within 36 hours with both pumps operational. Self-priming end suction pumps are used rather than deep well pumps to reduce cost. Ballast tank volumes are shown in Table 7-2.

Table 7-2. Ballast Tank Volumes

Tank Name	Volume (gallons)	Tank Name	Volume (gallons)
IB1-OTBD.P	24,758	L2-OTBD.S	36,781
IB1-INBD.P	20,543	L3-OTBD.P	35,961
IB1-INBD.S	38,168	L3-OTBD.S	22,223
IB1-OTBD.S	18,391	L4-OTBD.P	27,145
IB2-OTBD2.P	28,514	L4-OTBD.S	46,502
IB2-OTBD1.P	37,136	L5.P	28,965
IB2-INBD.P	23,752	L5.S	47,463
IB2-INBD.S	42,937	U1-OTBD.P	24,612
IB2-OTBD.S	20,690	U1-INBD.P	14,513
IB3-OTBD.P	48,597	U1-INBD.S	20,495
IB3-INBD.P	13,587	U1-OTBD.S	21,439
IB3-INBD.S	45,539	U2-OTBD.P	53,123
IB3-OTBD.S	35,755	U2-INBD2.P	74,421
IB4-OTBD.P	11,101	U2-INBD.P	35,642
IB4-INBD.P	23,815	U2-INBD.S	65,529
IB4-INBD.S	50,662	U2-INBD2.S	34,229
IB4-OTBD.S	37,508	U2-OTBD.S	33,989
L1-OTBD.P	49,515	U3-OTBD.S	42,144
L1-INBD.P	63,722	U4-OTBD.P	59,897
L1-INBD.S	69,334	U4-INBD.P	24,523
L1-OTBD.S	36,781	U4-INBD.S	43,820
L2-OTBD.P	28,012	U4-OTBD1.S	36,489
L2-INBD.S	17,293	U4-OTBD2.S	88,165

(2) Operational Draft, Trim, and Heel Control

Trim and heel are adjusted by transferring ballast between four trim/heel tanks. The nominal capacity of these tanks is intended to be maintained at approximately 50 percent. The tanks' capacity is sufficient to level the trim and heel of the FSS over the range of operating conditions (0 cfs to 1,000 cfs) while at the operational draft of 31 feet (nominal 25-foot fishing draft). Additional tank capacity margin is provided to adjust for minor operational weight shifts.

The ballast pumps transfer ballast between the trim/heel tanks. The capacity of a single pump is sufficient to transfer the required amount of water to correct for the worst-case operational condition weight shift within 30 minutes. The second pump is intended as a redundant backup but can serve to reduce the time required to shift ballast.

(3) Instrumentation and Control Hardware

An integrated monitoring, alarm and control system (IMAC) will serve as the operator interface for maintaining operational draft, trim, and heel. During transition between maintenance and operational drafts, the IMAC system will provide monitoring only; Valve control and pumps will be operated locally.

A PLC based control system with human-machine interface (HMI) will perform all monitoring and control functions. Mimic screens of the piping system and tanks will provide all relevant information to the operator. All instruments, including draft sensors, inclinometers, tank levels, actuated valve position, pressure indicators, and pump run indication, will be displayed on the HMI. The system will provide controls for changing valve position and running pumps.

The maximum draft, trim and heel deviations will determine the required accuracy of the instrumentation and the necessary level of redundancy. When the operating limitations are defined, the instrumentation will be selected and the alarm conditions will be determined. Currently the minimum level of instrumentation hardware is as follows:

- Each tank will be fitted with a pressure type level transmitter. The HMI will display the sounding, fill percentage and calculated volume.
- Pressure type draft sensors will be fitted at each of the 4 corners. One pressure type draft sensor will be located at the center of floatation. These draft sensors will provide calculated trim and heel. Additionally, maximum calculated deviation can be reported by comparing to the other sensor data.
- An electronic, dual axis inclinometer will monitor the platform attitude.
- Valve actuators will be fitted to allow remote actuation of trim tanks, junction pool, bilge suction, and overboard discharge.
- All actuated valves will be fitted with limit switches to provide position indication feedback.
- Pump motor starters will be configured for local and auto control. Additionally, the starter will provide run indication feedback.
- Pressure transmitters will be located at each pump discharge for monitoring pump operation and to provide run dry protection.

(4) Control Functional Description

The PLC control functionality is limited to the transfer of ballast between the trim/heel tanks. Ballast trim/heel tank uptake and discharge is not automated, and not anticipated to be required during normal operation.

The four trim/heel tanks will contain varying amounts of ballast depending on the operating condition (0 cfs to 1,000 cfs) of the FSS. The IMAC system will provide eight user-configurable ballast tank states. Each state will record the level of the four trim/heel tanks. Each state will be reconfigurable at any time by entering new levels or by saving the current tank levels.

The operator can select any of the programmed tank states, and the PLC will perform the following control function upon the operator selecting start transfer:

1. Open suction valves of tanks above target level.
2. Open fill valves of tanks below target level.
3. Run one pump while one suction and one fill valve are confirmed open.
4. Run two pumps while both suction and fill valves are confirmed open.
5. Close each valve when tank level reaches the target.
6. When pumps stop, close remaining valves.

Adjustments can be made manually at any time by opening valves and starting pumps. The manual transfer method will be used for fine tuning and for saving new tank states.

Alarms are annunciated if valve position or pump run indication do not match the control signal after a time delay. Run dry protection will annunciate an alarm and shut down the pumps when discharge pressure is below the minimum run dry setpoint for the time delay period.

When the attitude (angle) of the FSS is within 25 percent of the acceptable limit (based on draft sensors or an inclinometer), a warning alarm will be annunciated. When the attitude is within 10 percent of the acceptable limit, a shutdown alarm will be annunciated, and all valves will close and pumps will shut down. The operator can override either the inclinometer or the draft sensor alarms at any time, but never both.

b. Bilge and Stripping System

The bilge and stripping are provided by the ballast system. Ballast pumps are self-priming, and suctions are provided to each tank. Tanks above the inner bottom are provided with suction wells to allow complete draining of each tank. Inner bottom tanks are provided with suction bellmouths for effective stripping to below the stiffeners. Stripping the inner bottom tanks dry is accomplished with portable pumps. These portable pumps will be procured for the FSS and will be stored onboard.

Two direct bilge suctions, one at each end of the utility trunk, are provided for dewatering the utility trunk. One suction is manual and the other is remote operated. The remote operated direct suction and overboard valves are actuated valves controlled from the operating station. Suction strainer boxes are in accordance with ASTM F986.

7.5 NAVAL ARCHITECTURE ANALYSES – FSS

The intact and damage stability of the FSS were investigated to determine that the FSS can be successfully operated across a range of drafts and operating conditions. The naval architecture analysis was performed using General Hydrostatics (GHS) Version 16.20, a PC-based simulator of vessels in fluids and fluids in vessels. A summary of the load cases is included in Table 7-3. For damage cases, see Section 7.5.f.

Table 7-3. Load Case Summary (Intact Cases)

Load Case	Comment	LCF Draft (ft)	Trim (Deg, +aft)	Heel (Deg, +stbd)	Flood Point Height above WL (ft)	GMT (ft)	Stability Limit Attained (ft-deg)
Lightship	Maintenance draft (5.38 ft measured from bottom of FSS)	5.38	-0.43	0.48	28.11	133.43	406.21
Lightship w/ Freeflood and Leveling Ballast	Maintenance draft with flooding and ballast added for leveling	5.68	-0.02	0	28.31	123.41	476.27
Fill Inner Bottom	Inner bottom tanks filled	15.29	2.75	-2.93	19.35	43.28	324.76
Fill Ballast Tanks	Ballast tanks filled	31.1	0.01	0	2.9	24.03	137.5
1000 CFS Case	Both barrels operating	30.78	0	0	3.22	23.94	110.17
300 CFS Case	Inner barrel operating	30.87	0.07	-0.01	3.17	23.87	146.7
600 CFS Case	Outer barrel operating	30.87	0.06	-0.05	3.16	23.87	145.99
0 CFS Case	Neither barrel operating	31.18	0.13	-0.03	2.88	23.64	142.77

a. Fish Screening System Description

The fish screening system is designed to screen fish out of flow and direct the screened water into the WTCT at flow rates from 300 cfs to 1,000 cfs. Two barrels are used to meet the flow rate range. Each barrel is composed of a primary, secondary, and tertiary screening system. The system is gravity fed by having a head drop through the system and in the

WTCT. The flow rate is determined by the Cougar Dam powerhouse. The system is designed so that the head loss through the system (gravity fed) is constant during the range of flow rates.

The naval architecture analysis examines the different load conditions created by having different water elevations (and associated head loss) throughout the primary screen, secondary screen, and junction pool in the FSS.

b. Weight, CG, & RG

The estimated weight of the FSS is based on the structural model and estimates for the fish screening equipment, piping system, electrical system, and other miscellaneous system weights. The structural model includes weights for all side shell, decks, bulkheads, and all associated stiffeners and girders. A 5percent allowance for brackets, mill tolerance, and welding is also included in the structural weight.

Additionally, a 15 percent margin is included in the structure weight estimate as a concept phase, low-risk margin allowance. A 20 percent margin is included for all auxiliary equipment weights. A summary of the weight estimate is included in Table 7-4. Lastly, for the design phase the FSS center of gravity (VCG) was located 12 percent higher for additional margin.

Table 7-4. FSS Weight Estimate Summary

SWBS	Group Description	Margin	Weight	Margin	LCG	TCG	VCG
No.		%	LT	LT	ft +Aft Fr 0	ft +Stbd CL	ft +Abv BL
100	Hull Structure	15.0%	1,499.03	224.85	66.93	-5.48	14.82
300	Electric Plant	20.0%	3.24	0.65	58.63	-31.68	27.10
400	Command and Surveillance	20.0%	0.29	0.06	0.00	0.00	0.00
500	Auxiliary Systems	20.0%	22.03	4.41	61.31	-6.40	11.02
600	Outfit and Furnishings	20.0%	35.52	7.10	53.02	-12.14	22.99
700	Mission	10.0%	104.72	10.47	84.35	-11.31	37.49
	Lightship (Without Margins)		**1,664.83**		**67.63**	**-6.05**	**16.39**
	Design and Build Weight Margin	Varies	247.54				
	Design and Build VCG Margin	12.0%					1.97
	Lightship (With Margins)		**1,912.37**		**67.63**	**-6.05**	**18.36**

c. General Hydrostatics Model

Calculating stability using GHS requires a three-dimensional hull model. The hull model for the FSS includes the molded hull, deckhouse, tanks, voids, and fish barrels. Views of the 3-D hull model can be seen in Figure 7-2. Distances are referenced in feet aft of Frame 0 (outlet end), feet starboard of centerline, and feet above baseline. The analysis assumes the platform to be in freshwater with a specific gravity of 1.00.

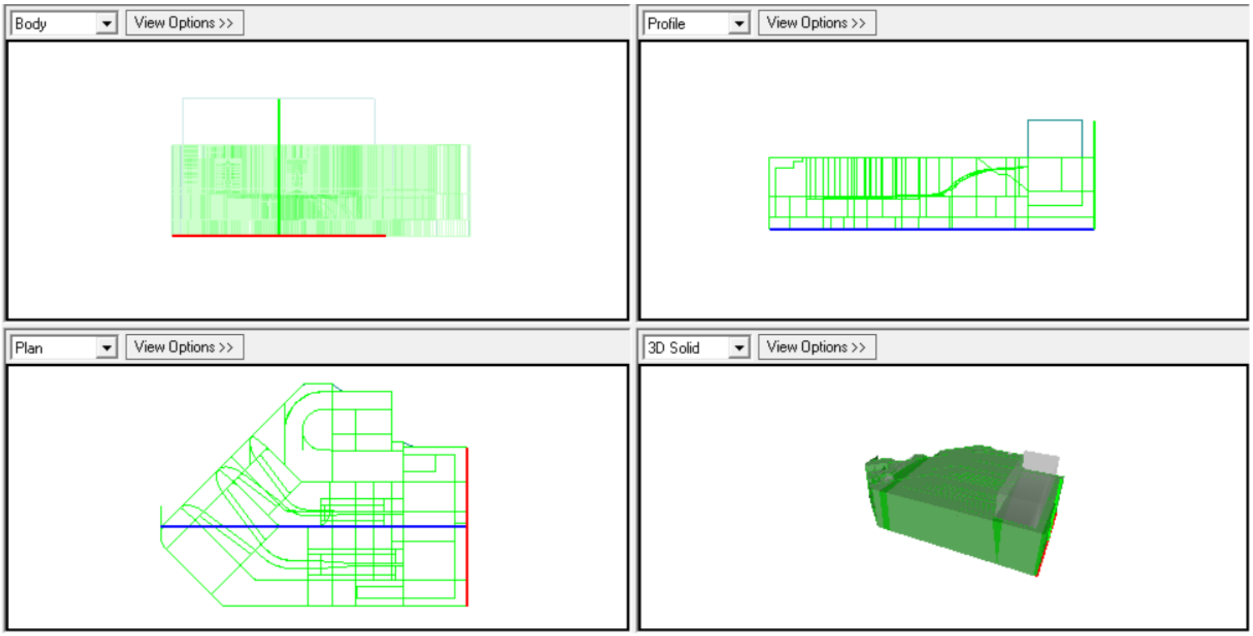


Figure 7-2. FSS 3-D Hull Model

d. Downflooding Points

The FSS hull model has downflooding points at the stairway entrances to the fish sorting area. The downflooding points are summarized in Table 7-5.

Table 7-5. Floating Screen Structure Downflooding Points

Point	Distance Aft (feet)	Distance OCL (feet, + stbd)	Distance ABL (feet)
Starboard Stairs	32.00	27.00	34.00
Port Stairs	32.00	-15.15	34.00

e. Ballasting Requirement

In order to increase the draft of the FSS from the maintenance draft (~5.4 feet) to the operational draft (~31 feet), a majority of the ballast tanks will need to be filled completely with fresh water ballast. Four tanks, designated in the stability calculations as U1_OTBD.S, U1_OTBD.P, U4_OTBD2.S, and U4_OTBD.P, will be partially filled and used to adjust the trim and heel of the FSS by transferring ballast water between tanks.

f. Intact & Damage Stability

The FSS is analyzed for the following stability criteria:

- USCG CFR 46 174.015 Intact Stability Criteria for Deck Cargo Barge
- USCG CFR 46 28.580 Damage Stability Criteria for Unintentional Flooding

For intact stability, all of the load conditions listed in Table 7-3 were analyzed and found to meet the required stability criteria. Table 7-6 shows the intact stability results.

Table 7-6. Intact Stability Results

Load Case	LCF Draft (feet)	Displacement (LT)	Required Righting Energy (ft-deg)	Attained Righting Energy (ft-deg)
Lightship	5.38	1,912.37	10.00	406.21
Lightship w/ Freeflood and Leveling Ballast	5.68	2,038.75	10.00	476.27
Fill Inner Bottom	15.29	3,981.61	10.00	324.76
Fill Ballast Tanks	31.1	7,743.90	10.00	137.50
1000 CFS Case	30.78	10,866.79	10.00	110.17
300 CFS Case	30.87	10,896.22	10.00	124.88
600 CFS Case	30.87	10,897.99	10.00	124.10
0 CFS Case	31.18	11,003.60	10.00	118.04

For damage stability, 13 load cases are analyzed. In each damage load case, the FSS is ballasted to a draft of 31 feet and then both the fish collection void and one additional void are flooded to simulate a two-compartment flooding situation. The fish collection void is the largest floodable void on the FSS by far, so that space is flooded in each load case to be conservative. All the damage load cases meet the required stability criteria. Table 7-7 shows the damage stability results.

Table 7-7. Damage Stability Results

Load Case	LCF Draft (feet)	Dmg. Comp. #1	Dmg. Comp. #2	Req. Crit. 1 (deg)[1]	Attn. Crit. 1 (deg)	Req. Crit. 2 (ft-deg)[2]	Attn. Crit. 2 (ft-deg)	Req. Crit. 3 (ft)[3]	Attn. Crit. 3 (ft)
#1	34.47	Fish Sort Area	U1_ OTBD.S	25.00	4.11	0.6	25.61	0.33	3.92
#2	34.16	Fish Sort Area	U1_ OTBD.P	25.00	3.03	0.6	29.35	0.33	4.06
#3	35.00	Fish Sort Area	U3_ VOID.P	25.00	2.36	0.6	12.83	0.33	2.32
#4	37.86	Fish Sort Area	U4 _OTBD2.S	25.00	7.80	0.6	11.48	0.33	2.39
#5	34.30	Fish Sort Area	U4 _OTBD.P	25.00	1.05	0.6	31.18	0.33	3.97
#6	38.78	Fish Sort Area	U5_ VOID.S	25.00	7.76	0.6	8.14	0.33	1.71
#7	34.90	Fish Sort Area	U6_ VOID.S	25.00	3.70	0.6	24.34	0.33	3.07
#8	34.34	Fish Sort Area	U5_ VOID.P	25.00	3.32	0.6	28.25	0.33	3.75
#9	34.59	Fish Sort Area	UTIL_ TRUNK_F	25.00	3.72	0.6	26.48	0.33	3.99
#10	34.58	Fish Sort Area	UTIL_ TRUNK_A	25.00	3.37	0.6	27.41	0.33	3.73
#11	34.51	Fish Sort Area	L6_ VOID.C	25.00	3.66	0.6	26.55	0.33	3.66
#12	34.28	Fish Sort Area	L2_ VOID.P	25.00	3.51	0.6	27.78	0.33	3.99
#13	34.24	Fish Sort Area	L2_ VOID.S	25.00	3.85	0.6	26.54	0.33	3.94

[1] Absolute angle at equilibrium less than 25.00 degrees
[2] Area from equilibrium to absolute-20 degrees greater than 0.60 foot-degrees
[3] Righting arm at maximum righting arm greater than 0.33 feet

7.6 NAVAL ARCHITECTURE ANALYSES – FLUME CONNECTION

The flume and cup structure were greatly simplified from the original design, as analysis of environmental conditions found that FSS motions would be of lower magnitude than originally anticipated. As a result, no separate naval architecture analysis was required for the flume connection. A buoyancy tank is incorporated into the cup to reduce submerged weight for lifting operations. See Section 7.3 for additional details on the flume connection design process.

7.7 MOORING AND FSS RELOCATION ANALYSIS

a. Mooring System

The mooring system for the FSS has three attachment points. Two points are provided from the mooring tower and the third is being integrated into the Water Temperature Control Tower. These mooring towers are being designed by the Portland District with input from the mooring analysis, discussed in detail in References 20 and 21. The tower designs are not part of this section.

The mooring system will only locally restrain longitudinal and transverse motions (horizontal motions) and will be free vertically. Global rotational loads will be taken by pairs of mooring attachments points.

The mooring system must be effective through the entire pool elevation range.

- Mooring connection points should be near the deck edge.
- Mooring connection points may be required to allow a rotational moment to handle trim and heel (check on motions and damage case)

The FSS design places a triangular mooring tower with 50-foot side lengths adjacent to the FSS, with one side of the triangular tower flush with the FSS structure. Each corner of the mooring tower is composed of a pile affixed to the bed of the reservoir, with the two piles flush with the FSS structure designated P2 (closest to the inshore corner of the FSS) and P2. The initial design placed P2 15 feet 6 inches down from the inshore corner of the FSS and called for the FSS to be moored to piles P2 and P2. A second design iteration added a third independent pile, designated P3 and located at the corner of the FSS nearest the WTCT. Subsequent iterations moved the mooring tower to better align with the center of wind pressure. The final design iteration increased the stiffness of pile P3 to reduce motions at the flume.

Table 7-8 shows expected FSS motion amplitudes. As shown, vertical motions are expected to be negligible. Sloshing in the plenums is also expected to be minimal due to the small roll and pitch angles expected.

Table 7-8. Summary of Extreme Floating Screen Structure Dynamic Motions Due to Waves

					Extreme Motion of FSS					
U(3-sec) mph	H_S ft	T_P sec	Lake Level ft	Draft ft	Surge ft	Sway ft	Heave ft	Roll deg	Pitch deg	Yaw deg
66	1.7	2.5	1690	33	0.013	0.064	0.004	0.026	0.004	0.028
66	1.0	1.8	1532	33	0.001	0.008	0.001	0.004	0.000	0.002
66	1.7	2.5	1690	8	0.037	0.054	0.013	0.030	0.009	0.025
66	1.0	1.8	1532	8	0.002	0.004	0.000	0.001	0.000	0.003

(1) Mooring Support Plan & Elevations

See References 6, 21, and 22.

(2) Mooring Attachments

The FSS is held in operating and maintenance position by the mooring tower and a single piling. These points provide a vertical range of motion that allows the FSS to follow the water level of the lake while maintaining a fixed position (+/- 3") in the horizontal plane.

Mooring tower attachments restrain FSS movement in the surge and sway direction. The pile attachment is designed to resist surge motions only. The attachments work together to resist yaw rotations.

The mooring tower attachment concept is a car with vertical and horizontal steel wheels running up and down a vertical rail connected to the tower leg. The wheels are attached to spars which are bolted to a foundation welded to the deck of the FSS. These spars can be removed to facilitate servicing and/or replacement of the wheels. The wheels will be in the dry and will be visible and accessible from the FSS deck, so they should not be subject to significant debris intake. However, should debris accumulate, it can be removed by an individual standing on the deck of the FSS.

A simple capture arm and the end structure of the FSS are used as an attachment to the pile. Low friction sliding plates contact the pile. These plates are mounted to elastomer (rubber) bases tuned (in combination with pile stiffness) to achieve the desired mooring stiffness at this attachment point. The capture arm is bolted to a spar that is in turn welded to the FSS.

It is important that the rails mounted to the mooring tower, the pile, and the WTCT face all be parallel. This will allow relatively tight position tolerances at the attachments while reducing the risk of binding as the FSS moves up and down with the lake level. The concept includes trimmable spacer plates between the mooring tower legs and vertical rails to facilitate this parallel alignment.

The movement in the mooring system is then managed by the flexible bellows joint between the cup and the FSS. The flexible bellows joint is custom designed to allow movement as discussed in Section 7.3.

(3) Lead & Guide Net Attachment

The mooring system design includes mooring points for a net system that may be implemented to improve the efficiency of the fish collector.

b. Wind and Waves

(1) Wind Conditions

Wind data was collected intermittently at the WTCT over a period of 5 years (2010-2015). A data analysis was performed to correlate the Cougar Dam wind data with the nearest airport located at Eugene, Oregon and to estimate long-term extreme wind speed at the dam. A wave hindcast was performed to define design wave conditions for the FSS moored at typical low and high pool elevations: 1,532 feet and 1,690 feet. Environmental conditions are not expected to be worse at the "survival" pool elevations of 1,516 feet and 1,699 feet.

We recommend the following 300-year return period design conditions for the FSS:

- Wind speed – 66 mph (3-second gust), 44 mph (mean).
- Wave height – 1.7 feet at pool 1,690 feet, 1.0 foot at pool elevation 1,532 feet.
- Wave period – 2.5 seconds at pool 1,690 feet, 1.8 seconds at pool elevation 1,532 feet.

A 5-year period is inadequate for reliable long-term extreme estimation. The analysis presented in this report assumes that the Cougar Dam and Mahlon Sweet Field Airport in Eugene, Oregon, separated by approximately 50 miles, both experience the same storm events. The terrain at Cougar Dam, as well as the dam itself, provides protection from the wind and the recorded wind speeds for 2010-2015 are much lower than those measured in Eugene as shown in Figure 7-3. The figure also illustrates the gaps in the data record. A total of 2.83 years of wind speed data is available at Cougar Dam spread over the 5-year time span.

The anemometer at Cougar Dam was located seven feet above the top of the WTCT (elevation 1,745 feet + 7 feet). The FSS will be located in the cul-de-sac at a lower elevation than the anemometer and will be protected by both the dam and the WTCT. The predictions are considered conservative estimates of the long-term extreme wind speeds that will be experienced by the FSS.

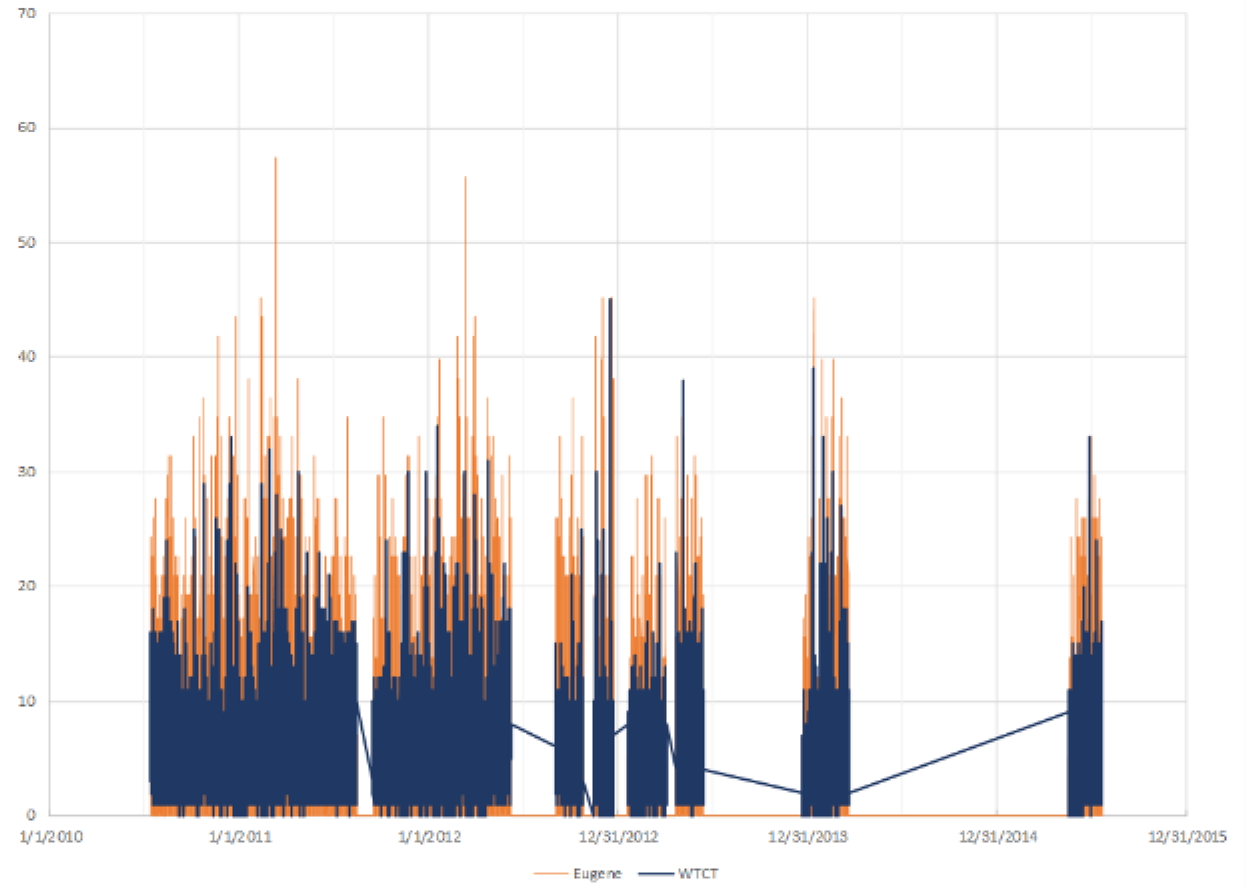


Figure 7-3. Cougar Dam Wind Data vs. Concurrent Eugene Airport Data, 3-Second Gust (mph)

Table 7-9 summarizes the recommended design wind speeds. The table lists both the 3-second gust suitable for calculating wind loads and the mean wind speed used for wave hindcasting. A typical mooring system will not respond to a 3-second gust; however, a 3-second gust may be appropriate for the FSS mooring system given the relatively stiff conceptual arrangement.

Table 7-9. Recommended Design Wind Speeds Based on Cougar Dam Data

Return Period [years]	Wind Speed 3-sec Gust [mph]	Wind Speed 1-hr Average [mph]
100	62	41
300	66	44
3000	76	50

(2) Wave Conditions

Fetch radials for an ACES wave hindcast were drawn using Google Earth. The cul-de-sac limits the fetch to 0.5 miles at low pool and 1.6 miles at high pool. Figure 7-4 shows the assumed fetch radials for pool elevations of 1,690 feet and 1,532 feet, respectively.

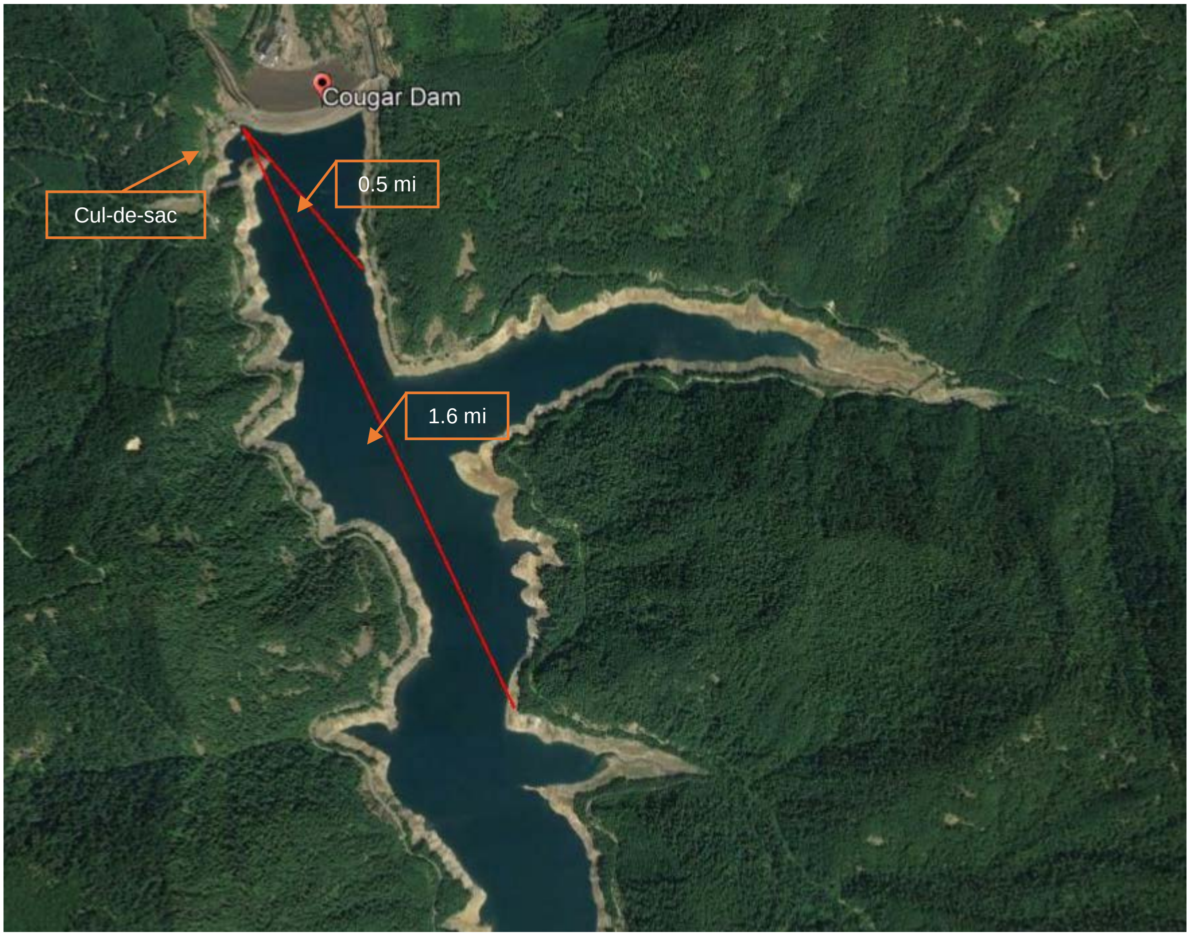


Figure 7-4. Cougar Dam Fetch Radials

Table 7-10 presents results of the ACES wave hindcast for inland wind observations assuming deep water and limited fetch. The hindcast assumes a zero-degree difference between air and sea temperature. The results include the duration of exposure generating maximum wave heights for the given fetch. The table includes results for an

ASCE 7-16 category IV mean wind speed for comparison. Note that the wave lengths associated with the peak period are a fraction of the overall length and width of the FSS.

Table 7-10. Hindcast Wave Conditions

Return Period [years]	Wind Speed* [mph]	Fetch [mi]	Duration [min]	Wave Height Hs [ft]	Peak Wave Period Tp [s]	Wave Length [ft]
100	41	1.6	34	1.6	2.4	29
100	41	0.5	16	0.9	1.7	15
300	44	1.6	42	1.7	2.5	32
300	44	0.5	18	1.0	1.8	17
3000	50	1.6	33	1.9	2.6	35
3000	50	0.5	13	1.2	2.0	20
ASCE 300	59	1.6	26	2.4	2.9	43
ASCE 300	59	0.5	11	1.4	2.1	23

Note: *Wind speed is mean speed = 3-second gust / 1.509

(3) Temporary Mooring & Towing Attachment

A four-point temporary mooring arrangement has been selected. The temporary mooring site has not been located, so the details of the mooring system will need to be analyzed in final design. The temporary mooring shall be capable of maintaining the station of the FSS through a full pool elevation range.

Hand winches were selected for the mooring connections, so that the temporary mooring system does not rely on power generation, which would need to be brought in. Four pre-installed anchors on an anchor spread will be connected to a buoy. Since the site is not selected, the anchor type is not selected either. The anchor type should be selected based on the anchor spread, soil conditions, and calculated anchor loads. When the FSS is brought into the temporary mooring positions via tugs, the soft lines on the hand winches will be run out to the buoys and secured.

Towing is mainly performed by head lines and stern lines connected to bitts or cleats. Given the shape of the FSS and the water it will be transiting, it is not recommended to tow this on a line, therefore towing padeyes are not provided.

7.8 ELECTRICAL SYSTEM

The FSS is to be equipped with an electrical power distribution system with sufficient capacity for fish operations and other necessary platform loads. The normal source of power for the FSS will be the existing site utility connection. An emergency generator on the WTCT will provide limited backup power to the FSS in case of a utility power blackout. The emergency generator is not large enough to allow fish capture operations to continue; see Section 7.8.d. for a discussion of standby power alternatives.

Two shore power umbilical cables will provide power transmission from the shoreside sources (utility and generator) to the FSS. The umbilical cables will be fed through cable reels, adjusting the umbilical length with the elevation of the FSS.

a. Shoreside Power Distribution

Shoreside power distribution for the FSS will primarily be located on the WTCT and will consist of the main utility connection, emergency generator, switchboard, and shore power cable reels.

(1) Utility Connection

The existing utility connection at the WTCT will be modified to power the new shoreside switchboard for the FSS. The details of the modifications required for this connection need to be determined. The FSS shore switchboard provides power distribution to the FSS shore cables, as well as FSS related equipment on shore such as the cable reels and emergency generator battery charger and preheaters. The switchboard also provides switching for the utility feed and the emergency generator power transfer switch system, and monitoring of the FSS shore cables.

(2) Emergency Generator

The emergency generator is located on the WTCT and is sized to provide sufficient backup power to maintain safety of the personnel on and around the FSS and prevent damage to the FSS, surrounding infrastructure, and captured fish. Emergency and navigation lighting, communication and alarm systems, and other essential systems will be provided emergency power to allow personnel to work safely on the FSS during a utility blackout (see Section 7.8.b.(4)).

Emergency power will also be available for all equipment necessary for stopping fishing operations during a blackout and recovering all fish captured on the FSS at the time of shutdown. All equipment required for shutting off water flow into the fish sorting area will be able to be powered by the emergency generator; the emergency generator is not designed to have sufficient capacity to continuously dewater the fish sorting area sumps. The details of the process and equipment required for shutting off flow to the fish sorting area need to be determined. Equipment necessary for fish recovery that is also powered by the emergency generator includes the air compressor, pod hoists and trolleys, and air lift pumps.

The emergency generator and transfer switch must comply with National Fire Protection Association (NFPA) 110 Standards for Emergency and Standby Power Systems. The installation class and type details will be selected based on future determinations of detailed emergency power requirements. The following should be considered when determining the details of the installation:

- An emergency power system that automatically starts and connects upon loss of the normal utility power source should be implemented, unless personnel authorized to manually start and connect the generator will be available at all times at the WTCT.

- The required duration of emergency operations should be based on the following:
  - Duration required to shut down FSS fishing operations and remove personnel from the FSS.
  - Average or expected duration of utility blackouts at the Cougar Dam site.
- Manual bypass switches for the main power transfer switch should be considered to improve reliability and reduce single points of failure.

The emergency generator is equipped for battery start, air-cooling, and should have an integral fuel tank. The fuel tank capacity needs to be determined based on the required duration of operation.

(3) Shore Power Cable Reels and Cable

A set of two shore power cables provides power transmission between the WTCT and FSS. Each cable is equipped with a cable reel to handle the cable as the elevation of the FSS relative to the WTCT changes. The cable and cable reel assembly is configured to accommodate the full range of reservoir elevation change (183-foot range, 1,516-to1,699-foot reservoir elevations) and FSS ballast conditions (~25-foot range, operating to maintenance drafts).

The cables reels are the motor driven mono reel type, which provide constant cable tension over the entire range of reel operation. The shore power cables are custom engineered and manufactured cables intended for a vertical reeling application and designed to accommodate the high tensile loads associated with the required cable length. The following are design features of each cable and reel system:

- Each reel:
  - Is driven by a set of several motors. All motors are fed from the WTCT switchboard, and will be supplied by the emergency generator upon utility blackout.
  - Is equipped with a backstop bearing which prevents uncontrolled deployment of cable if the drive motors malfunction.
  - Is equipped with a magnetic coupling which is set by the reel manufacturer such that the torque at the reel never exceeds the safe working tension of the cable. The magnetic coupling allows the reel to pay out additional cable regardless of the backstop bearing or drive motors.

  - Independently monitors the amount of cable deployed using a rotary encoder included with the reel. The output of the encoder can be combined with FSS draft and reservoir elevation data to provide independent monitoring of cable reel operation. The details of the encoder type and additional data sources need to be determined. It is recommended that the monitoring system produce an alarm to indicate when the deployed cable length does not match the expected length (based on reservoir and FSS data). This alarm will be helpful in detecting excess cable slack which could damage the cable and present a danger to personnel.

- The cable and reel provide transmission for power and data. Data transmission should be restricted to fiber-optics, to eliminate electromagnetic interference from power transmission. All electrical connections (power, ground, pilot signals) will be passed through the cable reel by way of slip rings. Fiber optic signals will be passed through the cable reel by way of a multi-pass transmitter. The following conductors will be included:

  - Three power conductors sized for the maximum required current, including de-rating of cable due to use on reel (~15 percent reduction)

  - Ground conductor sized in according with the National Electric Code.

  - Four pilot conductors to ensure the integrity of the shore connection; three for safe operation of shore and FSS breakers, one ground-check pilot wire for ground continuity verification.

  - Optical fibers for data transmission; the number and type of fibers will be determined upon on refinement of the communication and alarm system requirements (see Section 7.8.c.).

- Reel slip ring enclosure is equipped with electrical heater to reduce condensation.

- Cable connection at the FSS is by a waterproof plug. The plug is equipped with pins for connection of all the electrical connections described above. Details of these connections are as follows:

  - Ground connector is the first to make, last to break type.

  - Pilot connectors are all last to make, first to break type.

  - Fiber optic connections will require a breakout connector to a separate waterproof plug.

During normal operations, both shore cables will operate in parallel to power the FSS. The cables should be oversized for parallel operation to allow the FSS to continue fish operations, with loads reduced, with only one of the two cables in service.

The shore power cable is custom manufactured, and the cable manufacturer requires a minimum order length of 1,000 feet. The additional length of cable is sufficient to serve as a spare cable. It is recommended that a spare cable assembly be procured and be available in case of damage to one of the installed cables. The availability and lead time associated with other parts of the cable and reel system should be assessed to determine if spares should be kept available to avoid prolonged impacts on FSS operations.

Provisions for manual handling of slack cable may be required when the reservoir is at maximum elevation and the FSS is at maintenance draft, as the FSS cable connection may be above the cable reels on the WTCT. Details of these provisions need to be developed based on the final arrangement of the cable reels on the WTCT and FSS cable connection point.

b. FSS Power Distribution

The FSS power distribution system is comprised of a shore connection box, main distribution switchboard, and a 24 VDC battery-backed UPS. The shore connection box will be located in an exterior location below the cable reels installed on the WTCT; most other portions of the electrical distribution system will be located within the Electrical and Control Connex.

(1) Shore Connection Box

The shore connection box will be of robust watertight construction with waterproof receptacle sockets for the two shore power cable plugs and one temporary generator connection plug. The circuit for each socket will include a manual disconnect switch and indicator light.

(2) Main Switchboard

The main switchboard is of the integrated power system type, with main breakers, controls, distribution transformers, and distribution panels integrated in a single assembly built of several section modules. The switchboard assembly includes 480V and 208Y/120V distribution, with separate buses at both voltages for normal and emergency power. Only loads required to operate during utility blackout are fed from the emergency busses. During normal, utility powered operations both the normal and emergency busses are energized.

The main switchboard includes the following safety and control functions:

- Insulation monitoring or ground fault detection for each bus. A fault on any bus initiates an alarm but does not disconnect power.
- Safety interlocks for the main breakers which are supplied from the shore connection box. These interlocks prevent the breakers from being closed under unsafe conditions.

- Management of the power used on the FSS so that the power consumed does not exceed the power available. The details of this system need to be determined. It is recommended that this system be PLC based and configured to manage power consumption using loadshed trip of breakers feeding non-essential equipment and power-limit and run permissive signals to heavy consumers such as the ballast pumps and sump pumps. The management system should be configured to automatically detect the power available and implement different power management procedures based on the operating profiles: Utility Power, Utility Power with one Shore Cable, Emergency Power.

(3) Navigation Lights and Signaling Devices

Cougar Reservoir has several boat ramps and is regularly used by recreational vessels. Vessels operating on the lake need to comply with rules set forth by the Oregon State Marine Board under Chapter 250 of Oregon Administrative Rules. These rules include requirements for navigation lights and signaling devices (refer to OAR 250-011) for a vessel between 12m and 50m of length.

The FSS must comply with all applicable rules, and is equipped with the following navigational devices:

- One all-round light should be permanently installed in a visible location on the FSS. The light should be powered by 24VDC power provided with a backup battery source sufficient for four hours. It is recommended that the all-round light should be left illuminated at all times or provided with a timing mechanism to ensure it is always illuminated between sunset and sunrise.

- A ship’s bell and whistle permanently installed on the exterior of the FSS. The whistle is electronically powered by the UPS backed 24VDC source (see below). When the FSS is moored off-site the whistle and bell should be used in accordance with Oregon State Marine Board requirements during periods of reduced visibility. The use of noise signals should be discussed with local authorities to obtain further guidance regarding the use of noise signals.

- Portable stern, side, and special flashing lights should be available for use while the FSS is in transit. As transit operations will be infrequent and will likely be performed during good visibility and daylight, these lights will not be used frequently and can be stored out of the weather when not in use. These lights should be battery powered and should have a means of fixing in place (such as a magnetic base). The requirement for the portable lights may be omitted if transit operations will never be conducted between sunset and sunrise or in periods of limited visibility.

(4) UPS-Backed 24VDC Power

Electronics for critical systems are powered by a battery-backed uninterrupted power supply (UPS). The following system are powered by the UPS system:

- Communication systems
- Fire alarm system
- Power management system
- Navigation lights and sound signaling devices (whistle)
- Bilge monitoring system

The systems powered by the UPS and the size and capacity of the UPS equipment need to be finalized. Additional systems identified as being critical to FSS safety should be added to the above list. The power and energy capacity of the UPS equipment should be determined based on the final loads and the maximum period of time for which the battery backup system will need to operate.

(5) Electrical Grounding

The steel hull of the FSS is used as the grounding system for the platform, as is typical aboard steel vessels. The chassis of all electrical equipment aboard the FSS is effectively grounded to the hull.

Each of the two shore cables includes a ground conductor sized in accordance with the National Electrical Code or larger. The cable ground conductor is connected through a terminal on the cable reel slip ring to an effective ground on the WTCT. The FSS plug for each shore power cable includes a ground connector pin of the first-to-make and last-to-break type. The shore power circuits are also provided with a ground-check system, similar to that required for trailing cable applications for mining equipment. This system uses a ground check conductor in each shore power cable to ensure that the FSS is connected to the WTCT earth ground and trip open the shoreside FSS supply breakers if ground continuity is lost.

The steel hull of the FSS serves as the primary earth connection for protection in case of lightning strikes. Care should be taken to ensure that all equipment on the deck of the FSS is effectively grounded to the FSS structure. In particular, this includes all cranes, hoists, monorails, maintenance platforms, and Connex deck structures.

(6) Temporary Off-Site Generator

A temporary generator is required when the FSS is relocated to a temporary mooring site away from the main location at the WTCT. While moored offsite, the FSS will not be operating, but will require a small amount of electrical power for monitoring systems, electronics anti-condensate heaters, and a small bilge pump. The shore connection box on the FSS has a plug receptacle to connect the off-site generator.

The size of the generator required for offsite operation and the manner in which it is connected to the FSS need to be determined. The load during off-site operation is expected to be small enough that a commercial portable generator connected directly to the 208Y/120V emergency bus can be used. However, if the load during off-site operations increases above the level currently anticipated, a larger portable generator connected to the 480V emergency bus will likely be required.

c. Communication and Alarm Systems

The FSS is equipped with various systems to provide communication and alarm and monitoring functions. The primary means of voice and data communication between the FSS and shore is through optical fibers in the two shore power cables. The shore power cables are custom manufactured, so the number and type of optical fibers can be made to meet the FSS requirements. Optical fibers are preferred over electronic data cables which would be subject to electromagnetic interference from the power conductors. Converter systems are available for transmission of voice telephone 2-wire signals over fiber optics. It is recommended the shore communication system be composed of two redundant networks in parallel, such that communications are not affected with only one of the two shore cables connected.

A set of monitoring and alarm systems on the FSS ensures that events that could create unsafe conditions on or around the FSS are detected and brought to the attention of the FSS operators and shoreside monitoring. It is recommended that some type of wireless system be installed to allow remote monitoring of the FSS alarms while the FSS is temporarily moored off-site and not connected to the shore power cables. At minimum, the following functions should be part of the alarm and monitoring system:

- Stand-alone fire alarm and monitoring system with smoke and/or heat detectors and manual pull stations.

- Bilge level monitoring.

- Power system and shore connection monitoring.

Additional requirements for communication and monitoring on the FSS need to be determined based on the requirements of the operators and the need to gather data related to fish operations.

d. Standby Generator Alternative

Further work needs to be done to determine if a large standby generator, with sufficient capacity to allow fishing operations to continue during periods of sustained utility blackouts, should be installed. A large standby generator would increase both capital and maintenance costs, but would significantly reduce the possibility that the FSS would have to cease fish capture operations unexpectedly. It is recommended that an analysis be conducted to determine if installation of a large standby generator at the WTCT is beneficial; the analysis should include the increased cost of the large generator, the cost of unplanned disruptions to fish capture operations, and the frequency and duration of previous blackouts at the site.

It should be noted that installation of a large standby generator that allows the FSS to continue normal operations during blackouts will not remove the need for a separate emergency power system. An emergency power system meeting most or all of the requirements outlined in Section 7.8.a.(2) would still be required in addition to the large standby generator.

7.9 AMPHIBIOUS VEHICLE CONCEPT VALIDATION

The maximum width of the amphibious vehicle can be between 9 feet to 12 feet. The payload of the amphibious vehicle is assumed to be 9,200 lbs at 3.1 feet, considering the following:

- Two personnel with associated gear are assumed to be aboard, 200 lbs each.
- 1,000 gallons (total) of fish in fresh water. It is assumed that the specific gravity of fish in fresh water is the same as freshwater, 62.4 lbs per cubic foot. Total water/fish load is 8,400 lbs. Assume 600 lbs for tank and associated equipment (both tanks).
- The fish containers are approximately 5 feet by 5 feet by 5 feet, according to the 3-D arrangement model.
- Tank VCG is approximately 3.1 feet.

The maximum grade the vehicle is required to climb is 8-10 percent, and the vehicle will be equipped with a handling device to deploy the pods at the release site.

The Sealander SII proved to be capable of supporting the planned loads. This is a utility amphibious vehicle that is designed to be an all-wheel drive off-road vehicle while maintaining certified workboat capabilities. The machinery parts are “off the shelf” to simplify procurement and reduce maintenance cost. The arrangement of this AV, with a forward driving position and a clear aft deck is well suited for this purpose.

a. Commercially Available Amphibious Vehicles

(1) Cami Amphibious Responder and Hydratrek Land Tamer

These vehicles are rated at capacities of 2,800 lbs and 1,800 lbs, respectively, much less than the required capacity.

(2) Sealander Marine – SII Commercial Amphibious Vehicle

The Sealander SII proved to be capable of supporting the planned loads. This is a utility Amphibious Vehicle that is designed to be an AWD off-road vehicle while maintaining certified workboat capabilities. The machinery parts are “off the shelf” to simplify procurement and reduce maintenance cost. This AV's arrangement, with a forward driving position and a clear aft deck, is well suited for this purpose. See References 26, 27, and 28 for details.

These amphibious vehicles are designed to the UN Bus and Coach rules, which are more stringent than the USCG Subchapter T rules. The vehicle is designed to provide 100 percent propeller thrust and 40 percent front tire torque for landings. If the grade is greater than a 3:1 ratio, the amphibious vehicle can be modified to an all-terrain vehicle. To get more road clearance, the tire size must increase. This affects the land stability of the vehicle but does not affect marine stability. An A-frame may be added to the stern of the vehicle to support material handling. The vehicle maybe outfitted with floatation tires for increased buoyancy and stability. These are low pressure tires originally designed for the agricultural industry to reduce the impact on soil.

b. Military Amphibious Vehicles

Amphibious vehicles for military use that are in production now are larger but have lower payload capacity because of added vehicle armor weight. There is a secondary market for these vehicles, but maintenance could be an issue. The existing age on the lifespan of the vehicle must also be considered. Given these drawbacks, Glosten does not consider this a viable option, so no stability analyses were performed on these vehicles.

7.10 REFERENCES

1. Statement of Work, Exhibit D, Cougar Floating Screen Structure Contract No. W912BU-17-D-0004, Revised 23 March 2018.

2. Hull Lines Plan, Glosten, Drawing No. CUF1.1045A-101, 18 September 2018

3. General Arrangement, Glosten, Drawing No. CUF1.1045A-102, 18 September 2018.

4. Outboard Profile, Glosten, Drawing No. CUF1.1045A-103, 18 September 2018.

5. Hull Scantling Plan, Glosten, Drawing No. CUF1.1045AG1, Sheets 01-24, 18 September 2018.

6. FSS Structural Support, Glosten, Drawing No. CUF1.1045AG1, Sheets 25-28, 18 September 2018.

7. Hull Form and 3D Model, (3D Model), Glosten, Rev-, 18 September 2018. (FSS Model_Rev-.3dm).

8. FSS Structural Calculations, Glosten, 18 September 2018

9. FSS Structure Model, (3D Model), Glosten, 8 September 2018. (FSS Structure Model_Rev-.3dm).

10. Finite Element Analysis Summary Report, Glosten, Rev P0, 18 September 2018.

11. Floating Flume and Cup Connection System Arrangement, Glosten, Drawing No. CUF1.1045AN1, Sheets 01-06, 18 September 2018.

12. FSS Ballast Tank Capacity Plan, Glosten, Drawing No. CUF1.1045A-1, Sheets 04-06, 18 September 2018.
13. FSS Bilge and Ballast System Schematic, Glosten, Drawing No. CUF1.1045AV1, Sheets 01-02, 18 September 2018.
14. FSS Weight Estimate and Radii of Gyration, Glosten, 18 September 2018.
15. FSS Intact and Damage Stability Analysis, Glosten, 18 September 2018.
16. Flume Connector Naval Architecture Analysis, Glosten, 18 September 2018.
17. Fish Collector Naval Architectural and Ballast Condition Analyses, (.gf and GHS run files), Glosten, 18 September 2018.
18. Flume and Cup Scantling Calculations, Glosten, 18 September 2018.
19. Flume Connection System Weight Estimate and Radii of Gyration, Glosten, 18 September 2018.
20. Motion and Mooring Loads Analysis, Glosten, Rev P0, 18 September 2018.
21. FSS Mooring Arrangement, Glosten, Drawing No. CUF1.1045AP201, 18 September 2018.
22. FSS Relocation Procedures and Workboat Description, Glosten, Drawing No. CUF1.1045AP2, Sheets 02-07, 18 September 2018.
23. Electrical Load Analysis and Equipment List, Glosten, 18 September 2018.
24. Shore Power Arrangement Diagram, Glosten, Drawing No. CUF1.1045AK101, 18 September 2018.
25. Electrical Ground, Cathodic Protection, and Navigation Lighting Requirements, Glosten, 18 September 2018.
26. Crew Access and Amphibious Loading System Arrangement, Glosten, Drawing No. CUF1.1045A-107, 18 September 2018.
27. Amphibious Vehicle Memorandum, Glosten, 18 September 2018.
28. Sealander Stability Investigation, (PDF of GHS readouts), Glosten, 12 September 2018. (AMPHIB_VEHICLE_SCALED_OUTRIGGERS_250+750.pdf)
29. FSS Material Quantity Report, Glosten, Rev P0, 18 September 2018.
30. ABS Approval in Principle and Required Submittal List Memo, Glosten, 8 August 2018.

Note: All references except those provided in electronic format are included in the appendices to this Narrative Memorandum.

SECTION 8 - ELECTRICAL DESIGN

8.1 GENERAL

The Cougar Dam downstream fish passage project electrical features will be designed as described in this section, which covers references, basic data, and other electrical considerations. The electrical systems will be designed to provide adequate power, lighting, and control for the occupancy and use of the floating screen structure (FSS).

8.2 SEISMIC CONSIDERATIONS FOR ELECTRICAL EQUIPMENT

Typical seismic restraints for floor and wall-mounted equipment in the water temperature control tower (WTCT) will be required.

8.3 ELECTRICAL POWER

The existing electrical service to the Cougar intake tower, WTCT, and dam consists of redundant 500-kilovolt-ampere (kVA) feeders which do not have spare capacity for any new high demand or consumption type electrical loads. The redundant 500-kVA dam feeders are fed from the powerhouse 480-V station service auxiliary sections. Since the powerhouse’s double-ended station service is also supplied from 500-kVA transformers and serves all powerhouse and diversion tunnel loads in addition to the dam feeders, there is actually less than 500 kVA available for the dam feeder. According to the as-built drawings a 400-ampere (A) overcurrent device restricts the dam and tower loads to 330 kVA.

Since expansion of the existing electrical distribution system is not supported by Bonneville Power Administration, the current design assumes a gravity based water supply system with no additional pumping or other large electrical loads. The existing portable floating fish collector electrical supply will be reused for powering the new FSS, and the power requirements of the new system will not be allowed to exceed that of the existing portable floating fish collector. The 350 A overcurrent devices feeding the portable floating fish collector restricts the total FSS loads to 290 kVA. Consequently, it is assumed all electrical loads associated with the FSS may be supported by the existing portable floating fish collector electrical feeders as long as the new demand does not exceed 275 kVA. At 275 kVA there is little buffer for future growth. However, further analysis and review of historical electric energy usage at the intake tower is necessary to confirm these assumptions.

The existing emergency generator in the WTCT will remain, and a 100A feeder from the emergency bus will be run to the FSS power delivery system to provide minimal power on loss of the feeds from the powerhouse. Fish collection operations will not continue while the dam is running off of the emergency generator. Load shedding on the FSS will be required when the main feeders are lost and could be incorporated into the PLC control scheme

Reference Plate E-601in Appendix A for the electrical one line showing the source of power. Unfortunately, using the existing portable floating fish collector power supply lacks isolation from critical infrastructure equipment and has significant power restrictions. Reference Appendix G for the detailed load analysis of the current estimated fish loads provided by mechanical design.

The electrical components related to the FSS vessel systems (power distributions, bilge and ballast pumps, room lighting and HVAC, navigation lights, ballast controls, etc.) can be found in Section 7 of this report, prepared separately by the A-E firms Moffat & Nichol, and Glosten. Arc flash analysis and short circuit coordination studies will be performed by the vessel's A-E designer during plans and specs.

8.4 ELECTRICAL CONTROLS

a. Water Temperature Control Tower

The existing 12 gates within the WTCT slots are manually adjusted locally or remotely operated from the Cougar powerhouse and Lookout Point Dam control rooms. It is assumed the downstream fish passage project will require automatic control of the WTCT gates in some manner. Automatic gate control can be accomplished by modifying the existing PLC 5 control system software and/or hardware. Since the existing PLC 5 hardware is no longer supported by the manufacturer, now may be a good time to migrate the PLC 5 equipment to modern hardware. Where possible new hardware shall meet the requirements of the DoDIN APL (Department of Defense Information Network Approved Products List).

b. Floating Screen Structure

One or more programmable automation controllers will interface with various input/output devices including water level transmitters, valve actuators, motor starters, variable speed drives, graphic terminals, flow transmitters, and solenoid valves as required for remote monitoring, alarming, and control of the various processes and systems described in Section 6, Mechanical Design.

8.5 COMMUNICATIONS

Communications will be provided to the FSS for remote operations, monitoring, surveillance, and telephone. Radio links, or a communications cable in the umbilical cable, will be used to link shore communications to the floating structure. The existing analog POTS/PSTN telephone line at the temperature tower will be utilized for the FSS.

8.6 SECURITY AND SURVEILLANCE

Two cameras will be located on the existing WTCT. One will overlook the new FSS and the other will monitor the security gate and access road to the temperature tower. Cameras will also be provided on the floating screen structure for remote monitoring of each channel for blockage and other problems. Outdoor cameras will be Pelco # S6220-EG0 with pan-tilt-zoom. Video monitoring stations will be located on the FSS and incorporated into the existing remote monitoring station at Lookout Point Dam's control room.

PLC equipment will be protected by two layers of physical security, such as a locked cabinet and fence or locked room where possible. Intrusion detection hardware and access card readers are not required and will not be provided. Cybersecurity for the PLC network will follow Portland District policies, once they are established. Until established, ensure that the cybersecurity for the PLC network is coordinated in compliance with ECB 2018-11, which refers to UFC 4-010 06 2016 with Change 1 and the Critical Infrastructure Cyber Security Center of Expertise (CICS-MCX).

8.7 FIRE DETECTION

No monitored fire detection system is presently planned for the site.

8.8 LIGHTNING PROTECTION

According to the National Fire Protection Association (NFPA) 780 Annex L, the acceptable risk is less than the calculated risk, thus a lightning protection system is recommended. See Appendix P for calculations.

8.9 LIGHTING

All new luminaires on the site will utilize light-emitting diode (LED) technology unless otherwise noted. LED light sources have a longer lamp life, minimize power consumption, reduce maintenance, and provide better quality light.

A system of pole-mounted task lighting is proposed for working in low-light conditions. Additional lighting will be provided for illuminating the water surrounding the collector. Lighting will have high color rendering properties where appropriate.

The lighting design will utilize emergency and non-emergency lighting. Office areas, access ways, gangways, facilities, and working areas shall be illuminated by the minimum light levels specified in Table 7-1 of EM 385-1-1, as shown in Table 8-1.

Table 8-1. Minimum Lighting Requirements

Facility or Function	Lux	Foot-candles (lm/ft^2)
Accessways		
- general indoor	55	5
- general outdoor	33	3
- exitways, walkways, ladders, stairs	110	10
Administrative areas (offices, drafting and meeting rooms, etc.)	540	50
Chemical laboratories	540	50
Construction areas		
- general indoor		
- general outdoor	55	5
- tunnels and general underground work	33	3
areas (min 110 lux required at tunnel/shaft heading during drilling, mucking, and scaling)	55	5
Conveyor routes	110	10
Dam Operating Areas (Interior)		
-Tunnels and underground work areas	55	5
-Control Stations	150	15
Docks and loading platforms	33	3
Elevators, freight and passenger	50	5
Temporary Electrical Panels (Interior)	300	30
Temporary Electrical Panels (Exterior)	50	10
First-aid stations and infirmaries	300	30
Maintenance/operating areas/shops		
- vehicle maintenance shop	300	30
- carpentry shop	110	10
- refueling area, outdoors	55	5
- shops, fine - medium detail work	540-325	50-30
- welding shop	300	30
Mechanical/electrical equipment rooms	110	10
Outdoor parking areas	33	3
Toilets, wash, and dressing rooms	110	10
Visitor areas	215	20
Warehouses and storage rooms/areas		
- indoor rack storage	270	25
- outdoor storage	33	3
Work areas – general (not listed above)	325	30

8.10 GROUNDING

Grounding design for the FSS will be provided by the naval architects. Grounding in the WTCT will be as required by NFPA 70.

8.11 CONTROL OF HAZARDOUS ENERGY

All equipment shall be covered by a safe clearance (or lock-out/tag-out procedures) and all energy sources shall be controlled before performing service or maintenance on equipment in which the unexpected energizing, startup, or release of stored energy could occur and cause any of the following: Personal injury, property damage, loss of content, loss of protection, loss of capacity, or harm to the environment. Energy sources include electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or others.

All electrical equipment shall adhere to working clearances required by NFPA 70. Proper lock-out/tag-out stations will be provided as necessary. Electrical equipment will be properly locked-out and tagged-out in accordance with OSHA standard procedures. Refer to 29 CFR Part 1910.147 and 29 CFR 1910.333 and following internet link: https://www.osha.gov/OshDoc/data_General_Facts/factsheet-lockout-tagout.pdf

8.12 REFERENCES

The electrical design shall be consistent with standard engineering practices comply with the latest national codes, construction codes, and life safety codes. The electrical design will follow the list of publications below, where applicable.

DoDIN APL (Department of Defense Information Network Approved Products List), https://aplits.disa.mil/processAPList.action

Engineer Manual 385-1-1, Safety and Health Requirements, 2014.

NFPA 70: National Electrical Code®, 2017.

NFPA 780: Standard for the Installation of Lightning Protection Systems, 2017.

Institute of Electrical and Electronics Engineers C2, National Electrical Safety Code (NESC), 2017.

IESNA Lighting Handbook – 10th Edition, 2011.

UFC 3-310-04, Seismic Design for Buildings, 2013.

SECTION 9 - CIVIL DESIGN

9.1 GENERAL

The project features are shown on Plate 2C-003 in Appendix A: fish release area, amphibious vehicle (AV) garage area, floating screen structure (FSS) access, Rush Creek area, debris boom, and Slide Creek Campground. The scope of civil design for this project will include delineating site access, haul routes and staging areas, temporary environmental controls, and improvements to the site needed for the daily operations and maintenance of the FSS. Improvements under consideration that have been identified so far are: improving the roadway on the forebay side of the dam; improving access into the reservoir for debris removal operations; repair of pavement and drainage issues at the fish release site; siting the AV garage close to the existing garage at the Power House area; and reconnaissance of the U.S. Forest Service (USFS) trashrack on the upstream side of Rush Creek. Recent discussions, not included in this DDR, include improving roadway along eastern bank downstream of dam for AV travel, new security gates with electronic access, and an additional pump/water source at the fish release facility. These will likely be added/explored during plans and specifications.

9.2 SURVEY DATA

The project datum is NAD27/NGVD29, both adjusted for local project datum. The local project elevation datum is +0.96 feet higher than NGVD29 datum. The local horizontal offset is not known.

USACE has acquired planimetric, topographic and bathymetric survey information from the Portland District Survey Section at the powerhouse fish release area, dam area, Rush Creek area, and the Slide Creek Campground area. The dam area and Slide Creek areas were supplemented with Lidar data provided by Dogami. The Slide Creek Campground data was provided in the FSS architect/engineer (A-E) design contract so that the A-E firm can design work surfaces and launch facilities that will be required for assembling and mobilizing the FSS.

9.3 FACILITY ACCESS

The top of the dam and the WTCT are accessed from Aufderheide Drive (National Forest Road 19 [NF-19]) via Oregon State Route 126. State Route 126 is classified as a Group 1 highway by Oregon Department of Transportation. The largest size trucks that can transit along Highway 126 are either a truck-tractor or stinger-steered pole trailer (log truck) with a maximum length of 75 feet overall; or if using a truck-tractor with semitrailer, the trailer can be up to 53 feet long. Exceptions can be made with an oversize vehicle permit on a case-by-case basis.

The downstream fish release site can be accessed from National Forest Road 410 (NF-410). It is located behind a security fence with a gate. The dam’s powerhouse is also within the fenced area and security will need to be maintained during construction. There is ample room within the secure area for contractor to set up a lower staging area if needed. Construction traffic between the release site/lower staging area and the top of the dam can also travel along a switchback alternate access road that is located alongside the emergency spillway. It is not currently in use and has gates on both ends. Based on August site walk, it would also require some rehabilitation and improved stormwater controls along the lower portions. Also, widening and paving along the two switchbacks and guard rails along the upper portions. It would also require some minor clearing and grubbing for use.

Slide Creek Campground is most easily accessed by taking Aufderheide Drive (NF-19) around the west side of the reservoir. The roadway is paved with asphalt and includes a ½-mile long section of gravel road located north of Terwilliger Hot Springs. As of July, 2017 it was found to be in good condition, although on December 2017 it was badly pot-holed. The asphalt pavement ends after passing over the Westside Bridge at the southern end of the reservoir. The gate to the campground is approximately 1 mile from the Westside Bridge. An area close to this section was also closed for several months due to a rockslide that blocked the road and damaged the pavement.

There are three USFS bridges that will be crossed in order to access Slide Creek Campground. They are named Bruckart, South Fork, and Westside bridges. According to USFS Bridge Engineer William Butler, all three bridges have reasonable weight limits and there should not be any issues with obtaining overload permits. USFS requires three weeks for overload permitting; the contractor will need to be made aware of this in the plans and specifications. They will be required to apply for these permits from both the Oregon Department of Transportation and USFS.

The campground can also be accessed by driving National Forest Road 500 (NF-500) around the east side of the reservoir. NF-500 is narrow (approximately 10-12 feet wide) and is not maintained. If construction vehicles were to use this road it would require significant improvements.

9.4 CONSTRUCTION TRAFFIC

Construction traffic and haul roads will be compliance with the USACE safety manual, Engineer Manual 385-1-1. This manual specifies use of the “Manual of Uniform Traffic Control Devices” for highway construction signage. The contractor’s traffic safety plan will address construction traffic entry and exit points onto public roads and traffic control into the site. These requirements will need to be listed in the specifications.

9.5 CONTRACTOR’S STAGING AND WORK AREAS

Contractor’s staging areas will be available at several locations. The powerhouse has a large fenced area with more than 2 acres that are available for staging as needed. There are parking lots next to the spillway and the water temperature control tower, which combined can provide approximately 0.5 acres for construction trailers or equipment staging.

a. Slide Creek Campground

The largest work area that will be available for use is the location that has been chosen for the assembly of the FSS. Initially, there were two options under consideration for the assembly location. The first location is a day use area called Echo Boat Launch. The other location is a USFS campground with boat launch called Slide Creek Campground. Slide Creek was chosen as the assembly location because of the larger area available to work and ease of access. The Slide Creek Campground will provide approximately 3 acres of work area, as well as camp sites that could be used by the contractor. Additional coordination will need to occur with USFS as the design progresses. These include use of campground facilities by contractors (camping trailers, pit toilets, water well), modification of the hand pumped water well and the capacity of water available through the well, possible site modifications including changes to existing pavements (not anticipated, but possible), and construction of a work area that involves modifying the ground surface (grading and importing of rock) below the high water line. There are not currently any plans to place permanent fill below the high water line; the contractor will be required to restore the area to match existing conditions upon completion of construction.

Construction of the FSS at Slide Creek Campground will take place during the extended drawdown to elevation 1,450 feet needed for the excavation and construction at the water temperature control tower. Survey data has been provided to Moffat & Nichol to evaluate the area for FSS construction elevation and floating requirements. As of July 2018, Moffat & Nichol estimated a 10-month construction pad timeframe at elevation 1,662 feet, and a 17-month FSS construction time. See Appendix I for current information.

9.6 SECURITY FENCING, SIGNAGE

The powerhouse and adult fish facility are located within a secured area on the downstream side of the dam. A relatively large open area exists within that fenced area which can be used as staging areas. Temporary security fencing or other security measures will be required around construction areas that are normally open to the public. This will include construction facilities that are created near the boat launch area at Slide Creek Campground, where the FSS will be assembled and launched into the reservoir.

Warning signs and restricted access signs will be posted. It would also be advisable to have the Portland District Public Affairs Office create and post informational bulletins to educate the public about the work that is happening.

9.7 TEMPORARY ENVIRONMENTAL CONTROLS

During construction, storm water will be collected and sediment removed before being released to the reservoir and river. Disturbed work areas will be mulched and unused material stockpiles will be covered during rains producing runoff. Disturbed ground and stockpiles held over the winter will be protected with fiber bonded mulch. Sediment and erosion control measures will be renewed until permanent vegetation and permanent storm runoff control measures are effective.

9.8 ROADWAY IMPROVEMENTS

Transport of juvenile fish by amphibious vehicle requires road surface improvements along the upstream face of the dam. The existing gravel road is used to launch boats and to conduct maintenance and construction activities within the reservoir. If left unimproved, the increased traffic could cause roadway conditions to degrade, resulting in rough driving conditions and more frequent road surface maintenance.

The proposed roadway improvement (see Plate 4CS-101 in Appendix A) would include adding partially buried Jersey barriers to the existing gravel roadway. The barriers would be spaced periodically to allow water to freely runoff between the barriers, and include 8-foot-high (snow) post markers to delineate the road edge. The left barriers are from station 1+00 to 16+75. The right barriers begin at the retaining wall to station 16+90. The gravel surfacing would be widened in a few areas to facilitate debris removal. The widened areas would allow a dump truck to park at an angle to facilitate an excavator loading log debris into the bed. The existing gravel road surface has rounded aggregate from a bad source, this would be replaced with crushed surfacing. Any areas with sharp turns such as at the switchback (station 16+00 to 17+50) would be Portland Cement Concrete (PCC) pavement to prevent rutting. The PCC surface will be finished with a V-groove pattern (typical of boat launches) for traction. New fill would be placed at the same slope as the existing dam embankment 1.8 horizontal (H) to 1 vertical (V) (1.8H:1V). This is utilized until station 21+00 to minimize encroachment into the forebay. Beyond station 21+00, fill (rock disposal) is placed at 2H:1V.

The option of improving the road with a paved surface was discussed and not used. Project personnel thought a gravel surface would require less maintenance. The paved surface option included installing minimum 6-inch thick continuously reinforced PCC pavement. Reinforcement would consist of rebar 12 inches on-center. The pavement would require a minimum 12-inch compacted base course. The side slopes will be protected with riprap. The surface of the roadway will be finished with a V-groove pattern (typical of boat launches) for traction. The improved roadway surface will extend from the top of the dam down to the minimum conservation pool elevation 1,532 feet. Below elevation 1,532 feet, fish transfer operations will not occur.

Geotechnical investigations of the roadway will be conducted in December 2018. Borings into the roadway will help determine if the existing subbase and pavement surfacing are sufficient to serve as a base for the proposed concrete surface. The geotechnical investigations will also lead to the installation of dam monitoring equipment (separate from this project) which will need to be protected from impacts by construction activities.

Construction will need to be timed to ensure full curing of the concrete before reservoir levels become high enough to put water in contact with the un-cured concrete.

The Value Engineering (VE) study recommended using open cell articulating concrete block mats as an alternative to continuously reinforced concrete. This option is under consideration, as is leaving the roadway gravel. The main concern with improving the roadway is that dangerous conditions could occur during winter. Operations staff have the ability to maintain the roadway but there are concerns that the amount of work required to repair rutting will be more than they anticipate.

One VE recommendation that was accepted is to install a barrier system along the roadway. The VE team suggested using buried K-rail barriers so that a low curb is made along the roadway. The height of the curb has not been determined, but initial considerations are for a 1-foot-tall curb with markers extending a few feet above them, so that the location can be delineated by the AV crew when returning to the roadway. Other methods of providing railing can and should be considered.

The spillway access road will be used to transport juvenile fish from the dam crest at the right abutment to the release site. Designs for the improvement of this road, including rock slope stabilization measures, will be performed in the next phase of this project.

9.9 FISH RELEASE SITE IMPROVEMENTS

a. Surface Drainage

Stormwater and drainage system improvements will be made at the fish release site. The existing adult fish facility was constructed with a paved lot that includes two catch basins. These basins are used for collecting both stormwater and runoff from the fish transport trucks that occurs during fish transfer activities. The adult fish facility also includes an 8-inch overflow drain that connects to the catch basin in the parking area. The two catch basins are connected by 12-inch-diameter concrete pipes and drain into the river with an invert elevation of 1,252.77 feet. The storm catch basins and conveyance system appear to be undersized, and they overflow regularly during fish transfer operations. This overflowing is responsible for undermining the base rock in several locations around the asphalt apron, which is cracking in those locations. There is also an existing low spot adjacent to the PCC slab and asphaltic concrete pavement. This asphaltic concrete area could be cut out and repaired (raised) to avoid ponding during the rainy/winter months.

This project proposes to repair the damaged sections of pavement by removing damaged areas and rebuilding the subbase and base, then repaving. The proposal is to contain water on the pavement with curbs and curb cuts to convey surface water flow out at the low point along the river edge (west edge) from fish handling operations; see Plate 2CS-102 in Appendix A. The area on the east, west, and north sides of the asphaltic concrete pavement apron will have a curb installed to prevent fish transfer water from running off the pavement and undermining the pavement during fish transfer operations. Another option is to install curbing and trench drains along the same edges to contain any overflow during fish handling operations. The trench drains are not recommended as they will potentially require cleaning and maintenance to work satisfactorily over time.

Portland District Survey Section conducted a survey of the area the week of November 28, 2017, and the data was received in April 2018. A survey of the in-water portion of the fish drop area still needs to be conducted in order to design the fish flume.

b. Fish Release Water Supply and Flume

Water supply will need to be designed and installed at the fish release site. This water is needed for rinsing out the fish tank to ensure all fish make it out of the tank and remove any debris that remains and possibly bring the truck water temperature within 2 ºC of the fish release site water temperature. Supply for the water line has not been developed yet. This is a new requirement that has been discussed. Flow rate and pressure is not known either. Coordination with Mechanical Design and biologists is needed to determine water supply requirements. The most likely source of water will be the adult fish facility, which pumps water out of the river already; however, the adult facility may be shut down at certain times of the year. Tying into that water supply for this additional purpose will make the operation too complex. The current plan is for new pump and tank to flush and clean the AV tank. No acclimation tanks are planned.

See Section 6, Mechanical Design, for information on fish release equipment.

9.10 POWERHOUSE AREA SITE IMPROVEMENTS

a. Amphibious Vehicle Garage

At the time of this DDR, the final dimensions of the AV were not determined. The arrangement shown in Plate 2CS-103 in Appendix A assumes a garage with fours stalls and a 12-foot by 30-foot parking area. The size of the garage will be refined in plans and specifications, along with any stormwater pond/dispersion sizing. There appears to be ample room for dispersion/infiltration from the garage.

b. Emergency Power Generator

At the time of this DDR, a new emergency generator will not be part of the project. The existing intake tower emergency generator has capacity to supply emergency power to the FSS in case of an outage.

9.11 RESERVOIR DEBRIS REMOVAL

Prior to the development of the downstream fish passage facilities, there has been no regular schedule for removing woody debris from the reservoir. Debris management currently consists of the use of a single log boom to block some of the debris from reaching the dam and WTCT. Winds blowing in the downstream direction move the floating debris until it reaches the boom, and some debris follows the boom to the shoreline, where it can be collected. Boats may also be used to guide debris to the shoreline. The debris boom does not extend below the water surface, so there is a large amount of debris that is able to move underneath the boom.

Movement of debris past the debris booms can be largely reduced, but not altogether eliminated. Further investigation is being done to determine a design of debris boom that will be the most effective at stopping floating and submerged debris, as well as determining the cost effectiveness of employing a series of multiple debris booms. The existing boom appears to be Worthington Waterway Barriers “TOUGHBOOM™”. The existing boom has some areas of damage and will be demolished. In order to inform the design, a Request for Information (RFI) has been advertised by contracting to solicit information that will help determine the types of products available that can meet the requirements of this project. Three vendors (Hydrotika Products, Pacific Netting, and Worthington Tuff Boom) responded to the RFI.

Debris removal operations last occurred in May 2018. Conversations with Portland District Operations staff have indicated that the best time of the year to conduct debris removal operations is early May. This is because the pool reaches its peak height in May, resulting in the greatest amount of debris being floated and available for removal. Waiting too long to remove the debris once it floats will allow some debris to become saturated and sink below the surface, unable to be removed.

Historically, the water level in early May reaches an elevation of 1,680 to 1,690 feet about 70 percent of the time. Over the last 11 years, the longest period with the reservoir not reaching that elevation was 2 years (2015 and 2016). Since debris removal operations may not occur annually, it is sufficient to plan for removal only during years when the reservoir fills to a water level of at least elevation 1,680 feet in May.

a. Right Bank Location

In order to facilitate removal while maintaining fish transportation operations on the dam access road, another location will be developed. See Plate 2CS-106 in Appendix A for the right bank location. It is not practical for the new road to be at least 20 feet wide to accommodate the swing radius of the excavator. Therefore, stockpiling at the water level and loading at the asphaltic concrete roadway area would be the operational plan. A bar gate will be installed at the top of the road to prevent unauthorized access for boat launching, etc. This area extends to approximate elevation 1,686 feet, so corralling debris would be done when the reservoir is above elevation 1,686 feet. This leaves a small window for debris removal and stockpiling at the asphaltic concrete road area. There was some evidence of rock debris falling onto the asphaltic concrete roadway observed during the site visit. If work were to be conducted at the road level, additional rock fall protection may be warranted.

b. Existing Access Road Location

Widened areas along the existing access road on the upstream face of the dam will be constructed to allow trucks to park at an angle and facilitate debris removal during summer drawdown May through August. Anchor points for the debris boom could also facilitate corralling debris and securing the work boat. The area shown on Plate 2CS-106 in Appendix A would be used when the pool is above elevation 1,560 feet, which leaves a larger window for debris removal stockpiling.

The possibility of using the spillway entrance, elevation 1,630 feet, as a work area during this time period was also discussed, to corral and stockpile debris at the entrance and haul out. This idea was discarded as the storing of debris in front of the spillway gates posed unnecessary safety concerns.

Very likely, debris from the barges and from the debris boom would be removed at the same time, since all of the equipment (dump truck, log broncs, excavator) would be on-site. The most recent plan is to be able to remove debris at any reservoir elevation, but it would be more efficient to remove log boom debris during the late spring into summer under a full pool condition so the crew can maximize the collection of floating debris. After full pool condition, the pool would be drawing down as part of the operation and would require more usage of the access road. Coordination for the use of the access road between the AV crew and debris removal personnel will be necessary. When operations are occurring simultaneously, use of the access road by the AV for fish transport and FSS operations will always take precedent.

The boom would require two major items. It would need a gate for general boat traffic and that is large enough to fit AV traffic, and it would need to be able to open up wide enough to pull debris through that has been corralled by log broncs. These requirements should be well defined in the future debris boom design contract documents in plans and specifications.

At this time it is unclear whether USFS will take any of the debris; this is being pursued by USACE Environmental Stewardship Crew.

Anchorage for the new debris booms will also need to be designed by a Structural Engineer. See examples from Cougar Dam and Blue River Dam in the figures below. The anchors could be designed by the debris boom vendor such that it is an integrated system. The debris booms would need to isolate any debris originating from the Rush Creek culvert area as well as the main reservoir. The anchor location shown in previous DDR versions did not isolate this area, and also located the left anchor on an isolated island that can only be access by water or helicopter. This has been moved to the south at the current left anchor vicinity.

Figure 9-1. Left: Existing Anchor Point at Cougar Dam
Right: Existing Anchor Point at Blue River

Figure 9-2. Loading Woody Debris into Dump Truck on Cougar Dam Access Road

9.12 CRANE PAD REMOVAL

A concrete pad that can be used by cranes to remove debris from the WTCT regulating outlet (RO) is currently located next to the WTCT and has a finished grade elevation of 1,534.29 feet. This pad will have to be removed during construction of this project in order to excavate rock to allow the FSS to operate within this elevation. In the absence of the crane pad, the PDT is considered two options for managing debris that builds up around the structure; both of these have been removed from consideration.

a. New Access Road

The first option involves constructing a new access road on the northwest side of the WTCT, constructing a crane pad and using that location to remove debris in the future. This option was discarded due to the topography of the area. The side walls of the reservoir are very steep. Construction of an access road would require extensive blasting for rock removal, and likely require the relocation of the existing Aufderheide Drive to accommodate the road width. If a road was built, it could not go to a low enough elevation or be near enough to the RO to reach the debris without also building some sort of cantilevered platform. This would be a very extensive construction activity in order to build a pad for debris removal, which would not be done on a regular basis. Additionally, the installation of new debris booms and regular removal operations will likely reduce the buildup of debris, further reducing the need for debris removal.

b. Barge and Excavator

The second option is to use a barge and excavator to remove debris via a floating plant. This has also been removed from consideration do to the long-term operations and maintenance (O&M) costs, safety concerns, and long lead times required to conduct debris removal operations from a floating plant.

9.13 RUSH CREEK TRASHRACK AND ROUTING

An existing culvert is located upstream of Cougar Dam, between Rush Creek and the reservoir. This is a USFS culvert, and coordination with USFS will need to take place to get repairs in place and determine any maintenance agreements. The exact dimensions and type of culvert are still unknown, though it is assumed to be 5-10 feet in diameter and made of corrugated steel. With the recent drawdown, the culvert has become accessible, and two debris screen locations are located on a concrete headwall; both allow water to flow into a single culvert.

There is an existing gravel road off to the right of Aufderheide Drive, past the temperature control tower, which may lead down to the culvert for construction access. Further investigation of the gravel road access, trash rack installation, and debris removal will be discussed in plans and specifications.

During deep drawdown, Rush Creek entering the reservoir forebay requires channeling by the contractor to clear soil and debris and keep the creek along the left bank away from the tower.

Figure 9-3. Rush Creek During Deep Drawdown

9.14 SITE RESTORATION

Areas that are disturbed during construction will be restored to existing conditions upon the completion of work unless stated otherwise in the drawings and specification.

9.15 EXCAVATION DISPOSAL

Rock and overburden excavation is anticipated to produce approximately 15,000 cubic yards of rock (neat line). A bulking factor of 1.4 requires 21,000 cubic yards of disposal area. Two locations were considered – the old quarry downstream of the powerhouse, and the forebay adjacent to the dam embankment. The forebay disposal area is preferred, as it is located immediately adjacent to the excavation area, thereby minimizing hauling, and the excavated rock can be put to beneficial use during the improvement of the reservoir access road.

a. Forebay Elevation 1,479-Foot Turnaround

Disposal of excavated rock along the upstream dam embankment from station 16+50 to 28+35, elevation 1,552 to 1,479 feet, is estimated at 21,000 cubic yards, using a 2H:1V poolside slope beyond station 21+00; see Plate 4C-204 in Appendix A. The disposal area utilizes a turnaround with a 50-foot radius at elevation 1,479 feet. The disposal roadway is

12 feet wide. The left roadway fill from station 16+80 to 22+00 is over-widened, with zero slope from the left road edge to the embankment.

b. Forebay Elevation 1,470-Foot Turnaround (Not Sufficient Volume)

A turnaround at elevation 1,470 feet was evaluated and can hold approximately 16,540 cubic yards of rock disposal.

9.16 REFERENCES

U.S. Army Corps of Engineers. Engineer Manual 385-1-1, Safety and Health Requirements Manual.

U.S. Department of Transportation. Manual on Uniform Traffic Control Devices, for Streets and Highways, U.S. Department of Transportation, Federal Highway Administration; and Oregon Supplement, Standard Practice and Interpretations, Oregon Department of Transportation.

Oregon Department of Transportation. Truck Size and Length Limits, https://www.oregon.gov/ODOT/MCT/docs/size_limits.pdf

UFC 3-201-01, Civil Engineering, 1 June 2013.

SECTION 10 - GEOTECHNICAL DESIGN

10.1 GENERAL

This section summarizes the existing regional and site geologic conditions, the probable foundation conditions, and the subsequent geotechnical design recommendations for the proposed downstream juvenile fish passage facility at Cougar Dam.

10.2 LIMITATIONS OF GEOTECHNICAL DATA

No new explorations or laboratory testing have been performed for the design of the Cougar Dam downstream fish passage project and its features. The adoption of the geotechnical design values, establishment of geotechnical features, and the geologic conditions described herein are based on extensive historic construction records, prior site explorations, and prior design and construction efforts around the facility. This previous work was judged to be sufficient to characterize the site and design the proposed facilities. Expected site conditions will be verified through exploratory drilling and laboratory testing planned to take place early in the plans and specifications phase of the project and upon construction, which may necessitate modification to proposed design, barring any significant deviations from assumptions described in this section.

10.3 EXISTING GEOLOGIC CONDITIONS

a. Regional Geology

Cougar Dam is located at the transition zone between the Western Cascades and High Cascades geologic provinces in Oregon. The site lies along the faulted boundary between the young volcanic province of the High Cascades and the deeply eroded, uplifted Western Cascades. The geologic area is characterized by early and middle Tertiary pyroclastics, lava flows, and contemporaneous intrusive rocks. The lavas and pyroclastics were subsequently intruded by igneous dikes, sills, and stocks of varied types. These units have in turn been gently folded and faulted by tectonic deformation.

The oldest rock unit in the area is the Oligocene to lower Miocene tuff of Cougar Reservoir, which consists of tuffaceous debris-flow deposits, volcanoclastic sandstone, and mudstone with subordinate non-welded ash-flow tuff and minor welded ash-flow tuff. This primarily water-laid series was later faulted and intruded by basaltic to dacite dikes. These units were later covered by middle and upper Miocene basaltic to andesitic lava flows with some pyroclastic interbeds. Faulting and intrusives played an integral part in the structural deformational phases of the rock with hydrothermal processes altering the rock along the dacite/tuff contacts and along major fault planes.

b. General Site Geology

The site geology of the Cougar Dam area is described extensively in the 1957 Geology and Foundation memorandum (DM 10), the 1964 Foundation Report, and the 1997 Foundation Investigation report for the diversion tunnel (USACE 1957, 1967; Squier, 1997). Additional information can be found in the 1988 Geologic Map of the McKenzie Bridge Quadrangle (Priest, et al. 1988). Conditions in the immediate vicinity of the intake are described in the 1997 Cougar Lake Willamette Temperature Control Intake Structure memorandum, DM 21, and that project's associated Geotechnical Baseline Report (GBR) (USACE 1997).

The two primary rock units within the foundation of Cougar Dam are a series of bedded tuffs, referred to as the Cougar Dam Tuffs, and a younger unit of intrusive dacite, referred to as Cougar Dam Dacite. Boring logs and geologic maps from original dam construction refer to this dacite unit as basalt, but will herein be referred to correctly as dacite. The dam's right and left abutments are formed by the massive Cougar Dam Dacite intrusion, as shown in Figure 10-1. Across the valley floor, the river has eroded through the dacite separating it into two abutment masses.

The proposed project location is situated within a narrow notch that was excavated into the left abutment of the dam, where the foundation rock is solely comprised of Cougar Dam Dacite. No new explorations have been conducted for the FSS project. However, three borings were drilled during the original construction of the intake to investigate a major dike and fault zone that crossed the northeastern portion of the excavation. The angled borings were drilled to elevations 1,411 feet to 1,460 feet. A fourth boring drilled nearby at the diversion tunnel indicates that the dacite overlies the bedded layers of mudstone and lapilli tuff that make up the Cougar Tuffs. Figure 10-2 provides the boring locations relative to the intake structure, and the associated boring logs are provided in the geotechnical appendix. Eight additional exploratory borings were drilled in 1997 from inside of the diversion tunnel, (Squier 1997). Location of the borings is given on the boring log. The results of their explorations confirm the stratigraphy as developed from prior borings.

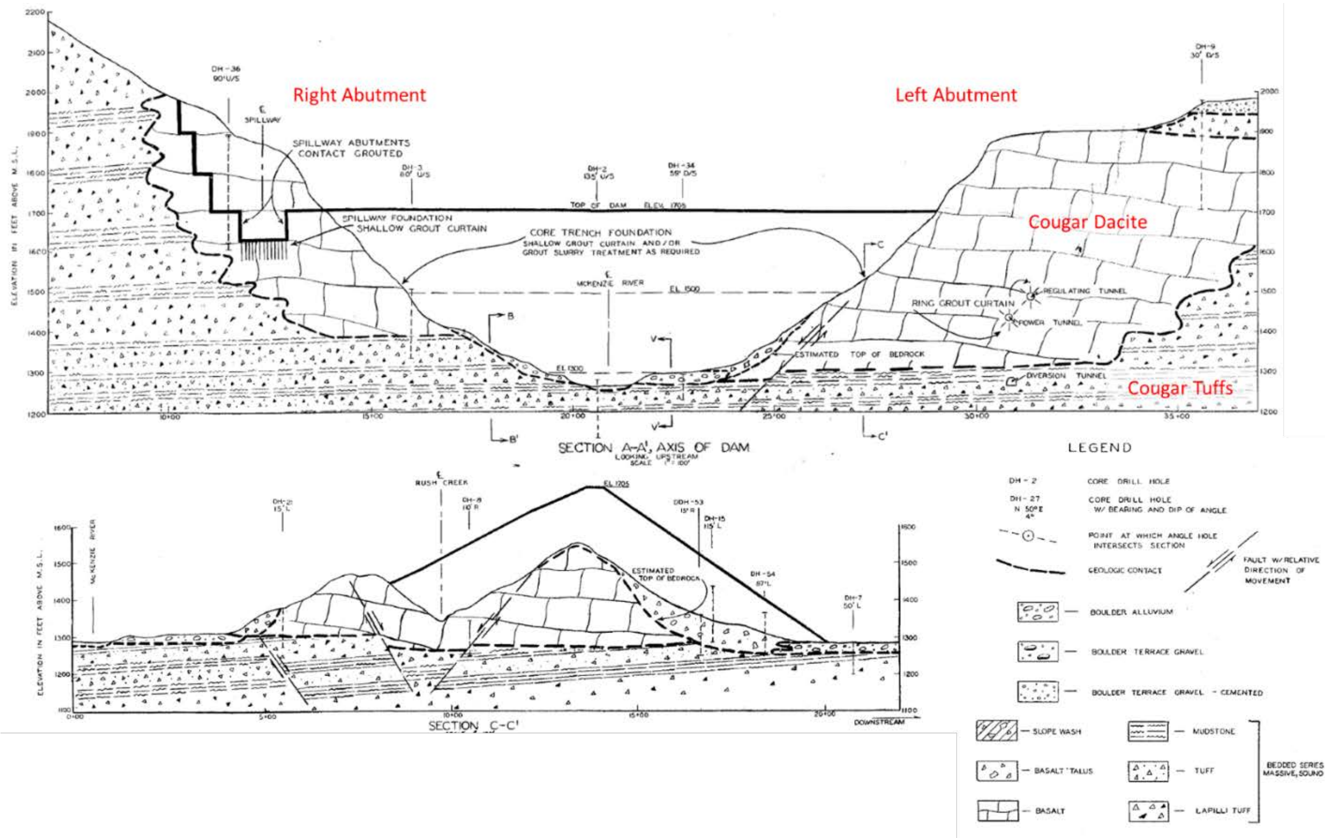


Figure 10-1. Geologic Map Showing Approximate Extents of Dacite and Tuffs, as Taken From 1964 Foundation Report

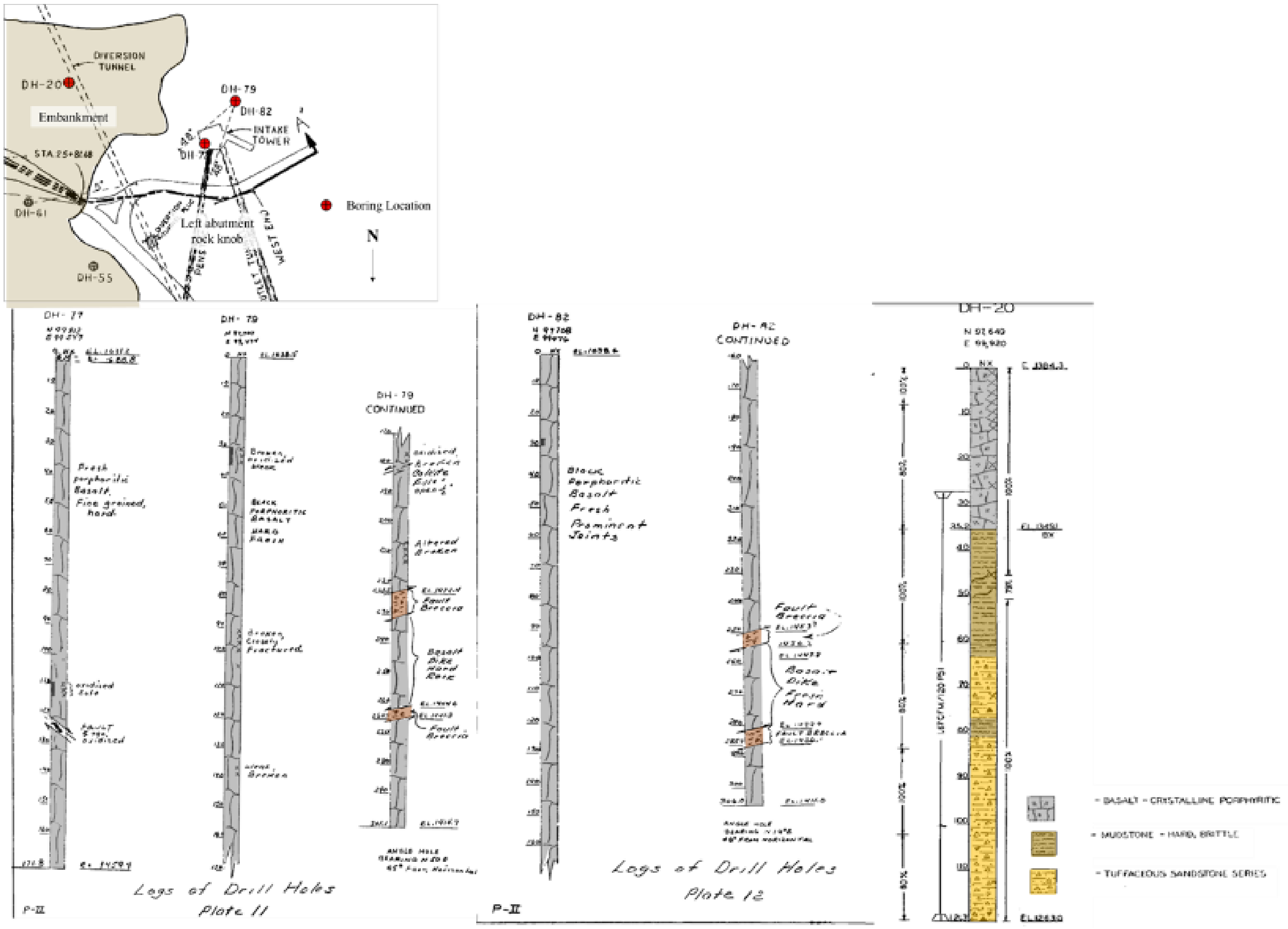


Figure 10-2. Boring Locations and Logs Taken Near the Intake During Original Construction

c. Existing Intake Structure and Water Temperature Control Tower

Existing conditions at the intake structure are based on the historic borings since no new geotechnical explorations have been conducted in the immediate vicinity of the proposed floating screen structure (FSS) yet. Construction records indicate that little to no overburden covered the bedrock in the vicinity of the intake structure. That which was removed during construction was scattered in limited patches 1 to 2 feet thick, consisting of weathered rock fragments in a silty matrix. Any overburden remaining in the area is expected to be localized shallow accumulations of rock fragments and soil.

The foundation for the intake structure consists entirely of massive, gray Cougar Dam Dacite. The dacite is unweathered, fine-grained, and hard with relatively little oxidation and mineralization. This observable feature is herein informally referred to as the rock knob and serves as the foundation of the embankment dam's left abutment. Based on geologic maps from the original construction, the contact of the Cougar Dam Dacite with the underlying Cougar Tuffs is roughly between elevations 1,300 feet and 1,350 feet. The rock knob is characterized by prominent, jointing trending between N20°W and N40°W and dip 70 to 85 degrees to the northeast. A series of closely spaced multiple near-parallel faults make up a larger fault zone approximately 80 feet wide, which trends across the northeast part of the penstock intake foundation. The fault zone parallels an intruded basalt dike. Individual faults generally strike between N40W and N50W and dip steeply in both directions. Gouge and brecciated zones are associated with the individual faults, with gouge zones up to 12 inches wide. The fault zone is present within the northeastern corner of the penstock structure foundation and caused slope stability problems for the northeastern cuts during the original intake excavation, including the trashrack bridge pier foundation, but reportedly did not affect the bearing capacity of the rock (USACE, 1964). Figure 10-3 shows a photo of the original intake excavation with an overlain outline of the approximate limits of the structure. Figure 10-4 shows the approximate extent of the fault zone uncovered during excavation. Figure 10-5 shows the same fault and dike zone highlighted on the photo and field sketches.

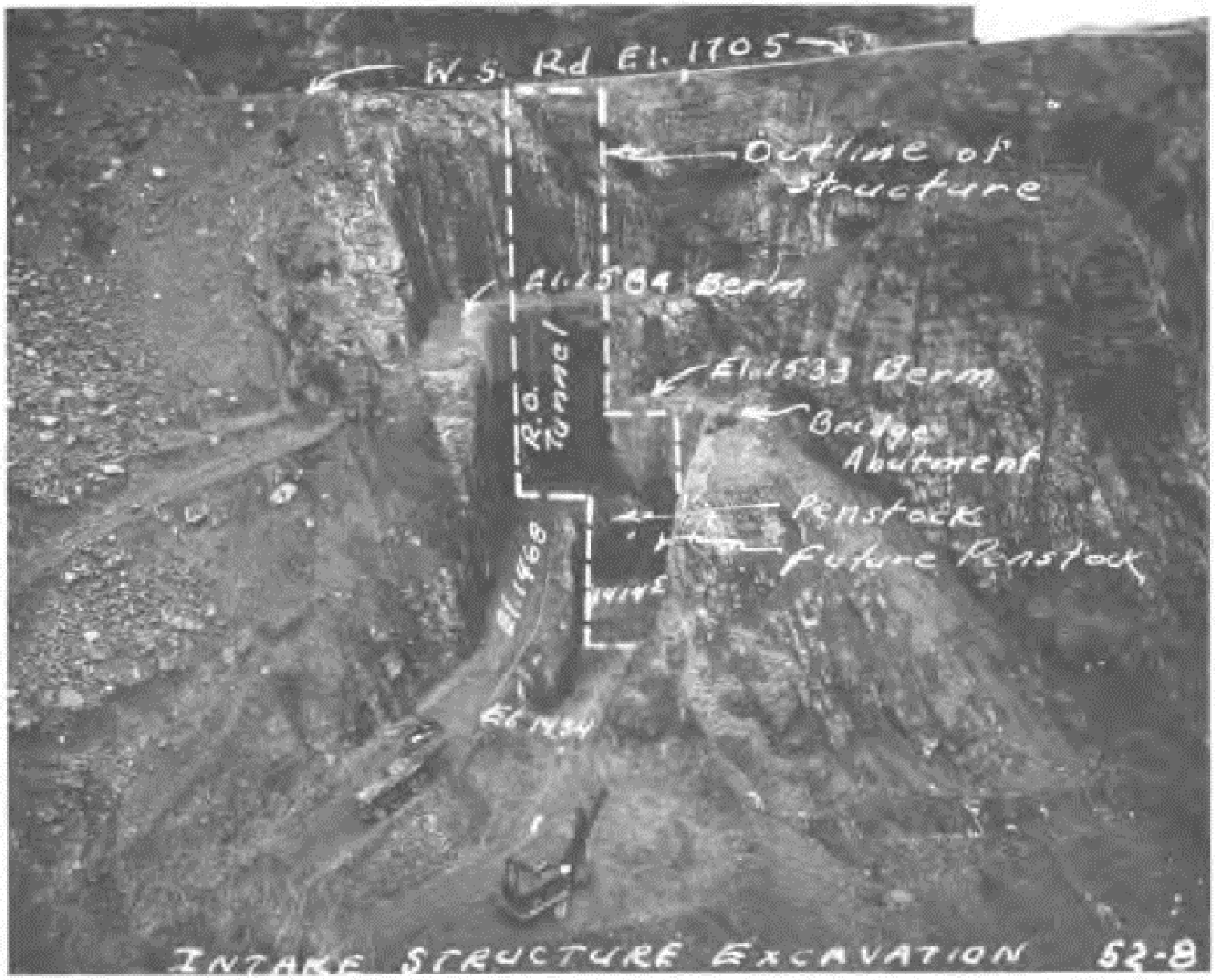


Figure 10-3. Original Intake Excavation: Dashed Outline Shows Location of the Intake Structure

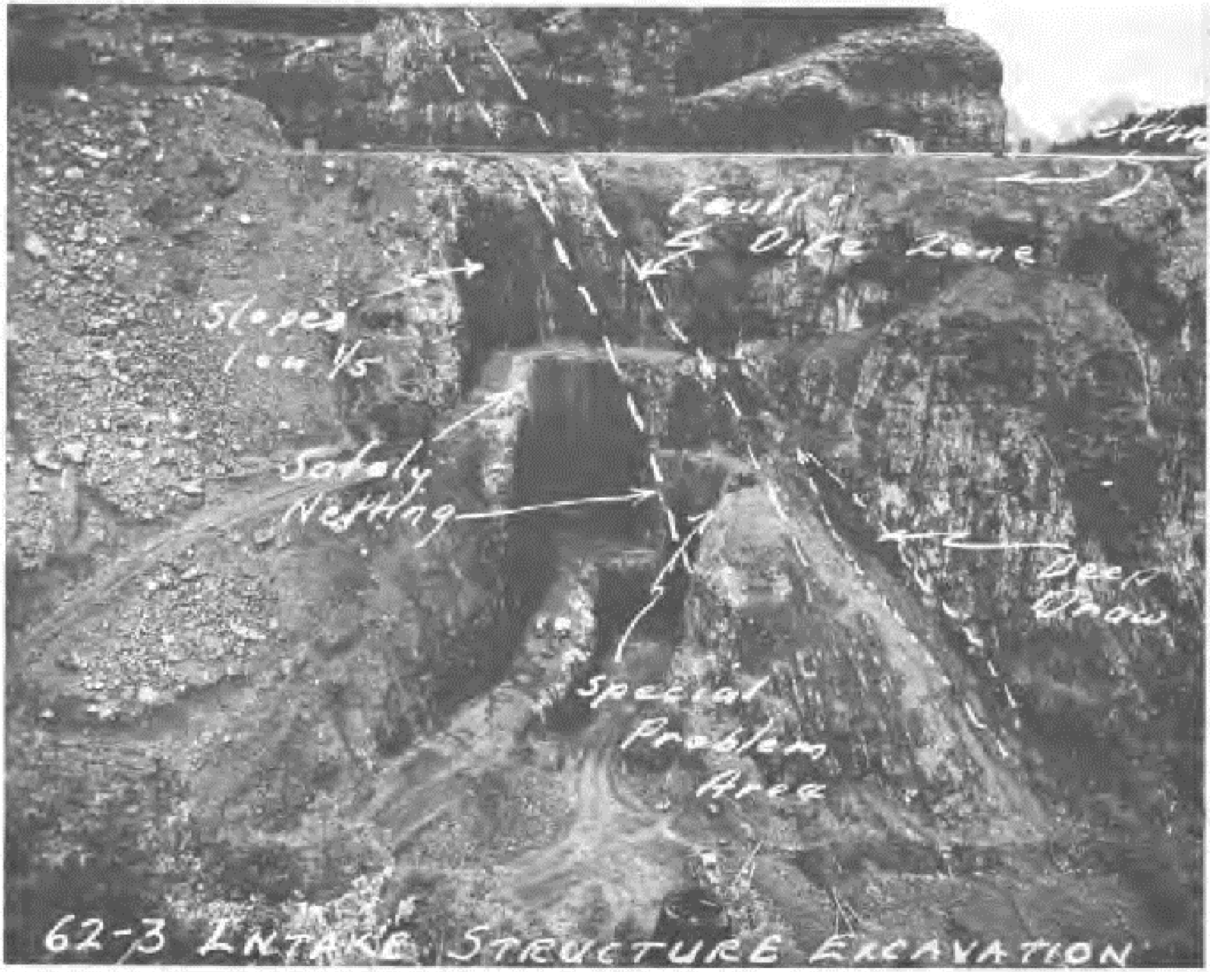


Figure 10-4. Extent of the Fault and Dike Zone Uncovered During Intake Excavation

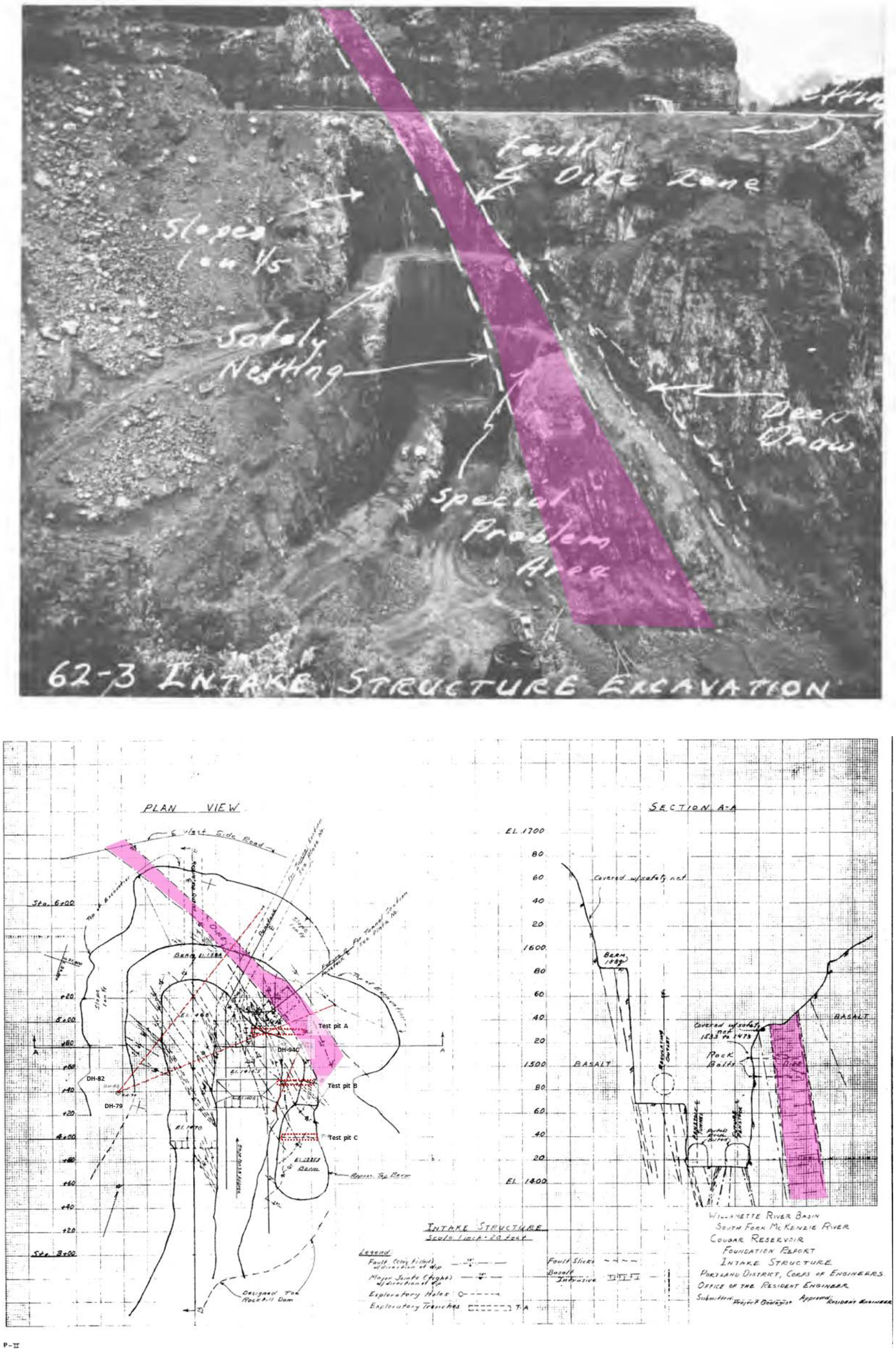
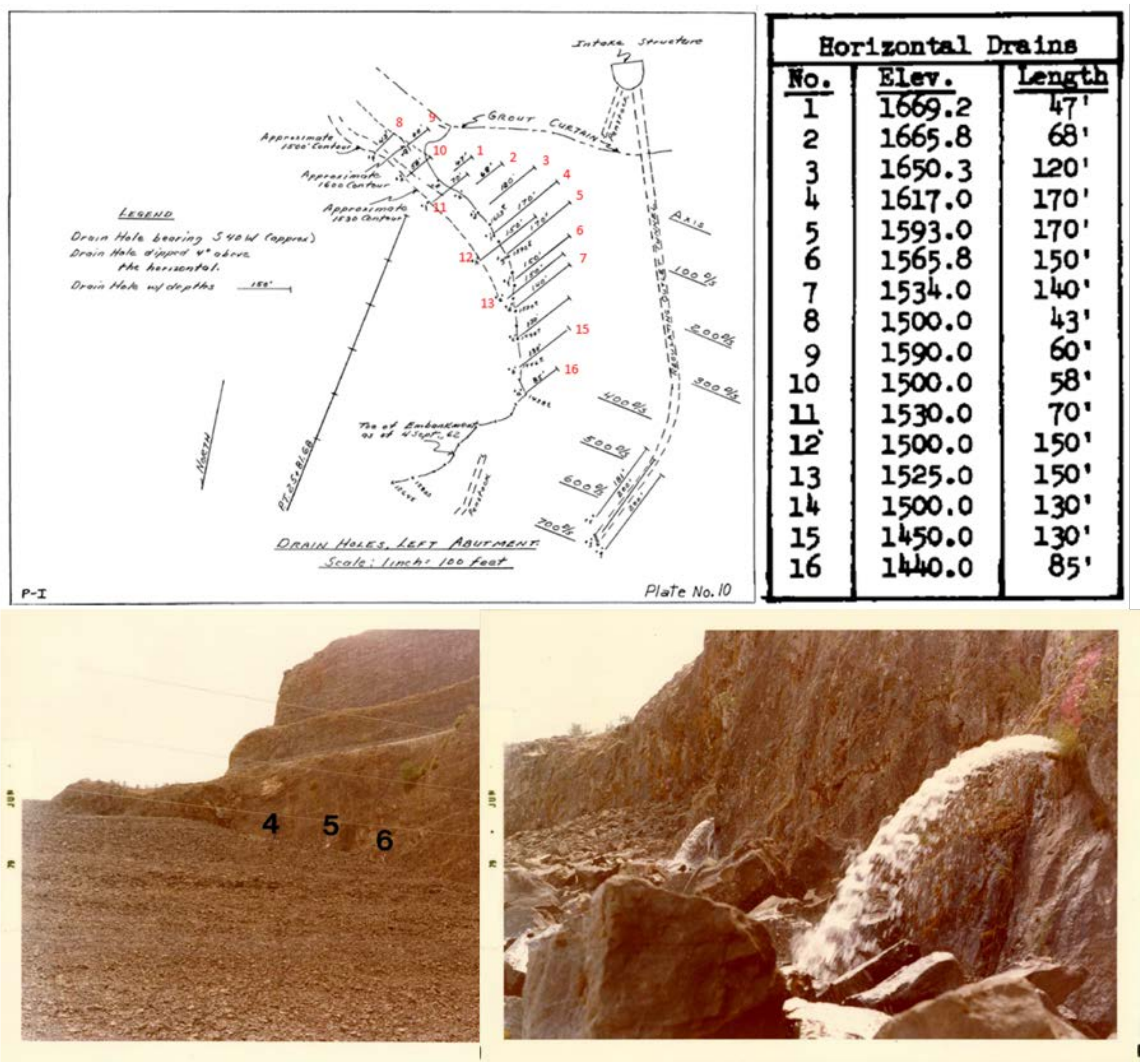


Figure 10-5. Photo of Intake Structure Excavation (top) and Field Sketches (bottom) With Location of Basalt Dike in Pink

The FSS is located between the southeast side of the existing intake tower and northwest of the embankment dam’s left abutment. New exploratory borings have not yet been conducted for this project, and all expected conditions are currently based on the interpretations of prior work in the vicinity. It is assumed that the project footprint will remain within the immediate vicinity of the intake structure and encounter similar conditions (rock mass and geologic jointing and faulting) described in historic construction documents. Foundation elements and rock reinforcement for the proposed FSS are expected to bear exclusively on Cougar Dam Dacite. If the footprint of the FSS extends nearer to the valley section, deeper foundation elements could penetrate into the underlying Cougar Dam Tuffs (bedded mudstone and lapilli tuff), though this is not expected given the current site plan. Excavation for the FSS will likely intersect the fault and dike zone, which will be a consideration in excavation design and location and depth verified during plans and specifications phase explorations. Subsurface conditions will be verified throughout construction with modifications to design implemented as necessary.

Minor amounts of groundwater were observed seeping from the left abutment during original construction. Currently, water is observed periodically flowing from the horizontal drains installed on the downstream side of the left abutment rock knob. The drains were originally designed to maintain drainage of the left abutment. The as-constructed locations are shown in Figure 10-6. Drains 4, 5, and 6 are clearly visible with a set of binoculars and have historically shown the most flow, though many of the other drains are obscured by vegetation or by rockfill placement. The amount of flow has historically been recorded qualitatively (e.g. dribble, trickle, full flow, etc.) since the drains locations are difficult to access, though the original foundation report documents the estimated flow during precipitation events to be 1 to 5 gpm per drain hole.



Horizontal Drains

No.	Elev.	Length
1	1669.2	47'
2	1665.8	68'
3	1650.3	120'
4	1617.0	170'
5	1593.0	170'
6	1565.8	150'
7	1534.0	140'
8	1500.0	43'
9	1590.0	60'
10	1500.0	58'
11	1530.0	70'
12	1500.0	150'
13	1525.0	150'
14	1500.0	130'
15	1450.0	130'
16	1440.0	85'

Figure 10-6. Left Abutment Horizontal Drains Locations (top)
and Observed Flows in Drains 4, 5, and 6 (bottom)

Weir flows from the left abutment toe drain are higher than those collected on the right abutment by about 150 gpm when the reservoir level increases above elevation 1,650 feet. It is surmised that the groundwater regime through the left abutment rock is influencing this flow, as well as the observed flow seeping from the left abutment downstream horizontal drains. As such, groundwater is expected to be encountered in the dacite rock face during construction depending on the time of year and could potentially cause localized rock instability in the work area. Temporary rock support will need to consider dewatering of the rock during rapid drawdown, and horizontal drains may be required during construction to relieve hydrostatic pressures. Groundwater conditions in the rock knob will be verified during the planned geotechnical explorations.

d. North Sunnyside and Slide Creek Campground Areas

The FSS will be constructed at one of two upstream sites along the eastern edge of the reservoir. Slide Creek Campground is along the east side of the reservoir upstream of the embankment dam, as shown on Figure 1-2. No explorations were conducted near Slide Creek Campground or North Sunnyside during the dam's original construction. Geologic mapping of the area characterizes the deposits at Slide Creek as Quaternary surficial deposits composed of a mix of unconsolidated alluvial and colluvial sediments. Much of the material is ancient landslide deposit overlying ancient alluvial deposits, so is expected to be a mix of silt, sand, gravel, cobbles, and boulders. The North Sunnyside area is a relatively flat area just south of Slide Creek on the east side of the reservoir, and is mapped as Pleistocene glacial outwash deposits.

e. Proposed Explorations

An exploration program targeting the main features of the FSS is planned for fall and winter of 2018/2019 during normal seasonal drawdown. Figure 10-7 shows the proposed borings around the intake area alongside historic explorations. Dashed lines represent borings drilled at an angle. Table 10-1 lists the proposed parameters of individual borings, which are subject to change as the design is advanced. The objectives of these borings are to explore the location of the bedrock, and characterize the rock properties for the intended design purposes.

Figure 10-8 shows the locations of the proposed test pit explorations at Slide Creek and North Sunnyside FSS construction areas.

Explorations within the vicinity of the FSS will consist of twelve drilled borings. Access to ten of the twelve boring locations will require that the reservoir be lowered 16 feet below normal low pool to minimum power pool (1,516 feet), which has been arranged to take place during the normal low pool period in the winter of 2018/2019. Borings for foundation features will terminate a minimum of 30 feet into bedrock. Some borings will require drilling through a portion of rockfill shell before reaching bedrock, which will require cased drilling methods and methods that adhere to ER 1110-1-1807. Borings to inform on blasting and rock reinforcement design will extend a minimum of 10 feet below the proposed excavated finish grade. The intent of the borings is to reduce the uncertainty in rock quality in the fault zone and top of rock elevation within the planned FSS work area. Currently, the top of rock is being estimated from pre-construction top of rock 10-foot contours. Rock quality, including amount of gouge and frequency of fractures, in the fault zone along the northeast corner of the intake area is not well-documented in construction boring logs, and all design parameters for dacite from original construction and water temperature control tower (WTCT) construction are applicable only to intact samples, which may be conservative. In addition to rock mass characterization, select core samples recovered from the borings will be subjected to unconfined compression strength testing.

An optical borehole imager will be lowered into all of the borings for in-situ joint mapping of the rock mass. Surface geologic mapping will be conducted in coordination with the drilled borings, which will assist in the design of rock slope reinforcement. Finally, mooring tower borings will be packer tested in order to determine the permeability of the rock fractures and therefore the expected amount of grout loss during construction of rock anchors.

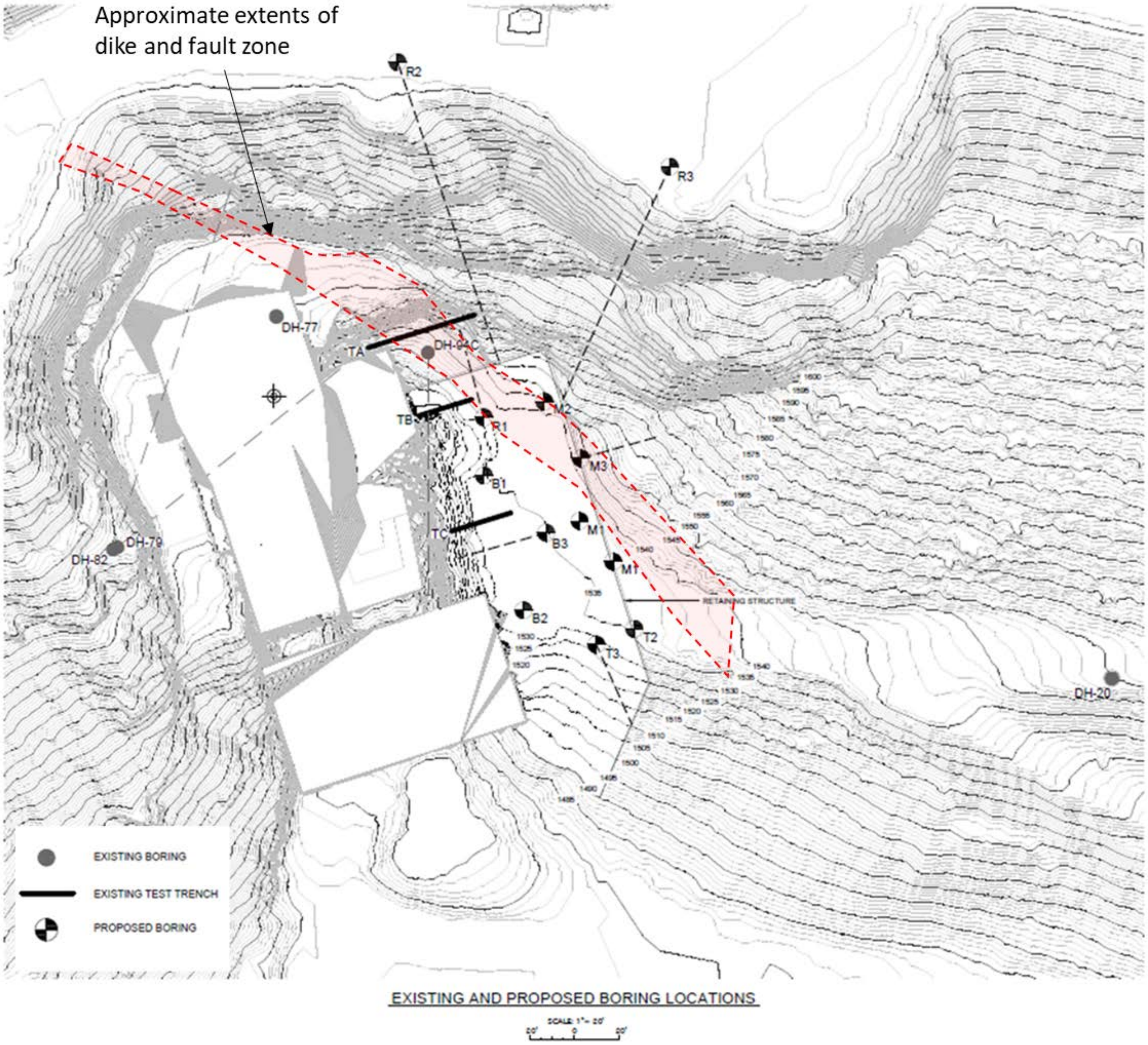
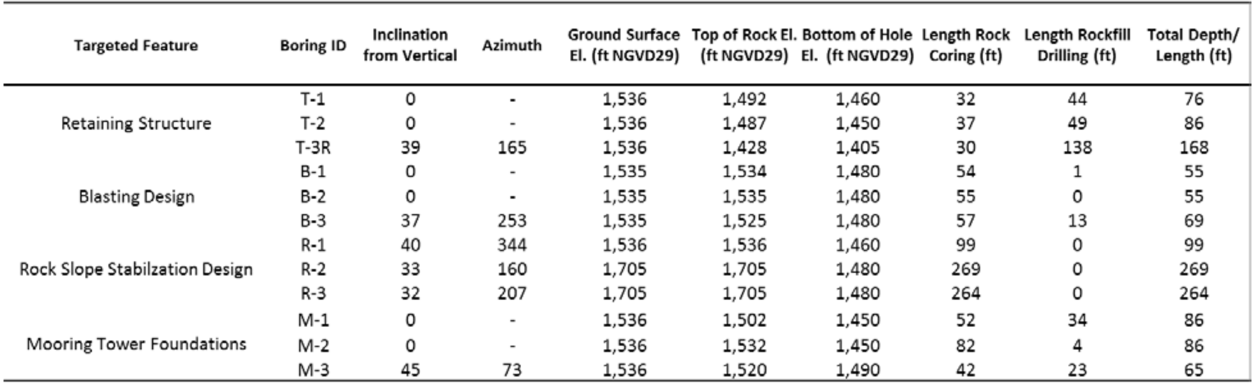


Figure 10-7. Proposed Borings Near the Intake

Table 10-1. Proposed Boring Parameters



Targeted Feature	Boring ID	Inclination from Vertical	Azimuth	Ground Surface El. (ft NGVD29)	Top of Rock El. (ft NGVD29)	Bottom of Hole El. (ft NGVD29)	Length Rock Coring (ft)	Length Rockfill Drilling (ft)	Total Depth/ Length (ft)
Retaining Structure	T-1	0	-	1,536	1,492	1,460	32	44	76
	T-2	0	-	1,536	1,487	1,450	37	49	86
	T-3R	39	165	1,536	1,428	1,405	30	138	168
Blasting Design	B-1	0	-	1,535	1,534	1,480	54	1	55
	B-2	0	-	1,535	1,535	1,480	55	0	55
	B-3	37	253	1,535	1,525	1,480	57	13	69
Rock Slope Stabilzation Design	R-1	40	344	1,536	1,536	1,460	99	0	99
	R-2	33	160	1,705	1,705	1,480	269	0	269
	R-3	32	207	1,705	1,705	1,480	264	0	264
Mooring Tower Foundations	M-1	0	-	1,536	1,502	1,450	52	34	86
	M-2	0	-	1,536	1,532	1,450	82	4	86
	M-3	45	73	1,536	1,520	1,490	42	23	65

Table 10-2. Existing and Proposed Geotechnical Explorations Around Water Temperature Control Tower

Targeted Feature	Boring ID	Inclination from Vertical	Azimuth	Ground Surface El. (ft NGVD29)	Top of Rock El. (ft NGVD29)	Bottom of Hole El. (ft NGVD29)	Length Rock Coring (ft)	Length Rockfill Drilling (ft)	Total Depth/ Length (ft)
Retaining Structure	T-1	0	-	1,536	1,492	1,460	32	44	76
	T-2	0	-	1,536	1,487	1,450	37	49	86
	T-3R	39	165	1,536	1,428	1,405	30	138	168
Blasting Design	B-1	0	-	1,535	1,534	1,480	54	1	55
	B-2	0	-	1,535	1,535	1,480	55	0	55
	B-3	37	253	1,535	1,525	1,480	57	13	69
Rock Slope Stabilzation Design	R-1	40	344	1,536	1,536	1,460	99	0	99
	R-2	33	160	1,705	1,705	1,480	269	0	269
	R-3	32	207	1,705	1,705	1,480	264	0	264
Mooring Tower Foundations	M-1	0	-	1,536	1,502	1,450	52	34	86
	M-2	0	-	1,536	1,532	1,450	82	4	86
	M-3	45	73	1,536	1,520	1,490	42	23	65

In addition to drilled borings around the intake, six test pits will be excavated to a maximum depth of 12 feet in the proposed construction staging area for the FSS at Slide Creek and another twelve test pits at the North Sunnyside site (Figure 10-8). This work does not require a special reservoir operation and both sites will be accessible during normal winter reservoir operations. Therefore, this work is expected to be completed in fall of 2018. Select samples will be collected and laboratory tested for soil classification. The intent is to better characterize the overburden and determine its suitability for cut and fill activities. This information will be provided to the contractor, who will be responsible for designing and constructing a suitable work pad for the FSS at the site of their choice (Slide Creek or North Sunnyside).

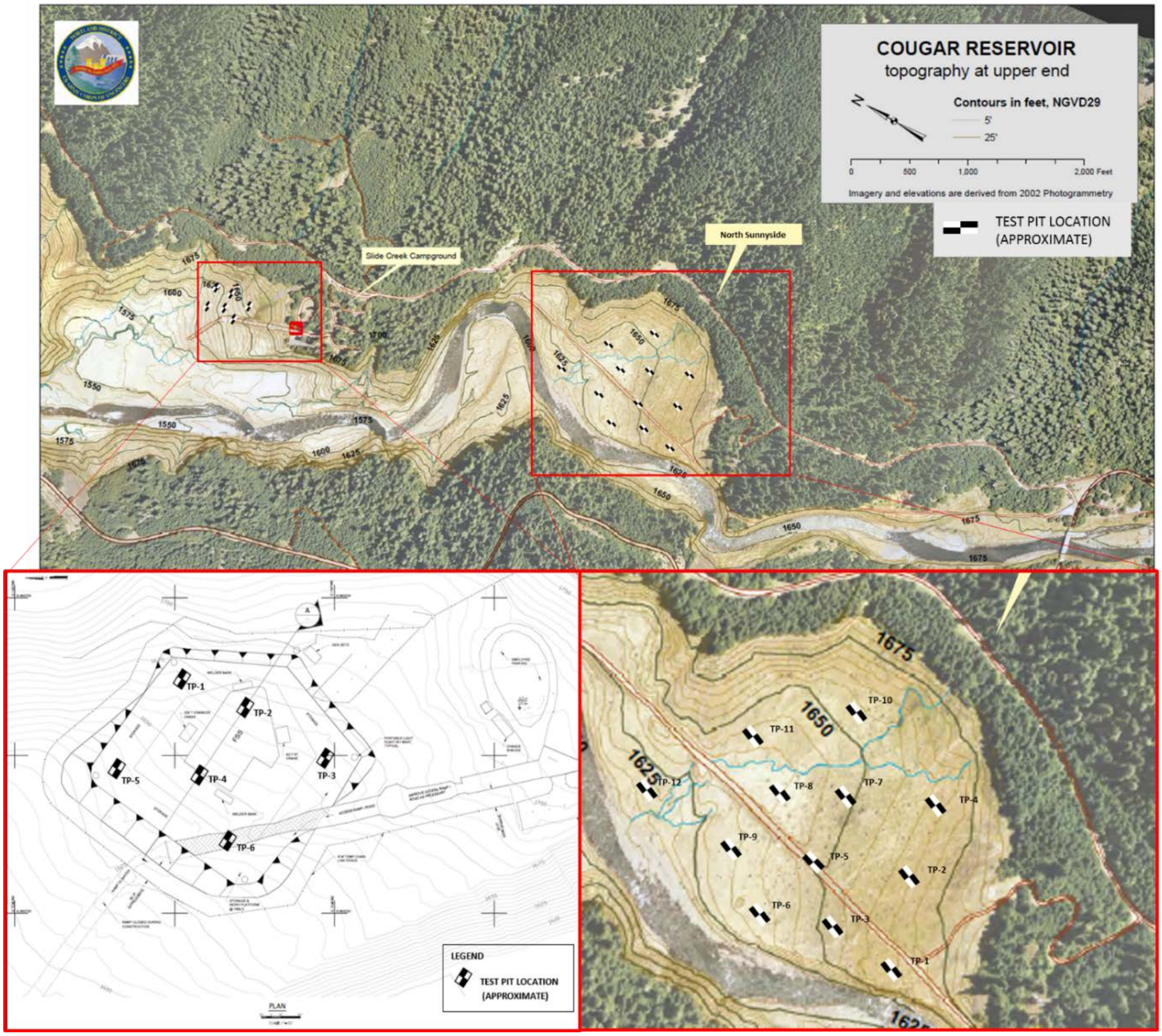


Figure 10-8. Proposed Test Pit Locations at Slide Creek Campground (left) and North Sunnyside (right)

f. Site Seismicity

A regional seismic study for the Willamette Valley was produced by Amec Foster Wheeler (Amec et al., 2017) for the USACE Risk Management Center in accordance with EM 1110-2-1806. The final version of this report was provided to USACE in June of 2017 and includes a detailed description of the seismo-tectonic setting (Amec et al. 2017). The three primary seismic sources for Cougar Dam are summarized as follows:

(1) Cascadia Subduction Zone Interface

Earthquakes that occur at the convergent boundary between the westward-moving North American and eastward moving Juan de Fuca/Gorda Plates, which runs offshore from southern British Columbia to northern California. Earthquakes generated at this margin produce strong ground motions and long durations of shaking (the bracketed duration, i.e., the time between the first and last exceedances of 0.05g, is estimated to be of the order of about 3 minutes). A full rupture at the interface has the potential for generating earthquake magnitudes (M_w) in excess of 9.0 every 450 to 550 years, though partial rupture events northern California and southern Oregon resulting in lower magnitudes may occur as frequently as every 200 years. The most recent major Cascadia Subduction Zone (CSZ) earthquake occurred in 1700 (Goldfinger et al. 2012).

(2) Cascadia Subduction Zone Intraplate

Earthquakes that occur from deep within the subducting Juan de Fuca Plate, having focal depths of 25 miles or more. The most recent recorded large intraplate earthquake was the M_w 6.8 Nisqually earthquake which occurred northeast of Olympia, Washington in 2001.

(3) Shallow Crustal

Earthquakes originating from local crustal faulting. Several crustal faults have been identified within a 100 mile radius of Cougar Dam. The nearest known mapped “active” fault is the White Branch Fault Zone, roughly 13 miles east of the dam. Many of these fault systems have no recorded recent seismic activity, though estimated slip rates, observed surface geomorphology and fault geometry suggest the maximum potential for M_w on the order of 6.0. Fault cuts through terminal moraines off of the Three Sisters Mountains indicate the most recent White Branch Fault activity was around 20,000 years ago.

Figure 10-9 provides the site-specific magnitude-deaggregation, which shows that the dominant seismic source at Cougar Dam is the CSZ interface (Amec et al. 2017).

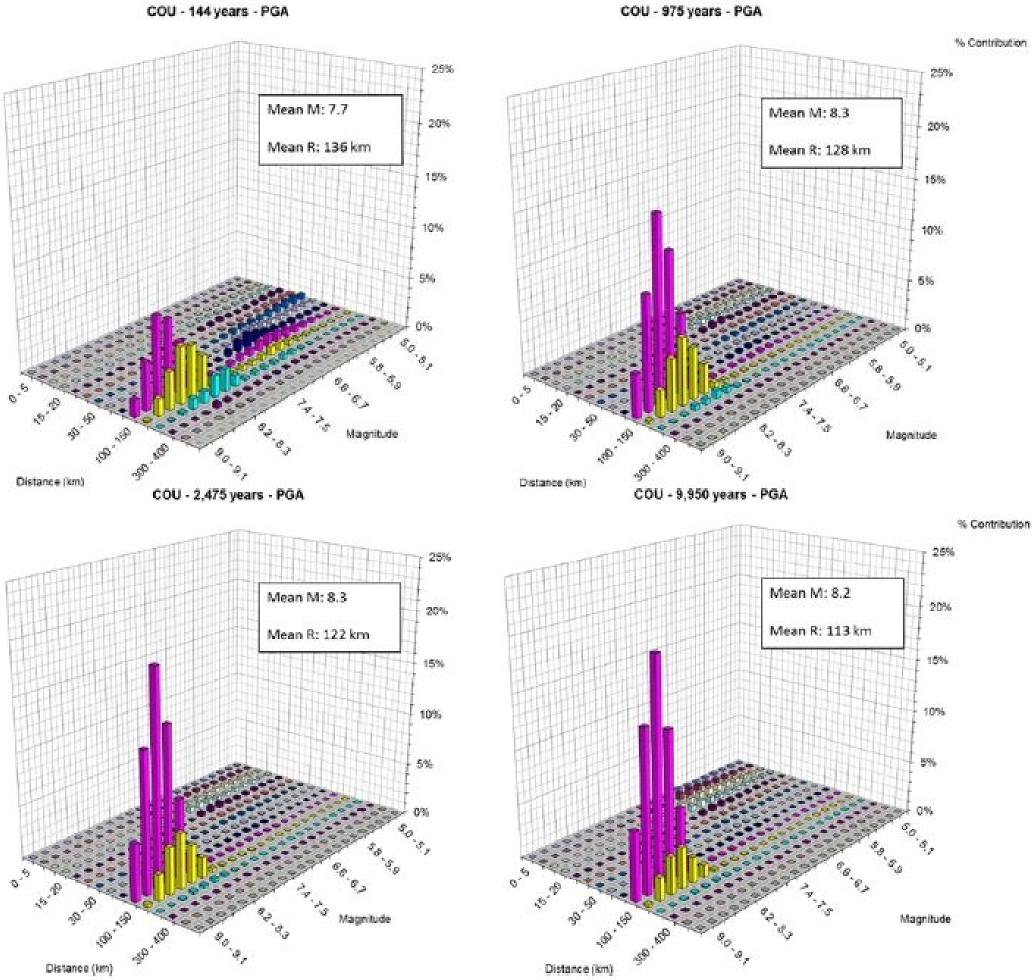


Figure 10-9. Magnitude-Distance Deaggregation for 144-Year, 975-Year, 2,475-Year, and 9,950-Year Events at Cougar (Amec et al., 2017)

10.4 GEOTECHNICAL CONSIDERATIONS AND RECOMMENDATIONS

a. Geotechnical Design Parameters

No new subsurface explorations have been conducted for the Cougar DS Fish Passage project at this time. Explorations are planned for the winter of 2018/2019 during the project's plans and specifications phase to investigate the rock condition and verify top of rock elevation along the alignment of the proposed retaining structure and FSS mooring tower footings. The exploration will also include extensive geologic mapping of the dike and fault zone that runs along the northeast portion of the intake excavation. Rock cores collected from the borings will be subjected to laboratory unconfined compressive and shear strength testing. In addition, borehole imaging will be conducted in all borings in order to better characterize the rock jointing and mass. The parameters summarized below will be updated accordingly as results from explorations and testing become available. Modifications to design during plans and specifications are expected, and further modifications during construction may be necessary should conditions vary from what is predicted by the subsurface exploration program.

Detailed survey of existing rock support elements (rock bolts, drains, and mesh) in the areas of construction under this project will be necessary as well, as these features will impact the excavation. The proposed borings will assist in evaluating the potential impacts previous blasting has had on the foundation materials in the rock wall, as well as the rock bench where footings and embedded structures are planned. Borehole imaging will contribute to the rock mass characterization.

While the original Foundation Report (USACE 1964) does not include a final survey of the intake excavation or the original geotechnical design values, sufficient data exists to inform on foundation design and preliminary recommendations, with the understanding that conditions may vary within the exact footprint of the proposed new structure. It is strongly recommended that conditions be verified prior to and continuously during construction to confirm foundation conditions once the location and type of foundations are finalized.

All supporting features to the FSS will be founded on rock (Cougar Dacite) with some portions embedded in the embankment rockfill shell. The following rock properties were adopted for design purposes and summarized in the WTCT Design Memorandum 21 (USACE 1998), and rockfill properties from original embankment design in Design Memorandum 15A USACE 1960). These values were used for design at the DDR stage of the FSS in the absence of new testing. Values will be updated and designs altered as necessary as new test values and site characterization data becomes available.

(1) Intake Area Dacite (1960 testing and adopted WTCT values)

Unit weight	175 pcf
Unconfined Compressive Strength	17,000 psi
Allowable Bearing Pressure	90 ksf
Shear Strength	
Intact	$\phi = 60^\circ$, $c = 50$ ksf
Residual	$\phi = 40^\circ$, $c = 0$
Modulus of Elasticity	7.0×10^6 psi
Poisson's Ratio	0.25

(2) Embankment Rockfill

Unit weight	110 pcf
Saturated unit weight	127 pcf
Shear strength	$\phi = 41^\circ$
Permeability	3.5×10^{-1} cm/s
Modulus of Elasticity	4.9×10^4 psi
Poisson's Ratio	0.3
D_{max} (average)	24 inches
D_{50} (average)	3 inches

During original design, unconfined compressive strength for the intake area dacite was determined to be in excess of 20,000 psi. Records indicate that the samples used in testing were of non-standard dimensions in length-to-diameter ratio, suggesting that the value may be overestimated. A 17,000 psi value was adopted as a best fit, noting that weathering of the dacite can significantly reduce its compressive strength. Unconfined compressive strength testing will be conducted on rock cores collected during early 2019 explorations. Recommended values will be adjusted accordingly.

Shear strength testing was not conducted on rock samples from the site. Instead, design values were derived from volcanic intrusive rocks of similar type at other USACE projects, in particular, Bonneville Lock and Dam. The intact and residual values represent the maximum and minimum for the given rock type, respectively. Although the residual strength parameters of the rock mass can be estimated in the laboratory, the in-situ properties may be altered by the rock reinforcement installed during previous construction – at least to the depth of the rock bolts.

The allowable bearing capacity of 90 kips per square foot (ksf) was determined for the intake area dacite in the 1998 WTCT design using Equation 6.1 with an applied factor of safety of 3.0 from EM 1110-1-2908, Rock Foundations, 30 November 1994. This value is appropriate for preliminary sizing and design of the necessary foundation elements for the FSS unless the uncovered conditions vary significantly from what was encountered during WTCT construction. As typical for shallow foundations in sound rock, the strength of the concrete will limit the allowable foundation loads rather than the underlying foundation rock.

Rock quality designations (RQD) between 70 and 100 were recorded for cores taken in the Cougar Dacite, indicating very good quality rock. However, this value is expected to be lower for rock within the large fault zone. As such, RQD and rock mass rating will be updated with 2018/2019 exploration results upon completion of that work. It will be necessary to update the Geotechnical Baseline Report (GBR) produced for the WTCT modifications in 2005 and supporting geotechnical and geologic supporting documents for the Contract Solicitation to indicate that the parameters are not able to quantitatively account for the presence of existing rock reinforcement and what impact they may have for the areas that are to be excavated.

The embankment rockfill within the work area consists of clean, angular, unweathered dacite and basalt rock fragments. Upstream rockfill was placed in 1.5-foot to 3-foot lifts and compacted with two passes of an 80,000-pound tractor. Field and laboratory classification of rockfill samples collected from the main embankment section in 2017 for the ongoing Issues Evaluation Study (IES) were consistent with original construction specifications. All parameters listed above reflect what was used for original design, with the exception of shear strength. Original design shear strength was 45 degrees. The referenced reduced shear strength was adopted for IES analyses based on the estimated confining stress and research from Leps (1970). The portion of rockfill that will be impacted/modified for this project is relatively shallow and under low confinement.

b. Seismic Design Parameters

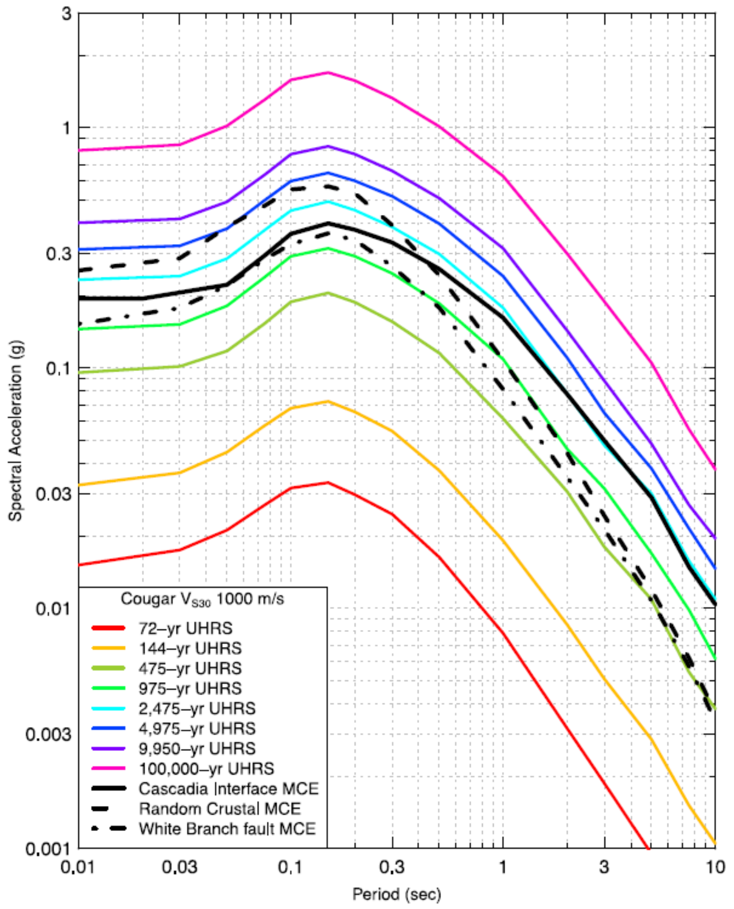
Minimum seismic design requirements have been established to assure that all features of civil works projects meet minimum seismic standards for serviceability and safety. The operating basis earthquake (OBE) is an earthquake that can reasonably be expected to occur within the service life of the project, typically a 50 percent probability of exceedance in 100 years (average return period of 144 years). Expected project performance is that there would be little or no damage and without interruption of function. The maximum design earthquake (MDE) is the maximum level of ground motion for which a structure is designed or evaluated. Under the MDE, the project is required to perform without loss of life or catastrophic failure, although severe damage or economic loss or loss of service may be tolerated. The minimum MDE is an event with a 10 percent probability of exceedance in 100 years (average return period of 950 years). Economic loss or loss of service is not defined in the Engineering Regulation (for example, ER 1110-2-1806, USACE 2016) and it is up to the PDT to determine the tolerable damage, economic loss and loss of service.

Seismic parameters are only applicable to the design of the connection of the FSS to the existing intake tower, mooring dolphins, personnel access stair tower, and reinforcement for the rock cut. It is probably not applicable to the floating structure, which is isolated from the earth except for the connection to the intake tower and moorings. A site-specific seismic study (Amec, 2017) covering six dams in the Willamette Valley was recently completed by Amec Foster Wheeler under contract with the USACE Risk Management Center. The study was conducted in accordance with EM 1110-2-1806 in 2017, which included a probabilistic seismic hazard analysis and deterministic seismic hazard analysis of Cougar Dam. Seismic Site Class B was recommended based on the hard, jointed volcanic rock foundation with no supporting shear wave velocity measurements. The following peak ground acceleration (PGA) ground motions with 5 percent damping were developed for a Seismic Site Class B rock site at Cougar Dam:

Site Class/V_{s30}	B (Rock)/1000 m/s
Operating Basis Earthquake (Approximate 144-year event)	PGA = 0.033g
Non-Critical Structure Maximum Design Earthquake (Approximate 975-year event)	PGA = 0.145g
2475-year event (approximately equal to CSZ MCE)	PGA = 0.233g

A magnitude-distance deaggregation included in the report indicates that the dominant seismic source for the area is at the CSZ interface, resulting in a mean magnitude of 7.7 and 8.3 for OBE and MDE events, respectively.

Uniform hazard response spectra (UHRS) for the recommended Site Class B are provided in Figure 10-10, which includes the deterministic maximum credible earthquakes (MCEs) for each of the three identified seismic sources. Also included is the magnitudes-distance combinations considered for long and short period events. The MCE is defined as the largest earthquake that can reasonably be expected to occur on a specific source, based on seismological and geological evidence. The recommended MCE for a given civil project is dependent on the criticality of the project and the project hazard potential classification, as defined in EM 1110-2-6053 and ER 1110-2-1806, respectively. For critical structures, the MDE is equal to the MCE. The conservative estimates of MCE ground motions for critical projects are a median plus one standard deviation (84th percentile). The best estimate MCE ground motions for non-critical, lower hazard potential projects are median (50th percentile). Determination of the criticality of the structure is key as the 84th percentile ground motions can be 1.5 to 2 times greater than 50th percentile ground motions. The three MCE response spectra in Figure 10-10 represent the 84th percentile ground motions. For work at Cougar, the Cascadia Interface MCE should be considered. Note that for periods 1 second and longer, this MCE is equal to the 2,475-year return period UHRS.



Dam	UHRS Return Period (years)	Short Period (0.2 s) CMS Scenario:				Long Period (1.0 s) CMS Scenario			
		Subduction Interface		Shallow Crustal		Subduction Interface		Shallow Crustal	
		M	Distance (km)	M	Distance (km)	M	Distance (km)	M	Distance (km)
Cougar	144	8.6	167	6.2	63	8.5	170	6.5	76
	975	8.7	148	6.3	33	8.7	150	6.7	45
	2,475	8.8	145	6.3	26	8.8	146	6.7	35
	9,950	8.8	141	6.3	19	8.8	142	6.7	25
	100,000	8.8	138	6.4	13	8.8	139	6.8	14

Figure 10-10. Uniform Hazard Response and 84th Percentile MCE Spectra for Cougar Dam (Site Class B) (Amec 2017)

Because ground conditions at the project site consist of bedrock and free-draining coarse, compacted, clast-supported gravel to cobble and boulder-sized rockfill, the foundation material is not considered susceptible to liquefaction.

c. Past Embankment Performance

Cougar Dam has performed well since first filling in 1964. The embankment has experienced ongoing upstream differential crest settlement since first filling, with settlement moderately increasing during periods of deep construction drawdown. Settlement has slowed since 1964, and cumulative rates are on the order of 1 percent of the embankment's total height. The embankment is subject to seasonal cycling of reservoir levels between elevations 1,532 feet and 1,690 feet, and has experienced two deep construction drawdowns in its lifetime. The first construction drawdown was for the WTCT construction, which took the reservoir to elevation 1,400 feet from 2002 to 2005. A rapid drawdown stability analysis conducted prior to the 2002 drawdown indicated a factor of safety of 1.5. The second drawdown was for emergency trashrack repairs and took the reservoir to elevation 1,450 feet for approximately one month in the late winter/early spring of 2016. Instrumentation in the embankment shows response to normal reservoir cycling, with no signs of internal erosion post-deep construction drawdown (e.g. turbid discharge). No otherwise adverse responses to regular reservoir cycling or the deep construction reservoir drawdowns have been detected. Greater detail of the embankment's past performance during deep drawdowns, including amount of settlement and response of the embankment's automated instrumentation, is provided in Appendix M.

Cougar Dam is rated a Dam Safety Action Class (DSAC) 2 (High Urgency) as defined in ER 1110-2-1156 (USACE 2014) and is currently in an IES in accordance with ER-1110-2-1156. A targeted Potential Failure Mode Analysis (PFMA) was conducted in July 2018 in order to evaluate the impacts of construction to existing risk driving failure modes currently under evaluation, previously excluded failure modes, and to identify any new risk driving potential failure modes introduced as a result of construction and operation of the FSS. Particular focus was given to the construction of the retaining wall in the embankment rockfill shell and blasted rock excavation near the embankment's left abutment. The results of the targeted PFMA, including failure mode descriptions and the recommended mitigation and monitoring plan for construction and operation, are included in Appendix M. In general, it was the consensus of the PFMA team that the construction and operation of the downstream fish passage project will not have an appreciable effect on the current risk estimate for the embankment. The embankment will be subject to heightened monitoring during drawdown, construction, and refill. Following the recommendations from the PFMA, a monitoring plan for the embankment was developed in conformance with ER 1110-2-1156. The plan is also located in Appendix M.

d. Retaining Structure

Accommodating the FSS at low reservoir elevations during normal reservoir cycling will require the excavation of a bench to elevation 1,490 feet, as shown conceptually in Figure 10-11. Excavation of the bench will require removal of an existing concrete crane pad located at elevation 1,535 feet. Figure 10-11 also shows a conceptual rendering of the retaining structure that will be necessary to retain a portion of embankment rockfill shell after excavation. The wall will be offset 22.5 feet from the edge of the FSS in order to accommodate crew boat access, and to allow for post-construction wall deflection. The proposed wall is a tangent pile wall consisting of reinforced-concrete drilled shafts with steel casing. The top of shafts will be connected with a reinforced grade beam. To reduce the structural demands on the individual shafts, the grade beam and the top of the tangent pile wall are proposed to be restrained by connecting them to the top of a second row of discrete drilled shafts that would be constructed further into the upstream dam embankment. Figure 10-11 does not show the second row of these discrete drilled shafts, which would function as “deadman” shafts. The entire structure is designed to reduce the shear and moment demands in the drilled shafts by frame action. Figure 10-12 shows a conceptual cross section of the retaining structure, which includes both the tangent pile wall and a discrete drilled shaft.

The retaining structure will be constructed first from the existing ground surface. The rock and embankment rockfill in front of the tangent pile wall will be excavated by a combination of blasting and excavation to expose the tangent pile wall and construct the bench at elevation 1,490 feet.

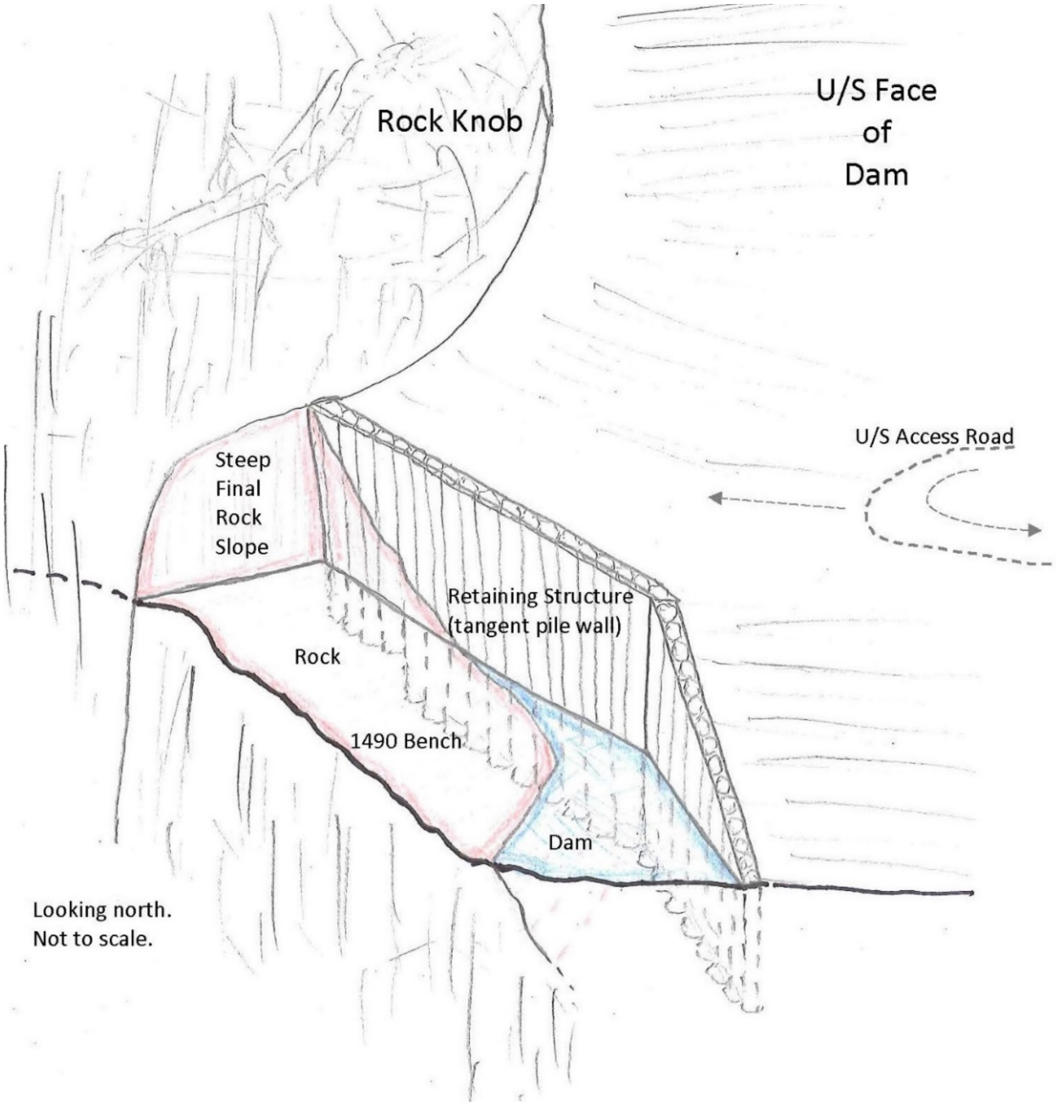


Figure 10-11. Conceptual Rendering of Retaining Structure (Refer to Figure 1-6 for relative location from the intake tower)

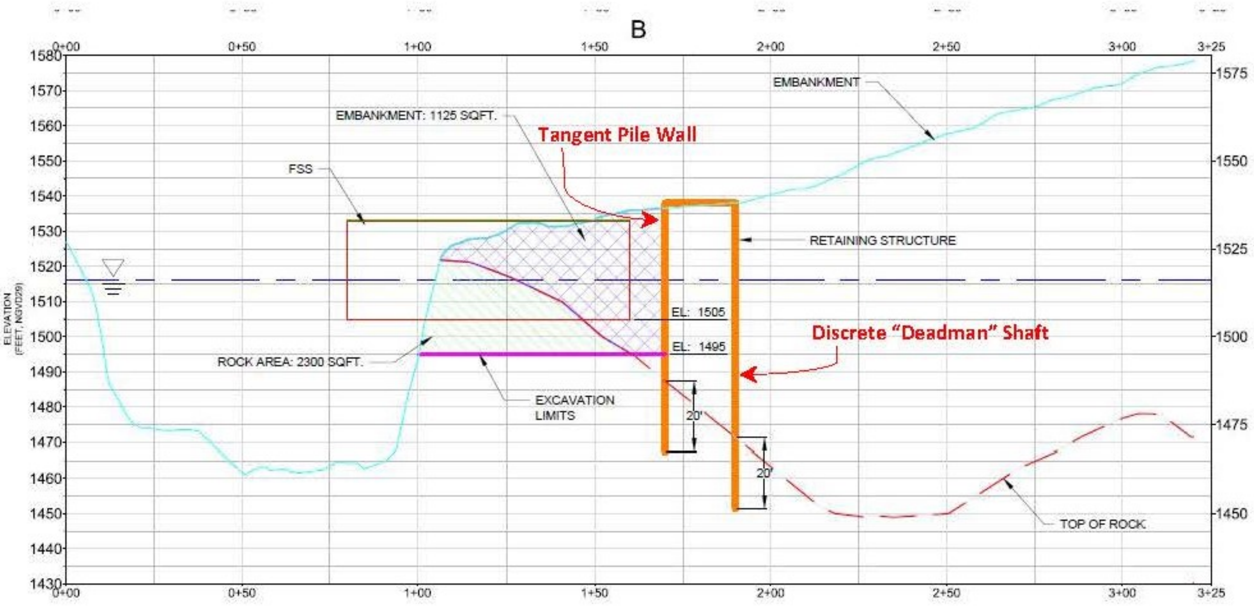


Figure 10-12. Conceptual Cross Section of Retaining Structure Showing Tangent Pile Wall Connected to Discrete Shafts

Listed below are geotechnical design recommendations that were not listed above in Sections 10.4.a., Geotechnical Design Parameters, and 10.4.b., Seismic Design Parameters.

(1) Earth Pressures

- Static: Active earth pressures are recommended for static conditions. Deflections at the top of wall of about a few inches is presumed for a wall height of about 45 feet, which is the estimated height of the tangent pile wall. These deflections are greater than the estimated wall deflections required to induce an active state of about ¼ to ½ inch for dense granular soils.

- Seismic: Mononobe-Okabe method for active conditions is recommended to estimate the dynamic earth pressures due to seismic loadings. Refer to, for example, American Association of State Highway and Transportation Officials (AASHTO) 2017.

(2) Seismic Coefficient k

Use the method in National Cooperative Highway Research Program Report 611 (Anderson et al. 2008). The seismic coefficient (k) values are a function of the wall height, shape of the response spectra of the input motion, and wall deflection. Because the wall is replacing a small portion of embankment rockfill, it will effectively become part of the dam and will therefore considered a critical structure in design. As such, the recommended k values are for an MDE (approximately equal to the 2,500-year return period UHRS) for rockfill (Site Class B/C: V_{s30} = 760 m/s). These k values are recommended to be used in Mononobe-Okabe equations and in estimating other inertia effects on the rockfill. Table 10-3 shows the k values as a function of the wall height (H).

Table 10-3. Seismic Coefficient (k) Values as a Function of Wall Height (H); MDE Motion

Wall height, H (ft)	Seismic coefficient, k
20	0.130
30	0.108
40	0.101
50	0.094

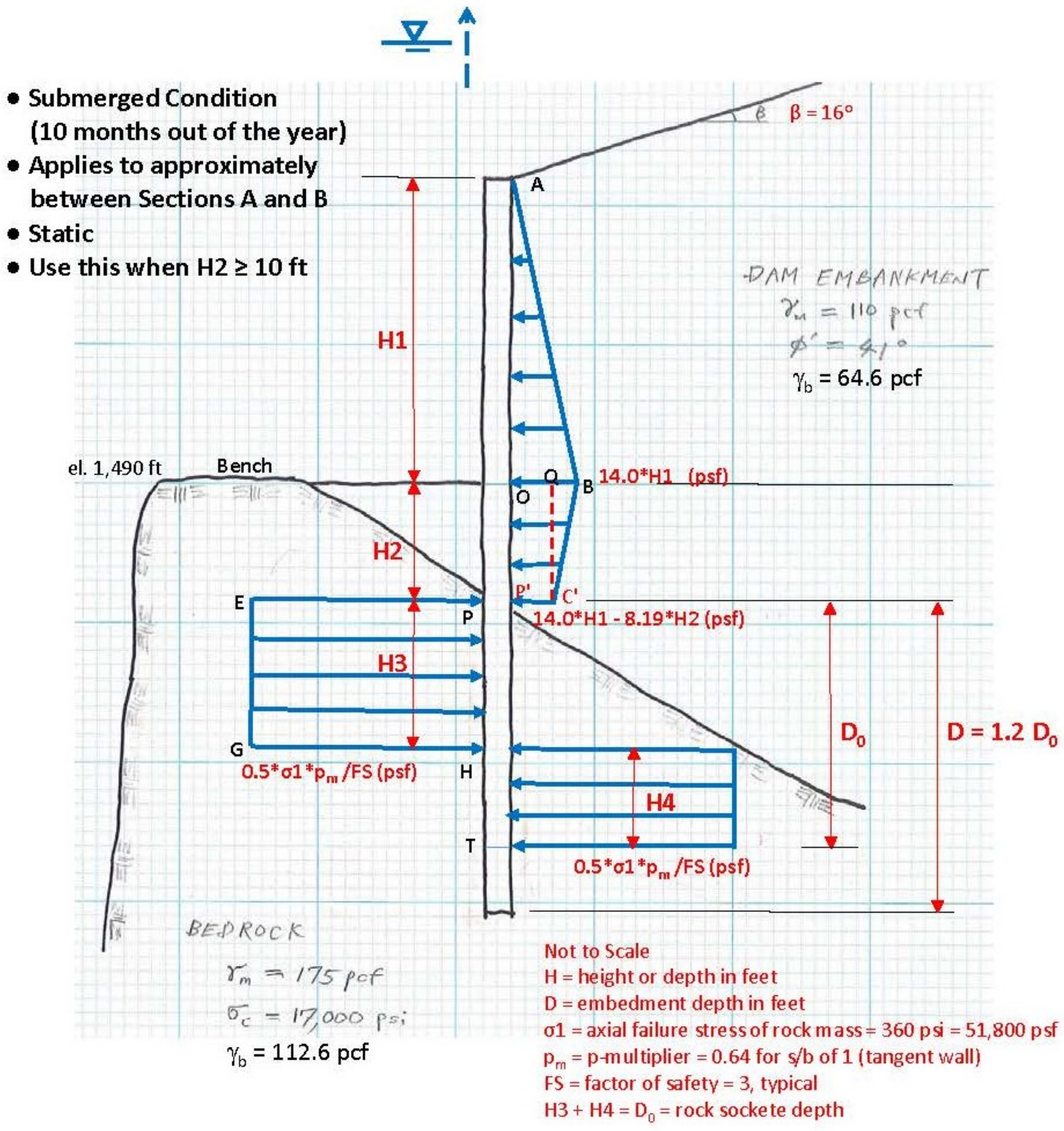
(3) Hydrodynamic forces:

Use the Westergaard method. Refer to, for example, Ebeling and Morrison 1992 (ITL-92-11). On the reservoir side, the critical case is when the hydrodynamic forces act as "suction" to reduce the hydrostatic forces. On the rockfill embankment side, it is estimated that the hydraulic conductivity of the rockfill of 3.5×10^{-1} centimeters/second is large enough for water to act independently to exert hydrodynamic forces on the wall. Since water occupies the pores of the rockfill, the full Westergaard hydrodynamic forces was multiplied by the porosity of the rockfill. Using a specific gravity of 2.75 and a saturated unit weight of the Class I rockfill of 127.0 pcf, the porosity was estimated to be about 40 percent. In the USACE Design Memorandum 15 Plate 107, the estimated value of the porosity is 35 percent.

(4) Load Diagrams

- Submerged, static condition: This will be the case 10 months out of the year. See Figure 10-13.
- Submerged, MDE (maximum design earthquake) condition. See Figure 10-14 and Figure 10-15

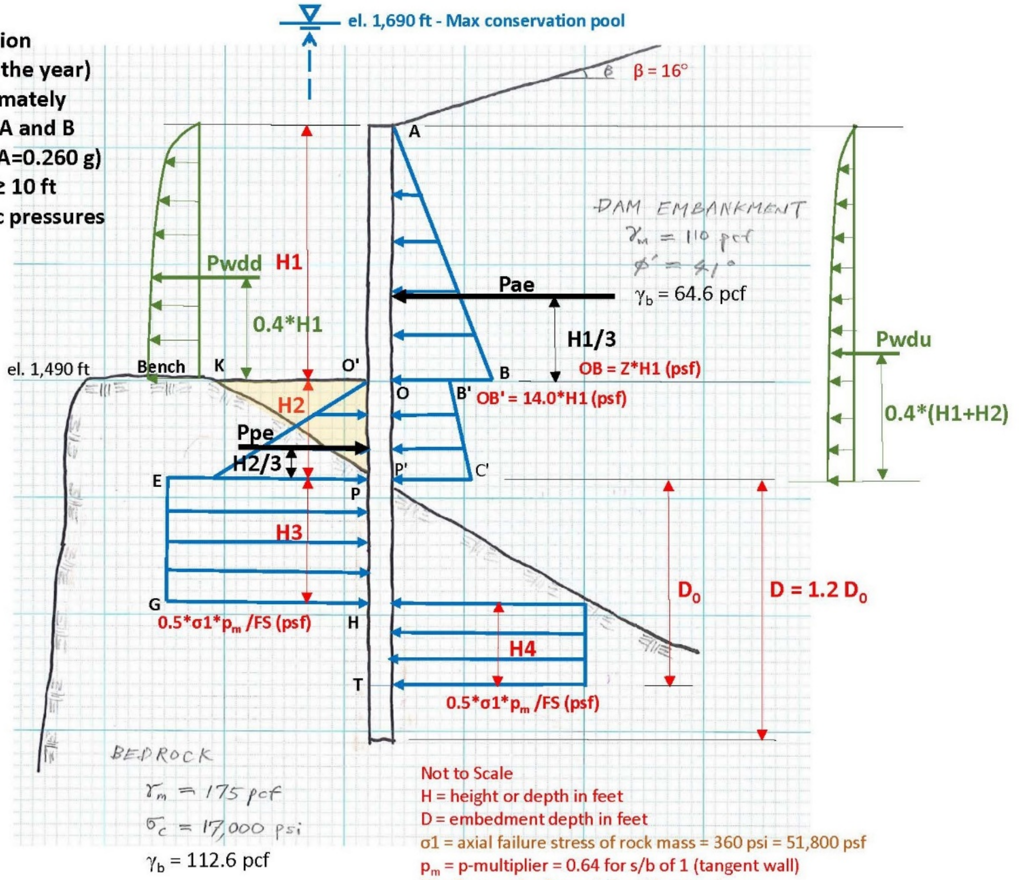
These diagrams will be updated to incorporate the effects of connecting the tangent pile wall to the discrete shafts in the embankment.



Modified from Figure 3.11.5.6-3 of AASHTO LRFD Bridge Design Specifications, 8th ed., 2017.

Figure 10-13. Load Diagram for Tangent Pile Wall (Without Connection to Discrete Shafts) for Submerged, Static Condition

- **Submerged Condition (10 months out of the year)**
- **Applies to approximately between Sections A and B**
- **Seismic - MDE (PGA=0.260 g)**
- **Use this when H2 ≥ 10 ft**
- **Add hydrodynamic pressures**



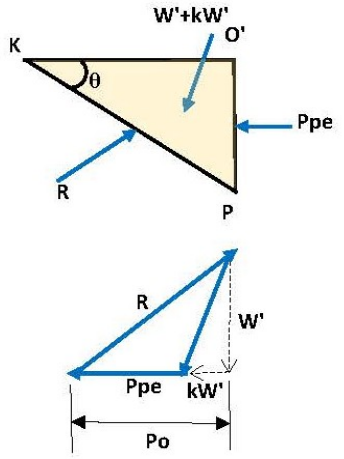
Not to Scale
H = height or depth in feet
D = embedment depth in feet
σ1 = axial failure stress of rock mass = 360 psi = 51,800 psf
p_m = p-multiplier = 0.64 for s/b of 1 (tangent wall)
FS = factor of safety = 1.5, subject to change.
H3 + H4 = D_0 = rock sockete depth
Solve for H3 and D_0 by setting $\Sigma_h = 0$, and $\Sigma M_T = 0$.
Pae = seismic active horizontal force, including static earth pressure.
Ppe = seismic passive horizontal force on wedge of dam embankment below bench level in front of wall, see supplemental figure
Pwdd = hydrodynamic water force on downstream side of wall full hydrodynamic force
Pwdu = hydrodynamic water force on upstream side of wall

Modified from Figure 3.11.5.6-3 of AASHTO LRFD Bridge Design Specifications, 8th ed., 2017.

Figure 10-14. Load Diagram for Tangent Pile Wall (Without Connection to Discrete Shafts) for Submerged, MDE Condition

H1 or H2 (ft)	kh	Kae	Z = Kae*γ_b (pcf)	Pae (kips/ft)
10	0.130	0.333	21.5	1.08
20	0.130	0.333	21.5	4.30
30	0.108	0.315	20.3	9.16
40	0.101	0.310	20.0	16.02
50	0.094	0.304	19.6	24.55

Seismic Passive Pressure Ppe



Ppe = Po - kW'

Note: Po is at-rest pressure
W' is buoyant weight of wedge

Pwdd = (7/12)*kh*γ_w*Hp^0.5*H1^1.5
Hp = depth of reservoir from base
Pwdu = n*(7/12)*kh*γ_w*Hp^0.5*(H1+H2)^1.5
n = porosity of dam embankment, 0.40 (see separate tab)

kh is a function of wall height H, see table.
H1 for Pae and Pwdd
H2 for Ppe
(H1+H2) for Pwdu

Dynamic earth pressure OB = Z*H1
Z is a function of wall height H1, see table.

Figure 10-15. Diagram and Table to Supplement Figure 10-14 for Tangent Pile Wall (Without Connection to Discrete Shafts) for Submerged, MDE Condition

e. Rock Excavation and Blasting Considerations

It is assumed, based upon the rock properties and the experience of previous construction, that rock excavation will require drill and blasting methods. Rock slope stabilization recommendations will be made by the A-E conducting the site explorations in January 2019. Existing 10V:1H near-vertical rock cut along the north side of the intake tower has remained stable with only minor amounts of sloughing and rockfall, so until more precise mapping of the area’s jointing is available, it is assumed that excavations can be safely made at this same near-vertical slope. As discussed, the east excavation along the proposed retaining wall will be offset 22.5 feet from the FSS. Excavation along the north/back end of the FSS will extend 30 feet into the existing rock face. The reason for the offset is to allow for potential future modifications to the FSS for piped bypass. The extent of the proposed excavation is shown on the plates at the end of this report.

The construction area is small and confined, and under steep rock slopes. To ensure safety to construction personnel, all rock slopes will need to be cleaned of loose debris, scaled, and supported before work can be performed beneath the existing steep rock slopes. This should be completed during the initial lowering of the pool (during drawdown). The neatline volume of rock excavation required to accommodate the footprint of the FSS at all reservoir levels is estimated to be approximately 10,500 cubic yards. This does not account for bulking, overbreak, or scaled rock removal during drawdown. Excavation into the dacite rock knob could affect the embankment since this rock serves as the left abutment's foundation. Blasting, if not controlled, could incur damage to the existing structure at the intake, as well as the embankment dam. Additional monitoring of the embankment's performance will be necessary during these construction activities, as detailed in Appendix M. The contractor will be required to submit a blasting plan and monitoring plan, which will be specified in plans and specifications. Blasting should be carried out in accordance with EM 1110-2-3800, Blasting for Rock Excavations, with close monitoring throughout construction to ensure that peak particle velocity and air overpressure are kept below the acceptable levels. Allowable levels will depend on the location of blasting relative to the dam features and the proposed monitoring points. Preliminary values of acceptable peak particle velocity and air overpressure are listed in Table 10-4.

Table 10-4. Preliminary Acceptable Levels of Peak Particle Velocity and Air Overpressure from Blasting

MONITORING LOCATION	PEAK PARTICLE VELOCITY	AIR OVERPRESSURE
Diversion Tunnel Portal	2.0 inch/second	140 dBL (0.029 psi)
Roadway Above Tunnel	2.0 inch/second	133 dBL (0.13 psi)
Penstock	2.0 inch/second	

Previous investigations for both the original dam construction and the subsequent modifications of the intake tower have provided data on the in-situ rock characteristics and mechanical properties. The supporting reference materials and the summations included in this report provide this information; however, both the blasting performed as part of previous construction and the installation of significant rock support and rock reinforcement during the modifications to the intake structure are likely to significantly impact rock excavation under this work. Lessons learned from previous contracts involving blasting rock that has been altered by blasting and reinforcement have indicated the need to emphasize there will likely be significant differences between the descriptions of "native" rock properties and parameters presented in the WTCT GBR and other supporting documentation, and the rock faces that exist after blasting and subsequent stabilization. It will be necessary to emphasize that the baseline assumptions of the previous GBR with respect to virgin rock still apply, but they do not apply to rock that has been subjected to blasting or where rock support/ reinforcement has been previously installed. In the rock mass, where rock bolts and mesh have been installed, it is important to consider that the material will respond to blasting as much like reinforced concrete as it does natural rock. There is little in the way of providing quantitative data for these new conditions, so it is important to provide as much detail of the rock support elements as possible to the contractor to assist their activities and reduce the potential for modifications or claims.

A detailed survey of the previously-installed reinforcement should be performed and a map of existing rock reinforcement and drain locations prepared prior to development of the contractor's blasting plan. The location and depths of existing drains in the rock mass to be excavated will have significant impact on the blasting plan and should be provided in the contract documents if possible. The GBR will include as much information as possible, but access to the rock below elevation 1,516 feet is not possible before the deep drawdown. The contract will require the construction contractor to complete the survey of reinforcements and drains below elevation 1,516 feet for their blasting plan.

The specifications for this work will be based upon EM 1110-2-3800, Blasting for Rock Excavations, and the most recent and applicable guide specification. The specifications will include monitoring requirements and criteria for ground motion and air blast, as well as defining the maximum overbreak tolerances.

Precision blasting methods will be essential to achieve these requirements, and a specialty contractor and third-party blasting consultant will be required to prepare appropriate pre-construction submittals and work plans for the work. In order to evaluate the contractor's submittals efficiently, separate submittals may be considered for (1) Drilling and Blasting Work Plan and Excavation and (2) Removal/Disposition of Blasted Rock. These submittals should include details of sequencing the work with respect to other aspects of the construction and pool regulation. The solicitation for this work should be a Best Value solicitation, requiring submittal of conceptual proposals in order to provide Portland District the opportunity to verify the level of understanding the offerors have of the work and the schedule constraints. This method permits Portland District to review the offerors' previous work experience on similar projects. The contractor may be required to perform separate smaller test blast sections in reinforced rock and unreinforced rock in order to refine means and methods.

In addition to sequencing blasting operations with pool elevations, the sequencing will have to be designed considering the rock mass properties as modified by rock reinforcement. The critical impact of the existing rock reinforcement is in its alteration of how the rock will perform during blasting. Rock that is knitted together with steel reinforcement will not transmit blast energy or shatter in the same manner as a natural rock mass because the steel imparts a greater tensile strength to the mass as a whole. Drain holes will complicate the blasting by relieving energy and providing an outlet for expanding gasses that are required to break up and separate the rock mass. Drain holes may act as rifles for loose materials and can project fly rock hundreds of feet at very high speeds. A demonstrably safe means of mitigating the drain holes by plugging with grout or stemming will have to be included in the work plan, and the offerors must be made aware of these conditions in order to prepare a reasonable proposal. It is for these reasons that the mechanical properties of the rock and the array and dimensions and types of reinforcement are all interrelated in determining the blasting sequence.

Rock bolts of various lengths were installed into the existing rock face. The longest of these sets of rock bolts is 25 feet. In order to effect a controlled excavation line, a pre-split line of holes will be necessary approximately 5 feet beyond the end of the 25-foot-long bolts, and this line will then become the new excavation face once the blasting and rock removal has proceeded. The location of the rock reinforcement will therefore be a factor in the geometry of the faces excavated and the amount of rock to be removed – in effect making it necessary to remove rock at least 5 feet beyond the extent of previously-installed reinforcement. This will have the effect of creating a bench of at least 25 feet to 30 feet wide.

If drilling and blasting is to be performed from suspended cables, instead of work baskets or work platforms, it will be necessary for this to be performed by personnel certified by the Society of Professional Rope Access Technicians. Provisions for anchorage and equipment associated with rope access will be necessary. Lightweight portable drills and work baskets may also be used, provided hole depths are not beyond 20 to 25 feet. Adequate provisions for inspection by USACE personnel will also be required, whether by someone with Society of Professional Rope Access Technicians training or in an appropriate work basket.

The initial pre-split line will likely be approximately vertical; however, depending upon the plan and layout, the contractor may choose to use an array of holes at various angles to the face. The vertical pre-split line may be drilled to full depth if adequate controls are in place to limit borehole deviation. The blasting operations will have to be coordinated with the scheduled lowering of the pool and other features of construction. Because of the need to control ground motion and protect the nearby structures, the lateral length of the shots may be limited in some areas. It will be essential to time the initial pre-split line (to be drilled in unreinforced rock) between the alignment of the tangent pile retaining wall prior to construction of that feature of the work in order for the pre-split to protect the new retaining wall from blasting. A minimum elapsed time in the range of 20-30 days will be necessary between the last backfill placement in the retaining wall and post-pre-split blasting in the vicinity of it in order for the backfill to reach adequate strength – both to mitigate damage to it from blasting and in order that it will provide support to the material it is retaining.

The sequencing of work to optimize the schedule while protecting both existing structures and features constructed in the contract should be an evaluation factor in the Contractor Selection Technical Criteria, and a submittal addressing these aspects in a detailed technical proposal by offerors required by the solicitation. The offerors should submit a conceptual sequence including the means and methods to access the face, perform the excavation and construction of the retaining wall, and complete the necessary temporary and permanent slope support in both embankment and natural materials. A preliminary work breakdown structure and Gant Chart of this should be included in the offerors' proposals.

Bench height is typically in the range of 6 feet to 10 feet, and the response of the rock in test blasts may be important in making the final decisions related to the geometry of the blasts. As blasting proceeds, the rock spoils will accumulate at the base of the rock slope. Scaling will be required to remove loose rock and protect workers as the blasting advances downslope. If it is proposed to install rock reinforcement while subsequent rounds of downslope blasting progresses, the work areas will have to be offset to prevent materials from falling on workers drilling and installing explosives below, and sufficient separation will be required to prevent blasting from damaging newly installed rock reinforcement. Measures to protect existing structures from both fly rock and rock accumulating in the pool may be necessary, and consideration of the overall volume of rock may make incremental disposal necessary as well. A review of the area where rock spoils will accumulate versus the volume will be necessary to determine how frequently removal and disposal will be necessary, and because of the space constraints these operations may be difficult to perform while drilling for subsequent blasting proceeds. A sequence of drilling and blasting cycles of one round per day may be expected, with a bench height from 6 feet to 10 feet. It may be possible once a pre-split line has been established to shoot the entire length of the necessary excavation in a single blast.

Groundwater seepage and the buildup of hydrostatic pressures upon dewatering could cause localized instability in the rock knob. Horizontal drains may be required at intervals and to depths determined during the geotechnical investigations during design and preparation of plans and specifications for areas of new rock excavation. Patterned rock bolt reinforcement will also be required for any new excavations into rock. The A-E contractor performing the 2018/2019 explorations will also be providing the design for the permanent rock slope reinforcement, which will be integrated into the plans and specifications.

Rock surface structural mapping, coring in rock, televiewer surveys in core holes, etc. will be performed in the upcoming geotechnical investigation program to collect information necessary to develop a detailed blasting plan, test blasting plan, and monitoring plan.

f. Rock Slopes

Rock slopes, anchors, and reinforcement are to be designed in accordance with EM 1110-1-2908, Rock Foundations, and EM 1110-1-2907, Rock Reinforcement.

(1) Rock Slope Scaling

Rock slopes have not been maintained for over 50 years. Because the proposed FSS will be occupied by at least two people during collection period, all slopes above the FSS will undergo rehabilitation/maintenance. The area to be rehabilitated is shown in Figure 10-16.

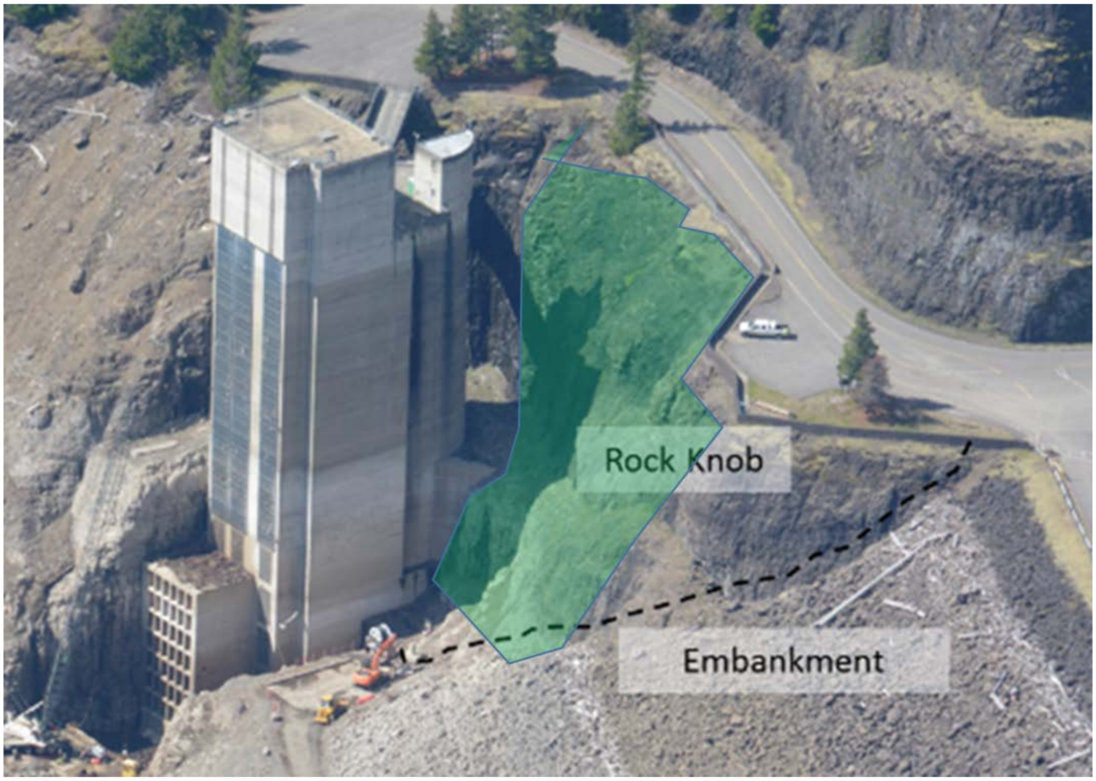


Figure 10-16. Rock Slope Protection Above Floating Screen Structure

This work will consist of rescaling of slopes to remove all loosened rocks, adding rock bolts where necessary, and meshing to improve the safety of people working below the slope. Rock scaling will follow standard requirements and practices by Oregon Department of Transportation. Since people will be routinely working below, the slopes may require periodic routine visual inspection and maintenance at intervals of 10 to 20 years or when required.

(2) Rock Reinforcement

Patterned rock bolting will be required for any new excavations into rock. Recommended design parameters are for the Cougar Dacite as it is the primary rock type at the project site. Excavations into rock will require patterned rock bolting. The A-E contractor performing 2018/2019 explorations will be responsible for designing permanent rock reinforcement. Reinforcement for the WTCT was designed to have the following properties:

- Spacing 10 feet by 10 feet.
- Inclination above horizontal (5 degrees).
- Length – 20 feet.
- Concrete-rock bond – complete resin encapsulation.

- Surface treatment – wire mesh anchored to rock bolts.

(3) Rock Slope Mesh

All rock slopes above the FSS will be meshed for life safety and reduce risk of damage to the FSS due to falling rocks. Design will be to State of Oregon Department of Transportation requirements and EM 385-1-1. Structural rock mesh specifically designed for rock stabilization will be anchored to the rock bolts. If the existing rock slopes do not have sufficient number of rock bolt for anchorages, new rock bolts will be installed to anchor the mesh. Additional hardware, accessories and cables may be necessary depending upon the final design of the mesh-bolt support system and the manufacturer's requirements.

g. Mooring Tower Foundations

The FSS will require mooring on three points along the structure in order to limit horizontal movements. The west side of the FSS will be moored to the existing intake tower. The east side will be moored at two points by a triangular steel frame structure that will be supported laterally by connection to rock anchors in the east rock slope. The proposed east mooring structure will extend 160 feet above ground in order to accommodate the FSS at all reservoir levels via movable connections or rails. All mooring foundation features are expected to remain close to the existing intake and left abutment and are therefore expected to bear solely on Cougar Dam Dacite. Foundations will consist of shallow spread footings anchored into competent rock, or with single discrete drilled shafts drilled into competent rock.

(1) Spread Footings

Shallow spread footings bearing on rock should be designed in accordance with EM 1110-1-2908, Rock Foundations. Allowable bearing capacity of shallow rock foundations in the intake area dacite was determined for the WTCT modifications in accordance with EM 1110-1-2908, Equation 6.1, with the recommended factor of safety of 3.0 applied, resulting in 90 ksf. This value can be used preliminarily for design of shallow foundations that are within the intake dacite. Note that this bearing capacity value applies to foundations that have some embedment depth, and not to perched foundations. Foundations perched on rock without embedment are not covered in the referenced EMs and will have to be specifically evaluated. Explorations planned for 2018/2019 will include unconfined compressive strength testing of the rock and joint mapping in order to verify bearing capacity, though mooring foundation design will be controlled by lateral loading and uplift, which will be resisted by rock anchors or shafts.

(2) Rock Anchors

Shallow footings will require anchorage into competent rock in order to resist lateral and uplift loading. Active (tensioned) bar or strand anchors are recommended to limit the amount of allowable lateral movement. Anchorages must be designed in accordance with EM 1110-1-2908 and the Post Tensioning Institute following procedures for uplift resistance of multiple anchors in fractured rock. Assuming vertical anchors spaced 8 feet on center and a maximum uplift load of 160 kips, preliminary sizing using the design guidelines cited above indicates anchors will need a minimum 34-foot embedment, where embedment is the distance between the ground surface and the centerline of the bond zone. Factoring in minimum free length and bond length, this amounts to a total anchor length of 42 feet. The bond strength between rock and grout in accordance with EM 1110-1-2908 will be governed by the compressive strength of the grout, given that 1/10 the uniaxial compressive strength of the rock is 1,700 psi, well in excess of the maximum 600 psi specified in EM 1110-1-2908.

Drilled explorations scheduled for 2018/2019 will include borehole imaging, which will provide better detailing of the rock fracturing and jointing. Rock fracturing could result in grout loss during anchor installation. As such, all borings in rock will include packer testing to provide rock permeability values.

During construction, testing of the individual anchors in accordance with Post Tensioning Institute standards will be required. Installation and testing should be conducted in the presence of USACE Portland District Geotechnical, Civil, and Environmental Design Section representatives. Anchors should be locked off and caps sealed in a manner that will allow future inspection and re-tensioning (i.e. not encapsulated in concrete) in 20 to 50 years. This may be accomplished by sealing the bar or strands in wax and capping with a watertight seal. Because the footings will be submerged during normal reservoir operations, any future re-tensioning of the anchors will require a deep reservoir drawdown and removal of the FSS from the cul-de-sac.

(3) Drilled Shafts

One mooring tower footing is located along the slope of the embankment, where the subsurface consists of embankment rockfill overlying dacite bedrock. Depending on the depth to bedrock, placement of a shallow spread footing and anchors may not be feasible at this location; therefore, a single drilled shaft could be used instead. 2018/2019 explorations are intended to confirm the top of rock contours. Current EMs do not provide design guidelines for drilled shafts into rock (rock sockets). Procedures outlined by the Federal Highway Administration are considered the most current state practice, implementing AASHTO LRFD procedures. The bond strength between rock and concrete in accordance with EM 1110-1-2908 will be governed by the compressive strength of the concrete, given that 1/10 the uniaxial compressive strength of the rock is 1700 psi, well in excess of the maximum 600 psi specified in the EM 1110-1-2908. Utilizing one of the discrete deadman piles behind the proposed retaining wall as a foundation element is being explored as the retaining wall's alignment becomes finalized entering plans and specifications phase. Dual use of this shaft will require a larger diameter and deeper embedment.

h. Upstream Access Road

The existing access road along the upstream face of the dam is proposed for use by the amphibious vehicles for crew and fish transport. The road will likely require rehabilitation in order to accommodate the increased traffic loads. The existing roadway consists of a 15- to 20-foot-width gravel road. The road is accessible from the right abutment through a locked gate, and is graded to a 10 percent slope extending from the right abutment across the upstream face, terminating near the existing intake tower.

The wearing surface is composed of clean angular gravel of unknown thickness. If the rehabilitated road surface remains gravel, it may require periodic maintenance of supplemental gravel and regarding every 5 to 10 years to maintain a suitable driving surface.

The underlying subgrade consists of the Class I rockfill material used to construct the embankment dam, as shown in the typical cross-section as-built:

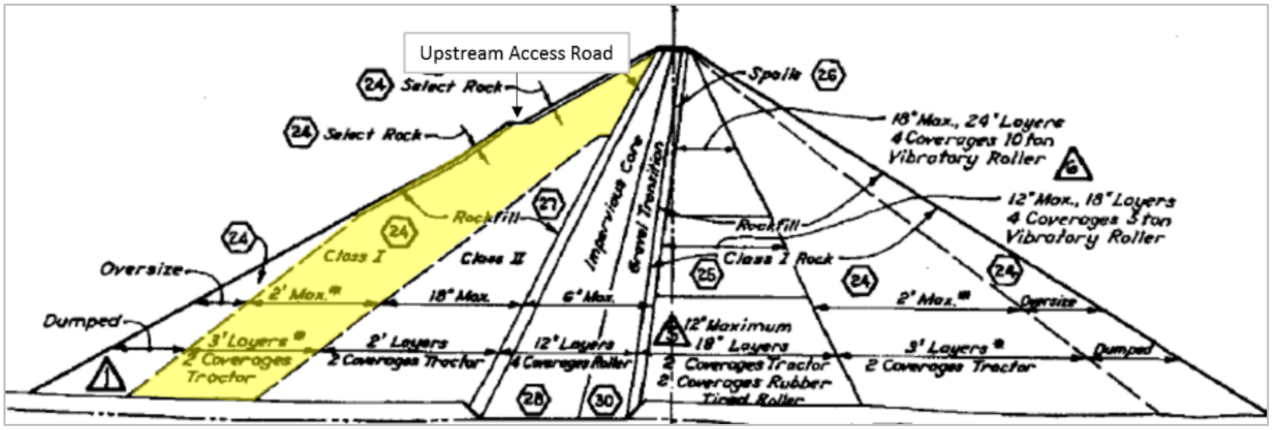


Figure 10-17. Typical Cross Section of Embankment

An approximate 5-foot-thick layer of “select rock” or revetment stone lies just upslope and downslope of the existing roadway at a 1.8 horizontal to 1 vertical (1.8H:1V) slope to allow for over steepening of slope both upslope and downslope to accommodate the road prism. This select rock consists of angular dacite fragments upwards of 5 or 6 feet in diameter. The photo below shows the existing conditions and the relative size of the revetment stone along the access road.

Figure 10-18. Existing Conditions Along Upstream Access Road - View to the East

The material used for the rockfill portion of the embankment was quarried from the massive dacite outcrop along the right abutment. Project specifications required that material for Class I rockfill consist of unaltered basalt (dacite) or andesite, and be free of silt, clay, organic material, and debris with maximum permitted particle size of 24 inches and minimal fines. Field descriptions and gradation ranges classify the material as a dense, poorly-graded coarse gravel (GP) in accordance with unified soil classification system and ASTM D 2488-00, though generally 50 percent or more is a boulder-cobble mixture of angular rock fragments. The range in material gradations taken during construction are provided below.

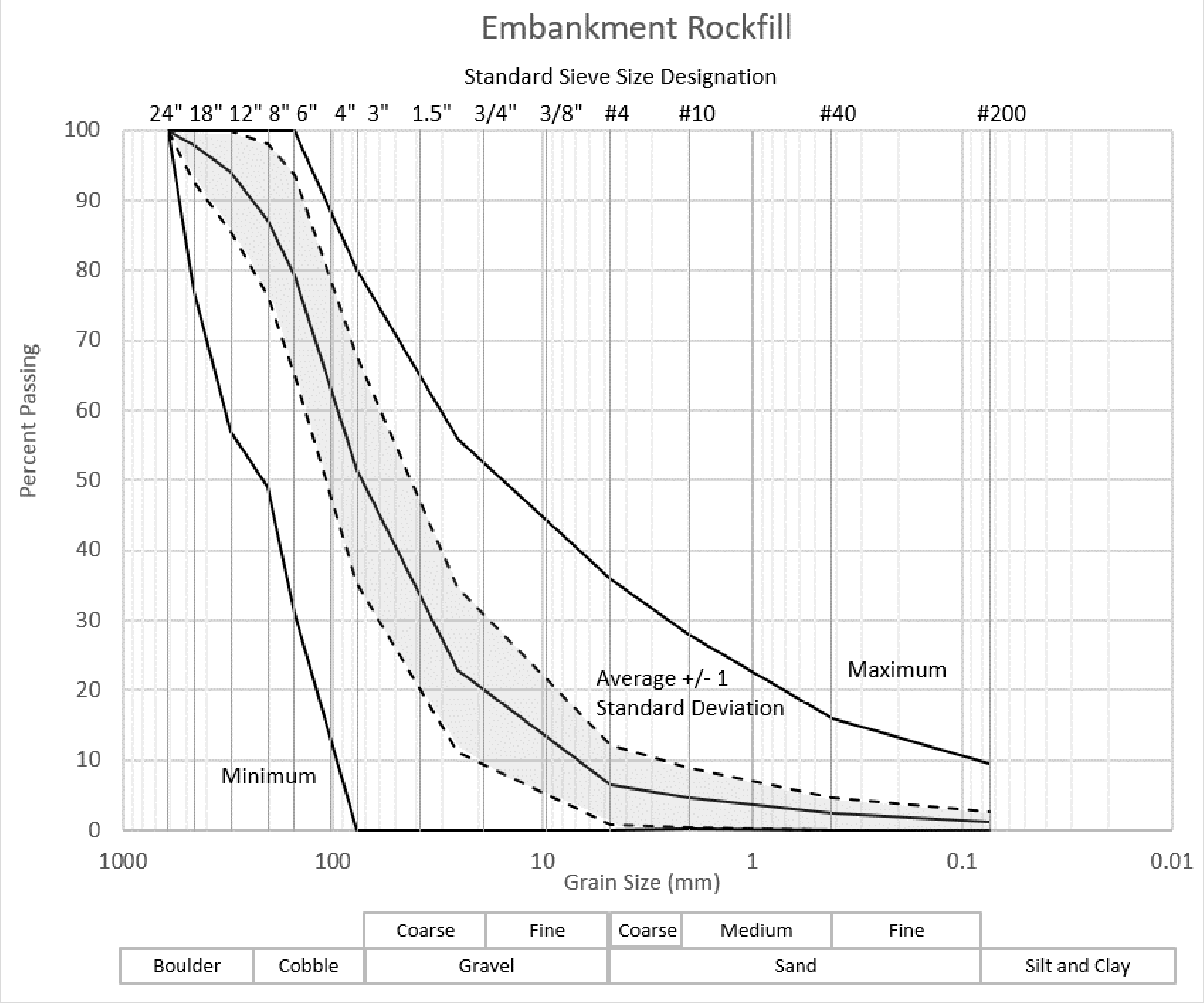
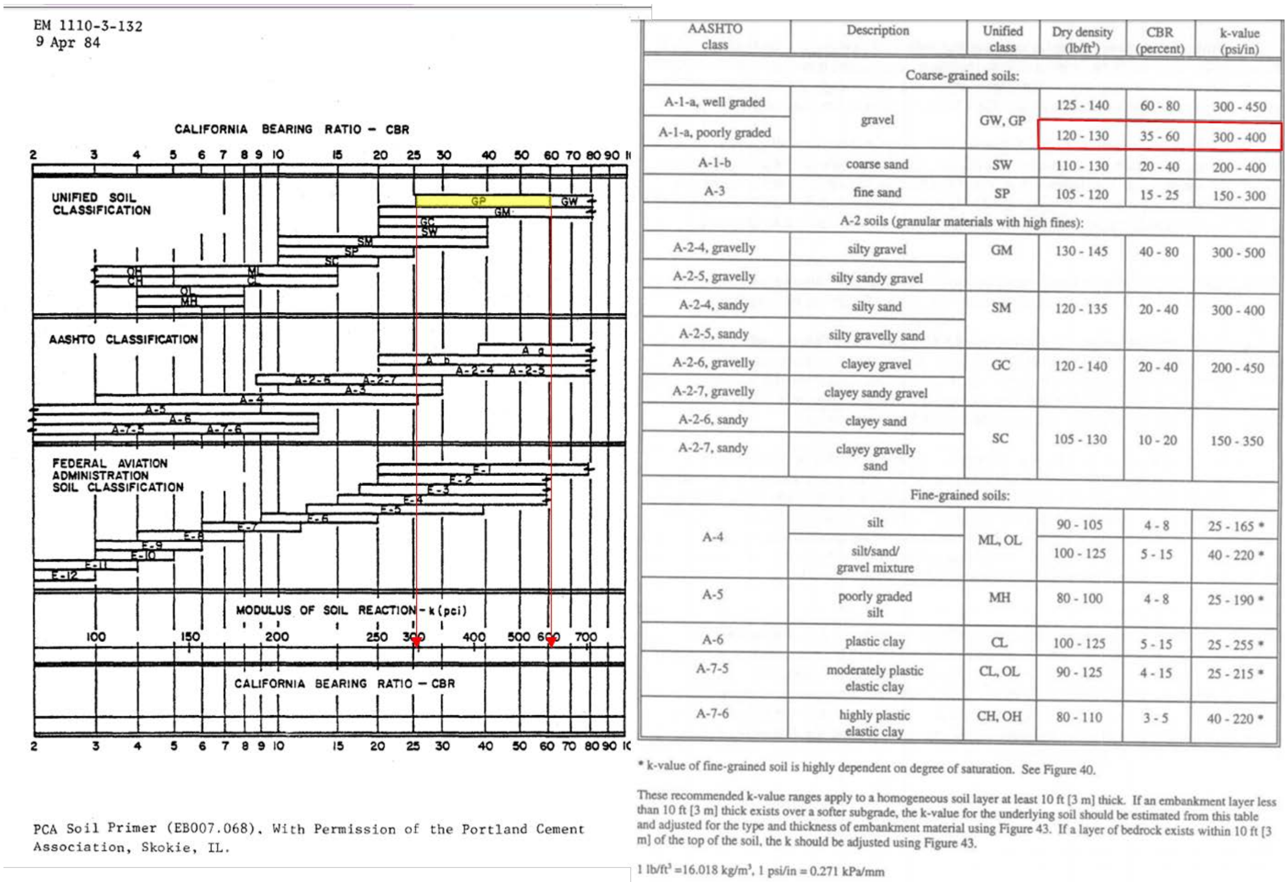


Figure 10-19. Construction Gradations of Embankment Rockfill

Construction records indicate that the upstream Class I rockfill was placed in 3-foot layers and tractor-compacted by a minimum of two passes. From the project specifications, the crawler tractors used for compaction were required to have a minimum weight of 60,000 pounds and exert a unit track pressure of 1,470 psf. The described compaction equipment and field testing conducted during construction suggest that compaction was generally good, yielding field dry density measurements between 92 percent and in excess of 100 percent of the maximum dry density. However, theoretical maximum dry density as determined through conventional laboratory compaction testing (ASTM D698 or D1557) was not feasible for the rockfill due to the high percentage of oversized particles, so all density measurements were field-determined. Construction records show measured dry densities along the upstream slope ranging from 100 to 131 lb/ft^3 with an average of 115 lb/ft^3.

The Federal Highway Administration provides guidance for estimating modulus of subgrade reaction (k) and California Bearing Ration values according to a soil's unified soil classification system classification. Based on the material classification of the Class I rockfill as a poorly-graded gravel (gp), k will typically range between 300 to 400 psi/inch and California Bearing Ration between 35 and 60 percent. This is consistent with recommended ranges from EM 1110-3-132, Rigid Pavements for Roads, Streets, Walks, and Open Storage Areas. The values selected for roadway design should tend toward the higher end of this range due to the presence of compacted oversized boulder and cobble-sized angular rock fragment material.



EM 1110-3-132
9 Apr 84

PCA Soil Primer (EB007.068). With Permission of the Portland Cement Association, Skokie, IL.

AASHTO class	Description	Unified class	Dry density (lb/ft³)	CBR (percent)	k-value (psi/in)
Coarse-grained soils:					
A-1-a, well graded	gravel	GW, GP	125 - 140	60 - 80	300 - 450
A-1-a, poorly graded			120 - 130	35 - 60	300 - 400
A-1-b	coarse sand	SW	110 - 130	20 - 40	200 - 400
A-3	fine sand	SP	105 - 120	15 - 25	150 - 300
A-2 soils (granular materials with high fines):					
A-2-4, gravelly	silty gravel	GM	130 - 145	40 - 80	300 - 500
A-2-5, gravelly	silty sandy gravel				
A-2-4, sandy	silty sand	SM	120 - 135	20 - 40	300 - 400
A-2-5, sandy	silty gravelly sand				
A-2-6, gravelly	clayey gravel	GC	120 - 140	20 - 40	200 - 450
A-2-7, gravelly	clayey sandy gravel				
A-2-6, sandy	clayey sand	SC	105 - 130	10 - 20	150 - 350
A-2-7, sandy	clayey gravelly sand				
Fine-grained soils:					
A-4	silt	ML, OL	90 - 105	4 - 8	25 - 165 *
	silt/sand/ gravel mixture		100 - 125	5 - 15	40 - 220 *
A-5	poorly graded silt	MH	80 - 100	4 - 8	25 - 190 *
A-6	plastic clay	CL	100 - 125	5 - 15	25 - 255 *
A-7-5	moderately plastic elastic clay	CL, OL	90 - 125	4 - 15	25 - 215 *
A-7-6	highly plastic elastic clay	CH, OH	80 - 110	3 - 5	40 - 220 *

* k-value of fine-grained soil is highly dependent on degree of saturation. See Figure 40.

These recommended k-value ranges apply to a homogeneous soil layer at least 10 ft [3 m] thick. If an embankment layer less than 10 ft [3 m] thick exists over a softer subgrade, the k-value for the underlying soil should be estimated from this table and adjusted for the type and thickness of embankment material using Figure 43. If a layer of bedrock exists within 10 ft [3 m] of the top of the soil, the k should be adjusted using Figure 43.

1 lb/ft³ =16.018 kg/m³, 1 psi/in = 0.271 kPa/mm

Figure 10-20. Typical Ranges of k and California Bearing Action for Poorly-Graded Gravel Soils From USACE EM 1110-3-135 (left) and Federal Highway Administration (right)

The rockfill subgrade is very dense and is not expected to be susceptible to pumping or settlement. The material is generally free-draining and pervious, so it is therefore not susceptible to frost formation during the winter months.

In 2017, three borings were drilled into the upstream access road to install dam safety instrumentation, including piezometers, inclinometers, and extensometers. In addition, two existing piezometers are located on the access road. The effort to drill and install these instrument was a significant expenditure and extreme care must be taken to ensure that they do not become damaged during construction and future operations. Currently, the instruments are covered by flush mount monuments. During construction, the instruments should be covered by temporary ramps or steel plates to prevent damage from construction traffic loads. Rehabilitation of the road must include traffic rated vault covers that will ensure that the increased loading from amphibious vehicles does not cause damage.

10.5 REFERENCES

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SECTION 11 - ENVIRONMENTAL AND CULTURAL RESOURCES

11.1 GENERAL

This section addresses environmental and cultural resources and permitting requirements as they apply to the Cougar downstream fish passage project, including a floating screen system (FSS) designed to collect and transport juvenile fish downstream, specifically spring Chinook, at Cougar Dam on the South Fork McKenzie River near Blue River, Oregon. The Cougar downstream fish passage project will provide fish collection, holding, and truck transportation features.

11.2 ENVIRONMENTAL PLANNING

a. National Environmental Policy Act

All actions that are federally funded, permitted, or constructed must satisfy the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.). The project team should seek to avoid and minimize environmental impacts in the design and construction of the Cougar downstream juvenile fish passage project. In order to comply with NEPA, a draft Environmental Assessment will be distributed for a 30-day public review and comment period for the proposed Cougar downstream fish passage project. The draft Environmental Assessment will address the alternatives analysis and temporary and permanent environmental impacts associated with project elements. Major project elements include: continued operation of the Cougar adult fish facility, construction and deployment of the FSS, fish transport, excavation, construction of a retaining wall, mooring connections to the existing Cougar temperature control tower, crew access, and debris management. After the public notice period has closed, any comments will be addressed in the final Environmental Assessment, and it is likely a Finding of No Significant Impact will be completed based on the assessment. If significant environmental concerns arise during the comment period, then an Environmental Impact Statement will be required.

b. Endangered Species Act

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, federally funded, constructed, permitted, or licensed projects must take into consideration impacts to federally listed or proposed species. Listed species under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) that may occur in Lane County include the following (Threatened (T), Endangered (E), Proposed (P), or Candidate (C):

- North American wolverine (*Gulo gulo luscus*) (P).
- Streaked Horned lark (*Eremophila alpestris strigata*) (T).
- Bradshaw's desert-parsley (*Lomatium bradshawii*) (E).
- Yellow-billed Cuckoo (*Coccyzus americanus*) (T).

- Marbled murrelet (*Brachyramphus marmoratus*) (T).
- Golden paintbrush (*Castilleja levisecta*) (T).
- Willamette daisy (*Erigeron decumbens*) (E).
- Kincaid's Lupine (*Lupinus sulphureus ssp. Kincaidii*) (T).
- Whitebark pine (*Pinus albicaulis*) (C).
- Fender's blue butterfly (*Icaricia icarioides fenderi*) (E).
- Northern spotted owl (*Strix occidentalis caurina*) (T).
- Bull trout (*Salvalinus confluentus*) (T).

Listed species under the jurisdiction of National Marine Fisheries Service (NMFS) include:

- Upper Willamette River Chinook salmon (*Oncorhynchus tshawytscha*) (T).

The Cougar downstream fish passage project is incorporated in the concurrently issued July 11, 2008, NMFS and USFWS ESA Section 7(a)(2) Consultation Biological Opinions (BiOps) on the "Willamette River Basin Flood Control Project.” The Cougar downstream fish passage project designs should also adhere to the NMFS 2011 Anadromous Salmonid Passage Facility Design Standards. Additionally, a summary identifying the potential amount and extent of take associated with construction and operation of Cougar downstream fish passage project will be submitted to NMFS and USFWS. The consultation pathway will depend on whether any of the effects could qualify as "take" under the ESA regardless of whether the net effect of the project will be beneficial. Based on conversations with NMFS General Counsel, even if NMFS finds the effects rise to the level of "take," NMFS currently believes they will be able to provide take coverage through the existing BiOp rather than an individual consultation.

c. Magnuson-Stevens Fishery Conservation and Management Act

In compliance with the Magnuson-Stevens Fishery Conservation and Management Act, an essential fish habitat assessment will be prepared and included as part of the summary described under 11.2.b and sent to and reviewed by NMFS. Formal Consultation was completed and incorporated in the above referenced 2008 NMFS Biological Opinion.

d. Fish and Wildlife Conservation Act

To meet compliance with the Fish and Wildlife Conservation Act, input from the USFWS and state fish and wildlife agencies concerning this proposal will be requested during the public notice comment period for the draft Environmental Assessment. Further, the Cougar downstream fish passage project is being developed in close collaboration with NMFS and USFWS, and their staff has had and will continue to have input throughout the design of the facility. All elements of the project design should pass review by the resource agencies. Comments from resource agencies were also received on the original Environmental Impact Statement for the Willamette River Project. Additionally, some requirements of this Act have been simultaneously addressed in conjunction with the ESA consultations referenced above.

e. Coastal Zone Management Act

This Act is not applicable to the Cougar downstream fish passage project due to its location outside the geographic boundaries of the Act.

f. Marine Protection, Research, and Sanctuaries Act Title I, Section 103

This project will not involve ocean dumping or any other action impacting the marine environment. Therefore, coordination under this Act is not required for this proposed action.

g. Clean Water Act, Sections 401, 404r, 404b (1)

This Act established the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The Clean Water Act (CWA) made it unlawful to discharge any pollutant into navigable waters, unless a permit was obtained. Section 401(a)(1) requires from the state that a discharge to waters of the U.S. in that state will not violate the states' water quality standards. The Corps seeks a state Water Quality Certification per 33 Code of Federal Regulations (CFR) 336.1 (a)(1) when its activities result in a discharge.

The current estimates of rock and rockfill excavation volumes near the WTCT are roughly 10,000 and 5,000 cubic yards, respectively. At the Slide Creek campground area, a 2.0 to 2.5 acre area will be leveled using about 40,000 cubic yards of excavated material to create a flat working area for assembling the modules. A 404(b) analysis will be completed for this project. Additionally, in order to comply with Section 404 of the Clean Water Act, dredge (e.g. excavation) and fill activities proposed at the Cougar downstream fish passage project will require an individual State 401 Water Quality Certification from the Oregon Department of Environmental Quality (ODEQ) for temporary and permanent impacts to wetlands and waters of the State. This requires submission of fees and a Joint Permit Application for Removal and Fill, which is accepted by both ODEQ and the Oregon Department of State Lands. The existing access road along the upstream face of the dam is proposed for use for construction access and debris management during operations as well as be used daily by the amphibious vehicle (AV) for crew and fish transport after construction is complete. To accommodate the increased traffic loads, the upstream access road will require rehabilitation consisting of thickening the gravel wearing surface. Because impervious surfaces are involved, the ODEQ 401 program also requires submission of a post-construction Stormwater Management Plan for permanent treatment of nonpoint discharge from the facility. ODEQ has accepted specific design criteria from five manuals. These approved design manuals and the checklist of information that will be required in the Stormwater Management Plan are referenced in the ODEQ Stormwater Management Plan Submission Guidelines.

Section 402(a)(1) authorizes the EPA, or states in which the EPA has delegated such authority, to issue permits for the discharge of pollutants under the National Pollutant Discharge Elimination System (NPDES) program for all land disturbances over an acre in size. Regulated categories of discharges generally include point-source discharges and stormwater runoff. Permit conditions are usually required to ensure compliance with all applicable effluent and water quality standards. Temporary impacts to water quality should be avoided and minimized during the project's construction and staging. An Erosion and Sediment Control Plan must be developed and implemented in compliance with the Corps' existing general NPDES 1200-CA permit issued by ODEQ for during-construction stormwater management. A guide for proper installation and maintenance of appropriate Best Management Practices for both uplands and in-water work can be found in the ODEQ Erosion and Sediment Control Manual. Low Impact Development techniques including infiltration and protection of existing soils and vegetation should be implemented wherever appropriate. Site grubbing and clearing as much as possible should be kept to the minimum required for the permanent project footprint.

Additionally, all in-water work will require an in-water work isolation plan for control of turbidity and plans for fish salvage and exclusion. The plans will be submitted with the Joint Permit Application and reviewed during ODEQ's Water Quality Certification evaluation. ODEQ usually defers to the ODFW and NMFS regarding appropriateness of proposed fish salvage and exclusion measures, and may simply require documentation of their acceptability to the agencies. Turbidity monitoring reports will be required during all in-water work.

The project will result in permanent impacts to wetlands and waters. These include permanent fill and removal of materials typically below the ordinary high water mark essential to constructing the retaining wall and FSS mooring, as well as a construction pad at Slide Creek for the construction of the FSS. Changes to channel dynamics are expected to remain localized and should avoid inducing significant up or downstream channel or bank instability. An ODFW blasting permit will be required. Impervious surfaces contribute to water quality degradation because they act as deposition and conveyance surfaces for accumulated air and traffic pollutants. Water quality treatment to avoid these impacts should be described in the Stormwater Management Plan. This plan must address all contributing impervious areas and provide treatment designed per an ODEQ-accepted manual or its equivalent.

Point source discharges for the facility operation is not expected. If final plans and specifications result in point source discharges, the facility will need to be covered under an NPDES permit issued by the ODEQ.

Restoration of water quality function will be required to address these impacts to waters of the State. Restoration of riparian vegetation and stream banks must be reflected in a site restoration and enhancement plan to be included with the Joint Permit Application. Any additional wetland impacts will also require mitigation, although none are expected. Any mitigation will be reviewed by the Oregon Department of State Lands and ODEQ when considering replacement of water quality function. The 2008 Biological Opinion also describes water quality and habitat restoration measures that should be considered in the mitigation and restoration plan development. Opportunities to meet these obligations likely exist on site.

h. Clean Air Act

Section 118 (42 U.S.C. 7418) of the Clean Air Act specifies that each department, agency, and instrumentality of the executive, legislative, and judicial branches of the Federal government (1) having jurisdiction over any property or facility or (2) engaged in any activity resulting, or which may result, in the discharge of air pollutants, shall be subject to, and comply with, all Federal, State, interstate, and local requirements respecting the control and abatement of air pollution in the same manner, and to the same extent as any non-governmental entity. USACE activities resulting in the discharge of air pollutants must conform to National Ambient Air Quality Standards and State Implementation Plans, unless the activity is explicitly exempted by EPA regulations. Construction of the Cougar Downstream Fish Passage Facility is anticipated to remain in compliance with the Clean Air Act and the State Implementation Plans. This is not a transportation project, it will not qualify as a major stationary source of emissions of criteria pollutants, and the project does not appear to be located in a non-attainment area for limited air quality. Any emissions that do occur during and after construction from motor vehicles or facility functions are expected to be de minimis and will be from activities of a similar scope and operation to those of the original facility.

i. Applicable Local and State Statutes

Under the Clean Water Act, the Corps will need to comply with state and/or local requirements, including obtaining permits and paying reasonable service charges, respecting the control and abatement of water pollution. This will include obtaining a Section 401 Water Quality Certification from the ODEQ. The Water Quality Certification will likely require that in-water work occur with the ODFW-preferred time window, which for the McKenzie River and tributaries above Leaburg Dam is July 1 to August 15. Under State law, ODEQ requires that the activity is compatible with local land use plans. This can be achieved if Lane County signs the City/County Planning Department Land Use Affidavit section of the Joint Permit Application. Under Federal law, USACE is not required to comply with local land use laws and is only required to comply with the local requirements respecting the control and abatement of water pollution. Therefore, any requirements by the County must be based on water quality-related requirements only. The Corps may need to obtain a permit from the Oregon Department of State Lands for the discharge of fill material into waters of the United States. The Oregon Department of State Lands may require functional restoration for impacts to waters and wetland mitigation based on ratios set forth under State law. The Corps should attempt to align any Oregon Department of State Lands requirements consistent with its own Clean Water Act Section 404(b)(1) evaluation of the impacts.

j. National Historic Preservation Act

Section 106 of the National Historic Preservation Act requires that federally assisted or federally permitted undertakings account for the potential effects on sites, districts, buildings, structures, or objects that are included in or eligible for inclusion in the National Register of

Historic Places. Cougar Dam was built in 1963 and is recommended eligible to the National Register of Historic Places. It will be necessary to ensure that project construction is consistent with "in-kind" maintenance of the structure and will not impact eligibility. Any proposed drawdown to elevation below the minimum conservation pool elevation of 1,516 feet has the potential to expose documented archeological sites and to expose new sites. Areas exposed will need to be inventoried prior to construction and known archeological sites will need to be monitored to update site condition to current State Historic Preservation Office standards. During any drawdown, law enforcement or rangers will need to increase patrols along the shoreline to watch for potential looting as sites are exposed. Consultation with the State Historic Preservation Office and the tribes will be conducted, which will include consultation on the Area of Potential Effect, which is assumed to include the dam, any staging areas, and the area exposed by the deep drawdown.

11.3 WILLAMETTE PROJECT JEOPARDY BIOLOGICAL OPINIONS TERMS AND CONDITIONS

The NMFS and USFWS 2008 Willamette Project Jeopardy BiOps Incidental Take Statements (NMFS 2008, USFWS 2008 respectively) outline reasonable and prudent measures (RPMs) and their related terms and conditions considered necessary and appropriate to minimize incidental take to the extent practicable and to monitor the incidental take of the ESA-listed species resulting from implementation of the BiOps.

The NMFS 2008 BiOp RPMs relevant to the Cougar downstream passage project include RPMs 1 and 4:

> RPM 1. Minimize incidental take from general construction activities associated with project implementation by applying best management practices to avoid or minimize adverse effects to listed species or to water quality, riparian habitat, or other aquatic system components of critical habitat.
>
> RPM 4. Ensure completion of a monitoring and reporting program to demonstrate compliance with the requirements of this incidental take statement.

The USFWS 2008 BiOp RPM relevant to the Cougar Downstream Passage Facility includes RPM 7:

> RPM 7. Minimize incidental take of bull trout from construction projects implemented under the proposed action.

In order to be exempt from the take prohibitions of Section 9 of the ESA and regulations issued pursuant to Section 4(d) of the ESA, the Corps must carry out the following terms and conditions, which implement the RPMs listed above. In all proposed actions involving construction in or near waterways, USACE must ensure that Best Management Practices for construction activities to control sediment, disturbance, and other potential detrimental effects to listed salmonids and critical habitat, described below are followed. Based on recent coordination with NMFS staff, additional Best Management Practices to the 2008 BiOp from more recent programmatic biological opinions for construction actions in the region are incorporated in the list below.

To implement RPM 1 of the NMFS 2008 BiOp, in all proposed actions involving construction in or near waterways, USACE must ensure that Best Management Practices for construction activities to control sediment, disturbance, and other potential detrimental effects to listed salmonids and critical habitat, described below, are followed.

a. Minimize Areas Impacted by Construction

Construction impacts will be confined to the minimum area necessary to complete the project. Boundaries of clearing limits associated with site access and construction will be marked to avoid or minimize disturbance of riparian vegetation, wetlands and other sensitive sites.

b. Preconstruction Activity

Complete the following actions before significant alteration of the project area:

(1) Marking

Flag the boundaries of clearing limits associated with site access and construction to prevent ground disturbance of critical riparian vegetation, wetlands, and other sensitive sites beyond the flagged boundary. Before any significant ground disturbance or entry of mechanized equipment or vehicles into the construction area, clearly mark with flagging or survey marking paint the following areas:

- Sensitive areas, e.g., wetlands, water bodies, ordinary high water spawning areas.
- Equipment entry and exit points.
- Road and stream crossing alignments.
- Staging, storage, and stockpile areas.

(2) Emergency Erosion Controls

Ensure that the following materials for emergency erosion control are on site:

- A supply of sediment control materials (e.g., silt fence, straw bales).
- An oil-absorbing, floating boom whenever surface water is present.

(3) Temporary Erosion Controls

All temporary erosion controls will be in place and appropriately installed downslope of project activity within the riparian buffer area until site rehabilitation is complete.

c. Work Area Isolation

- Isolate any work area within the wetted channel from the active stream whenever ESA-listed fish are reasonably certain to be present, or if the work area is less than 300 feet upstream from known spawning habitats.

- Engineering design plans for work area isolation will include all isolation elements and fish release areas.

- Dewater the shortest linear extent of work area practicable, unless wetted in-stream work is deemed to be minimally harmful to fish, and is beneficial to other aquatic species.

  - Use a cofferdam and a bypass culvert or pipe, or a lined, non-erodible diversion ditch to divert flow around the dewatered area. Dissipate flow energy to prevent damage to riparian vegetation or stream channel and provide for safe downstream reentry of fish, preferably into pool habitat with cover.

  - Where gravity feed is not possible, pump water from the work site to avoid rewatering. Maintain a fish screen on the pump intake to avoid juvenile fish entrainment.

  - Pump seepage water to a temporary storage and treatment site, or into upland areas, to allow water to percolate through soil or to filter through vegetation before reentering the stream channel with a treatment system comprised of either a hay bale basin or other sediment control device.

  - Monitor below the construction site to prevent stranding of aquatic organisms.

  - When construction is complete, re-water the construction site slowly to prevent loss of surface flow downstream, and to prevent a sudden increase in stream turbidity.

- Whenever a pump is used to dewater the isolation area and ESA-listed fish may be present, a fish screen will be used that meets the most current version of NMFS's fish screen criteria (NMFS 2011). NMFS approval is required for pumping at a rate that exceeds 3 cfs.

d. Vegetation

- Alteration or disturbance of the stream banks and existing riparian vegetation will be minimized to the greatest extent possible.

- Mechanical removal of undesired vegetation and root nodes is permitted, but not herbicide use.

- All existing vegetation within 150 feet of the edge of bank should be retained, to the greatest extent possible.

e. Timing of In-Water Work

Work below the bankfull elevation will be completed during the State of Oregon's preferred in-water work period (ODFW 2008) as appropriate for the project area, unless otherwise approved in writing by NMFS. Other project specific requirements may apply (e.g., notification of NMFS prior to, or at the end of, in-water work) as identified during review of proposed project plans by NMFS.

f. Cessation of Work

Construction project activities will cease under high flow conditions that may result in inundation of the project area, except for efforts to avoid or minimize resource damage. All materials, equipment, and fuel must be removed if flooding of the area is expected to occur within 24 hours.

g. Fish Screens

All water intakes used for a construction project, including pumps used to isolate an in-water work area, will have a fish screen installed, operated, and maintained according to NMFS' fish screen criteria. This clause does not authorize screens for any permanent use.

- Submit to NMFS for review and approval fish screen designs for surface water diverted by gravity or by pumping at a rate that exceeds 3 cfs.

- All other diversions will have a fish screen that meets the following specifications:

    - An automated cleaning device with a minimum effective surface area of 2.5 square feet per cfs, and a nominal maximum approach velocity of 0.4 fps, or no automated cleaning device, a minimum effective surface area of 1 square foot per cfs, and a nominal maximum approach rate of 0.2 fps.

    - A round or square screen mesh that is no larger than 2.38 mm (0.094 inches) in the narrow dimension, or any other shape that is no larger than 1.75 mm (0.069 inches) in the narrow dimension.

- Each fish screen will be installed, operated, and maintained according to NMFS's fish screen criteria.

h. Fish Passage

Passage must be provided for any adult or juvenile salmonid species present in the Project area during construction, unless otherwise approved in writing by NMFS, and maintained after construction for the life of the Project. Passage will be designed in accordance with NMFS' Anadromous Salmonid Passage Facility Design (NMFS 2011). Upstream passage is required during construction if it previously existed.

i. Pollution and Erosion Control Plan

Prepare, in consultation with NMFS, and carry out a Pollution and Erosion Control Plan to prevent pollution caused by survey, construction, operation, and maintenance activities. Construction activities associated with erosion control measures must meet or exceed best management practices and other performance standards contained in the applicable state and Federal permits. The plan will be available for inspection upon request by NMFS.

(1) Plan Contents

The Pollution and Erosion Control Plan will contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

- The name and address of the parties responsible for accomplishment of the Pollution and Erosion Control Plan.

- Practices to prevent erosion and sedimentation associated with access roads, decommissioned roads, stream crossings, drilling sites, construction sites, borrow pit operations, haul roads, equipment and material storage sites, fueling operations, and staging areas.

- Practices to confine, remove, and dispose of excess concrete, cement, and other mortars or bonding agents, including measures for washout facilities.

- A description of any regulated or hazardous products or materials that will be used for the project, including procedures for inventory, storage, handling, and monitoring.

- A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.

- Practices to prevent construction debris from dropping into any stream or water body, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.

- Erosion control materials (e.g., silt fence, straw bales, aggregate) in excess of those installed must be available on site for immediate use during emergency erosion control needs.

- Temporary erosion and sediment controls will be used on all exposed slopes during any hiatus in work exceeding 7 days.

(2) Erosion Control During Construction

- Complete earthwork in wetlands, riparian areas, and stream channels as quickly as possible.

- Cease project operations when high flows may inundate the project area, except for efforts to avoid or minimize resource damage.

- If eroded sediment appears likely to be deposited in the stream during construction, install additional sediment barriers as necessary.

- Temporary erosion control measures may include fiber wattles, silt fences, jute matting, wood fiber mulch and soil binder, or geotextiles and geosynthetic fabric.

- Soil stabilization using wood fiber mulch and tackifier (hydro-applied) may be used to reduce erosion of bare soil, if the materials are free of noxious weeds and nontoxic to aquatic and terrestrial animals, soil microorganisms, and vegetation.

- Remove sediment from erosion controls if it reaches 1/3 of the exposed height of the control.

- Whenever surface water is present, maintain a supply of sediment control materials and an oil-absorbing floating boom at the project site.

- Stabilize all disturbed soils following any break in work unless construction will resume within 4 days.

(3) Inspection of Erosion Controls

During construction, the operator must monitor in-stream turbidity and inspect all erosion controls daily during the rainy season (October through May) and weekly during the dry season (June through September), or more often as necessary, to ensure the erosion controls are working adequately.

- If monitoring or inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs, install replacements, or install additional controls as necessary.

- Remove sediment from erosion controls once it has reached one-third of the exposed height or capacity of the control.

(4) Water Quality

- Landward erosion control methods shall be used to prevent silt-laden water from entering waters of the U.S. These may include, but are not limited to, filter fabric, temporary sediment ponds, check dams of pea gravel-filled burlap bags or other material, and/or immediate mulching of exposed areas.

- Wastewater from project activities and water removed from within the work area shall be routed to an upland disposal site (landward of the ordinary high water mark or extreme high tide line) to allow removal of fine sediment and other contaminants prior to being discharged to the waters of the U.S.

- All waste material such as construction debris, silt, excess dirt or overburden resulting from this project will generally be deposited above the limits of flood water in an upland disposal site. However, material from pushup dikes may be used to restore microtopography (e.g., filling drainage channels).

(5) Planting and Erosion Control

- Within 7 calendar days from project completion, any disturbed bank and riparian areas shall be protected using native vegetation or other erosion control measures as appropriate. For erosion control, sterile grasses may be used in lieu of native seed mixes. Alternative methods (e.g. spreading timber harvest slash) may be used for erosion control if approved by USACE.

- If native riparian vegetation is disturbed it will be replanted with native herbaceous and/or woody vegetation after project completion. Planting will be completed between October 1 and April 15 of the year following construction. Plantings will be maintained as necessary for 3 years to ensure 50 percent herbaceous and/or 70 percent woody cover in year 3, whatever is applicable. For riparian impact areas greater than 0.5 of an acre, a final monitoring report will be submitted to USACE in year 3.

- Fencing will be installed as necessary to prevent access to revegetated sites by livestock, beavers or unauthorized persons. Beaver fencing will be installed around individual plants where necessary.

j. Construction Discharge Water

Treat all discharge water created by construction (e.g., concrete washout, pumping for work area isolation, vehicle wash water, drilling fluids) using best management practices to remove debris, sediment, petroleum products, and any other pollutants likely to be present (e.g., green concrete, contaminated water, silt, welding slag, sandblasting abrasive, grout cured less than 24 hours, drilling fluids), to avoid or minimize pollutants discharged to any perennial or intermittent water body. Pump seepage water from the dewatered work area to a temporary storage and treatment site or into upland areas and allow water to filter through vegetation prior to reentering the stream channel. Treat water used to cure concrete until pH stabilizes to background levels. Treat all discharge water as follows:

(1) Water Quality

Design, build, and maintain facilities to collect and treat all construction discharge water, including any contaminated water produced by drilling, using the best available technology applicable to site conditions. Provide treatment to remove debris, nutrients, sediment, petroleum hydrocarbons, metals, and other pollutants likely to be present.

(2) Discharge Velocity

If construction discharge water is released using an outfall or diffuser port, velocities will not exceed 4 fps, and the maximum size of any aperture will not exceed one inch.

(3) Spawning Areas

Do not release construction discharge water within 300 feet upstream of spawning areas. Clean construction discharge may be released.

(4) Pollutants

Do not allow pollutants, including green concrete, contaminated water, silt, welding slag, sandblasting abrasive, or grout cured less than 24 hours to contact any wetland or the 2-year floodplain, except cement or grout when abandoning a drill boring or installing instrumentation in the boring.

(5) Drilling Discharge

All drilling equipment, drill recovery and recycling pits, and any waste or spoil produced, will be completely isolated to prevent drilling fluids or other wastes from entering the stream.

- All drilling fluids and waste will be completely recovered then recycled or disposed to prevent entry into flowing water.
- Drilling fluids will be recycled using a tank instead of drill recovery/recycling pits, whenever feasible.
- When drilling is completed, attempts will be made to remove the remaining drilling fluid from the sleeve (e.g., by pumping) to reduce turbidity when the sleeve is removed.

k. Turbidity Monitoring

Where practicable, a turbidity and/or debris containment device shall be installed prior to commencing in-water work. When working in-water, some turbidity monitoring may be required, subject to potential the Corps permit requirements or Clean Water Act Section 401 certification. Turbidity monitoring generally is required when working in streams with more than 40 percent fines (silt/clay) in the substrate. Turbidity will be monitored only when turbidity generating work takes place, for example, installation of coffer dams, pulling the culvert in-water, reintroducing water. The applicant will measure the duration and extent of the turbidity plume (visible turbidity above background) generated. The data will be submitted to USACE and NMFS immediately following project construction. Turbidity measurements will be taken in nephelometric turbidity units and are used by project proponents to develop procedures to minimize turbidity and estimate take for future projects.

l. Surface Water Withdrawal

- Surface water may be diverted to meet construction needs, including dust abatement, only if water from developed sources (e.g., municipal supplies, small ponds, reservoirs, or tank trucks) are unavailable or inadequate.

- Diversions may not exceed 10 percent of the available flow and will have a juvenile fish exclusion device that is consistent with NMFS's criteria (NMFS 2011a).

m. Temporary Access Roads

Whenever reasonable, use existing access roads and paths preferentially. Minimize the number and length of temporary access roads and paths through riparian areas and floodplains.

(1) Steep Slopes

Do not build temporary access roads or paths where grade, soil, or other features suggest slope instability. Do not build temporary roads mid-slope. Any road on a slope steeper than 30 percent will be designed by a civil engineer with experience in steep road design.

(2) Minimizing Soil Disturbance and Compaction

Low-impact, tracked drills will be walked to a survey site without the need for an access road. Minimize soil disturbance and compaction for other types of access whenever a new temporary road is necessary within 150 feet of a stream, water body, or wetland by clearing vegetation to ground level (no grubbing) and placing clean gravel over geotextile fabric, unless otherwise approved in writing by NMFS. Minimize removal of riparian vegetation.

(3) Temporary Stream Crossings

- Do not allow equipment in the flowing water portion of the stream channel where equipment activity could release sediment downstream, except at designated stream crossings.

- Minimize the number of temporary stream crossings.

- Design new temporary stream crossings as follows:

  - Survey and map any potential spawning habitat within 300 feet downstream of a proposed crossing.
  - Do not place stream crossings at known or suspected spawning areas, or within 300 feet upstream of such areas if spawning areas may be affected.
  - Do not place temporary crossings in areas that may increase the risk of channel re-routing or avulsion.
  - Design the crossing to provide for foreseeable risks (e.g., flooding and associated bedload and debris) to prevent the diversion of stream flow out of the channel and down the road if the crossing fails.
  - The substrate at the cross will be bedrock or coarse rock and gravel or mats or logs will be used in soft bottom situations to minimize compaction while driving across streams.
  - Vehicles and machinery will cross riparian buffer areas and streams at right angles to the main channel wherever possible.
  - Equipment crossing will be free of external petroleum-based products, soil and debris has been removed from the drive mechanisms and undercarriage.
- Obliteration. When the project is completed, obliterate all temporary access roads, stabilize the soil, and revegetate the site. Abandon and restore temporary roads in wet or flooded areas by the end of the in-water work period.

n. Equipment, Vehicles, and Power Tools

- Avoid use of heavy equipment, vehicles or power tools below ordinary high water unless project specialists determine such work is necessary, or would result in less risk of sedimentation or other ecological damage than work above that elevation.
- Before entering the water, inspect any watercraft, waders, boots, or other gear to be used in or near water and remove any plants, soil, or other organic material adhering to the surface.
- Ensure that any generator, crane or other stationary heavy equipment that is operated, maintained, or stored within 150 feet of any water body is also protected as necessary to prevent any leak or spill from entering the water.

Restrict use of heavy equipment as follows:

(1) Choice of Equipment

When heavy equipment will be used, the equipment selected will have the least adverse effects on the environment (e.g., minimally sized, low ground pressure equipment).

(2) Equipment Staging

Store construction materials and fuel, operate, maintain, and store vehicles as follows:

- To reduce the staging area and potential for contamination, ensure that only enough supplies and equipment to complete a specific job will be stored on site.
- Complete vehicle staging, cleaning, maintenance, refueling, and fuel storage, except for that needed to service boats, in a vehicle staging area placed 150 feet or more from any stream, water body, or wetland, unless otherwise approved in writing by NMFS.
- Inspect all vehicles operated within 150 feet of any stream, water body, or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by NMFS.
- Before activities begin and as often as necessary during construction activities, steam clean all equipment that will be used below the bankfull elevation until all visible external oil, grease, mud, and other visible contaminates are removed. Any washing of equipment must be conducted in a location that will not contribute untreated wastewater to any flowing stream or drainage area.
- Diaper all stationary power equipment (e.g., generators, cranes, stationary drilling equipment) operated within 150 feet of any stream, water body, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream, water body, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream or water body.
- When not in use, vehicles and equipment containing oil, fuel, and/or chemicals will be stored in a staging area located at least 150 feet from the Corps' jurisdictional boundary of wetlands and water bodies. If possible staging will be located at least 300 feet away from the Corps' jurisdictional boundary of wetlands and water bodies, and on impervious surfaces to prevent spills from reaching ground water. When moving equipment daily at least 150 feet of water bodies would create unacceptable levels of disturbance (multiple stream crossings, multiple passes over sensitive vegetation) a closer staging location with an adequate spill prevention plan may be proposed.

(3) Equipment Use

- Before entering wetlands or working within 150 feet of a water body:

- Power wash all heavy equipment, vehicles and power tools, allow them to fully dry, and inspect them for fluid leaks, and to make certain no plants, soil, or other organic material are adhering to the surface.

- Replace petroleum-based hydraulic fluids with biodegradable products in hydraulic equipment, vehicles, and power tools.

- Repeat cleaning as often as necessary during operation to keep all equipment, vehicles, and power tools free of external fluids and grease, and to prevent a leak or spill from entering the water.

- When conducting in-water or bank work, machine hydraulic lines will be filled with vegetable oil for the duration of the project to minimize impacts of potential spills and leaks. If this conservation measure is not practicable, the applicant will propose alternative Best Management Practices to avoid the discharge of hydraulic fluids to the aquatic environment. If this conservation measure is not practical the applicant will use low-hour machinery.

- Spill prevention and clean-up kits will be on site when heavy equipment is operating within 25 feet of the water.

- To the extent feasible, work requiring use of heavy equipment will be completed by working from the top of the bank (i.e. landward of the ordinary high water mark or extreme high tide line).

o. Site Preparation

Conserve native materials for site rehabilitation.

- If possible, leave native materials where they are found.

- If materials are moved, damaged, or destroyed, replace them with a functional equivalent during site rehabilitation.

- Stockpile any large wood, native vegetation, weed-free topsoil, and native channel material displaced by construction for use during site rehabilitation.

- All native, non-invasive organic material (large and small wood) cleared from the action area for access will remain on site.

p. Isolation of In-Water Work Area

If adult or juvenile fish are reasonably certain to be present, or if the work area is less than 300 feet upstream of spawning habitats, completely isolate the work area from the active flowing stream using inflatable bags, sandbags, sheet pilings, or similar materials, unless otherwise approved in writing by NMFS. Isolation materials will be removed after completion of the project.

q. Capture and Release of Fish in Construction Salvage Operations

Before and intermittently during pumping to isolate an in-water work area, attempt to capture fish from the isolated area using trapping, seining, electrofishing, or other methods as are prudent to minimize risk of injury, then release them at a safe and suitable release site.

- If practicable, allow listed fish species to migrate out of the work area or remove fish before dewatering; otherwise remove fish from an exclusion area as it is slowly dewatered with methods such as hand or dip-nets, seining, or trapping with minnow traps (or gee-minnow traps).

- Conduct fish capture activities during periods of the day with the coolest air and water temperatures possible, normally early in the morning to minimize stress and injury of species present.

- The entire capture and release operation will be conducted or supervised by a fishery biologist experienced with work area isolation and competent to ensure the safe handling of all ESA-listed fish.

- If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000) and summarized below.

    - Do not electrofish near adult salmon in spawning condition or near redds containing eggs.

    - Keep equipment in good working condition. Complete manufacturers' preseason checks, follow all provisions, and record major maintenance work in a log.

    - Train the crew by a crew leader with at least 100 hours of electrofishing experience in the field using similar equipment. Document the crew leader's experience in a logbook. Complete training in waters that do not contain listed fish before an inexperienced crew begins any electrofishing.

    - Measure conductivity and set voltage as follows:

Conductivity (µS/cm)	**Voltage**
Less than 100	900 to 1100
100 to 300	500 to 800
Greater than 300	150 to 400

        - USGS collects specific conductance data continuously at McKenzie River near Vida, Oregon (USGS ID: 14162500, https://or.water.usgs.gov/cgi-bin/grapher/grapher.pl). Conductance typically ranges between 35 and 65. Higher values occur in late summer during baseflow periods. Lower values during the wet season when baseflow is diluted by younger, surface water.

        - Use direct current at all times.

  - Begin each session with pulse width and rate set to the minimum needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured. Start with a pulse width of 500µs and do not exceed 5 milliseconds. Pulse rate should start at 30 hertz and work carefully upward. In general, pulse rate should not exceed 40 hertz, to avoid unnecessary injury to the fish.

  - The zone of potential fish injury is 0.5 meters from the anode. Care should be taken in shallow waters, undercut banks, or where fish can be concentrated, because in such areas the fish are more likely to come into close contact with the anode.

  - Work the monitoring area systematically, moving the anode continuously in a herringbone pattern through the water. Do not electrofish one area for an extended period.

  - Electrofishing will be used during the coolest time of day, only after other means of fish capture are determined to be not feasible or ineffective.

  - Do not electrofish when the water appears turbid, e.g., when objects are not visible at depth of 12 inches.

  - Do not intentionally contact fish with the anode.

  - Begin electrofishing with a minimum pulse width and recommended voltage, then gradually increase to the point where fish are immobilized.

  - Immediately discontinue electrofishing if fish are killed or injured, i.e., dark bands visible on the body, spinal deformations, significant descaling, torpid or inability to maintain upright attitude after sufficient recovery time. Recheck machine settings, water temperature and conductivity, and adjust or postpone procedures as necessary to reduce injuries.

  - Whenever possible, place a block net below the area being sampled to capture stunned fish that may drift downstream.

  - Monitor the nets frequently enough to ensure they stay secured to the banks and free of organic accumulation.

  - Record the electrofishing settings in a logbook along with conductivity, temperature, and other variables affecting efficiency. These notes, with observations on fish condition, will improve technique and form the basis for training new operators.

- Do not use seining or electrofishing if water temperatures exceed 18 degrees Celsius unless no other more suitable and effective method of capture is available.

- Handle ESA-listed fish with extreme care, keeping fish in water to the maximum extent possible during seining and transfer procedures, to prevent the added stress of out-of-water handling.

- Transport fish by providing circulation of clean cold water in aerated buckets, tanks, or in sanctuary nets that hold water during transfer. Minimize holding times.

- If buckets are used to transport fish:

    - Minimize the time fish are in a transport bucket.

    - Keep buckets in shaded areas or, if no shade is available, covered by a canopy.

    - Limit the number of fish within a bucket; fish will be of relatively comparable size to minimize predation.

    - Use aerators or replace the water in the buckets at least every 15 minutes with cold clear water.

    - Release fish in an area upstream with adequate cover and flow refuge; downstream is acceptable provided the release site is below the influence of construction.

    - Be careful to avoid mortality counting errors.

- Monitor and record fish presence, handling, and injury during all phases of fish capture and submit a fish salvage report (Appendix A, Part 1 with Part 3 completed) to USACE and the Standard Local Operating Procedures for Endangered Species mailbox (slopes.nwr@noaa.gov) within 60 days.

- Release fish into a safe and appropriate release site as quickly as possible, and as near as possible to the original capture sites.

- Do not transfer ESA-listed fish to anyone except NMFS personnel, unless otherwise approved in writing in advance of the transfer.

- Obtain all other Federal, state, and local permits necessary to conduct the capture and release activity.

- Allow NMFS or its designated representative to accompany the capture team during the capture and release activity, and to inspect the team's capture and release records and facilities.

- An electronic copy of the Salvage Report Form is submitted to NMFS within 10 calendar days of completion of the salvage operations, noting the quantities and species of fish salvaged.

- Fish salvage operations must be re-conducted should the isolated construction areas be temporarily hydraulically re-connected to the adjacent waterway, such as after a high-water event or cofferdam failure.

r. Staging, Storage, and Stockpile Areas

- Designate and use staging areas to store hazardous materials, or to store, fuel, or service heavy equipment, vehicles and other power equipment with tanks larger than 5 gallons, that are at least 150 feet from any natural water body or wetland, or on an established paved area, such that sediment and other contaminants from the staging area cannot be deposited in the floodplain or stream.

- Natural materials that are displaced by construction and reserved for restoration, e.g., LW, gravel, and boulders, may be stockpiled within the 100-year floodplain.

- Dispose of any material not used in restoration and not native to the floodplain outside of the functional floodplain.

- After construction is complete, obliterate all staging, storage, or stockpile areas, stabilize the soil, and revegetate the area

s. Earthwork

Complete earthwork (including drilling, excavation, dredging, filling, and compacting) as quickly as possible.

(1) Excavation

Material removed during excavation will only be placed in locations where it cannot enter sensitive aquatic resources. Whenever topsoil is removed, it must be stored and reused on site to the greatest extent possible. If riprap is used for protecting a culvert inlet or outlet, it will be class 350 metric or larger, and topsoil will be placed over the rock and planted with native woody vegetation.

(2) Site Stabilization

Stabilize all disturbed areas, including obliteration of temporary roads, following any break in work, unless construction will resume within 4 days.

(3) Source of Materials

Obtain boulders, rock, woody materials, and other natural construction materials used for the project outside the riparian buffer area. Spawning gravel for augmentation of spawning habitats must be washed (i.e. cleaned, rinsed rock) river rock, of suitable size for Upper Willamette River spring Chinook spawning or for Upper Willamette River winter steelhead spawning (as appropriate by location), and if possible, from a source within the local watershed.

t. Drilling, Boring, and Sampling

If drilling, boring, or jacking is used, the following conditions apply.

- Isolate drilling operations from stream channels using a steel pile, sleeve, or other appropriate isolation method to prevent drilling fluids from contacting water.
- If it is necessary to drill through a bridge deck, use containment measures to prevent drilling debris from entering the stream channel.
- If directional drilling is used, the drill, bore, or jack hole will span the channel migration zone and any associated wetland or wetted stream channel.

(1) Waste Containment

- Sampling and directional drill recovery/recycling pits, and any associated waste or spoils, will be completely isolated from surface waters, off-channel habitats, and wetlands. All drilling fluids and waste will be recovered and recycled or disposed of to prevent future entry into flowing water. Use a tank to recycle drilling fluids.
- All waste or spoils will be covered if precipitation is falling or imminent.
- When drilling is completed, remove as much of the remaining drilling fluid as possible from the casing (e.g., by pumping) to reduce turbidity when the casing is removed.
- If a drill boring case breaks and drilling fluid or waste is visible in water or a wetland, make all possible efforts to contain the waste and contact NMFS within 48 hours. All drilling activity will cease, pending written approval from NMFS to resume drilling.

u. Stormwater Management

Prepare and carry out a stormwater management plan for any project that will produce a new impervious surface or a land cover conversion that slows the entry of water into the soil. The plan must be available for inspection on request by NMFS.

(1) Plan Contents

The goal is to avoid and minimize adverse effects due to the quantity and quality of stormwater runoff for initial construction, and throughout the life of the project by maintaining or restoring natural runoff conditions. The plan will meet the following criteria and contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

- A system of management practices and, if necessary, structural facilities, designed to complete the following functions:

  - Minimize, disperse and infiltrate stormwater runoff onsite using sheet flow across permeable vegetated areas to the maximum extent possible without causing flooding, erosion impacts, or long-term adverse effects to groundwater.

  - Pretreat stormwater from pollution generating surfaces, including bridge decks, before infiltration or discharge into a freshwater system, as necessary to minimize any nonpoint source pollutant (e.g., debris, sediment, nutrients, petroleum hydrocarbons, metals) likely to be present in the volume of runoff predicted from a 6-month, 24-hour storm.

- Document completion of the following storm water management activities according to a regular schedule for the operation, inspection and maintenance of all structural facilities and conveyance systems, in a log available for inspection on request by NMFS.

  - Inspect and clean each facility as necessary to ensure that the design capacity is not exceeded, heavy sediment discharges are prevented, and whether improvements in operation and maintenance are needed.

  - Promptly repair any deterioration threatening the effectiveness of any facility.

  - Post and maintain a warning sign on or next to any storm drain inlet that says, as appropriate for the receiving water, “Dump No Waste - Drains to Ground Water, Streams, or Lakes.”

  - Only dispose of sediment and liquid from any catch basin in an approved facility.

(2) Runoffs/Discharge Into a Freshwater System

When stormwater runoff will be discharged directly into fresh surface water or a wetland, or indirectly through a conveyance system, the following requirements apply.

- Maintain natural drainage patterns and, whenever possible, ensure that discharges from the project site occur at the natural location.

- Use a conveyance system comprised entirely of manufactured elements (e.g., pipes, ditches, outfall protection) that extends to the ordinary high water line of the receiving water.

- Stabilize any erodible elements of this system as necessary to prevent erosion.

- Do not divert surface water from, or increase discharge to, an existing wetland if that will cause a significant adverse effect to wetland hydrology, soils or vegetation.

- The velocity of discharge water released from an outfall or diffuser port may not exceed 4 fps.
- Waste anesthetic-laden water must be disposed of in accordance with applicable laws.

v. <u>Hazardous Material Safety</u>

At the project site:

- Post written procedures for notifying environmental response agencies, including an inventory and description of all hazardous materials present, and the storage and handling procedures for their use.
- Maintain a spill containment kit, with supplies and instructions for cleanup and disposal, adequate for the types and quantity of hazardous materials present.
- Train workers in spill containment procedures, including the location and use of the spill containment kits.
- Temporarily contain any waste liquids generated under an impervious cover, such as a tarpaulin, in the staging area until the wastes can be properly transported to, and disposed of, at an approved receiving facility.

w. <u>Barge Use</u>

Any barge used as a work platform to support construction will be:

- Large enough to remain stable under foreseeable loads and adverse conditions.
- Inspected before arrival to ensure vessel and ballast are free of invasive species.
- Secured, stabilized and maintained as necessary to ensure no loss of balance, stability, anchorage, or other condition that can result in the release of contaminants or construction debris.

x. <u>Dust Abatement</u>

- Use dust abatement measures commensurate with soil type, equipment use, wind conditions, and the effects of other erosion control measures.
- Sequence and schedule work to reduce the exposure of bare soil to wind erosion.
- Maintain spill containment supplies on-site whenever dust abatement chemicals are applied.
- Do not use petroleum-based products.

- Do not apply dust-abatement chemicals (e.g., magnesium chloride, calcium chloride salts, ligninsulfonate) within 25 feet of a water body, or in other areas where they may runoff into a wetland or water body.

- Do not apply ligninsulfonate at rates exceeding 0.5 gallons per square yard of road surface, assuming a 50:50 solution of ligninsulfonate to water.

y. Implementation Monitoring

A status of a project or a description of the completed project will be provided in an annual report. This annual report will be submitted to NMFS describing the status of projects and, if completed, the success in meeting the RPMs and associated terms and conditions of the Opinion. It will include the following:

(1) Project Identification

- Project implementer name, project name, detailed description of the project.

- Project location by 5th or 6th field Hydrologic Unit Code and by latitude and longitude as determined from the appropriate U.S. Geological Survey 7-minute quadrangle map.

- Starting and ending dates for the work completed, or expected completion date for ongoing projects.

(2) Photo Documentation

Photo documentation of habitat conditions at the project site before, during, and after project completion.

- Include general views and close-ups showing details of the project and project area, including pre- and post-construction.

- Label each photo with date, time, project name, photographer's name, and documentation of the subject activity.

(3) Other Data

Additional project-specific data, as appropriate, for individual projects:

- Work cessation. Dates work ceased because of high flows, if any.

- Fish screen. Compliance with NMFS’ fish screen criteria.

- Pollution and Erosion Control Plan. A summary of pollution and erosion control inspections, including any erosion control failures, contaminant releases, and correction efforts.

- Description of site preparation.
- Isolation of in-water work area, capture, and release.
    - Supervisory fish biologist's name and address.
    - Methods of work area isolation and take minimization.
    - Stream conditions before, during, and within 1 week after completion of work area isolation.
    - Means of fish capture.
    - Number of fish captured by species.
    - Location and condition of all fish released.
    - Any incidence of observed injury or mortality of listed species.
- Streambank protection.
    - Type and amount of materials used.
    - Project size – one bank or two, width, and linear feet.
- Site rehabilitation. Photo or other documentation that site rehabilitation performance standards were met.

NMFS will be reviewing the detailed construction plans submitted to advise the Corps regarding whether or not those plans are likely to meet the Best Management Practices articulated in the 2008 BiOp incidental take statement's terms and conditions, or such additional best management practices that NMFS deem appropriate.

To implement RPM 4 of the NMFS 2008 BiOp, USACE must complete all monitoring and reporting requirements in the RPA and Proposed Action. They must also report all observations of dead or injured salmon or steelhead adults or juveniles coincident with carrying out the terms and conditions of the above measures (noting whenever possible the species of these individuals) to NMFS within 2 days of their observance, and include a concise description of the causative event (if known), and a description of any resultant corrective actions taken (if any) to reduce the likelihood of future mortalities or injuries. Reports of dead or injured salmon or steelhead should be sent to:

Willamette Project Staff Lead
Hydropower Division
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, Oregon 97232
(503) 736-4720

To implement RMP 7 (construction) of the USFWS 2008 BiOp, USACE must adhere to the following: For major construction projects (e.g., the development of fish collection facilities) with the potential to effect bull trout and Oregon chub, or any other listed species under the jurisdiction of the USFWS, the Corps may need to complete project-specific Section 7 consultation. The need for future consultation will be assessed by USACE, Bonneville Power Administration, and USFWS. These future project specific consultations will tier to this programmatic USFWS 2008 BiOp.

11.4 GOVERNMENT TO GOVERNMENT CONSULTATION

Tribal consultation for this project began in November 2017. USACE is consulting with the Confederated Tribes of Grand Ronde, the Confederated Tribes of Siletz Indians, and the Confederated Tribes of Warm Springs. On November 17, 2017 the Tribes were mailed a consultation letter that included information about the proposed project location and the purpose and need for the project. Additionally, the consultation invited the Tribes to provide any comments or concerns regarding the proposed project or meet with project team members to discuss the project in more detail. The Confederated Tribes of Grand Ronde requested a meeting, which was held at The Confederated Tribes of Grand Ronde Tribal Governance Building on January 9, 2018. USACE presented information about the proposed project location, proposed actions, and the purpose and need for the project. The Tribal members and staff present at the meeting expressed support for the project, a willingness to provide assistance and information if needed, and emphasized continued communication with them as the project progressed. On February 5, 2017, USACE hosted a field trip to the project site with representatives from the Confederated Tribes of Grand Ronde. On November 6, 2018, USACE provided the draft Environmental Assessment to the Tribes listed above for their review and comment in advance of public review.

11.5 REFERENCES

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ODEQ. 2005. General 1200-CA Permit. WQ File No. 114926. ODEQ Northwest Region, Portland, Oregon.

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National Marine Fisheries Service (NFFS). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Portland, Oregon.

NMFS. 2008a. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat

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NMFS. 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

Oregon Department of Fish and Wildlife. 2008. Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources. ODFW, Northwest Region North Coast Watershed District

U.S. Army Corps of Engineers. 2002. Excerpted from the Civil Works Environmental Desk Reference. http://www.usace.army.mil/CECW/Documents/cecwp/envdref/2002ProfilesofLaws.pdf

U.S. Fish and Wildlife Service. 2008. Final Biological Opinion on the Willamette River Basin Flood Control Project Endangered Species Act Section 7 Consultation on the Continued Operation and Maintenance of the Willamette River Basin Project and Effects to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act. USFWS, Portland, Oregon.

SECTION 12 - COST ESTIMATES

12.1 GENERAL

This section presents the cost estimate for the Cougar downstream fish passage project, as presented in this report. The Total Project Cost (TPC), which includes design and construction, estimated at the 90-percent DDR phase, is $150 million. The construction contract, including escalation to the midpoint of construction and a 26-percent contingency, is estimated to cost $120 million.

12.2 CRITERIA

ER 1110-2-1302, Engineering and Design Civil Works Cost Engineering, provides policy, guidance, and procedures for cost engineering for all USACE Civil Works projects. For a project at this phase, the cost estimates are to include construction features, lands and damages, relocations, environmental compliance, mitigation, engineering and design, construction management, and contingencies. The cost estimating methods used are to establish reasonable costs to support a planning evaluation process. The design is at a preliminary level and the cost estimate is at a similar level.

12.3 BASIS OF THE COST ESTIMATE

The cost estimate is based on discrete costs for equipment, manpower, and materials where quantities and/or costs for such items can be assumed with reasonable confidence at this design level, and parametric unit costs where such assumptions cannot reasonably be made.

A formal Cost and Schedule Risk Analysis has been completed. Results and conclusions of the analysis are included in Appendix N.

12.4 COST ITEMS

The floating screen structure (FSS) is the largest cost item. The cost estimate for this feature is compared to similar facilities recently constructed in the Pacific Northwest. The Upper Baker Floating Surface Collector represents the low end of the range at $42 million (2017). The Swift Floating Surface Collector represents the high end of the range at $59 million (2017). The Cougar FSS is estimated to cost $62 million.

The other major features included in the cost estimate are mooring dolphins at $12 million, modifications to the water temperature control tower at $5 million, and rock excavation and retaining wall at $5 million.

12.5 ACQUISITION STRATEGY

The acquisition strategy will be Full and Open Competition with a Best Value Trade Off source selection.

12.6 SUBCONTRACTING PLAN

The cost estimate assumes that the prime contractor will be marine contractor that will self-perform marine work, civil work, and structural work. Subcontractors are expected for the electrical, mechanical, metal fabrication, and blasting work.

12.7 FUNCTIONAL COSTS

a. Planning Engineering and Design (30 Account)

Engineering and Design costs are determined from the budgets for the expected design and engineering effort. These costs include engineering costs for design and development of a contract package (plans and specifications), Portland District review, contract advertisement, award activities, and engineering during construction. This effort is estimated to cost $15 million, including a 26-percent contingency.

b. Construction Management (31 Account)

Construction Management costs are determined from the budget of the expected effort for supervision, administration and quality assurance for the construction contract. This effort is estimated to cost $15 million, including a 26-percent contingency.

12.8 ANNUAL OPERATIONS AND MAINTENANCE

Annual operations and maintenance costs have not been estimated at this time.

SECTION 13 - OPERATIONS AND MAINTENANCE

13.1 GENERAL

This section covers operations and maintenance (O&M) considerations. Operations and maintenance details will be refined during the plans and specifications phase. During construction, an operations and maintenance manual will be produced.

13.2 RESERVOIR OPERATIONS DURING CONSTRUCTION

The Cougar project will operate normally during construction, with one significant exception. During 2021, the reservoir will be lowered to elevation 1,450 feet using the diversion tunnel to allow dry access to the base of the temperature control tower.

During construction, the contractor may request minor deviations from normal operations to facilitate construction activities. These requests will be coordinated with Operations and Reservoir Regulation staff during the weekly construction coordination meetings.

13.3 OPERATIONS AND MAINTENANCE POST CONSTRUCTION

a. Floating Screen Structure Period of Operations

The floating screen structure (FSS) will operate over a range of reservoir elevations from 1,528 to 1,690 feet. If the reservoir is expected to increase above elevation 1,690 feet or decrease below elevation 1,528 feet, the FSS will be shut off and hydraulically disconnected from the water temperature control tower (WTCT). If the pool will drop below elevation 1,528 feet, but stay above elevation 1,516 feet, the FSS will be de-ballasted into the maintenance position to avoid hitting the bench elevation of 1,490 feet. If the pool will drop below elevation 1,516 feet, the FSS would be disconnected, moved out of the cul-de-sac into deeper water, and secured. The operation of the FSS for fish collection will be as follows:

- The FSS will be operated from January 1 to June 30 and September 1 to December 31.

- The annual maintenance period will be July 1 to August 31. The annual maintenance period may be extended or shortened depending on maintenance schedule and environmental conditions. Shortening or extending the maintenance period will require coordination with the Willamette Fish Passage Operation and Maintenance (WFPOM) team. The amount and type of maintenance will vary from year to year and the scheduled maintenance period will be adjusted accordingly.

- If temperatures exceed 21 degrees Celsius, which is the sampling limit per the 2008 BiOp, the FSS will be shut off and fish collection and transport will be halted. This temperature criteria may either increase or decrease the period of operations.

- During the fish collection season, the FSS will operate 7 days a week, 24 hours per day.

b. Staffing Needs During Floating Screen Structure Operations

Two people will be required on site for operating the FSS and for safety considering the FSS is remotely located in Cougar Reservoir. A Fish Biologist (Supervisory) and two General Maintenance workers will be required for the FSS operations. Seasonal or permanent Biological Science Technicians or a Fish Biologist will be required for the daily fish collection operations and sampling. The Fish Biologist will oversee the operation and maintenance of the FSS. The maintenance staff will be required to keep the FSS mechanically operational and completed daily, monthly, and annual maintenance tasks. The maintenance staff will also be responsible for the transportation vehicle and transporting the fish to the release location below Cougar Dam. The Fish Biologist and General Maintenance staff will be responsible for maintaining an inventory of parts and supplies for the FSS. The staffing needs for operating the FSS are as follows.

- <u>12-Hour Shifts</u>. If 12-hour shifts are the desired staffing, the FSS will need eight technicians (or biologists) to operate the FSS. The technicians (or biologists) would work seven days on followed by seven days off. The maintenance staff would require General Maintenance staff to ensure that coverage is available on a daily basis.

- <u>8-Hour Shifts</u>. If 8-hour shifts are the desired staffing, then a rotation of 8-12 technicians (or biologists) would be needed. The maintenance staff requirements are the same as those listed above.

c. Emergency Operations of the Floating Screen Structure

Operations of the FSS during an emergency will depend on the emergency. In the event of a power failure, the FSS backup generator will supply enough power to the ballast pumps, emergency lighting, monorail crane, and communications system. Fish being held on the FSS will be transported, by the monorail crane, in their tanks to the AV. There will not be a need to manually move fish from the transport tanks. However, it might be necessary to manually remove a small amount of fish from the sample area. FSS personnel will use the AV for egress of the FSS.

13.4 SYSTEM OPERATIONS

a. Pool Operation Ranges

The following operation activities will occur for these ranges of pool elevation:

- 1,699 (maximum pool) to 1,690 feet (maximum conservation pool) – No fish collection.

- 1,690 to 1,571 feet (lowest *current* temperature control) – Collection of 300 to 1,000 cfs with excess flow passing through temperature control slots up to total project outflow of 3,000 cfs.

- 1,571 to 1,532 feet (minimum conservation pool) – Collection of 300 to 1,000 cfs through FSS to WTCT with excess flow passing through the RO bypass gate into the WTCT.
- 1,532 to 1,528 feet – Collection of 150 cfs to maximum capacity determined by flume weir with excess flow passing through the regulating outlet (RO) bypass gate into the WTCT.
- 1,528 to 1,516 feet – No fish collection. FSS will be de-ballasted into maintenance position.

b. Collection Channel Operation

Secondary dewatering screens are to be tuned to meet velocity gradient criteria and are to be operated in an on or off condition. Variable flow control through the secondary channels will not be achieved during day to day operation but through rigorous testing and calibration of the control weirs. Due to this added effort, a minimum flow rate for the FSS is defined by the minimum outflow of the interior secondary collection channel.

Primary dewatering screens are to have variable outflow, which will be used to accommodate incremental changes in total project outflows under 1,000 cfs during operation. These dewatering screens have flow control weirs that are operated by a PLC to adjust with total project outflow.

The starboard collection channel has a variable capacity to pass flow from 145 cfs up to 455 cfs.

13.5 DEBRIS MANAGEMENT

a. Debris Management Outside the Floating Screen Structure

Debris collected outside the debris barrier will be removed annually, during high pool. The debris will be worked through the gate in the barrier, moved to the dam upstream access road, and removed from the reservoir.

The method of removal for debris that may accumulate on the elevation 1,490 feet bench below the FSS is to be determined. When the FSS is fishing at pool elevation 1,528 feet, there will be approximately 5 feet clearance between the bottom of the FSS and the bench for motions and debris accumulation. An ROV may be used to inspect for debris on the bench.

b. Debris Management Within the Floating Screen Structure

Debris reaching the FSS will need to be removed to not impede operation, and removal depends on where the debris is located within the FSS. The following describes the methods of debris removal in each area for when the FSS is in normal operation.

(1) Collection Channel Entrance

At the front of the FSS there is a course trashrack to stop debris such as large branches and logs. This debris will be removed with the trash rake automatically or manually. The trash rake will remove the debris from the racks and transport it along the overhead rail system to the debris barge located in the AV slip on the FSS. The debris barge will then be towed by the AV to the dump site (see Section 13.5.a, Debris Management Outside the Floating Screen Structure).

(2) Primary Dewatering Screens

Past the coarse trashrack are the primary dewatering screens. The screens are vertically orientated wedge wire with small gaps that allow water through, but not fish or debris. These screens can become impinged with algae and small debris and must be cleaned once the water reaches a preset differential (designed to be 0.1 foot of head) from one side of the screen to the other, or else on set intervals determined by the project staff. Cleaning will be performed using a traveling brush submerged within the flow of water. The brush will be lowered from the overhead rail and placed on the upstream side of the primary screens. It will then travel the full length of the screens, dislodging debris and sending it downstream. See Section 6, Mechanical Design, for details on the operational scheme of the primary screen cleaners.

(3) Secondary Dewatering Screens

The next section downstream from the primary dewatering screens is the secondary dewatering screens. This area is narrow with an upward ramping floor. This makes a traveling cleaner in the flow of water not feasible, and a water burst system will be used instead. The water burst system will consist of an array of nozzles positioned behind the secondary screens, which will traverse along the screen and spray water through to dislodge debris and send it downstream. The nozzle array will be attached to a network of piping and pumps pulling screened water from the secondary plenum on a set interval determined by the project staff.

(4) Intermediate Debris Rack

A concept for intermediate debris racks is still being discussed and investigated. Within this concept, debris that passes through the course trashrack at the collection channel entrance will encounter the intermediate debris racks. These racks consist of four bars angled away from the flow of water that are spaced from the channel centerline to the wall. There will be two sets of bars in each channel spaced a foot downstream from each other with each set terminated at separate channel walls. Debris that gets entangled on the bars will be removed by hand and placed in a bucket for later addition to the debris hopper.

Further investigation must be completed, and a decision made regarding if these intermediate debris racks are safe in this high-velocity portion of the collection channel. There is a danger of caught debris becoming a “strainer” and injuring passing fish.

(5) Tertiary Dewatering Screens

Downstream of the intermediate debris rack is the tertiary dewatering screens. Debris that passes through the previous racks and screens will likely pass through the tertiary dewatering screens as well. Smaller debris and algae may impinge on the screens and will need to be removed by hand and placed in a bucket for later addition to the debris hopper.

(6) Fish Sorter

The fish sorter downstream of the tertiary dewatering screens will also sort debris. Larger debris will slide down the bars into the adult holding tank. Smaller debris will fall through the bars and end up in the fish counter and sampler. Any debris that clings to the sorter will need to be removed by hand and placed in a bucket for later addition to the debris hopper.

(7) Adult Holding Tank

Debris that passes over the bars of the fish sorter will move to the adult holding tank. A partially submerged conveyor located in the corner of the tank will raise debris and deposit it into a flume. The debris will then travel down the flume into the debris hopper. Fine debris may be skimmed out by hand and deposited directly into the hopper as well. Debris that sticks and any algae buildup will be washed down the flume.

(8) Fish Counter and Sampler

Debris passing through the bars of the fish sorter will end up in the fish counter and sampler. Once in, the debris will be removed by hand and placed in a bucket to be transferred to the debris hopper.

(9) Debris Hopper

The debris hopper is the final collector for any debris that passes through the entrance debris racks and into the collection channels. The hopper will be located on the lower level of the fish sorting area of the FSS. The hopper will be the same size as the adult fish pod (250 gallons) so removal by hand will not be feasible and the overhead monorail system will need to be utilized. The hopper will be lifted up and travel down the rail until it dumped into the debris barge or be lowered and secured to the AV in the same position as the adult fish pod. If secured to the AV, debris can be removed from the hopper at the dump site of the debris from the log boom or the quarry. See Section 13.5.a, Debris Management Outside the Floating Screen Structure, for more information on the dump site.

13.6 SPECIAL SAFETY REQUIREMENTS

Portland District Safety and Occupational Health Office identified the following areas to focus on during plans and specifications.

a. Fall Protection

The FSS design uses guard railing to eliminate most fall hazards. Considerations are:

- Anywhere there will be personnel working below the walking surface, e.g. a lower deck, please ensure a toe board is also installed integral to the guard railing.
- Those areas where employees will need to work outside of guarded areas, e.g. where fall restraint or arrest equipment will be utilized, dedicated fall protection anchors need to be included in the design. A minimum of two anchors must be present for each worker, one for the worker and a second for a rescuer in the event of a fall.

b. Ladder

Where ladders are used, please ensure rungs are coated with anti-slip material and if over 20 feet are equipped with a ladder climbing device. Ladder cages are no longer an authorized fall protection system. Ladder side rails should also be extended 36 inches beyond the walking surface to allow for a smooth transition to the deck and guarded with a self-closing gate.

c. Plumbed Eyewash/Shower

Determine what chemicals are going to be brought aboard the FSS for operations and maintenance. If clove oil is to be used, the Safety Data Sheet says that an eyewash station with 15 minutes of flush time should be available when using this product. This can be accomplished using a portable system. The end users need to determine if any other hazmat brought aboard will require the installation of plumbed eyewash/shower, or can these materials be replaced by a less toxic/dangerous material.

d. Machine Guarding

The FSS will require a lot of moving pieces and parts. Every time we commission a new fish facility/structure we typically identify multiple machine guarding or interlock issues that need to be modified. Any rotating shafts, moving parts, cables, sheaves, etc. that can be physically contacted by a worker shall be guarded. This is a high interest area for OSHA and Portland District. The more we can mitigate during design means the less the project will have to address following commissioning.

In addition, Portland District Safety and Occupational Health Office provided an Analysis of Human Risk Factors Associated with Ergonomics document for consideration. This document has been shared with the design PDT.

13.7 EMERGENCY OPERATIONS

The following emergency and non-emergency situations need to be addressed during the development of the operations and maintenance manual. The provided list is a general overview of the type of situations that may occur. Specifics for each situation need to be fully detailed out during the development of the operations and maintenance manual.

- Momentary and extended loss of power.
- Load rejection from the turbines.
- Reservoir pool elevations outside FSS operating range.
- Flow path for water outside FSS operating range.
- Malfunction of the cup during elevation changes.
- Minimum reservoir elevation to allow FSS to be removed from cul-de-sac.

13.8 MAINTENANCE

a. Inspections

Inspections will occur during the maintenance period in late summer, when the FSS is de-ballasted up into the low-draft maintenance position and the fish passage system components are out of the water. The bottom of the FSS hull will require inspection by divers at a frequency documented in the Marine Design section.

b. Hull Maintenance

Hull maintenance is expected to be minimal over time due to the relatively benign water conditions and limited movements of the FSS. Maintenance or repair may be accomplished, depending on the location and nature of the hull work, with the FSS in the maintenance position (minimum draft) via barges located adjacent to the FSS. If hull bottom or low-elevation maintenance or repair is required, the FSS will be disconnected from the WTCT and floated up-reservoir to the Slide Creek Campground location for dry-docking. The contractor hired for the maintenance or repair would be tasked with reestablishing a flat pad with supports at Slide Creek for the dry-docking. The dry-docking operation would be a reverse of the initial launch operation.

13.9 LIFE-CYCLE COSTS

A life-cycle cost analysis will be conducted during the plans and specifications phase. When completed, this subsection of the DDR will summarize the method and results.

SECTION 14 - CONSTRUCTION

14.1 GENERAL

This section presents the basic construction considerations, restrictions, and coordination of the major feature construction for the Cougar downstream fish passage project. A Product Development and Construction Schedule is located in Appendix N.

14.2 SCHEDULE

Notice to Proceed is anticipated to be issued in the spring of 2020. The reservoir will be lowered using the diversion tunnel in January of 2021 to allow for tower modifications to occur in the dry during the 2021 calendar year. Construction will be completed in December 2022.

14.3 CONSTRUCTION

The FSS will be built off site at a metal fabrication shop in modules that can be trucked to the Cougar reservoir. The modules will be assembled upland at the Slide Creek Campground boat ramp staging area on the reservoir shoreline. Once fully assembled, the FSS will likely be launched by allowing the reservoir to pick up the FSS when the reservoir refills after the 2021 drawdown. An alternate plan is to launch the FSS like a boat by sliding it down crane rails, using hydraulic dollies to drive it, or rolling it on inflatable cylinders. Tugs will then move the FSS into position at the temperature control tower.

During the reservoir drawdown, the following features will be constructed. Rock excavation will be completed at the base of the temperature control tower to make room for the FSS at low reservoir elevations. Modifications to the water temperature control tower will be completed to allow the FSS to be hydraulically connected to the tower. The mooring towers will be constructed.

Figure 14-1. Skanska Launching the Lower Baker Floating Surface Collector with Hydraulic Dollies and Dump Trucks

14.4 RESERVOIR OPERATIONS DURING CONSTRUCTION

The Cougar project will operate normally during construction with the exception of an approximate 1-year deep drawdown to facilitate construction activities at the temperature control tower. The reservoir will be lowered using the diversion tunnel to allow dry access to the base of the water temperature control tower. The diversion tunnel will pass flows during the drawdown. The drawdown is limited to one summer for environmental reasons. The drawdown can start as early as November 2020 and must end in December of 2021 to ensure a full pool in the summer of 2022. In December of 2021, normal operations will resume.

It is likely that during construction the contractor will request minor deviations from normal operations to facilitate construction activities. These requests will be coordinated with Operations and Reservoir Regulation staff during the weekly construction coordination meeting.

14.5 PROBABILITY OF REFILL

Following drawdown of the reservoir to 1,450 feet for the construction of the FSS foundation elements, the reservoir will begin to refill to its normal rule curve, which is 1,532 feet in January, and a targeted maximum elevation of 1,690 feet by June. To facilitate launching of the floating surface collector, the reservoir pool elevation must rise above the level at which the collector is constructed. The maximum pool elevation realized during refill is dependent upon the natural inflows to the reservoir during the refill period and how that water is managed. The non-exceedance probabilities of achieving various elevations during the refill period immediately following the 1,450-foot drawdown are shown in Figure 14-2. These elevations may be used to inform the decision at what elevation to construct the collector.

Pool elevation non-exceedance probabilities are based on outcomes of a reservoir regulation simulation model (HEC-ResSim). Seventy-three years of operations, including drawdown to 1,450 feet then subsequent refill, were simulated using historical hydrology from 1936 to 2008. Drawdown and refill is consistent with the proposed construction schedule. Reservoir operations are conducted for hydropower, flood risk management, and environmental and biological functions. The simulation assumed that refill would be prioritized such that Cougar would not be used to meet BiOp minimum flow requirements at Salem and Albany; however, local BiOp requirements for outflow ramping rates and minimum flows were maintained.

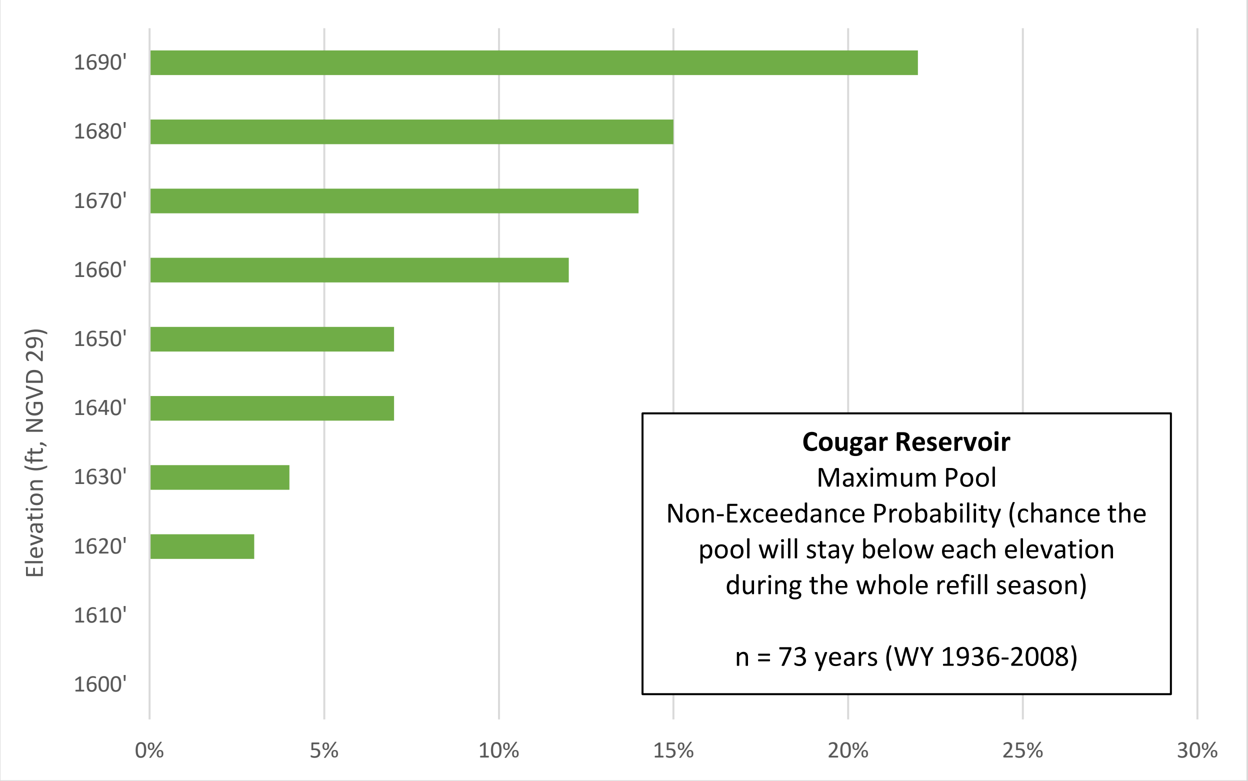

Figure 14-2. Non-Exceedance Probability of Maximum Pool

14.6 BLASTING

The U.S. Fish and Wildlife Service granted USACE a variance to allow blasting within the restricted period of March 1 through July 16. Rock was recently blasted in the area during the 2005 water temperature control tower construction.

14.7 STAGING AREAS

The floating surface collectors recently built by power companies in Oregon and Washington were all built on the bank of the reservoir and then launched into the water like a boat. The terrain around Cougar is steep. Two locations appear to be possible staging areas for assembly of the collector. The Echo day use area and boat launch and the Slide Creek Campground and boat launch. Slide Creek Campground will be pursued as the primary staging area because it is wider than Echo, not as steep, and the terrain to the left and right of the paved boat ramp is also relatively flat. The Slide Creek Campground will be impacted during calendar years 2021 and 2022.

It is anticipated that some minor improvements to the Slide Creek boat ramp will be necessary to assemble the FSS. The improvements could include cutting in a straight access road, grading to create flat surfaces, gravel placement, temporary fencing for security, and it is possible that small cofferdam is used to protect the FSS from high reservoir elevations. The contract will require that the Slide Creek Campground and boat ramp be restored as part of demobilization.

When construction activities occur at the temperature control tower it is expected that the contractor will use the parking lot, the tower, and the dam face road to stage equipment and materials and access the site.

Figure 14-3. Lower Baker Floating Surface Collect Being Assembled at the Shore of Lake Shannon by Skanska

14.8 PUBLIC ACCESS

Public access will not be significantly impacted. The Slide Creek Campground and boat ramp will be the most impacted with partial or total closure to the public during 2021 and 2022. There may be intermittent road closures or delays caused by construction traffic.

SECTION 15 - REAL ESTATE

15.1 GENERAL

The Cougar Dam project is located 4.4 miles above the mouth of South McKenzie River, and approximately 50 miles east of Eugene, Oregon, via U.S. Highway 126. Cougar consists of +/- 5,483.81 acres (5,385.77 acres Withdrawn Lands, 93.55 acres Fee Ownership, and 4.11 acres Easement Reservation). All land is located within the boundaries of the Willamette National Forest. Project lands are in federal ownership with approximately 5,385.77 acres being withdrawn National Forest lands, lands that have been segregated from the operation of public land laws by Executive Order 10355 dated 26 May 1952 (Appendix 1). On 19 October 1987, Earnest E. Swanson, Chief, Real Estate Division, Portland District, USACE, wrote a Re-justification Statement for the Continuation of Withdrawal (Appendix 2) for an additional 100 years. The remaining 97.66 acres are acquired by USACE for project purposes. Of the 5,385.77 acres of Withdrawn Lands, 3,613.8 acres were withdrawn for construction purposes.

15.2 PROJECT AUTHORIZATION

The Cougar project as described in House Document 531 (published in 1951) was authorized by Congress under the Flood Control Act of June 28, 1938 (Public Law 761, 75th Congress, Chapter 795, 3rd Session). The law approved the general comprehensive plan for flood control, navigation, and other purposes in the Willamette River Basin.

As authorized by law, USACE is responsible for the construction and operation of the project for its primary purposes, which included flood control, navigation, consumptive water use, and power production; and in carrying out these functions has basic jurisdiction over all project areas including withdrawn National Forest lands. The use or utilization of withdrawn National Forest lands for purposes extraneous to project operation remains under the jurisdiction of the U.S. Forest Service (USFS). The responsibility for administering all other project lands within the National Forest boundary for recreation, fire protection, and land management is vested with the USFS in accordance with a Memorandum of Understanding between the U.S. Department of Agriculture and the U.S. Department of the Army, effective August 13, 1964.

USACE has primary control over the water surfaces and all lands adjacent to and beneath the water surfaces of the project to the extent required to execute those functions related to the operation of the project for its primary purposes. The occupancy and use of all project lands and waters within the National Forest must be coordinated with the office of the USFS, Willamette National Forest.

15.3 CONSTRUCTION RIGHT-OF-WAY REQUIREMENTS

Based on a review of the downstream fish passage, no additional permanent real estate will be required for the proposed structure, taking into consideration that USACE already owns and controls Cougar Dam. There is no permanent construction outside of the existing Cougar Dam area.

General access to the project site is from Highway 126. Water access to the project is from the Slide Creek Campground boat ramp, 7.5 miles past Cougar Dam on NF-500 on the east side of the reservoir. This boat ramp is the most logical choice for deploying marine equipment to support construction. The Slide Creek boat ramp is 30 feet wide by 200 feet long with a parking lot with capacity for 16 vehicles and trailers. The Slide Creek Campground (approximately 6.5 acres), directly south of the boat ramp, offers 16 camping sites with an open season from mid-April to mid-September.

It should be noted that the Slide Creek boat ramp and campground is under the administrative jurisdiction of the USFS, and any use by USACE and/or its contractors will require coordination with the office of the USFS, Willamette National Forest.

Construction activities may require closure of the boat ramp and campground in full or in part for an extended period of time. Therefore, the impacts of closing the boat ramp and campground and proposed alternatives shall be further explored at a later stage when more definitive design and scheduling information is available.

The Echo boat launch is considered a secondary water access point, located 2.3 miles past Cougar Dam on NF-1993. The Echo boat ramp is under the administrative jurisdiction of the USFS, and any use by USACE and/or its contractors will require coordination with the office of the USFS, Willamette National Forest.

15.4 CONCLUSION

USACE retains the authority and jurisdiction to undertake construction activities upon withdrawn lands at Cougar Reservoir to meet the primary purposes of the project. However, as a courtesy, further coordination with the office of the USFS, Willamette National Forest is required to secure Slide Creek boat ramp and campground and/or Echo boat ramp to meet the needs of the downstream fish passage. At this time, the office of USFS, Willamette National Forest, has verbally communicated approval of the proposed construction activities to include the full or partial closure of Slide Creek. The USFS has requested to review USACE project plans and NEPA documentation before issuing formal approval.